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THE THERMOCHEMISTRY OF THE CHEMICAL SUBSTANCES

THE ASSEMBLY OF A SELF CONSISTENT TABLE OF "BEST" VALUES FOR THE HEATS OF FORMATION OF THE CHEMICAL SUBSTANCES (EXCEPT CARBON COMPOUNDS CONTAINING MORE THAN TWO CARBON ATOMS), INCLUDING HEATS OF TRANSITION, FUSION, AND VAPORIZATION

By

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THIS BOOK IS DEDICATED TO THE LATE

EDWARD W. WASHBURN

WITHOUT WHOSE ENCOURAGEMENT ITS
COMPILATION WOULD NOT HAVE
BEEN POSSIBLE.

PREFACE

The assembly of the table of values for the heats of formation in the section on Thermochemistry in the International Critical Tables was the first attempt ever made to collate all the published data involving heats of reaction and to prepare therefrom a self-consistent table of "best" values for the heats of formation of the chemical substances. The present book is a complete revision and extension of that original work, which was sponsored by the late Edward W. Washburn as Editor-in-Chief of the International Critical Tables and carried out by one of the present authors (F. R. B.)

The assembly of a self-consistent table of values for the heats of formation of all the chemical substances requires (1) that all the original experimental data be recalculated with the use of appropriate auxiliary data, (2) that the value selected for the heat of formation of a given substance be as accurate as it is possible to obtain from the known data, and (3) that the selected "best" value be as consistent as possible with all the other values in the table and with all the known thermochemical data on reactions involving that substance.

There are four main sections to the present book: (1), the introduction or explanatory part; (2), the table of heats of formation, which is the fruit of the work; (3), the text, in which the original published data are cited and discussed; and (4), the list of references to the literature, which includes references to all the published data bearing on thermochemistry.

The introduction gives all the necessary information concerning the units, symbols, abbreviations, method of utilizing the table, etc.

The table of values contains a list of all the chemical substances (except carbon compounds containing more than 2 carbon atoms), for which there are thermochemical data, together with values for the heats of formation (or heat of transition, fusion, or vaporization) of each substance. It was deemed expedient not to include in the present table values for the heats of formation of carbon compounds containing more than two carbon atoms. It should be possible to obtain from this table, by simple addition and subtraction, the heat of any process involving any of the substances given, with an accuracy as great as is actually known. There are listed in the table 5840 values of heats of formation, and, in addition, 350 values of heats of transition, fusion, vaporization, or reaction, for substances for which no values are given for the heat of formation.

In the text, each paragraph or group of paragraphs is labeled with the formula of a chemical substance (or substances), and under that heading are cited all the published thermochemical data on reactions which can

be utilized to compute the heat of formation of the given substance (or substances).

In the list of references are given the citations to the literature for all the published works bearing on thermochemistry which are discussed or mentioned in the text. This list of 3730 references includes all the publications covered by Chemical Abstracts up to January 1, 1931, and nearly all of the important and significant contributions which have been published in the period from January 1, 1931, to January 1, 1934.

The symbols given in this book for the various heats of reaction, fusion, vaporization, sublimation, transition, dissociation, and formation are merely abbreviations used for convenience in the present work, and are not proposed to be used in lieu of, or in connection with, the regularly accepted symbols of chemical thermodynamics.

The standard temperature selected for the values given in this book is 18° Centigrade, following the procedure of the thermochemistry section (Bichowsky[1]) of the International Critical Tables. The authors have been reluctant not to use the almost universally accepted standard temperature of 25° Centigrade for thermodynamic calculations; but the selection of 18° as the standard temperature is practically necessary in this case because all of the monumental work of Julius Thomsen and of Marcellin Berthelot was done at or near 18° and there are not now available sufficient heat capacity data with which to make accurate conversion to 25° (this is especially important for reactions involving substances in aqueous solution where the temperature coefficient is usually very large). In later years, as the data on heat capacities become available, or as the heats of many of the reactions, which have until the present time been measured only by Thomsen or Berthelot or both, are redetermined, it will be quite feasible to use 25° as the standard temperature.

Where it is expedient and necessary, each unusual method of calculation used in the text is explained. The ordinary and simple methods of calculating thermochemical values are assumed to be known to the reader, and the advanced methods which are used but not described may be found explained in one of the many current books on advanced physical chemistry or thermodynamics.

The authors will greatly appreciate the cooperation of readers in making known the errors which they find in this book. Grateful acknowledgment is made to Anne Landgraff Rossini for aid in compilation and checking the copy and proofs.

In compiling the present book, the authors hope that their work will materially aid all those who have need of the data of thermochemistry, and will feel amply rewarded if their efforts help to stimulate renewed activity in the much-neglected but vastly important field of thermochemical research.

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Frederick D. Rossini

Washington, D. C.

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INTRODUCTION

Scale of temperature. With a few exceptions all temperatures recorded in this book are on the Centigrade scale, and, for convenience, temperatures on the Centigrade scale are indicated by a numeral and degree mark without the letter "C," as 18°.

Unit of energy. The fundamental unit of energy in modern thermochemical measurements is the electrical joule, which is derived from standards of resistance and electromotive force maintained at the various national standardizing laboratories.

In the section on Thermochemistry in the International Critical Tables (see Bichowsky[1]), the values were recorded in joules, in the hope that thermochemists might come to use this fundamental unit in their calculations and writings. But the attempt to break away from the calorie as a unit in thermochemical and thermodynamical calculations proved to be unpopular and apparently hopeless of accomplishment. In order to satisfy the popular demand for the calorie as a unit in calculations and tabulations, and at the same time depart as little as possible from the fundamental unit of energy, the joule, in terms of which all accurate thermochemical measurements are actually made, we have used in this book a **defined calorie,** that is, one which has no actual relation whatever, except incidentally and historically, to the heat capacity of water.

In our calculations, the modern experimental data, which have been fundamentally obtained in terms of the international joule, have been converted to a **defined calorie** by means of the following relations (see Rossini[3, 13]): 1 calorie = 4.1850 absolute joules; 1 international joule = 1.0004 absolute joules; 1 calorie = 4.1833 international joules. The values from the older experimental data have been converted to this unit by means of the appropriate factors.

For conversion of values expressed in terms of the **defined calorie** to other desired units, the following factors can be used:

To convert the value in kilocalories to its equivalent in	Multiply the value in kilocalories by
International kilojoules	4.1833
Absolute kilojoules	4.1850
Absolute volt-electrons	0 04337

For converting data on the electromotive force of cells, the value of the **Faraday** constant has been taken as equal to 23.066 kilocalories per international volt-equivalent.

All the energy values, unlabeled with regard to units, that are given in the text and table are in terms of the kilocalorie *defined in the foregoing manner.*

Unit amount of substance. The unit amount of each chemical substance is taken to be that mass represented by its gram formula weight. In recomputing the data of those investigators who reported their results in terms of "weights in air," the authors have reduced to *vacuo* all pertinent weights, when such reduction was significant. *All values of energy given in this book are understood to be for one mole of the given substance (or reaction).* The atomic weights given in the table are those from the 1934 Report of the Committee on Atomic Weights of the International Union of Chemistry (see Baxter, Curie, Hönigschmid, Le Beau, and Meyer[1]). Where the necessary changes were at all significant, the thermochemical values given in the text and table have been changed to conform to the foregoing table of atomic weights.

However, it should be pointed out that great caution must be exercised in attempting any such conversion because of the many different methods which have been used to determine the amount of a given calorimetric reaction. For example, to determine the amount of the reaction, $Na(c) + H_2O\ (liq.) = NaOH\ (aq.) + \frac{1}{2} H_2\ (g)$, one can (1) determine the mass of Na used, (2) determine the mass of H_2 produced, or (3) determine the amount of NaOH by titration with (for example) an aqueous solution of HCl which has been standardized with $AgNO_3$ which in turn has been prepared from a weighed amount of pure Ag. The calculation of the number of moles of reaction taking place will depend in case (1) on the atomic weight of Na, in case (2) on that of H, and in case (3) on that of Ag. Another example is that the value obtained by Rossini[4,8] for the heat of combustion of 1 mole of CH_4 is independent of the atomic weight of carbon, because the amount of calorimetric reaction was determined from the mass of H_2O formed in the combustion.

Standard states. The standard or reference state of each of the elemental substances is taken to be that physical state (or one of them, if there are two or more) in which the element naturally exists at a pressure, or a fugacity, of one atmosphere and at a temperature of 18°. The isotopic composition of each element in its standard state is understood to be the naturally existing one. For the element carbon, we have selected its form as diamond, C (c, diamond), as the standard state because no other form of solid carbon is at present a reproducible and invariable one.

Aqueous Ions. In order to facilitate the computation of the heats of formation of aqueous strong electrolytes, we have taken as an arbitrary reference point for aqueous ions the heat of formation of aqueous hydrogen ion, $H^+(aq.)$, to be zero. Therefore, the values given in the table for the heats of formation of individual aqueous ions are not the actual

heats evolved in the reaction of forming those individual ions from their elements in the standard states, but the sum of the values for a number of ions whose charges sum to zero does represent the actual heat of formation of the sum of those aqueous ions.

Conventions as to temperature, pressure, and concentration. *Every heat of formation or heat of reaction value given in the table or in the text is understood to be, unless otherwise specified, the value for the heat evolved when the reaction takes place at a constant pressure, or a fugacity, of one atmosphere and at a temperature of 18°.* This means that those data obtained at some other temperature have been converted, when the conversion is at all significant, to a temperature of 18°; and that those data obtained at other than constant pressure have been converted to constant pressure. For substances in aqueous (or other) solution, the concentration, when known, is indicated. When the concentration is not indicated, it is understood to be for a "dilute" solution.

Physical state and its description. The physical state of each substance is indicated, in the text and in column 2 of the table, as gaseous, liquid, crystal, glass, colloidal, or in aqueous or other solution. (See the list of abbreviations on page 14.) All states are for a pressure, or a fugacity, of one atmosphere and a temperature of 18°, unless otherwise indicated.

Numerals, in column 2 of the table or in the text in parentheses following the formula of the substance, indicate that one mole of the substance is dissolved in that number of moles of H_2O. When the concentration is not known, there is written, instead of the numeral, the abbreviation "aq." which indicates a large number of moles of H_2O, i. e., the solution is "dilute."

When the substance is dissolved in a solvent other than water, the formula (or name) of the solvent is given, and, if known, the number of moles of it per mole of solute. When the concentration is not given, the solution is understood to be "dilute."

In column 3 of the table are recorded items which serve to identify the substance for which the value of the heat of formation is given. For crystalline substances having stable transition points, the various solid crystalline forms are indicated as I, II, III, IV, etc., beginning with the form stable at the normal melting point. For atoms, ions, and certain molecules, in the gaseous state, the electron configuration and term symbols are given (see Mulliken,[6] Jevons,[1] and Bacher and Goudsmit[1]).

Heat of formation. The heat of formation of a substance, as MX (crystal), is taken to mean the heat evolved in the reaction of forming one mole (gram formula weight) of that substance from its elements in their standard states (as, for example: M (liq.) $+\frac{1}{2}X_2$ (g) $=$ MX(c)) at a constant pressure (or a fugacity) of one atmosphere and, unless otherwise

specified, at a temperature of 18°. The values for the heats of formation of the substances are given in the table in the column headed *Qf*. In the text these values are also labeled *Qf*. Translated into the nomenclature of Lewis and Randall,[5] $Qf = -\Delta H°$ (formation), the decrement in heat content accompanying the reaction of forming the given substance from its elements in their standard states.

In this book, the values for the heats of formation of substances in aqueous or other solution represent values of the apparent molal heat content, not the partial molal heat content (see Lewis and Randall[5] and Rossini[5]). That is to say, for example, the value of *Qf* for NaCl (200) means actually the heat of the reaction, $Na\ (c) + \frac{1}{2}\ Cl_2\ (g) + 200\ H_2O\ (liq.) = (NaCl \cdot 200\ H_2O)\ (liq.)$, though it is written here for convenience as $Na\ (c) + \frac{1}{2}\ Cl_2\ (g) = NaCl\ (200)$. And, similarly, the difference between the values of *Qf* for NaCl (200) and NaCl (400) gives the heat of the reaction, $(NaCl \cdot 200\ H_2O)\ (liq.) + 200\ H_2O\ (liq.) = (NaCl \cdot 400\ H_2O)\ (liq.)$, which equation is written, by the convention of this book, as NaCl (200) = NaCl (400).

Computation of the heat of any process. To compute the heat of any process involving the disappearance of a substance or substances in the states given in the table and the appearance of other or the same substances in states given in the table: Add together the heat of formation (values for *Qf*) of the products of the process in the final states and subtract therefrom the sum of the heats of formation (values for *Qf*) of the reactants in their initial states. The value so obtained represents the heat evolved when the given process takes place at a constant pressure (or a fugacity) of one atmosphere and at a temperature of 18°. The following are examples:

Heat of reaction

$$BaCl_2\ (400) + H_2SO_4\ (400) = BaSO_4\ (c) + 2\ HCl\ (400).$$

$$Q = -\Delta H = \{Qf\ [BaSO_4\ (c)] + 2\ Qf\ [HCl\ (400)]\} - \{Qf\ [BaCl_2\ (400)] + Qf\ [H_2SO_4\ (400)]\}.$$

$$= \{349.4 + 2\ (39.525)\} - \{207.350 + 211.84\} = 9.260.$$

Heat of solution

$$KCl\ (c) = KCl\ (400).$$

$$Q = -\Delta H = Qf\ [KCl\ (400)] - Qf\ [KCl\ (c)] = 99.899 - 104.361 = -4.462.$$

Heat of dilution

$$HCl\ (50) = HCl\ (3200).$$

$$Q = -\Delta H = Qf\ [HCl\ (3200)] - Qf\ [HCl\ (50)] = 39.629 - 39.257 = 0.372.$$

Heat of ionization in aqueous solution

$$HC_2H_3O_2\ (\infty) = H^+(\infty) + C_2H_3O_2^-(\infty).$$

$$Q = -\Delta H = \{Qf\ [H^+(\infty)] + Qf\ [C_2H_3O_2^-(\infty)]\} - Qf\ [HC_2H_3O_2\ (\infty)]$$
$$= \{0.000 + 117.946\} - 118.070 = -0.124.$$

Heat of ionization in the gaseous phase

$$H\ (g) = H^+(g)\ [+\theta\ (g)].$$

$$Q = -\Delta H = Qf\ [H^+(g)] - Qf\ [H\ (g)] = -365.58 - (-51.90) = -313.68.$$

Heat of dissociation

$$I_2\ (g) = 2\ I\ (g).$$

$$Q = -\Delta H = 2Qf[I\ (g)] - Qf\ [I_2\ (g)] = 2\ (-25.59) - (-14.91) = -36.27.$$

Heat of sublimation

$$KCl\ (c) = KCl\ (g).$$

$$Q = -\Delta H = Qf\ [KCl\ (g)] - Qf\ [KCl\ (c)] = 52.4 - 104.361 = -52.0.$$

Accuracy of the values. All the values recorded in the table have been recomputed from the original experimental data, using consistent values for all subsidiary quantities. Heats of reaction, of dilution, of solution, of neutralization, of transition, etc., may be computed by difference with an accuracy as high as is known. The number of significant figures in any one value in the table does not indicate the absolute accuracy of that value, which will be less than that of the least accurate determination in the total chain of reactions used to calculate the value. In most cases, sufficient information to deduce the accuracy of any value is given in the text.

References to the literature. References to the original data are given in the text, as Washburn.[2] The exact citation can then be found in the list of references, which are given in alphabetical (and numerical) order, as Washburn,[2] *Bur. Standards J. Research* **10**, 525 (1933), where the numerals indicate, respectively, the volume, page, and year. The abbreviations used for the titles of the periodicals are those adopted as standard by the International Union of Chemistry (See, for example, Chemical Abstracts' "List of Periodicals Abstracted"). When the citation is that of a book, it is written as Washburn, "Introduction to the Principles of Physical Chemistry," McGraw-Hill Book Co., New York (1921), where the title is in quotation marks, and then in order follow the name of the publisher, the place of publication, and, in parentheses, the year of publication. If the book citation includes volume and page numbers, these follow immediately after the title.

Superscripts and subscripts. A numeral superscript, as E^{25}, indicates the temperature in degrees Centigrade. For convenience, the super-

script "$_z$" (as, for example, D^z) is used in place of the superscript "$^{-273}$" to indicate the absolute zero of temperature.

The asterisk superscript "*" applied to the formula of a given chemical substance indicates that the given ion, atom, or molecule is in an excited state, that is, in an electronic state having an energy content greater than that of the ground or normal state.

A numeral subscript, as A_{100}, indicates the number of moles of H_2O per mole of solute in the solution. A word subscript, as A_{CH_3OH}, with or without a numeral subscript giving the number of moles of solvent, indicates the solvent, if other than H_2O. These subscripts and superscripts may be attached either to the symbol representing the kind of reaction or to the number representing the value of the heat of the reaction.

Abbreviations. The following abbreviations are used:

amorp.	Amorphous, or ill defined solid state.
aq	In a dilute aqueous solution.
c	Macrocrystalline.
C	Heat of combustion. The heat evolved in the combustion of the given substance at constant pressure in oxygen.
D	Heat of dissociation. When applied to gaseous diatomic molecules, *D* represents the heat evolved in the reaction, Z_2 (g) $=2\,Z$ (g), at constant pressure (or fugacity). When applied to hydrates, ammines, etc., *D* represents the heat evolved, per mole of gaseous H_2O (or of NH_3, etc.) in the reaction, $Z \cdot n\,H_2O\,(c) = Z \cdot (n-a)\,H_2O\,(c) + a\,H_2O\,(g)$, at constant pressure.
E	Excitation energy. The energy evolved in the process of elevating a gaseous substance from a given electronic energy state to a higher electronic energy state.
F	Heat of fusion. The heat evolved in the reaction, Z (c) = Z (liq.), at constant pressure.
g	Gas.
gls.	A glass or solid supercooled liquid.
I	Energy of ionization of a gaseous substance. The energy evolved in the process of removing an electron from a gaseous substance.
(ideal)	In the condition indicated by the formula, e. g., for N_2O_4 (g), the word "(ideal)" indicates that the heat of formation is for a gas composed only of N_2O_4 molecules.
liq.	Liquid.

N Heat of neutralization. The heat evolved in the reaction, HX (aq.) + MOH (aq.) = MX (aq.) + H_2O (liq.), at constant pressure.

ppt. Precipitated.

Q Heat of reaction. The heat evolved when the given reaction takes place at constant pressure. In the nomenclature of Lewis and Randall,[5] $Q = -\Delta H$.

Qf Heat of formation. The heat evolved in the reaction of forming the given substance from its elements in their standard states, at constant pressure. In the nomenclature of Lewis and Randall,[5] $Qf = -\Delta H^\circ$ (formation).

S Heat of solution (in water unless specified otherwise by a word subscript). The heat evolved in the reaction, Z (c, liq., or g) = Z (aq.) (or other solvent), at constant pressure.

satd. In a saturated solution in water.

$T^{110}{}_{\rightarrow II}$ Heat of transition. For example, when given in connection with the substance Z (c, I), $T^{110}{}_{\rightarrow II}$ is the heat evolved in the reaction, Z (c, I) = Z (c, II), at constant pressure and at 110°.

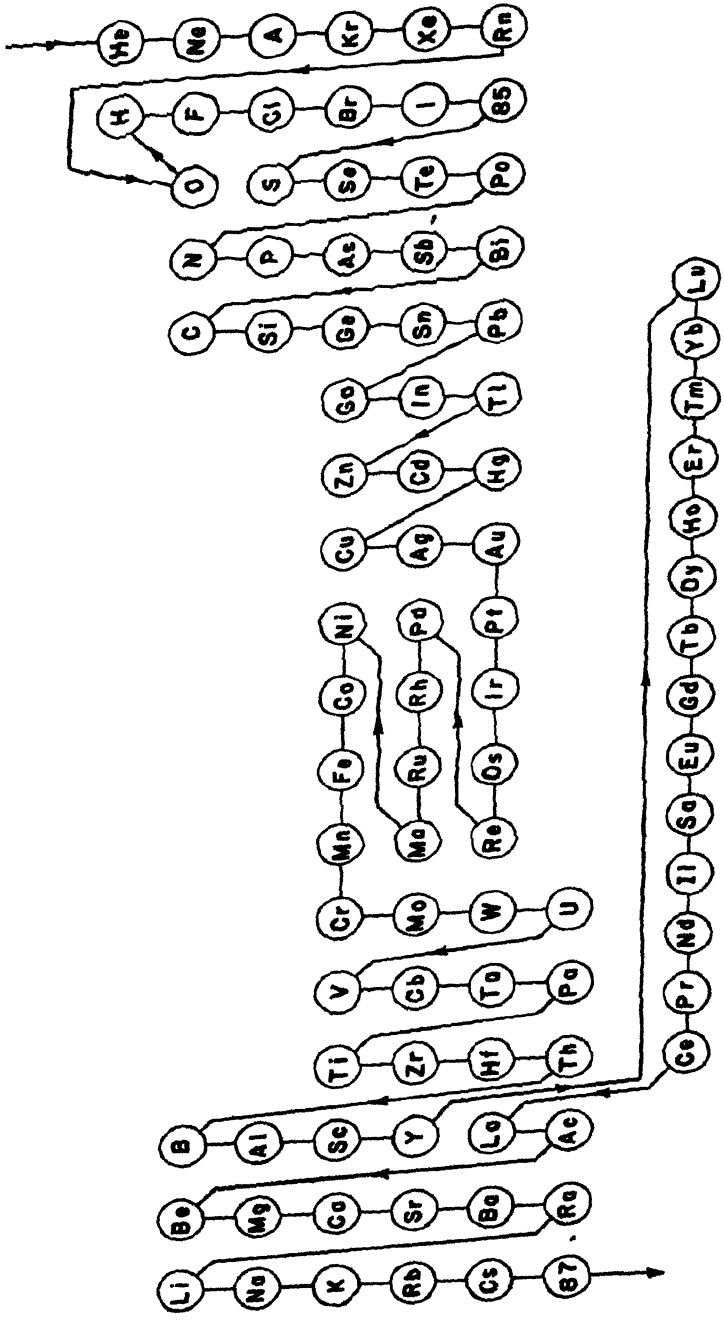
X F, Cl, Br, or I.

V Heat of vaporization. The heat evolved in the reaction, Z (liq.) = Z (g), at constant pressure.

Vs Heat of sublimation. The heat evolved in the reaction, Z (c) = Z (g), at constant pressure.

0 Electron gas.

Order of arrangement of the chemical substances in the table. The substances listed in the thermochemical table are arranged in a manner analogous to that used in the International Critical Tables. The principle of this method is as follows: The chemical elements are arranged in a certain prescribed order, as *a, b, c, d, e, f, g, h*, etc. Then all the chemical substances will be arranged in the table in the following order: *a; b, ba; c, ca, cb, cba; d, da, db, dba, dc, dca, dcb, dcba*; etc. In this book, the prescribed order of the elements is that given in the diagram on page 16. With several exceptions, the arrangement follows the periodic table quite closely, starting with the rare elements, going through the negative elements, and ending with the most positive substance, element 87.



Order of arrangement of the chemical elements.

Helium

Atomic number 2 Standard state He (g) Atomic weight 4.002

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
He	g	$1s^2$ ($^1S_0$)	0.000	
	liq.			V — 0.022$_{\cdot}^{270}$
	c			F — 0.03^{-268}
He *	g	$2s$ ($^3S_1$)	— 456.46	I^s — 109.47
	g	($^1S_0$)	— 471 74	I^s — 91.19
He$^+$	g	$1s$ ($^2S_{1/2}$)	— 565.93	I^s — 564.475
He^{++}	g		—1826.59	I^s —1249.21
He$_2$ *	g	$^2\Sigma^+_u$	— 404.16	D^s — 51.4
	g	$^1\Sigma^+_u$	— 411.1	
He$_2^+$	g	$^2\Sigma^+_u$	— 503 4	

Neon

Atomic number 10 Standard state Ne (g) Atomic weight 20.183

Ne	g	$2p^6$ ($^1S_0$) •	0.000	
	liq.			V — 0 44^{-246}
	c			F — 0.078^{-249}
Ne *	g	$2p^5(^2P_{1/2})3s$ (3^1_0)	— 383.77	E^s — 383 77
	g	(4^1_0)	— 380 41	E^s — 380.41
	g	$2p^5(^2P_{3/2})3s$ (1^1_2)	— 381.56	E^s — 381.56
	g	(2^1_1)	— 382.75	E^s — 382 75
Ne$^+$	g	$2p^5$ $^2P^1_{3/2}$	— 496 56	I^s — 495.11
Ne$^+$ *	g	$^2P^1_{1/2}$	— 498.79	E^s — 2.23
	g	$2p^6$ $^2S_{1/2}$	—1014.47	E^s — 617.91
Ne^{++}	g	$2p^4$ $^3P_2$	—1438.67	I^s — 940.66
Ne^{+++}	g	$2p^3$ $^4S^1_{3/2}$	—2896.8	I^s —1456 7

Argon

Atomic number 18 Standard state A (g) Atomic weight 39 944

A	g	$3p^6$ $^1S_0$	0.000	
	liq.			V — 1 50^{-186}
	c			F — 0.265^{-189}
A·5H$_2$O	c		356.7	D — 14.8$^{\rightarrow H_2O(liq.)}$
A*	g	$3p^5(^2P_{3/2})4s$ (1^1_2)	— 265.14	E^s — 265 141
	g	(2^1_1)	— 266.87	E^s — 266.867
	g	$3p^5(^2P_{1/2})4s$ (3^1_0)	— 269 15	E^s — 269.153
	g	(4^1_1)	— 271.56	E^s — 271.562
A$^+$	g	$3p^5$ ($^2P^1_{3/2}$)	— 362 29	I^s — 361.839
A$^+$ *	g	$^2P^1_{1/2}$	— 366.36	E^s — 4.07
	g	$3p^6$ $^2S_{1/2}$	— 671.82	E^s — 309.532
A^{++}	g	$3p^4$ $^3P_2$	— 999.61	I^s — 635.87
A^{++} *	g	$^3P_1$	—1002.76	E^s — 3.16
	g	$^3P_0$	—1004.09	E^s — 4.48
A^{+++}	g	$3p^3$ $^4S^1_{3/2}$	—1939.0	I^s — 937.95
A^{++++}	g	$3p^2$	—5860.	I^s —3920.

Krypton

Atomic number 36 | Standard state Kr (g) | Atomic weight 83.7

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Kr	g	$4p^6$ $^1S_0$	0.000	
	liq.			V — 2.31^{-151}
	c			F — 0.36^{-157}
$Kr \cdot 5H_2O$	c		356.6	D — $14.7^{6}_{\rightarrow H_2O\,(liq}$
Kr*	g	$4p^5(^2P_{3/2})5s$ (1^1_2)	— 227.66	E^s — 227.662
	g	(2^1_1)	— 230.36	E^s — 230.360
	g	$4p^5(^2P_{1/2})5s$ (3^1_0)	— 242.52	E^s — 242.521
	g	(4^1_1)	— 244.39	E^s — 244.386
Kr^+	g	$4p^5$ $^2P_{3/2}$	— 322.90	I^s — 321.445
Kr^+ *	g	$(^2P_{1/2})$	— 338.18	E^s — 15.29
Kr^{++}	g	$4p^4$ $^3P_2$	— 943.	I^s — 619.
Kr^{+++}	g	$4p^3$ $(^4S^1_{3/2})$	—1664.6	I^s — 720.15

Xenon

Atomic number 54 | Standard state Xe (g) | Atomic weight 131.3

Xe	g	$5p^6$ $^1S_0$	0 000	
	liq.			V — 3.27^{-109}
	c			F — 0.49^{-140}
$Xe \cdot 6H_2O$	c		428.	D — $18.^{12}_{\rightarrow H_2O\,(liq\,)}$
Xe*	g	$5p^5(^2P_{3/2})6s$ (1^1_2)	— 139.69	E^s — 139.688
	g	(2^1_1)	— 142.35	E^s — 142.353
	g	$5p^5(^2P_{1/2})6s$ (3^1_0)	— 165.68	E^s — 165.677
	g	(4^1_1)	— 168.49	E^s — 168.490
Xe^+	g	$5p^5$ $^2P_{3/2}$	— 228.73	I^s — 227.27
	g	$^2P_{1/2}$	— 231.73	E^s — 3.00
	g	$5p^6$ $^2S_{1/2}$	— 487.42	E^s — 258.69
Xe^{++}	g	$5p^4$ $^3P_2$	— 717.17	I^s — 486.99
Xe^{+++}	g	$5p^3$ $^4S^1_{3/2}$	—1376.0	I^s — 657.5

Radon

Atomic number 86 | Standard state Rn (g) | Atomic weight 222.

Rn	g	$^1S_0$	0.000	
	liq.			V — 43^{-62}
	c			F — 0.8^{-71}
Rn*	g	$6p^5(^2P_{3/2})7s$ (1^1_2)	— 155.49	E^s — 155.49
	g	(2^1_1)	— 159.39	E^s — 159.39
	g	$6p^5(^2P_{1/2})7s$ (3^1_0)	— 193.32	E^s — 193.32
	g	(4^1_1)	— 196.12	E^s — 196.12
Rn^+	g	$6p^5$ $(^2P_{3/2})$	— 248.24	I^s — 246.79

Oxygen

Atomic number 8 Standard state O_2 (g)† Atomic weight 16.0000

Formula	State	Description	*Qf, kcal. mole*$^{-1}$	*Q, kcal. mole*$^{-1}$
O	g	$2s^22p^4$ ($^3P_2$)	− 59.10	$D^s_{O_2}$ − 117.4
O*	g	($^3P_1$)	− 59.55	E^s − 0.45
	g	($^3P_0$)	− 59.74	E^s − 0.64
	g	(D_2)	− 104.28	E^s − 45.18
	g	($^1S_0$)	− 155.30	E^s − 96.20
O+	g	$2s^22p^3$ ($^4S^1_{3/2}$)	− 373.22	I^s − 312 67
O+ *	g	($^2D^1_{5/2}$)	− 449.56	E^s − 76.34
	g	($^2D^1_{3/2}$)	− 449.62	E^s − 76.40
	g	($^2P^1_{3/2}$)	− 488.42	E^s − 115.20
	g	($^2P^1_{1/2}$)	− 488.44	E^s − 115.22
O++	g	$2s^22p^2$ ($^3P_0$)	− 1180.39	
O++ *	g	($^3P_1$)	− 1180 72	E^s − 0 33
	g	($^3P_2$)	− 1181.27	E^s − 0.88
O+++	g	$2s^22p$ ($^2P^1_{1/2}$)	− 2447.3	I^s − 1265.
O+++ *	g	($^2P^1_{3/2}$)	− 2448.4	E^s − 1.10
O++++	g	$2s^2$ ($^1S_0$)	− 4224.	I^s − 1775.5
O+++++	g	2s ($^2S_{1/2}$)	− 6742.	I^s − 2517.8
O++++++	g	$1s^2$ ($^1S_0$)	− 9914.	I^s − 3170 2
O+++++++	g	1s ($^2S_{1/2}$)	−26817.	I^s −16900.
O++++++++	g		−46810.	I^s −19992.
O−	g		− 30.	
O—	g		− 225.	
O_2	g	($^3\Sigma^-_g$)	0.000	
	liq.			V − $1.629^{-183.0}$
	c	I		F − $0.106^{-218\ 7}$
	c	II		T − $0.178^{-229\ 4}{}_{\rightarrow I}$
	c	III		T − $0.023^{-250}{}_{\rightarrow II}$
	aq.		3.85	S 3.85
O_2 *	g	($^1\Sigma^+_g$)	− 37.36	E^s − 37.36
O_2+	g		− 280.	D^s − 149.6
O_3	g		− 34.5	
	liq.			V − $2.96^{-112\ b}$
	aq.		− 32.7	S 1.8
O_4	g		0.13	

†Natural mixture of isotopes.

Hydrogen

Atomic number 1 Standard state H_2 (g)‡ Atomic weight 1.0078

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
H	g	1s ($^2S_{1/2}$)	− 51.90	$D^z_{H_2}$ − 102.9
H^+	g		− 365.58	I^s − 312 23
	aq.	(by convention)	0.000	
H^-	g		− 34.85	
H_2	g	equilibrium‡	0.000	
	liq.			V − $0\ 216^{-255}$
	c			F − 0.0282^{-262}
	aq.		1.42	S 1.42
	solid	adsorbed on Pt	13.8	
H_2^*	g	B ($^1\Sigma^+_u$)	− 256.8	E^z − 256.8
	g	C ($^1\Pi_u$)	− 282.2	E^z − 282.2
H_2^+	g	($^2\Sigma^+_g$)	− 357.52	I^s − 356.07
OH	g	$^2\Pi$	5 93	
OH*	g	$^2\Sigma^+$	− 86 33	
OH^-	g		− 58.	
	∞		54.660	N $13\ 710_\infty$
H_2O	g		57 801	V − 10.571
	liq		68.370	
	c			F − 1.437^0
H_2O_2	g		33 59	V − 11.61
	liq.		45.20	S 0.46_{200}
	c			F − 2.52^{-2}
	200		45.66	
	6.3		45.64	
	2.6		45.63	
	1.0		45.4	

‡Natural mixture of isotopes; molecules in equilibrium with respect to symmetric and antisymmetric rotational states.

Fluorine

Atomic number 9 Standard state F_2 (g) Atomic weight 19.00

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
F	g	$2p^5$ ($^2P^1_{3/2}$)	− 31.75	$D^z_{F_2}$ − 62.6
F*	g	($^2P^1_{1/2}$)	− 32.91	E^z − 1.16
F+	g	$2p^33s$ ($^5S^1_2$)	− 462.95	I^z − 429.75
F+ *	g	$2p^33p$ ($^5P_1$)	− 503.64	E^z − 73 89
	g	($^5P_2$)	− 503 67	E^z − 73.92
	g	($^5P_3$)	− 503 73	E^z − 73 98
F++	g	$2p^3$ ($^4S^1_{3/2}$)	−1262.05	I^z − 797.65
F+++	g	$2p^2$ ($^3P_0$)	−2601 30	I^z −1133.8
F+++ *	g	($^3P_1$)	−2601 99	E^z − 0.66
	g	($^3P_2$)	−2602 48	E^z − 1.18
F++++	g	2p ($^2P^1_{1/2}$)	− 4562.3	I^z −1959.6
F+++++	g	$2s^2$ ($^1S_0$)	− 7169.8	I^z −2606.
F++++++	g	2s ($^2S_{1/2}$)	−10697.	I^z −3526.
F+++++++	g	$1s^2$ ($^1S_0$)	−14941.	I^z −4213.
F++++++++	g	1s ($^2S_{1/2}$)	−17124.	I^z −2181.
F−	g		66 3	
	∞		78.20	
F_2	g		0.000	
	liq.			V − 1 60^{-188}
	c			F − 0.34^{-220}
HF	g	ideal	64.0	S 11.56$_{200}$
	liq.		71 0	S 4.60$_{200}$
	c			F − 1.09^{-83}
	600		75.7	
	200		75.56	
	12		75.56	
	6		75.46	
	2.2		75.11	
	1.7		74.74	
	0.5		73.5	
HF_2^-	aq.		153.4	
$(HF)_{2.3}$	g	at 745 mm. pressure	229.	
H_6F_6	g		424.	
F_2O	g		− 5.5	

Chlorine

Atomic number 17 Standard state Cl_2 (g) Atomic weight 35.457

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Cl	g	$3s^23p^5$ ($^2P^1_{3/2}$)	− 28.90	$D^s_{Cl_2}$ − 56.9
Cl*	g	($^2P^1_{1/2}$)	− 31.41	E^s − 2.506
Cl+	g	$3s^23p^4$ ($^3P_2$)	− 329.46	I^s − 299.11
Cl+ *	g	($^3P_1$)	− 331.44	E^s − 1.98
	g	($^3P_0$)	− 332.29	E^s − 2.83
Cl++	g	$3s^23p^3$ ($^4S^1_{3/2}$)	− 863.97	I^s − 533.06
Cl+++	g	$3s^23p^2$ ($^3P_0$)	−1782.91	I^s − 916.49
Cl+++ *	g	($^3P_1$)	−1784.31	E^s − 1.398
	g	($^3P_0$)	−1786.73	E^s − 3.818
Cl++++	g	$3s^23p$ ($^2P^1_{1/2}$)	−2888.	I^s −1094.
Cl++++ *	g	($^2P^1_{3/2}$)	−2892.	E^s − 4.24
Cl+++++	g	$3s^2$ ($^1S_0$)	−4451.	I^s −1563.
Cl++++++	g	$3s$ ($^2S_{1/2}$)	−6500.	I^s −2047.
Cl+++++++	g	$2p^6$ ($^1S_0$)	−9126.	I^s −2625.
Cl−	g		61.	
	∞		39.687	
Cl_2	g		0.000	
	liq.			V − 4.4^{-36}
	c			F − $1.62^{-102.3}$
	aq.	saturated	5.3	S 5.3
	aq.	ideal	7.0	
	CCl_4		4.5	S $4.5^{u}_{CCl_4}$
$Cl_2{\cdot}6H_2O$	c		428.2	
Cl_3	g		− 25	
ClO	g		− 31.	
ClO^-	aq.		25.9	
ClO_2	g		− 23.5	S 6.6
	liq.		− 17.0	V − 6.52
	aq.		− 16.9	
ClO_3^-	∞		20.75	
ClO_4^-	∞		39.5	
Cl_2O	g		− 18.25	
	aq.		− 8.81	
	aq.	ideal	− 8.	
HCl	g		22.06	
	liq.			V − 3.86^{-35}
	c	I		F − 0.476^{-114}
	c	II		T − $0.284^{-174.8}{}_{\rightarrow I}$
	∞		39.687	
	6400		39.647	
	3200		39.629	
	1600		39.606	
	800		39.572	
	400		39.525	

Chlorine

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
HCl	200		39.465	
	100		39.382	
	50		39.257	
	25		39.032	
	20		38.92	
	18		38.86	
	15		38.73	
	12		38.55	
	10		38.35	
	8		38 06	
	6		37.52	
	5		37.10	
	4		36.44	
	3		35.43	
	2		33.56	
	1		28.3	
	CCl_4		25.7	S $3.68^{0}_{CCl_4}$
	C_2H_5OH		32.6	S $10.6_{C_2H_5OH}$
HCl^+	g		− 296.	I^s − 318.
$HCl{\cdot}2H_2O$	c			F − 2.5^{-18}
HClO	400		29.78	
$HClO_2$	aq.		13.8	
$HClO_3$	aq.		20.8	
$HClO_4$	660		39.6	
	200		39.6	
	96		39.63	
	42		39.59	
	10		39 54	
	6		39.24	
	4.15		39.00	
	3.08		38.37	
	2.33		35.24	
	1.43		32.23	
	1.0		27.9	
ClF	g		25.7	
	liq.			V − 2.27^{-101}

Bromine

Atomic number 35 Standard state Br_2 (liq.) Atomic weight 79.916

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Br	g	$4s^24p^5$ ($^2P^1_{3/2}$)	− 26.88	$D^s_{Br_2}$ − 45.24
Br*	g	($^2P^1_{1/2}$)	− 37.37	E^s − 10.49
Br$^+$	g	$4p^35s$ ($^5S^1_2$)	− 298.92	I^s − 270.59
Br$^+$ *	g	$4p^34d$ ($^5D^1_0$)	− 299.37	E^s − 0.447
	g	($^5D^1_1$)	− 299.45	E^s − 0.529
	g	($^5D^1_2$)	− 299.53	E^s − 0.612
	g	($^5D^1_3$)	− 299.64	E^s − 0.717
	g	($^5D^1_4$)	− 299.75	E^s − 0 831
Br^{++}	g	$4p^25s$ ($^4P_{1/2}$)	− 741.	I^s − 442.
Br^{++} *	g	($^4P_{3/2}$)	− 742.53	E^s − 1.48
	g	($^4P_{5/2}$)	− 744.90	E^s − 3.85
	g	$4p^24d$ ($^4P_{5/2}$)	− 753.90	E^s − 12.85
	g	($^4P_{3/2}$)	− 755.22	E^s − 14.17
	g	($^4P_{1/2}$)	− 755.81	E^s − 14.76
Br^{+++}	g	4p5s ($^1P^1_1$)	−1333.	I^s − 592.
Br$^-$	g		61.6	I^s − 87.9
	∞		28.67	
Br_2	g		− 7.65	V − 7.65
	liq.		0.000	
	c			F − 2.53^{-7}
	aq.	ideal	1.2	
	CCl_4		− 0.5	S − 0.5_{CCl_4}
	$CHCl_3$		− 0.6	S − 0.6_{CHCl_3}
	CS_2		− 1.4	S − 1.4_{CS_2}
$Br_2 \cdot 10H_2O$	c		700.	D − 7.9^{-10}
Br_3^-	aq.		31.1	
Br_5^-	aq.		35.7	
BrO^-	aq.		21.3	
BrO_3^-	∞		11.2	
HBr	g		8.65	S 19.89_{400}
	liq.			V − $4.21^{-66.7}$
	c	I		F − $0.575^{-86.9}$
	c	II		T − $0.26^{-160}{}_{\rightarrow I}$
	c	III		T − $0.14^{-160}{}_{\rightarrow II}$
HBr	∞		28.67	
	3200		28.62	
	1600		28.60	
	800		28.58	
	400		28.55	
	200		28.52	
	100		28.47	
	50		28.39	
	25		28.23	

Bromine

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
HBr	10		27.68	
	6		26.83	
	5		26.20	
	3		24.49	
	2		22.4	
	1		19.	
$HBr \cdot H_2O$	c			F — 3.0^{-11}
$HBr \cdot 2H_2O$	c			D — $16.9^{0}{}_{\rightarrow H_2O\,(liq.)}$
$HBrO$	aq.		25.2	
$HBrO_3$	aq.		11.30	
$BrCl$	g		— 3.07	

Iodine

Atomic number 53 Standard state I_2 (c) Atomic weight 126.92

I	g	$5s^25p^5$ ($^2P^1{}_{3/2}$)	— 25 59	$D^z{}_{I_2}$ — 35.40
I*	g	($^2P^1{}_{1/2}$)	— 46.73	E^z — 21.14
I+	g	$5p^36s$ ($^5S^1{}_2$)	—267 54	I^z —240 5
I−	g		53.0	
	∞		13.37	
I_2	g		— 14.91	V — 14.91
	liq.			F — $4\ 0^{113\ 5}$
	c		0 000	
	aq.		— 5 0	
	C_6H_6		— 6.0	S — $6.0_{C_6H_6}$
	C_2H_5OH		— 1.7	S — $1.7_{C_2H_5OH}$
	$(C_2H_5)_2O$	in diethyl ether	— 1.6	S — $1.6_{(C_2H_5)_2O}$
	CCl_4		— 5.8	S — 5.8_{CCl_4}
	$CHCl_3$		— 6.0	S — 6.0_{CHCl_3}
	CS_2		— 5.0	S — 5.0_{CS_2}
I_3^-	aq.		12.14	
IO^-	aq.		20.	
IO_3^-	∞		54.5	
IO_4^-	aq.		37.6	
IO_6^{-----}	aq.		146.4	
I_2O_5	c		42 5	S — 1.96_{200}
HI	g		— 5.91	S 19.19_{200}
	liq.		— 8.89	V — $4.72^{-35\ 4}$
	c	I		F — $0.686^{-50\ 8}$
	c	II		T — $0.192^{-147\ 5}{}_{\rightarrow I}$
	c	III		T — $0.019^{-203.0}{}_{\rightarrow II}$
	∞		13.37	

Iodine

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
HI	1600		13.31	
	800		13.30	
	400		13.29	
	200		13.28	
	100		13.26	
	50		13.22	
	25		13.11	
	20		13.07	
	10		12.65	
	5		11.46	
	3		8.89	
	2		6.6	
HIO	aq.		38.	
HIO_3	c		56.77	S — 2.17
	aq.		54.6	
HIO_6^{----}	aq.		158.5	
$H_2IO_6^{---}$	aq.		171.4	
$H_3IO_6^{--}$	aq.		182.1	
$H_4IO_6^{-}$	aq.		174.4	
H_5IO_6	c		184.4	S — 1.38_{2000}
	aq.		183.0	
$I_2O_5 \cdot HIO_3$	c		99.7	S — 4.29^{12}
ICl	g		— 3.46	
	liq.		6.06	
	c	β	8.15	
	c	α	8.38	F — 2.33
ICl_3	c		20.0	
IBr	g		— 9.6	
	liq.		2.5	

Element 85

Atomic number 85 Standard state X (c) Atomic weight (212?)

Sulfur

Atomic number 16 Standard state S (c, rhombic) Atomic weight 32.06

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
S	g	$3s^23p^4$ ($^3P_2$)	− 66.3	$D^o_{S_2}$ − 102.6
	liq.	λ	− 0.33	F − $0.35^{119}_{\text{monoclinic}}$
	liq.	μ	− 0.75	T $0.41_{\rightarrow\lambda}$
	c	rhombic	0 000	
	c	monoclinic	0.075	T − $0.093^{95}_{\rightarrow\text{rhombic}}$
	S_2Cl_2		− 1.5	
S*	g	$3s^23p^4$ ($^3P_1$)	− 67.42	
	g	($^3P_0$)	− 67.93	
	g	$^2D_1$	− 103.20	E^o − 36.90
S^+	g	$3s^23p^3$ ($^4S^1_{3/2}$)	− 334.53	I^o − 237.06
S^+ *	g	($^2D^1_{3/2}$)	− 376.81	E^o − 42.28
	g	($^2D^1_{5/2}$)	− 376.90	E^o − 42.37
	g	($^2P^1_{1/2}$)	− 404.35	E^o − 69.82
	g	($^2P^1_{3/2}$)	− 404.48	E^o − 69.95
S^{++}	g	$3s^23p^2$ ($^3P_0$)	− 873.5	I^o − 537.54
S^{++} *	g	($^3P_1$)	874.35	E^o − 0.85
	g	($^3P_2$)	− 875.88	E^o − 2.38
S^{+++}	g	$3s^23p$ ($^2P^1_{1/2}$)	−1679.9	I^o − 804.9
S^{+++} *	g	($^2P^1_{3/2}$)	−1682.6	E^o − 2.71
S^{++++}	g	$3s^2$ ($^1S_0$)	−2767.5	I^o −1086.2
S^{++++} *	g	$3s3p$ ($^3P^1_0$)	−2885.	I^o −1428.
S^{+++++}	g	$3s$ $^2S_{1/2}$	−4303.	I^o −1535.
S^{++++++}	g	$2p$ ($^1S_0$)	−6325.	I^o −2022.
S^{--}	g		− 146.	
	∞		− 10 0	
S_2	g	$^3\Sigma^1_g$	− 29.2	
S_2*	g	Σ^1_u	− 120.95	E^o − 91.75
S_2^{--}	aq.		− 9.3	
S_3^{--}	aq.		− 7.8	
S_4^{--}	aq.		− 5.3	
S_6	g		− 22.6	
S_8	g		− 20.0	
	CS_2		− 3.3	
SO	g		− 6.3	D^o − 118.20
SO_2	g		70.92	
	liq.		77.0	V − 6.07^{-10}
	c			F − 1.9^{-73}
	2000		79.48	S 8.56
	1000		79.15	S 8.23.
	500		78.81	S 7.89
	200		78.37	S 7.45
	100		78.04	S 7.12
	75		77.92	S 6.99
$SO_2 \cdot 7H_2O$	c		568.54	

Sulfur

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
SO_2	g		93.9	V — 10.3
	liq.		104.2	S 41.18_{5000}
	c	β, "wool-like"	105.2	S 40.25_{5000}
	c	α, "ice-like"	106.0	Vs — 12.1
SO_3^{--}	aq.		148.5	
SO_4^{--}	∞		215.8	
$S_2O_3^{--}$	aq.		145.5	
$S_2O_4^{--}$	aq.		162.	
$S_2O_5^{--}$	aq.		229.6	
$S_2O_6^{--}$	aq.		280.2	
S_2O_7	c		193.4	S 56.7
$S_2O_8^{--}$	aq.		323.3	
$S_3O_6^{--}$	aq.		279.	
$S_4O_6^{--}$	aq.		272.3	
$S_5O_6^{--}$	aq		269 5	
HS^-	aq.		3.9	
H_2S	g		5.3	
	liq.			V — 4.5^{-61}
	c			F — 0.4^{-110}
	aq.		9.9	S 4.6
$H_2S \cdot 6H_2O$	c		431.4	
H_2S_2	g		— 8.94	V — 8.54
	liq.		— 0.4	
	c			F — $1\ 80^{-90}$
H_2S_5	liq.		2.6	
HSO_3^-	aq.		149.0	
H_2SO_3	200		146.74	
HSO_4^-	aq.		213.3	
H_2SO_4	liq.		193.75	S — 17.75_{200}
	c		196.34	F — 2.55^{10}
	∞		215.8	
	20000		214.74	
	15000		214.54	
	10000		214.38	
	8000		214.16	
	6000		213.92	
	4000		213.56	
	2000		212.96	
	1000		212.41	
	800		212.25	
	600		212.08	
	400		211.84	
	200		211.5	
	100		211.29	
	80		211.23	

Sulfur

Formula	State	Description	*Qf, kcal. mole*$^{-1}$	*Q, kcal. mole*$^{-1}$
H_2SO_4	60		211 17	
	50		211.12	
	40		211.05	
	30		210.93	
	20		210.79	
	15		210.39	
	10		209.63	
	9		209.35	
	8		209.00	
	7		208.63	
	6		208.12	
	5		207.50	
	4		206.57	
	3		205.37	
	2		203.51	
	1.5		202.54	
	1.0		200.46	
	0.5		197.50	
	$5(C_2H_5)_2O$		205.13	
	$10(C_2H_5)_2O$		206.35	
	$20(C_2H_5)_2O$		208.11	
$H_2SO_4 \cdot H_2O$	liq		268.74	
	c		273.28	F — $4.45^{9.6}$
$H_2S_2O_4$	aq.		161.1	
$H_2S_2O_6$	600		280.7	
$H_2S_2O_7$	liq.		299.6	F — 2.64^{20}
	c		302.25	S 53.92_{1650}
$H_2S_2O_8$	aq.		318.5	
$H_2S_4O_6$	aq.		269.2	
SF_6	g		262.	
	liq.			F — $1.39^{-50.8}$
	c			Vs — $5.64^{-63.8}$
SCl_4	liq.		13.7	
S_2Cl_2	g		5.65	V — 8.65
	liq.		14.3	
S_2Cl_4	liq.		24.1	
$SOCl_2$	g		42.7	V — 7.48^{76}
	liq.		50.2	S 39.2
SO_2Cl_2	g		86.2	V — 6.7^{99}
	liq.		92.9	
$S_2O_5Cl_2$	g		153.3	V — 13.2
	liq.		166.5	S $222.4_{8KOH\ (aq.)}$
SO_3HCl	liq.		142.3	S 40.3_{200}
S_2Br_2	liq.		4.0	
$SOBr_2$	liq.			V — 10.4^{140}

Selenium

Atomic number 34 Standard state Se (c, hexagonal) Atomic weight 78.96

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Se	g	$4p^35p$ ($^3P_2$)	− 61.	$D^o_{Se_2}$ − 92.
	liq.			F − 1.6^{200}
	c	I, hexagonal	0.000	
	c	II, red, monoclinic	− 0.2	T $0.18^{15c}{}_{\rightarrow I}$
	gls.	vitreous	− 1.1	T $1.08^{12s}{}_{\rightarrow I}$
Se*	g	$4p^35p$ ($^3P_1$)	− 66.44	E^s − 5.44
	g	($^3P_0$)	− 68.22	E^s − 7.22
	g	(D_2)	− 88.24	E^s − 27.24
	g	$^1S_0$	−127.48	E^s − 66.48
Se^+	g	$4s^24p^3$ ($^4S^1{}_{3/2}$)	−286.4	I^s −223.92
Se^{--}	aq.		− 37.3	
Se_2	g		− 29.5	
Se_6	g		− 32.5	
Se_8	g		− 34.8	
SeO_2	c		56.36	S − 0.93_{2000}
	2000		55.43	
SeO_3^{--}	aq.		123.3	
SeO_4^{--}	aq.		146.4	
HSe^-	aq.		− 26.4	
H_2Se	g		− 18.5	
	aq.		− 16.1	S 2.43
$HSeO_3^-$	aq.		124.8	
$HSeO_4^-$	aq		144.2	
H_2SeO_3	c		119.69	S − 4.11
	aq.		123.8	
H_2SeO_4	liq.		126.8	S $16.80^{15}{}_{800}$
	c		130.25	S $13.35^{15}{}_{800}$
	∞		146.4	
	4000		144.6	
	1200		143.8	
	800		143.6	
	400		143.2	
	200		142.9	
	1		131.6	
$H_2SeO_4 \cdot H_2O$	liq.		200.0	S $12.02^{15}{}_{800}$
	c		204.5	S $7.45^{15}{}_{800}$
SeF_6	g		246.	
	liq.			F − $2.0^{-34.6}$
	c			Vs − $6.60^{-46.6}$
$SeCl_2$	g		10.0	
Se_2Cl_2	liq.		22.13	
$SeCl_4$	c		46.12	
$SeO_2 \cdot SO_3$	c		168.5	S $321.^{15}{}_{4000}$

Tellurium

Atomic number 52 Standard state Te (c, II) Atomic weight 127.61

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Te	g	$5s^25p^4$ ($^3P_2$)	− 55.	$\mathcal{D}^s_{Te_2}$ − 85.
	liq.			F − 4.27^{445}
	c	I		T 0.80^{343} .II
	c	II	0.000	
	amorp	precipitated	− 2.7	
Te*	g	$5s^25p^4$ ($^3P_0$)	− 73.20	E^s − 18.20
	g	($^3P_1$)	− 73.60	E^s − 18.60
	g	$^1D_2$	− 85.06	E^s − 30.06
	g	$^1S_2$	−106.0	E^s − 51.0
Te^+	g		−256.	I^s −200.
Te_2	g		− 24.0	V − 22.0^{1300}
TeO_2	c		77.58	
	HCl(aq.)		76.6	
TeO_3^{--}	aq.		141.0	
TeO_4^{--}	aq.		168.9	
H_2Te	g		− 34.2	S $58.2^{16}_{FeCl_3(aq.)}$
H_2TeO_3	c		145.0	S 0.0
	aq.		145.0	
H_2TeO_4	400		165.3	
$H_2TeO_4 \cdot 2H_2O$	c		305.4	S − 3.35^{14}_{600}
TeF_6	g		315.	
	liq.			F − $1.9^{-37.8}$
	c			Vs − $6.74^{-38.9}$
$TeCl_4$	c		77.4	
$TeBr_4$	c		49.3	S $7.05_{NaC_2H_3O_2(aq.)}$
$2TeO_2 \cdot SO_3$	c		291.7	S $61.4^{16}_{KOH(aq.)}$

Polonium

Atomic number 84 Standard state Po (c) Atomic weight (210)

Nitrogen

Atomic number 7 Standard state N_2 (g) Atomic weight 14.008

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
N	g	$2s^22p^3$ ($^3S^1_{3/2}$)	− 85.1	$D^s_{N_2}$ − 169.3
N*	g	($^2D^1_{3/2}$)	− 139.76	E^s − 54.66
	g	($^2P^1_{1/2}$)	− 167.11	E^s − 82.01
N+	g	$2s^22p^2$ ($^3P_0$)	− 420.75	I^s − 334.20
N+ *	g	($^3P_1$)	− 420.89	E^s − 0.14
	g	($^3P_2$)	− 421.13	E^s − 0.38
	g	$^1D_2$	− 469.36	E^s − 43.61
N++	g	$2s^22p$ ($^2P^1_{1/2}$)	− 1102.20	I^s − 680.0
N++ *	g	$^2(P^1_{3/2})$	− 1102.70	E^s − 0.496
N+++	g	$2s^2$ ($^1S_0$)	− 2197.1	I^s − 1093.4
N++++	g	$1s^22s$ ($^2S_{1/2}$)	− 3975 7	I^s − 1777.3
N+++++	g	$1s^2$ ($^1S_0$)	− 6225 0	I^s − 2247.8
N++++++	g	1s ($^2S_{1/2}$)	−18831.	I^s −12605.
N+++++++	g		−34020.	I^s −15187.
N_2	g	$^1\Sigma$	0.000	
N_2	liq.			V − 1.336^{-196}
	c	I		F − 0.169^{-210}
N_2*	g	A, $^3\Sigma$	− 188.5	E^s − 188.5
	g	a	− 196.4	E^s − 196.4
	g	B, $^3\Pi$	− 215.4	E^s − 215.4
	g	b	− 295 0	E^s − 295.0
	g	b^1	− 297.2	E^s − 297.2
	g	C, $^3\Pi$	− 299.5	E^s − 299.5
N_2+	g	$^2\Sigma$	− 362.5	I^s − 361.
	g	A, $^2\Sigma$	− 436 2	E^s − 73.7
N_3^-	aq.		− 58.4	
NO	g		− 21.6	
	liq.			V − 3.293^{-152}
	c			F − 0.550^{-164}
NO*	g	A, $^2\Sigma$	− 147.3	E^s − 125.7
	g	B, $^2\Pi$	− 150.7	E^s − 129.1
	g	C, $^2\Sigma$	− 170.3	E^s − 148.7
NO_2	g		− 8.03	
NO_2^-	aq.		25.3	
NO_3	g		− 13.	
NO_3^-	∞		49.19	
N_2O	g		− 19.65	
	liq.			V − 4.0^{-89}
	c			Vs − 5.69^{-113}
	aq.		− 13.4	S 6.2^0
N_2O $6H_2O$	c		405.4	D − 14.8$^0_{\rightarrow H_2O\,(liq.)}$
$N_2O_2^{--}$	aq.		− 3.5	
N_2O_3	g		− 20.0	
	liq.			V − 9.40^{20}

Nitrogen

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
N_2O_4	g		− 3.06	
	liq.		− 12.2	V − 9.2^{20}
	c			F − 3.0^{-10}
N_2O_5	g		− 0.6	
	c		13.1	S 16.7
NH	g	$^3\Sigma$	− 33.9	D^s − 102.2
NH*	g		− 118.6	E^s − 84.69
NH_2	g		11.00	
	liq.		16.07	V − 5.56^{-33}
	c			F − 1.42^{-78}
	∞		19.35	
	200		19.35	S 8.35_{200}
	100		19.36	
	50		19.35	
	20		19.31	
	10		19.27	
	4		19.07	
	2.33		18.97	
	1.5		18.49	
	1.0		17.6	
NH_4^+	g		20.	
	∞		31.455	
N_2H_4	aq.		− 4.5	
$N_2H_4H^+$	aq.		5.1	
$N_2H_4H_2^{++}$	aq.		5.1	
HN_3	aq.		− 54.6	
NH_2HN_2	c		− 20 2	C 157.0
	aq.		− 26.9	S − 6.74^{17}_{600}
HNO_2	aq.		28.5	
HNO_3	g		34.4	V − 7.2
	liq.		41.66	S 7.44_{800}
	c			F − 0.60^{-47}
	∞		±9.19	
	6400		49.154	
	3200		49.142	
	1600		49.129	
	800		49.116	
	400		49.105	
	200		49.1	
	100		49.104	
	50		49.124	
	25		49.162	
	20		49.12	
	10		48.98	
	5		48.33	

Nitrogen

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
HNO_3	3		47.37	
	2		46.44	
	1		44.95	
	$30(C_2H_5)_2O$	in diethyl ether	51.16	
	$20(C_2H_5)_2O$		51.00	
	$10(C_2H_5)_2O$		50.74	
	$5(C_2H_5)_2O$		50.26	
NH_2OH	liq.		25.5	S — 3.8
	aq.		21.7	
$NH_2OH\ H^+$	aq.		31.0	
NH_4OH	aq.		87 67	
NH_3OHOH	aq.		90 1	
$H_2N_2O_2$	aq.		8.4	
NH_4NO_2	c		61.5	S — $4.75^{13}{}_{400}$
	aq.		56.8	N 9.1
NH_4NO_3	c	I		T $1\ 02^{126}{}_{\rightarrow II}$
	c	II		T $0.32^{83}{}_{\rightarrow III}$
	c	III		T' $0.399^{32}{}_{\rightarrow IV}$
	c	IV	87.13	S — $6\ 32^{16}{}_{200}$
	c	V		T' — $0.13^{-18}{}_{\rightarrow IV}$
	∞		80.66	
	1000		80.684	
	500		80 710	
	200		80.81	
	100		80.914	
	50		81.143	
	25		81 556	
	20		81.63	
	10		82.06	
	5		82.68	
	3		82.99	
	2 5		83 32	
$NH_2OH{\cdot}HNO_3$	c		86 9	S — $5.93^{11}{}_{400}$
	aq.		81.	N 9.42_{400}
$N_2H_4{\cdot}H_2O$	c		62.0	S 1.92_{400}
	aq.		63.9	
$N_2H_4{\cdot}HNO_3$	aq.		54.4	N 9.75
$N_2H_4{\cdot}2HNO_3$	aq.		103.4	N 9.70
$NH_4NO_3{\cdot}5NH_3$	liq.		171.5	D — 5.9^{-20}
	c			F — 2.0^{-19}
NOF	liq.			V — $4\ 60^{-60}$
NO_2F	liq.			V — 4.32^{-72}
NH_4F	c		111.6	S — 1.5
	aq.		110.1	N 19.2_{100}
NCl_3	CCl_4		— 55.0	

Nitrogen

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
NOCl	g		− 12.8	*S* $37.1_{2\,KOH\,(aq.)}$
	liq.		− 18 9	*V* − 6.1^{-15}
NH_4Cl	g		44.	
	c	I		*T* $1.03^{184}{}_{\rightarrow II}$
	c	II	74.95	*S* − 3.92_{200}
	c	III		*T* − $0\,356^{-31}{}_{\rightarrow II}$
	∞		71.132	
	1000		71.089	
	500		71 069	
	400		71 06	*N* 12.30_{200}
	200		71 032	
	100		71.020	
	50		71.031	
	25		71.079	
	10		71.58	
$N_2H_4{\cdot}HCl$	c		50 0	*S* − $5.44^{17}{}_{500}$
	aq.		44.6	*N* 9.65^{17}
$N_2H_4{\cdot}2HCl$	c		90 3	*S* − $6\,20^{19}{}_{400}$
	aq.		84 1	*N* 9 7
$NH_4Cl\ 3NH_3$	c		130 1	*D* − 22.8
$NH_4Cl\ 6NH_3$	liq.		180 6	*D* − 17.0
$NH_2OH{\cdot}HCl$	c		74.0	*S* − $3\,65_{450}$
	aq		70 4	*N* $9\,26_{400}$
NH_4ClO_4	c		78.1	*S* − $6.36^{20}{}_{200}$
	aq.		71.7	*N* 12.90_{500}
NOBr	g		− 17 7	
	liq.		− 11.6	*S* $23\,8_{2\,KOH\,(aq.)}$
$NOBr_3$	g		− 4 9	*V* − 6.6
	liq.		1.7	*S* $52.5_{4\,KOH\,(aq.)}$
NH_4Br	c	I		*T* $0.76^{138}{}_{\rightarrow II}$
	c	II	64.58	*S* − 4.45_{200}
	aq.		60.13	
NH_4Br_3	c		69.73	*D* − 12.8
$NH_4Br{\cdot}NH_3$	c		83.5	*D* − 7.95
$NH_4Br{\cdot}3NH_3$	c		121.2	*D* − 7.9
$NH_4Br\ 6NH_3$	c		170.9	*D* − 5.6
NH_4I	c	I	48.39	*S* − 3.56_{200}
	c	II		*T* − $0.70^{-18}{}_{\rightarrow I}$
	aq.		44.83	
$NH_4I{\cdot}NH_3$	c		67.6	*D* − 8.2
$NH_4I{\cdot}3NH_3$	c		103.5	*D* − 7.0
$NH_4I{\cdot}6NH_3$	c		153.5	
NS	c		− 31.9	
$N_2O_3(SO_3)_2$	c		253.	*S* $107^{22}{}_{KOH\,(aq.)}$
NH_4HS	c		38.9	*S* − 3.3

Nitrogen

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
NH_4HS	200		35.55	N 6.35$_{100}$
$(NH_4)_2S$	400		55.00	N 6.50$_{200}$
NH_4S_4	c		31.9	S — 4.3[13]
	aq.		28.1	
$(NH_4)_2S_5$	c		64.7	S — 83[13]
	aq.		56.2	
NH_4S_2	c		32.2	S — 4.3[13]
	aq.		27.9	
NH_4HSO_3	aq.		180 35	N 14.89
NH_4HSO_4	c		244.64	S — 0.02$_{200}$
	800		245.20	
	400		244.88	
	200		244.62	
	100		244.43	
	50		244.32	
	20		244.20	
	10		243.83	
$NH_2OH{\cdot}H_2SO_4$	aq.		244.4	N 11.07$_{400}$
$(NH_4)_2SO_3$	c		212.3	S — 1.54[8]$_{3\cdot0}$
	aq.		211.1	N 25.40[8]$_{440}$
$(NH_4)_2SO_3{\cdot}H_2O$	c		283.6	S — 4.3[13]
$(NH_4)_2SO_4$	c		281.46	S — 2.38$_{400}$
	∞		278.71	
	800		279.06	
	400		279.08	N 28.96$_{400}$
	200		279.15	
	100		279.27	
	50		279.46	
	30		279.65	
	10		279.90	
$N_2H_4{\cdot}H_2SO_4$	c		227.8	
	aq.		219.3	N 11.29[17]
$(NH_2OH)_2{\cdot}H_2SO_4$	c		287.7	S — 0.96$_{600}$
	aq.		276.6	N 21.6$_{600}$
$(NH_4)_2S_2O_3$	c		299.5	S — 6.3[8]$_{400}$
	aq.		292.3	
$(NH_4)_2S_2O_8$	c		395.4	S — 9.2[16]$_{1000}$
	aq.		386.2	
$(N_2H_4)_2H_2SO_4$	aq.		225.8	N 22.33
NSe	c_1		— 42.3	D — 42.3
NH_4HSe	aq.		5.1	
$(NH_4)_2Se$	aq.		25.6	

Phosphorus

Atomic number 15 Standard state P (c, I, yellow) Atomic weight 31.02

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
P	c	I, yellow	0.000	
	c	II, yellow		T — $1.27^{-80}{}_{\rightarrow I}$
	c	red	4.22	T — $4.22_{\rightarrow I}$
	liq.	yellow		F — $0.155^{44}{}_{I}$
	g	$3s^23p^3$ ($^4S^1_{3/2}$)	— 31.6	D_{P_2} — 45.5^{1000}
P+	g	$3s^23p^2$ ($^3P_0$)	— 279 36	I^s — 246.31
P+ *	g	($^3P_1$)	— 279.83	E^s — 0.471
	g	($^3P_2$)	— 280.70	E^s — 1.338
	g	$3s^23p3d$ ($^3D^1_1$)	— 465.12	E^s — 185.76
	g	($^3D^1_2$)	— 465.18	E^s — 185.82
	g	($^3D^1_3$)	— 465.28	E^s — 185.915
	g	($^3P^1_0$)	— 498.06	E^s — 218.70
	g	($^3P^1_1$)	— 498 03	E^s — 218.67
	g	($^3P^1_2$)	— 497 89	E^s — 218 53
	g	$3s^23p4s$ ($^3P^1_0$)	— 526.17	E^s — 246 81
	g	($^3P^1_1$)	— 526.30	E^s — 246 94
	g	($^3P^1_2$)	— 527.39	E^s — 248 03
P++	g	$3s^23p$ ($^2P^1_{1/2}$)	— 737.72	I^s — 456 91
P++ *	g	($^2P^1_{3/2}$)	— 737.87	E^s — 0.159
P+++	g	$3s^23p$ ($^3P^1_0$)	—1431.87	I^s — 692.72
P+++ *	g	($^3P^1_1$)	—1432.52	E^s — 0.651
	g	($^3P^1_2$)	—1433.87	E^s — 1.983
P++++	g	$3s$ ($^2S_{1/2}$)	—2420.20	I^s — 986.88
P+++++	g	$2p^6$ ($^1S_0$)	—3911.92	I^s —1490.28
P_2	g		— 20.7	D_{P_4} — 31.5^{800}
	CS_2		— 0.92	
P_4	g		— 13.2	
PO_3^-	aq.		235.2	
PO_3^{---}	aq.		216.4	
PO_4^{---}	aq.		297.6	
P_2O_5	c	"volatile"	360.0	
	amorp		367.0	
	gls.		371.7	
$P_2O_7^{----}$	aq.		537.2	
P_4O_{10}	g		700.	
PH	g	$^3\Sigma^-$	— 30.	D^s — 53.
PH*	g	$^3\Pi$	— 113.	E^s — 83.
PH_3	g		2.3	
	liq.			V — 3.9^{-80}
$PH_3 \cdot 6H_2O$	c		426.0	D — $13.5^{0}{}_{\rightarrow H_2O\,(liq.)}$
P_2H	c		11.9	
HPO_2^-	aq.		128.9	
HPO_3	c		224.8	S 9.76
	aq.		234.6	

Phosphorus

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
HPO_3^{--}	aq.		227.	
HPO_4^{--}	aq.		305.6	
$H_2PO_2^-$	aq.		142.6	
$H_2PO_3^-$	aq.		228.	
$H_2PO_4^-$	aq.		307.1	
H_3PO_2	c		141.4	S — $0\ 17^{19}{}_{150}$
	liq.		139.0	S $2.18^{19}{}_{150}$
	450		141.41	
	250		141.2	
	220		141.17	
	110		140.70	
	55		140.45	
H_3PO_3	c		228.93	S $0.13^{19}{}_{150}$
	liq.		225 86	S $2.94^{19}{}_{150}$
	aq.		228.8	
H_3PO_4	c		303.37	S $2.69^{19}{}_{150}$
	liq.		300.85	S $5\ 22^{19}{}_{150}$
	400		306.16	
	200		306.1	
	100		306.02	
	50		305.92	
	20		305.69	
	9		305 26	
	3		304.05	
	1		302.49	
$H_3PO_4 \cdot \frac{1}{2}H_2O$	c		340.4	S $0.14^{13}{}_{200}$
	liq.		344.1	S $3.78^{13}{}_{200}$
$HP_3O_7^{---}$	aq.		540 0	
$H_2P_2O_5^{--}$	aq.		385.1	
$H_2P_2O_7^{--}$	aq.		540 2	
$H_3P_2O_7^-$	aq.		540.6	
$H_4P_2O_5$	aq.		384.3	
$H_4P_2O_6$	c			S 2.2
	liq.			S . 6.6
$H_4P_2O_7$	c		513.7	S 7.93
	liq.		529.4	S 10.22
	aq		539.6	
$H_4P_2O_7\ 1\frac{1}{2}H_2O$	c		637.5	S 4.49
	liq.		634.4	S 7.63
PF_3	g			S $107.7_{KOH(aq.)}$
PCl_3	g		70.0	V — 6.9
	liq.		76.9	
PCl_5	g		91.0	Vs — 15.5
	c		106.5	
$POCl_3$	g		138.4	V — 8.2^{107}

Phosphorus

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
$POCl_3$	liq.		147.1	S $72.2^{19}{}_{1000}$
	c		150 3	F — 3.2^{2}
PH_4Cl	g		40 8	
	c		67.8	
PBr_3	liq.		45.	
PBr_5	c		60.6	
$POBr_3$	c		106.9	
PH_4Br	c		34.2	
PI_2	c		9.9	
PI_3	c		10.9	S 3.3_{CS_2}
	CS_2		14.2	
PH_4I	c		20.6	
P_3N_5	c		75.0	C 1099.4
$NH_4H_2PO_4$	400		338 9	
$(NH_4)_2HPO_4$	500	$2NH_4^+(aq.)+HPO_4^{--}(aq.)$	368 5	
	500	$2NH_4^+(aq.)+H^+(aq.)+PO_4^{---}(aq.)$	360.5	
$(NH_4)_3PO_4$	600		397.5	

Arsenic

Atomic number 33 Standard state As (c, α, metallic) Atomic weight 74 91

As	g	$4p^3$ $(^4S^1{}_{3/2})$	— 30.3	D_{As_2} — $35\ 0^{1000}$
	liq.			F_a — 5.1^{818}
	c	α, metallic	0.000	
	amorp.	β	— 1.0	T $1.0_{\alpha\to\alpha}$
	c	γ, yellow	— 3 5	T $3.5_{\gamma\to\alpha}$
As*	g	$4p^3$ $(^2D^1{}_{3/2})$	— 60.45	E^s — 30 15
	g	$(^2D^1{}_{5/2})$	— 61.37	E^s — 31.07
As^+	g	$4p^2$ $(^3P_0)$	— 262	I^s — 230.
As^+ *	g	$(^3P_1)$	— 265.0	E^s — 3 00
	g	$(^3P_2)$	— 269.2	E^s — 7.23
	g	$(^1D_2)$	— 298 0	E^s — 35.97
As^{++}	g	4p $(^2P^1{}_{1/2})$	— 726.9	I^s — 463.4
As^{++} *	g	$(^2P^1{}_{3/2})$	— 734.4	E^s — 7.53
As^{+++}	g	$4s^24p$ $(^3P^1{}_0)$	—1355.2	I^s — 626.9
As^{+++} *	g	$(^3P^1{}_1)$	—1358.5	E^s — 3 27
	g	$(^3P^1{}_2)$	—1365.7	E^s — 10.47
As^{++++}	g	$(^2S_{1/2})$	—2334.3	I^s — 977.6
As^{+++++}	g	$3p^6$ $(^1S_0)$	—3773.7	I^s —1438.0
As_2	g		— 25.7	$D^V{}_{a_4}$ — 25.0^{1000}

Arsenic

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
As_4	g		− 30.4	Vs_a − 31.8^{400}
AsO_3^{---}	aq.		141 9	
AsO_4^{---}	aq.		209 2	
As_2O_3	g		125.	$D_{As_4O_6}$ − 17.0^{1200}
	c	octahedral	154.1	S 7.50$_{4NaOH\,(200)}$
	c	monoclinic	148.	
	aq.		146 6	
As_2O_5	c		217 9	S 80.8$_{12NaOH\,(200)}$
	aq.		223.9	
As_4O_6	g		268 0	
AsH_3	g		− 43.6	
$AsH_3\,6H_2O$	c		384.4	D − 17.8$^{0}{}_{\rightarrow H_2O\,(liq.)}$
$HAsO_3^{--}$	aq.		155.4	
$HAsO_4^{--}$	aq.		214.6	
$H_2AsO_3^-$	aq.		168.4	
$H_2AsO_4^-$	aq.		215.7	
H_3AsO_3	aq.		175.3	
H_3AsO_4	c		214.9	S − 0 40$_{300}$
	aq.		214.5	
AsF_5	liq.			V − 5.00^{-53}
	c			F − 2.74^{-80}
$AsCl_3$	g		64.0	V − 7.5
	liq.		71.5	
$AsBr_3$	g		33.	V − 10.^{220}
	liq.		43.1	F − 2.8^{32}
	c		45 9	S 59.8$^{9}{}_{KOH\,(aq.)}$
AsI_3	g		− 7.8	
	liq.		11.4	V − 19 2
	c		13.6	F − 2.2
As_2S_3	c		20.	

Antimony

Atomic number 51 Standard state Sb (c, trigonal) Atomic weight 121.76

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal mole^{-1}
Sb	g	$5s^25p^3$ ($^4S^1_{3/2}$)	− 40.	
	liq.			F − 4.8^{630}
	c	trigonal	0.000	
	c	"explosive"	− 2.32	
Sb*	g	$5s^25p^3$ ($^2D^1_{3/2}$)	− 64.23	E^s − 24.23
	g	($^2D^1_{5/2}$)	− 68 05	E^s − 28.05
	g	($^2P^1_{1/2}$)	− 86.67	E^s − 46.67
	g	($^2P^1_{3/2}$)	− 92.56	E^s − 52.56
Sb^+	g	$5s^25p^2$ ($^3P_0$)	− 234.0	I^s − 192.5
Sb^{++}	g	$5s^25p$ ($^2P^1_{1/2}$)	− 669.2	I^s − 443.7
Sb^{++} *	g	($^2P^1_{3/2}$)	− 687.9	E^s − 18.74
Sb^{+++}	g	$5s^2$ ($^1S_0$)	−1240.7	I^s − 570.1
Sb^{++++}	g	$5s$ ($^2S_{1/2}$)	−2256.1	I^s −1013.9
Sb^{+++++}	g	$4p^6$ ($^1S_0$)	3536.6	I^s −1279.
Sb_2	g		− 52.	
SbO	g		− 17.	
SbO_4^{---}	aq.		187.6	
Sb_2O_3	c	I, orthorhombic	165.4	S $20.2^{\%}{}_{7HF(100)}$
	c	II, octahedral	166.6	S $19.0^{\%}{}_{7HF(100)}$
	aq.		166.0	
Sb_2O_4	c		213 0	
Sb_2O_5	c		230 0	
	aq.		228 0	
Sb_4O_6	g		186.6	Vs_{II} − 47.3^{600}
	liq.			F_{II} − 29.5
Sb_6O_{13}	c		660.	
SbF_3	c		216.6	S − $1.6^{\%}{}_{200}$
	aq.		214.9	
H_3SbF_6	aq.		443.5	
$SbCl_3$	g		77.4	V − 10.95^{125}
	liq.		88.4	F − 3.01^{73}
	c		91.4	
$SbCl_5$	g		93.7	V − 11.05^{67}
	liq.		104.9	
	c		107.3	F − 2.45^{-6}
SbOCl	c		89.2	
$Sb_4O_5Cl_2$	c		346.1	
$SbBr_3$	liq.		56.5	F − 3.52^{100}
	c		60.0	S $3.6^{25}{}_{CS_2}$
	CS_2		56.4	
SbI_3	c		22.8	
	aq.		22.0	
Sb_2S_3	c	orange ppt.	35.7	

Antimony

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Sb_2S_3	c	black	35 8	
	c	lilac (?)	31 5	
	c	brown (?)	37.1	
$Sb_2(SO_4)_3$	c		572.2	S $118.7_{NaOH(aq)}$
$SbF_3 NH_3$	c		241.7	D — 14 1
$SbF_3 2NH_3$	c		264.7	D — 12.1
$SbF_3 3NH_3$	c		284.9	D — 9.2
$SbF_3 \cdot 4NH_3$	c		303 5	D — 7.6
$SbF_3 \cdot 6NH_3$	c		340 4	D — 7 5

Bismuth

Atomic number 83 Standard state Bi (c) Atomic weight 209.00

Bi	g	$6s^26p^3$ ($^4S^1_{3/2}$)	— 47.8	
	liq.			F — 2.64^{271}
	c		0 000	
Bi*	g	$6s^26p^3$ ($^2D^1_{3/2}$)	— 80 30	E^z — 32.50
	g	($^2D^1_{5/2}$)	— 91.74	E^z — 43.94
Bi^+	g	$6s^26p^2$ ($^3P_0$)	— 216.0	I^z —166.71
Bi^+ *	g	($^3P_1$)	— 253 9	E^z — 37.93
	g	($^3P_2$)	— 264.5	E^z — 48.47
Bi^{++}	g	$6s^26p$ ($^2P^1_{1/2}$)	— 607.	I^z —390.
Bi^{++} *	g	($^2P^1_{3/2}$)	— 651.	E^z — 44.
Bi^{+++}	g	$6s^2$ ($^1S_0$)	—1178.	I^z —569.
Bi_2	g		— 76.2	D^z — 18.5
BiO	c		49.5	
Bi_2O_3	c		137.1	
	amorp.	hydrated	136.8	
$Bi(OH)_3$	c		171.1	
$BiCl_3$	c		90.6	
	HCl (25)		84.5	
BiOCl	c		89.8	
BiI_3	c		24.	S 2 88
	aq.		27.	
Bi_2S_3	c		26.0	
$Bi_2(SO_4)_3$	c		408.0	S $54.6_{NaOH(aq)}$

Carbon

Atomic number 6 Standard state C (c, diamond) Atomic weight 12.00

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
C	g	$2s^22p$ ($^3P_0$)	$-170.0+a$†	
	liq.			$F - 11^{3600}_{\text{graphite}}$
	c	diamond	0.000	
	c	β graphite	0.22	
	c	α graphite	0.49	
	c	"carbonado"	− 0.10	
	"amorp."	"acetylene" carbon	− 0.3	
	"amorp."	"gas" carbon	− 1.5	
	"amorp."	charcoal	− 2.0	
	"amorp."	"Glanzkohlenstoff," density = 2.07	− 2.1	
	"amorp."	"Glanzkohlenstoff," density = 2.0	− 2.3	
	"amorp."	"Glanzkohlenstoff," density = 1.86	− 3.2	
C*	g	$2s^22p$ ($^3P_1$)	$-170.04+a$	$E^s - 0.042$
	g	($^3P_2$)	$-170.12+a$	$E^s - 0.120$
	g	($^1D_2$)	$-197.63+a$	$E^s - 27.63$
	g	($^1S_0$)	$-230.23+a$	$E^s - 60.23$
C^+	g	$2s^22p$ ($^2P^1_{1/2}$)	$-430.55+a$	$I^s - 259.10$
C^+ *	g	($^2P^1_{3/2}$)	$-430.82+a$	$E^s - 0\ 267$
	g	$2s2p^2$ ($^4P_{1/2}$)	$-550.58+a$	$E^s - 120\ 03$
	g	($^4P_{3/2}$)	$-550.64+a$	$E^s - 120.09$
	g	($^4P_{5/2}$)	$-550.69+a$	$E^s - 120.17$
	g	$^2D_{5/2}$	$-643.86+a$	$E^s - 213.313$
	g	$^2D_{3/2}$	$-643.86+a$	$E^s - 213.317$
C^{++}	g	$2s^2$ ($^1S_0$)	$-991.84+a$	$I^s - 559.84$
C^{++} *	g	$2s2p$ ($^3P^1_0$)	$-1140.77+a$	$E^s - 148.93$
	g	($^3P^1_1$)	$-1140.84+a$	$E^s - 149.00$
	g	($^3P^1_2$)	$-1141.00+a$	$E^s - 149.16$
C^{+++}	g	$2s$ ($^2S_{1/2}$)	$-2092.6+a$	$I^s - 1099.3$
C^{+++} *	g	$2p$ ($^2P^1_{1/2}$)	$-2276.2+a$	$E^s - 183\ 57$
	g	($^2P^1_{3/2}$)	$-2276.5+a$	$E^s - 183.88$
C^{++++}	g	$1s^2$ ($^1S_0$)	$-3574.9+a$	$I^s - 1480.8$
C^{+++++}	g	$1s$ ($^2S_{1/2}$)	$-7127.+a$	$I^s - 3552.$
C^{++++++}	g		$-18375.+a$	$I^s - 11246.$
C_2	g	$^3\Pi_u$	$-177.3+2a$	$D^s - 161.8$
C_2*	g	$^3\Pi_g$	$-232.4+2a$	$E^s - 55.1$
CO	g	$^1\Sigma^+$	26.84	C 67.61
	liq.			$V - 1.444^{-191.5}$
	c	I		$F - 0.1997^{-205\ 0}$
	c	II		$T - 0.1513^{-211\ 6}{}_{\rightarrow I}$

†See text, page 232.

Carbon

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
CO	aq.		29.6	S 2.8
CO*	g	a, $^3\Pi$	− 111.3	E^s − 138.1
	g	A, $^1\Pi$	− 157.4	E^s − 184.2
	g	c, $^3\Pi$	− 235.4	E^s − 262.2
	g	B, $^1\Sigma$	− 220.6	E^s − 247.4
	g	b, $^3\Sigma$	− 211.9	E^s − 238.7
CO+	g	$^2\Sigma$	− 301.5	I^s − 327.
CO+ *	g	A^1, $^2\Pi$	− 359.4	E^s − 57.9
	g	B^1, $^2\Sigma$	− 431.5	E^s − 130.
CO_2	g		94.45	
	liq.			V − 6.0^{-56}
	c			F − 2.24^{-56}
	aq.		99.21	S 4.76
$CO_2 \cdot 6H_2O$	c		519.6	D − $14.9_{\rightarrow H_2O\,(liq.)}$
CO_2^+	g		− 237.	I^s − 330.
CO_3^{--}	g		60.	
	∞	carbonate ion	160.5	
$C_2O_4^{--}$	aq.	oxalate ion	195.6	
C_3O_2	liq.	carbon suboxide		V − 6.1^6
CH	g	$^2\Pi$	− 127.9+a	E^s − 73.1
CH*	g	A, $^2\Delta$	− 194.8+a	E^s − 66.9
	g	B, $^2\Sigma^-$	− 201.0+a	D^s − 20.0
	g	C, $^2\Sigma^+$	− 218.5+a	E^s − 90.6
CH_3^+	g		− 286 8	
CH_4	g	methane	18.24	C 212.95
	liq.			V − 2.18^{-159}
	c	I		F − 0.22^{-183}
	c	II		T − $0.018^{-263}{}_{\rightarrow I}$
CH_4^+	g		− 315	I^s − 336.0
$CH_4 \cdot 6H_2O$	c		442.7	D − $14.2_{\rightarrow H_2O\,(liq.}$
C_2H_2	g	acetylene	− 53.9	C 311.1
	liq.			V − $5.74^{-81\,5}$
	c			F − $0.60^{-81\,5}$
	aq		− 49.9	S 4.0
$C_2H_2\,6H_2O$	c		371.4	D − $15.1_{\rightarrow H_2O\,(liq.}$
$(C_2H_2)_3$	g	polymer	− 158.7	D − 3.03
C_2H_4	g	ethylene	− 11.0	C 336.6
	liq.			V − 3.5^{-104}
	c			F − 0.70^{-170}
$C_2H_4 \cdot 6H_2O$	c		414.6	D − $15.4_{\rightarrow H_2O\,(liq.}$
C_2H_6	g	ethane	20.96	C 373.05
	liq.			V − $3.33^{-88.6}$
	c			F − $0.668^{-183.7}$
CHO_2^-	aq.	formate ion	99.8	
HCO_3^-	aq.	bicarbonate ion	164.8	

Carbon

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
HCHO	g	formaldehyde	28 7	C 134.1
HCOOH	g	formic acid	88 65	
	liq		100 0	C 62 8
	c		103 0	F − $3.05^{8\ 0}$
	200		100 16	
	100		100 15	
	50		100 13	
	2 0		100 17	
	1.0		100 17	
	0.5		100 12	
$(HCOOH)_2$	g	polymer	191 4	V − 8 57
H_2CO_3	aq.	carbonic acid	167 58	
CH_3O^-	CH_3OH	$(CH_3O\dot{H} = H^+ + CH_3O^-)$		I − 1.3
CH_3OH	g	methyl alcohol	48 44	C 182.75
	liq.		57 45	V − 9 01
	c	I		F − 0.76^{-98}
	c	II		T − $0.14^{-112}{}_{\rightarrow I}$
	∞		59 7	
	33 8		59.19	
	16 0		59 12	
	7.11		58 84	
	4.15		58.57	
	2 67		58 31	
	1 19		57.97	
	0 44		57.74	
$HC_2O_4^-$	aq.	bioxalate ion	196.	
$(CHO)_2$	g	glyoxal	75	
	c		84.5	C 172.0
	aq.		83 3	S − 1.22
$(COOH)_2$	g	oxalic acid, $H_2C_2O_4$	175 9	Vs − 21 65
	c		197.6	C 59.7
	300		195 3	S − 2.26_{300}
	CH_3OH		196 7	S − $0\ 87_{CH_3OH}$
	C_2H_5OH		196.3	S − $1.27_{C_2H_5OH}$
$(COOH)_2\ 2H_2O$	c		340 2	S − $8.44^{20}{}_{300}$
$C_2H_3O_2^-$	∞	acetate ion	117 916	
$C_2H_3O_3^-$	aq.	glycollate ion	156 0	
CH_3CHO	g	acetaldehyde	44 0	C 280.5
	liq.		50 6	V − 6.6^{22}
	c			F − 0.77^{-118}
	aq.		54.2	
$(CH_3CHO)_x$	liq.	paraldehyde	$(54.8)x$	
	c			F − 1.11^{12}
CH_3CHO	c	metaldehyde	57.0	

Carbon

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
C_2H_4O	g	ethylene oxide	17.	
	liq.		23.3	V — 6.3[13]
	aq.		24.8	S 1.5
CH_3COOH	liq.	acetic acid	117.7	C 208.3
	c		120.4	F — 2.70[17]
	∞	$H^+(\infty)$ + $C_2H_3O_2^-(\infty)$	117.946	
	∞	undissociated	118 070	
	6400	actual	118.067	
	3200		118.065	
	1600		118.062	
	800		118.059	
	400		118.055	
	200		118.045	
	100		118.024	
	50		117.983	
	25		117.91	
	8		117.70	
	4		117.59	
	2		117.54	
	1.5		117.53	
	1.0		117 55	
	0 5		117.57	
$HCOOCH_3$	g	methyl formate	84.9	C 240 7
	liq.		91.6	V — 6 75[31]
	c			F — 2.9^{-100}
$CH_2OHCOOH$	c	glycollic acid	159 0	C 166.6
	aq.		156.2	S — 2.76[10]$_{400}$
$(OH)_2CHCOOH$	c	glyoxylic acid	200 4	C 125.2
	aq.		197.9	S — 2.51
$C_2H_5O^-$	C_2H_5OH	($C_2H_5OH = H^+ + C_2H_5O^-$)		I — 2.8
C_2H_5OH	g	ethyl alcohol	56.95	C 337.06
	liq.		67.14	V — 10.19
	c			F — 1.15^{-114}
	200		69.815	
	100		69.70	
	50		69.662	
	25		69.54	
	10.2		69.10	
	5.94		68.57	
	3.84		68.11	
	1.70		67.55	
	0.64		67.28	
	0.28		67.21	

Carbon

Formula	State	Description	Qf, *kcal mole*$^{-1}$	Q, *kcal mole*$^{-1}$
$(CH_3)_2O$	g	dimethyl ether	46 4	C 347 6
	liq			V — 4.45^{-25}
	aq		54 7	
$(CH_2OH)_2$	g	ethylene glycol	98.	V — 13 2^{197}
	liq		112 1	C 281 9
	aq		113 8	
CF_4	g		163	
CH_2FCH_2OH	g	monofluoroethanol	97.	
	liq		111.	
CHF_2CH_2OH	liq	difluoroethanol	162 9	
CH_2FCOOH	c	monofluoroacetic acid	162 2	
CHF_2COOH	liq	difluoroacetic acid	205 6	
CCl_4	g	carbon tetrachloride	25 9	
	liq.		33 8	V — 7 27^{77}
	c	I		F — 0 67^{-24}
	c	II		T — 1 10^{-49} $_{.1}$
C_2Cl_4	g	tetrachloroethylene	— 6	
	liq		3	V — 8 27^{120}
C_2Cl_6	g	hexachloroethane	37.	Vs — 17.
	c		54	
CBr_4	g	carbon tetrabromide	— 12	
$COCl_2$	g	phosgene	53 5	
	liq		59 3	V — 5 90
CCl_3COO^-	aq	trichloroacetate ion	133.2	
CCl_3COCl	liq.	trichloroacetyl-chloride	79 0	
CH_3Cl	g	methyl chloride	20 1	
	liq.			V — 5.17^{-24}
CH_2Cl_2	g	methylene chloride	21 7	
	liq.		28 6	V — 6 69^{40}
$CHCl_3$	g	chloroform	23 6	
	liq.		31 2	V — 7 01^{61}
	c			F — 2 1
	aq.		33 4	S 2.2
CH_2CHCl	g	vinyl chloride	— 9.	
	liq		— 4 1	V — 4.9
C_2H_5Cl	g	ethyl chloride	25 7	
	liq.		31 6	V — 5.95^{12}
CH_2ClCH_2Cl	g	ethylene chloride	29.3	
	liq.		37.6	V — 7.75^{84}
CH_3CHCl_2	g	ethylidene chloride	29.3	
	liq.		36.4	V — 6.65^{57}

Carbon

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$CHCl_2CHCl_2$	g	symmetrical tetrachloroethane	33.	
	liq.			V — 9.9[145]
CCl_3CHCl_2	g	pentachloroethane	35.	
	liq.		45.	V — 9.9
CH_3COCl	g	acetylchloride	60 9	
	liq.		66.8	
CH_2ClCHO	liq.	chloroacetaldehyde	62.3	
$(CH_2ClCHO)_x$	c	polymer	$(66.5)x$	
CH_2ClCOO^-	aq.	monochloroacetate ion	122.1	
$CH_2ClCOOH$	g	monochloroacetic acid	107.4	V — 13.0[61]
	liq.		120 4	F — 4.63[61]
	c	α (m.p. 61°)	125.	
	c	β (m p. 56°)	124 9	F — 4.45[56]
	c	γ (m.p. 51°)	124.2	F — 3.79[61]
	200		121.6	S — 3.35
CH_2ClCH_2OH	liq.	monochloroethanol	75.0	
	aq.		76 3	
$CH_2ClCOCl$	liq.	chloroacetyl chloride	68.4	
$CHCl_2COOH$	g	dichloroacetic acid	114.	
	liq.		125.	S $2\ 58^{15}_{400}$
	c		126 8	F — 1.83[11]
	aq.		127.6	
CCl_3CHO	g	chloral	45.5	V — 8.0
	liq.		53.5	S 11.9
	aq.		65.4	
$(CCl_3CHO)_x$	c	polymer of chloral	$(61.0)x$	
CCl_3COOH	liq.	trichloroacetic acid	130.	F — 1.41[59]
	c		131.4	S 2.70^{15}_{400}
	aq.		134.1	
$CCl_3CH(OH)_2$	g	chloral hydrate	104.	
	liq.		128.7	
	c	I	131.6	T $2.4_{\rightarrow 11}$
	c	II	134.2	S — 0.4
$COBr_2$	g	carbonyl bromide	22.3	D — 3.14
CH_3Br	g	methyl bromide	8.5	
CH_2Br_2	g	methylene bromide	1.	
$CHBr_3$	g	bromoform	— 6.	
C_2H_5Br	g	ethyl bromide	15.5	
	liq.		22.3	V — 6.6[38]
CH_2BrCH_2Br	g	ethylene bromide	10.6	
	liq.		19.7	V — 9.1

Carbon

Formula	State	Description	Q_f, kcal. mole^{-1}	Q, kcal. mole^{-1}
$CBr_3CH(OH)_2$	c	bromal hydrate, I	105.	S $12.1_{KOH(aq.)}$
	c	II	101.0	S $16.1_{KOH(aq.)}$
	aq.		106.9	
$C_2H_5Br_3$	liq.	ethyl perbromide	24.8	
$CH_3OH{\cdot}HBr$	c			F — 0.6^{-83}
	c	$\rightarrow CH_3OH(c) + HBr(g)$		D — 13.5^{-83}
$CH_2BrCOOH$	c	monobromoacetic acid		S — 3.06_{400}
$CHBr_2COOH$	c	dibromoacetic acid		S — 0.85_{400}
CBr_3COOH	c	tribromoacetic acid		S — 0.48_{400}
CH_3COBr	liq.	acetyl bromide	54.9	
C_2I_4	c	tetraiodoethylene	— 73.	
CH_3I	g	methyl iodide	— 4.5	
	liq.		2.1	V — 6.5^{42}
CH_2I_2	g	methylene iodide	— 25.	V — 10.4
	liq.		— 15.	
CHI_3	g	iodoform	— 44.	
	c		— 33.	
C_2H_5I	g	ethyl iodide	1.0	
	liq.		8.4	V — 7.1^{72}
CH_2ICH_2I	g	ethylene iodide	— 16.	
	c		0	
CH_3COI	liq.	acetyl iodide	41.5	
CH_2BrCH_2I	c	bromoiodoethane	11.4	
CS	g	carbon monosulfide	20.	
$(CS)_x$	c	polymer of CS	$(-13.)x$	
CS_2	g	carbon bisulfide	— 22.	
	liq.		— 15.4	V — 6.35^{46}
	c			F — 0.66^{-116}
COS	g	carbonyl sulfide	35.	
	liq.			V — 4.6^{-70}
CH_3SH	g	methyl mercaptan	3.6	
	liq.		9.6	V — 6.0^{14}
$(CH_3)_2S$	g	dimethyl sulfide	8.0	
	liq.		16.3	V — 8.2^{26}
C_2H_5SH	g	ethyl mercaptan	10.	
	liq.		16.9	V — 6.75^{40}
$C_2H_5SO_4^-$	aq.	ethylsulfate ion	207.7	
$C_2H_5HSO_4$	aq.	ethysulfuric acid	208.2	
CN	g			D^0 — 160.
CN*	g	$^2\Pi$		E^1 — 31.14
	g	$^2\Sigma^+$		E^1 — 73.44
CN^-	g		52.	
	aq.	cyanide ion	— 34.9	

Carbon

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
CN_4	c	carbon perazuride	− 92.6	C 186 1
C_2N_2	g	cyanogen	− 71.	C 260.
	liq.			V − 5 9^{-20}
	aq.		− 64.	S 7
$(CN_4)_x$	c	polymer of CN_4	(− 80.2)x	
CNO^-	aq.	cyanate ion	34.5	
HCN	g	hydrocyanic acid	− 30.7	
	liq.		− 24.0	V − 6.67^{25}
	c			F − 1.72^{-14}
	1		− 25 4	
	4		− 24 3	
	100		− 23.9	
CH_3NH_2	g	methylamine	7.3	C 259.7
	liq.			V − 6.40^{-7}
	300		18.00	S_g 10 70^{25}
	500		18.05	
	1000		18.17	
$CH_3NH_3^+$	aq.	methyl ammonium ion	31.2	
NH_2CN	liq.	cyanamide		F − 2.1^{44}
	c		− 8.8	C 171.6
	aq.		− 12.4	S_o − 3.6$^{15}{}_{1000}$
NH_4CN	c	ammonium cyanide	1.1	S − 4.4$_{400}$
	aq.		− 3.3	
$(NH_2)_2CNH$	c	guanidine	31.1	S 1 2
	aq.		32.3	N 14.1
$(NH_2)_2CNH\ H^+$	aq.	guanidine ion	32 1	
CH_3CN	g	acetonitrile	− 19.4	C 310 9
	liq.		− 11.8	V − 7 0^{80}
CH_3NC	g	methyl isocyanide	− 34.3	
	liq.		− 27.3	
$(CH_3)_2NH$	g	dimethylamine	8.2	C 420.
	liq.		14.7	V − 6.5^{8}
	aq.		20.9	
$C_2H_5NH_2$	g	ethylamine	13.0	C 415.2
	liq.		19.6	V − 6.6^{15}
	aq.		25.94	$S_{liq.}$ 6.34
$(CH_3)_2NH{\cdot}H^+$	aq	dimethyl aminium ion	32.8	
$C_2H_5NH_2{\cdot}H^+$	aq.	ethyl aminium ion	39.15	
$NH_2CH_2CH_2NH_2$	aq.	ethylene diamine	14.5	
$(CH_2NH_2{\cdot}H)_2^{++}$	aq.	ethylene diaminium ion	− 37.7	
$NH_2C(:NH)NHCN$	c	dicyandiamide	− 3.1	C 328.7
	aq.		− 8.9	S − 5.77

Carbon

Formula	State	Description	Q_f, kcal. mole^{-1}	Q, kcal. mole^{-1}
HCNO	aq.	cyanic acid	36.5	
$CH_2NO_2^-$	aq.	nitromethane ion	20.2	
$HCONH_2$	liq.	formamide	62.0	C 134.9
	aq.		57.8	
CH_3NO_2	g	nitromethane	18 6	V — $8\ 25^{99}$
	liq.		27 6	C 169.4
	aq.		27.0	S — 0.6
$HCOONH_4$	c	ammonium formate	133.2	S — $2.94^{10}{}_{140}$
	aq.		131.3	N . $11.9^{10}{}_{200}$
NH_4HCO_3	c	ammonium bicarbonate	203 0	S — 6.8_{1200}
	400		196.19	
	200		196.29	
	100		196.4	
	40		196.58	
NH_4CNO	c	ammonium cyanate	73.5	S — 6.23
	aq.		67.3	
$(NH_2)_2CO$	c	urea	78.5	S — 3.35
	aq.		75.15	
NH_2COONH_4	c	ammonium carbamate	159.0	S — 3.80^{15}
	aq		155.2	
$(NH_4)_2CO_3$	aq.	ammonium carbonate	223.6	
$(NH_2)_2CO{\cdot}HNO_3$	c	urea nitrate	135.1	S — 10.7
	aq.		124.4	
$(NH_2)_2C(.NH){\cdot}HNO_3$	c	guanidine nitrate	92.1	C 207.5
	aq.		82 0	S — 10.15
$CONH_2COO^-$	aq.	oxamate ion	153.6	
CH_3NCO	liq.	methyl isocyanate	22.	C 269.4
$HOCH_2CN$	liq.	glycollic nitrile	34.8	C 256.7
$CONH_2COOH$	c	oxamic acid	161.4	C 130.1
	aq.		154.0	S — 7.4^{11}
$CH_3CHNO_2^-$	aq.	nitroethane ion	27.	
$NH_2CH_2COO^-$	aq.	aminoacetate, or glycinate, ion	112.0	
CH_3CONH_2	c	acetamide	77.98	
	liq.			F — 0.43^{81}
	200		75.93	S — $2.05^{17}{}_{200}$
CH_3CHNOH	c	acetaldoxime	19.2	C 340.6
C_2H_5ONO	g	ethyl nitrite	25.9	C 333.9
$C_2H_5NO_2$	g	nitroethane	23.	
	liq.		33.	V — 9.9^{21}
	aq.		32.	

Carbon

Formula	State	Description	Q_f, kcal. mole^{-1}	Q, kcal. mole^{-1}
NH_2CH_2COOH	c	aminoacetic acid, glycine	126 4	C 233.4
	aq.		122 8	S − 3.58
$C_2H_5ONO_2$	g	ethyl nitrate	33.4	
	liq.		41.5	
$COOHCOONH_4$	aq.	ammonium bioxalate	226 7	N 12 5
$NH_2CH_2COOH \cdot H^+$	aq.	glycinium ion	123 6	
CH_3COONH_4	c	ammonium acetate	149 0	S $0\ 25^{24}_{200}$
	∞	$NH_4^+(\infty) + C_2H_3O_2^-(\infty)$	149.10	
	400		149.31	
	200		149 27	
	100		149.18	
	50		119 05	
	25		148 85	
	10		148.45	
	5		148 10	
	2		147 55	
$CH_2OHCOONH_4$	c	ammonium glycollate	190 9	S − 3 2
	aq.		187 7	N 12.2
$CH_3NH_2HCO_3$	aq.	methylamine bicarbonate	196.0	N 9 0
$(OH)_2CHCOONH_4$	aq.	ammonium glyoxylate	229 1	N 12 2
$(CONH_2)_2$	c	oxamide	122 4	C 203 2
$NH_2CONHCHO$	liq	formyl urea	118 6	C 207.0
	aq		111.3	S − 7.3
$(CH_3)_2NNO$	liq.	dimethyl nitrosoamine	0.	C 394.
$C_2H_5NHNO_2$	liq.	ethyl nitroamine	22.	C 372.
$(CH_2NH_2)_2 \cdot H_2O$	c	ethylene diamine monohydrate	77.8	C 453.
$(COONH_4)_2$	c	ammonium oxalate	267.2	S − 8.0
	aq.		259.2	
$(COONH_4)_2 \cdot H_2O$	c	ammonium oxalate monohydrate	339.1	S − 11.5
$(CH_2NH_2 \cdot HNO_3)_2$	aq.	ethylene diaminium nitrate	− 138.7	
$CHF_2CH_2NH_2$	liq.	difluoroethylamine	116.7	
CH_2FCONH_2	c	monofluoroacetamide	117.1	
$CHF_2CH_2NHNO_2$	c	difluoroethylnitroamine	118.	

Carbon

Formula	State	Description	*Qf, kcal. mole*$^{-1}$	*Q, kcal mole*$^{-1}$
CNCl	g	chlorocyanogen	− 36 5	*V* − 8.3
	liq		− 28.2	
CH_3NH_2 HCl	aq.	methylamine hydrochloride	70 8	*N* 13.0
$(CH_3)_2NH$·HCl	aq.	dimethylamine hydrochloride	72.0	*N* 11.81_{400}
$C_2H_5NH_2$·HCl	c	ethylamine hydrochloride	81.1	*S* − 2.23
	aq.		78 8	*N* 13.44_{400}
$(CH_2NH_2$ HCl$)_2$	c	ethylene diammonium chloride	123.4	*S* − 6 65
	aq.		116.7	
$CH_2ClCONH_2$	c	monochloroacetamide	88 5	
	aq.		77.8	
NH_2CH_2COOH HCl	aq.	glycine hydrochloride	163.2	*N* 0.97
$CH_2ClCOONH_4$	aq.	ammonium monochloroacetate	153 8	*N* 12 9
$CHCl_2CONH_2$	aq	dichloroacetamide	82.7	
CCl_3CONH_2	c	trichloroacetamide	107.4	*C* 165 2
	aq.		87.2	
CCl_3COONH_4	aq.	ammonium trichloroacetate	165 1	*N* 13 1
CNI	c	iodocyanogen	− 39 1	*S* − 2 8
	aq.		− 41 9	
CNS^-	aq.	thiocyanate ion	− 18 9	
HCNS	aq.	thiocyanic acid	− 19 1	
$(NH_2)_2CS$	c	thiourea	31.5	*C* 270.6
	aq.		26 2	*S* -5.33^{10}_{100}
NH_4CNS	c	ammonium thiocyanate	18.2	*S* − 5.7
	aq		12.5	
CH_3CNS	g	methyl thiocyanate	− 35.	
	liq.		− 23.	
CH_3NCS	g	methyl isothiocyanate	− 28.	
	c		− 10.	
$(NH_2)_2CS$·HNO_3	c	thiourea nitrate	83 8	*S* − 8.5
	aq.		75.3	

Silicon

Atomic number 14 Standard state Si (c) Atomic weight 28.06

Formula	State	Description	Qf, kcal, mole^{-1}	Q, kcal. mole^{-1}
Si	g	$3s^23p^2$ ($^3P_0$)	− 85.	
	c		0 000	
	amorp.		− 1.0	
Si*	g	$3s^23p^2$ ($^3P_1$)	− 85.22	E^s − 0.22
	g	($^3P_2$)	− 85.64	E^s − 0.64
	g	($^1D_2$)	− 102.93	E^s − 17.93
	g	($^1S_0$)	− 128.82	E^s − 43.82
Si$^+$	g	$3s^23p$ ($^2P^1_{1/2}$)	− 273.7	I^s − 187 22
Si$^+$ *	g	($^2P^1_{3/2}$)	− 274.5	E^s − 0.82
	g	($^2D_{3/2}$)	− 431.1	E^s − 157.44
	g	($^2D_{5/2}$)	− 432 1	E^s − 157.48
Si^{++}	g	$3s^2$ ($^1S_0$)	− 650.1	I^s − 375.26
	g	($^3P^1_3$)	− 742.0	E^s − 111.59
	g	($^3P_2$)	− 742.4	E^s − 111.96
	g	($^3P_1$)	− 743.1	E^s − 112.71
Si^{+++}	g	$3s$ ($^2S_{1/2}$)	−1421.0	I^s − 769.12
Si^{++++}	g	$2s^22p^6$ ($^1S_0$)	−2459.1	I^s −1036 6
Si^{+++++}	g	$2s^22p^5$ ($^2P^1_{3/2}$)	−6355.	I^s −3895.
SiO_2	g		120	V − 79^{1900}
	liq.			F − 1.84^{1630}
	gls.		201.0	
	c	β cristobalite 1600° form		T $0.15^{270}{}_{\rightarrow\alpha\ \text{crist}\ 1600^\circ}$
	c	β cristobalite 1100° form		T $0.06^{230}{}_{\rightarrow\alpha\ \text{crist}\ 1100^\circ}$
	c	α cristobalite 1600° form	202.61	
	c	α cristobalite 1100° form	202.45	
	c	β tridymite		T 0.02 α tridymite
	c	β quartz		T $0.18^{573}{}_{\rightarrow\alpha\ \text{quartz}}$
	c	α quartz	203.34	
	colloid	in water	199.1	
SiH_4	g		8.7	D − 8.7
	liq.			V − 3.03^{-112}
Si_2H_6	g			V − 5.11^{-15}
Si_3H_8	liq.			V − 7.1^{53}
Si_4H_{10}	liq.			V − 8.9^{109}
H_2SiO_3	c	ppt.	267.8	D − 10.9
H_4SiO_4	c	ppt.	330.1	D − 8.7
	colloid	in water	335.9	
$H_2Si_2O_5$	c	ppt.	458.7	D − 12.7
$H_6Si_2O_7$	c	ppt.	603.5	D − 10.1
SiF_4	g		360.1	S $33.9_{2\,HF\,(aq.)}$
	liq.			V − 4.46^{-90}
	c			F − 1.7^{-95}
SiF_6^{--}	aq.		544.0	

Silicon

Formula	State	Description	Qf, *kcal mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
$HSiF_6^-$	aq.		544 5	
H_2SiF_6	aq.		545.0	
$SiCl_4$	g		142.5	V — 7.19[57]
	liq.		150.1	
	c			F — 1.85[−70]
Si_2Cl_6	liq.			V — 11.0[139]
Si_3Cl_8	liq			V — 12.1[213]
$(SiCl_3)_2O$	liq.			V — 9.4[137]
$SiClH_3$	g			V — 5.1[−10]
$SiCl_2H_2$	g			V — 6.1[12]
$SiBr_4$	liq.		93 6	S 83 0[7300]
$SiBrH_3$	g			V — 5.85[2]
$SiBr_2H_2$	g			V — 7.4[66]
SiI_4	c		29.8	S 85.7
SiS_2	c	yellow	30.9	
	c	white	34.1	
Si_3N_4	c		157.0	
$(NH_4)_2SiF_6$	c		621.6	S — 8.4[7][1200]
	aq.		613.2	
SiC	c		28.	
$(C_2H_5O)_4Si$	liq.	ethylorthosilicate	320.	S 21.6
$(CH_3O)_4Si$	liq.	methyl silicate		V — 7.08[121]

Germanium

Atomic number 32 Standard state Ge (c) Atomic weight 72.60

Ge	g	$4s^24p^2$ ($^3P_0$)	— 85.	
	c		0.000	
Ge*	g	$4s^24p^2$ ($^3P_1$)	— 86.58	E^s — 1.58
	g	($^3P_2$)	— 89.01	E^s — 4 01
	g	($^1D_2$)	— 105.29	E^s — 20.29
	g	($^1S_0$)	— 131.59	E^s — 46.59
Ge^+	g	$4s^24p$ ($^2P^1_{1/2}$)	— 275.9	I^s — 189.47
Ge^+ *	g		— 280.9	E^s — 5.03
Ge^{++}	g	$4s^2$ ($^1S_0$)	— 543.6	I^s — 366.20
Ge^{+++}	g	$4s$ ($^2S_{1/2}$)	−1330.8	I^s — 785.81
Ge^{++++}	g	$3d^{10}$ ($^1S_0$)	−2377.0	I^s −1044.75
GeO_2	colloid	in water	230.	
Ge_2H_6	liq.			V — 6 3[29]
Ge_3H_8	liq.			V — 7.6[111]
$GeCl_4$	g		216.	V — 9.2[86]
	liq.		226.	

Tin

Atomic number 50 Standard state Sn (c, II, tetragonal) Atomic weight 118.70

Formula	State	Description	Q_f, kcal. mole^{-1}	Q, kcal. mole^{-1}
Sn	g	$5p^2$ ($^3P_0$)	− 78.	
	liq.			F − 1.69^{232}
	c	I, rhombic		T $002^{161}{}_{\rightarrow II}$
	c	II, tetragonal	0.000	
	c	III, "gray" cubic	− 0.6	T $0.6_{\rightarrow II}$
Sn*	g	$5p^2$ ($^3P_1$)	− 82 82	E^s − 4.82
	g	($^3P_2$)	− 87.76	E^s − 9.76
	g	($^1D_2$)	− 102.52	E^s − 24.52
	g	($^1S_0$)	− 126.86	E^s − 48.86
Sn^+	g	$5p$ ($^2P^1{}_{1/2}$)	− 258.0	I^s − 168.51
Sn^+ *	g	($^2P^1{}_{3/2}$)	− 270 1	E^s − 12.11
Sn^{++}	g	$5s^2$ ($^1S_0$)	− 594.5	I^s − 335.1
Sn^{+++}	g	$5s$ ($^2S_{1/2}$)	−1299 5	I^s − 704.0
Sn^{++++}	g	$4d^{10}$ ($^1S_0$)	−2237.0	I^s − 936.
Sn^{+++++}	g	$4d^9$ (^2D)	−3580.	I^s −1340.
SnO	c		67.7	C 70.4
SnO_2	c	I		T $0.30^{540}{}_{\rightarrow II}$
	c	II		T $0.45^{430}{}_{\rightarrow III}$
	c	III	138.1	
SnH_4	liq.			V − $4\ 55^{-150}$
$Sn(OH)_2$	c	ppt.	136.1	
$Sn(OH)_4$	c	ppt.	268.9	
SnF_6--	aq.		469.8	
H_2SnF_6	aq.		470.4	
$SnCl_2$	g			V − 21.1^{623}
	c		81.1	
	HCl (200)		81.5	
$SnCl_2{\cdot}2H_2O$	c		223.5	S 5.29
$SnCl_4$	g		118.4	V − 8.0^{116}
	liq.		127.4	S $29.92^{20}{}_{250}$
	c			F − 2.20^{-33}
	HCl(200)		157.3	
$SnOCl_2$	aq.		146.8	
$SnBr_2$	c		61.4	
	aq.		59.8	
$SnBr_4$	liq.		91.8	F − 3.00^{27}
	c		94.8	S $15.5^{15}{}_{1000}$
	aq.		110.3	
$SnBr_4{\cdot}8H_2O$	liq.		653.7	F − 10.20^{15}
	c		663.9	S − $6.64^{15}{}_{1200}$
SnI_2	c		38.9	S − 5.8
	aq.		33.1	
SnS	c		22.7	

Tin

Formula	State	Description	*Qf, kcal. mole*$^{-1}$	*Q, kcal. mole*$^{-1}$
$Sn(SO_4)_2$	c		391.1	*S* $91.1_{KOH(aq.)}$
$SnCl_4 \cdot 2H_2S$	c			*D* — 6.2^{-58}
$SnCl_4 \cdot 4H_2S$	c			*D* — 6.2^{-81}
$SnCl_2 \cdot 2\frac{1}{2}NH_3$	c		146.7	*S* $14.0_{HCl(aq.)}$
$SnCl_2 \cdot 4NH_3$	c		162.1	*D* — 9.3
$SnCl_2 \cdot 9NH_3$	c		254.9	*D* — 7.6
$SnBr_2 \cdot 2NH_3$	c		116.2	*S* $7.3_{HCl(aq.)}$
$SnBr_2\ 3NH_3$	c		139.7	*S* $14.8_{HCl(aq.)}$
$SnBr_2 \cdot 5NH_3$	c		181.2	*D* — 9.8
$SnBr_2 \cdot 9NH_3$	c		255.3	*D* — 7.55
$SnI_2\ NH_3$	c		65.8	*D* — 16.0
$SnI_2\ 2NH_3$	c		90.1	*D* — 13.3
$SnI_2 \cdot 3NH_3$	c		112.9	*D* — 11.9
$SnI_2 \cdot 5NH_3$	c		155.2	*D* — 10.2
$SnI_2\ 9NH_3$	c		230.6	*D* — 7.9
$SnCl_4 \cdot 1\frac{1}{2}PH_3$	c		148.5	
SnBi	c		— 0.37	
$SnBi_2$	c		— 0.17	
$SnBi_5$	c		— 0.19	
Sn_2Bi	c		— 0.12	
Sn_6Bi	c		— 0.78	

Lead

Atomic number 82 Standard state Pb (c)† Atomic weight 207.22

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Pb	g	$6p^2$ ($^3P_0$)	47.5	V — 45.^{1620}
	liq.			F — 1.30^{327}
	c	fine crystals, non-radioactive	0 000	
	c	"stick"	— 0.07	
Pb*	g	$6p^2$ ($^3P_1$)	— 69.76	E^s — 22 26
	g	$^3P_2$	— 78 82	E^s — 30.32
	g	$^1D_2$	— 108.59	E^s — 61.09
	g	$^1S_0$	— 147.96	E^s — 100.46
Pb^+	g	6p ($^2P^1_{1/2}$)	— 219.25	I^s — 170.30
Pb^+ *	g	($^2P^1_{3/2}$)	— 259 30	E^s — 40 05
Pb^{++}	g	$6s^2$ ($^1S_0$)	— 565 89	I^s — 345.19
	aq.		0.2	
Pb^{+++}	g	6s ($^2S_{1/2}$)	—1304 0	I^s — 736 68
Pb^{++++}	g	$4d^{10}(^1S_0)$	—2318.7	I^s —1013.3
PbO	c	red	52 46	
	c	yellow	52 06	
PbO_2	c		65 0	
Pb_2O	c		51 3	
Pb_3O_4	c		172 4	
$Pb(OH)_2$	c	ppt.	123.0	
PbF_2	g		100	V — 39 4^{1200}
	c		159 5	
$PbCl_2$	g		49.4	V — 28 5^{818}
	liq			F — 5.6^{500}
	c		85 71	S — 3 44
	aq.		82 3	
$PbCl_2 \cdot PbO$	c		142.7	S 18.1$_{HCl\,(aq.)}$
$PbCl_2 \cdot 2PbO$	c		195.9	S 40 0$_{HCl\,(aq.)}$
$PbCl_2 \cdot 3PbO$	c		247 9	S 63.2$_{HCl\,(aq.)}$
$PbBr_2$	g		5.	V — 28.1^{916}
	c		66.27	
	aq.		56 2	S 10 04
$PbBr_2 \cdot PbO$	c		119.8	S 24 0$_{HBr\,(aq.)}$
$PbBr_2 \cdot 2PbO$	c		171.4	S 50.$_{HBr\,(aq.)}$
$PbBr_2 \cdot 3PbO$	c		223.4	S 75.6$_{HBr\,(aq.)}$
PbI_2	g		— 10.	V — 27.7^{800}
	liq.			F — 5.3^{375}
	c		41.77	
$PbI_2 \cdot HI \cdot 5H_2O$	c		400 9	S — 3.8$^{11}_{200}$
PbS	c		22 3	
$PbSO_4$	c	II	218.5	

†Non-radioactive.

Lead

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$PbSO_4$	c	I		T $4.06^{866}{}_{\rightarrow II}$
PbS_2O_3	c		151.1	
PbS_2O_5	aq.		280 4	
$PbS_2O_6 \cdot 4H_2O$	c		562.4	S — 8.54_{400}
PbS_3O_6	c		284.0	S — 5.0
	aq.		279.	
$PbSO_4 \cdot PbO$	c		280.	
$PbSO_4 \cdot 2PbO$	c		339.	
$PbSO_4\ 3PbO$	c		398.	
$PbSO_4 \cdot 2HCl$	c		276.	D — 6.8
PbSe	c		20.	
$PbSeO_4$	c		148.6	
	aq.		146 6	
PbTe	c		6.0	
PbN_6	c		103.0	
$Pb(NO_3)_2$	c		106 89	S — 7.6_{400}
	400		99.28	
	200		99.80	
	100		100.56	
	40		101.78	
$Pb(NO_3)_2\ PbO$	c		167.6	
$PbCl_2\ NH_3$	c		109 0	D — 13.3
$PbCl_2\ 1\frac{1}{2}NH_3$	c		121.0	D — 11.7
$PbCl_2\ 2NH_3$	c		132.0	D — 11.0
$PbCl_2 \cdot 3\frac{1}{4}NH_3$	c		157 4	D — 9.4
$PbCl_2\ 8NH_3$	c		248.4	D — 8.2
$2PbCl_2 \cdot NH_4Cl$	c		246.66	
$PbBr_2\ NH_3$	c		92.8	D — 15.6
$PbBr_2\ 2NH_3$	c		115 2	D — 11.4
$PbBr_2 \cdot 3NH_3$	c		135 6	D — 9.5
$PbBr_2 \cdot 5\frac{1}{2}NH_3$	c		185 6	D — 9.0
$PbBr_2 \cdot 8NH_3$	c		207 0	D — 8.2
$PbI_2 \cdot \frac{1}{2}NH_3$	c		54.5	D — 14.4
$PbI_2 \cdot NH_3$	c		66.6	D — 13.2
$PbI_2 \cdot 2NH_3$	c		88.8	D — 11.3
$PbI_2 \cdot 5NH_3$	c		150.8	D — 9.7
$PbI_2\ 8NH_3$	c		207.0	D — 7.8
$3PbI_2 \cdot 4NH_4I$	c		315.1	S — 10.25
$3PbI_2 \cdot 4NH_4I \cdot 6H_2O$	c		598.1	S — 19.76
$PbSO_4\ (NH_4)_2SO_4$	c		502.3	S — 3.74
$PbHPO_3$	c		231.7	
$3PbI_2 \cdot PI_3$	c		131.8	S 27.6
$3PbI_2 \cdot PI_3 \cdot 12H_2O$	c		977.3	S 2.5
$3PbI_2 \cdot AsI_3$	c		111.0	S 12.5
$3PbI_2 \cdot AsI_3 \cdot 12H_2O$	c		952.2	S — 8.2

Lead

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$3PbI_2 \cdot SbI_3$	c		127.0	*S* 20.6
$3PbI_2 \cdot SbI_3 \cdot 12H_2O$	c		976.5	*S* − 8.5
$3PbI_2 \cdot BiI_3$	c		136.0	*S* 16.6
$3PbI_2 \cdot BiI_3 \cdot 12H_2O$	c		990.2	*S* − 17.2
$PbCO_3$	c		168.0	
PbC_2O_4	c	lead oxalate	206.2	
$PbCO_3 \cdot PbO$	c		222.6	
$PbCO_3 \cdot 2PbO$	c		274.8	
$Pb(CHO_2)_2$	c	lead formate	206.9	*S* − 6.9[10]
	aq.		200.0	
$Pb(C_2H_3O_2)_2$	c	lead acetate	234.3	*S* $1.4^{11}{}_{220}$
	400		235.7	
$Pb(C_2H_3O_2)_2 \cdot 3H_2O$	c		446.7	*S* − 6.14
$Pb(C_2H_3O_2)_2$	c	lead glycollate	317.3	*S* − 5 74
	aq.		311.5	
$PbO \cdot Pb(C_2H_3O_2)_2$	c	basic lead acetate	292.9	
$Pb(CN)_2 \cdot 2PbO \cdot H_2O$	c		125.	*S* $36.8_{HNO_3(aq.)}$
$Pb(SCN)_2$	c	ppt.	− 30.7	
$PbI_2 \cdot SnI_2$	c		68.6	*S* 12.7
$PbI_2 \cdot SnI_2 \cdot 8H_2O$	c		635.8	*S* − 7.5

Gallium

Atomic number 31 Standard state Ga (c) Atomic weight 69.72

Ga	g	4p $(^2P^1{}_{1/2})$	− 52.	
	c		0.000	
Ga*	g	4p $(^2P^1{}_{3/2})$	− 54.35	E^z − 2.35
	g	$^2S_{1/2}$	− 122.57	E^z − 70.57
Ga^+	g	$4s^2$ $(^1S_0)$	− 194.0	I^z − 140.57
Ga^{++}	g	4s $(^2S_{1/2})$	− 666.5	I^z − 471.0
Ga^{+++}	g	$3d^{10}$ $(^1S_0)$	−1363.4	I^z − 705.4
	aq.		34.	
Ga^{++++}	g	$3d^9$ (^2D)	−2837.	I^z −1472.
Ga_2O_3	c		256.	
$GaCl_3$	aq.		143.	
	HCl(9)		146.	

Indium

Atomic number 49 Standard state In (c) Atomic weight 114.76

Formula	State	Description	*Qf, kcal. mole*$^{-1}$	*Q, kcal. mole*$^{-1}$
In	g	5p ($^2P^1_{1/2}$)	− 52.	
	c		0.000	
In*	g	5p ($^2P^1_{3/2}$)	− 58.30	E^a − 6.30
	g	6s ($^2S_{1/2}$)	− 121.38	E^a − 69.38
In^+	g	$5s^2$ ($^1S_0$)	− 186.30	I^a − 132.85
In^{++}	g	5s ($^2S_{1/2}$)	− 621.1	I^a − 433.7
In^{+++}	g	$4d^{10}$ ($^1S_0$)	−1266.3	I^a − 643.8
	aq.		27.	
In^{++++}	g	$4d^9$ ($^2D_{5/2}$)	−1360.	I^a −1000.
In_2O_3	c		240.	
InCl	c		44.6	
$InCl_2$	c		86.8	
$InCl_3$	c		128.5	S 16.9
	aq.		145.4	
$InBr_3$	c		97.2	S $16.9_{HCl(\infty)}$
	aq.		112.7	
InI_3	c		56.5	S $10.5_{HCl(22)}$
	aq.		67.0	
$InCl_3 \cdot NH_3$	c		112.0	D − 22.2
$InCl_3 \cdot 2NH_3$	c		192.7	D − 20.3
$InCl_3 \cdot 3NH_3$	c		223.4	D − 19.7
$InCl_3 \cdot 5NH_3$	c		268.9	D − 11.8
$InCl_3 \cdot 7NH_3$	c		308.0	D − 8.6
$InCl_3 \cdot 15NH_3$	c		536.8	D − 7.65
$InBr_3 \cdot 3NH_3$	c		190.4	S $15.5_{HCl(22)}$
$InBr_3 \cdot 5NH_3$	c		240.0	D − 14.3
$InBr_3 \cdot 6NH_3$	c		279.6	D − 8.8
$InBr_3 \cdot 15NH_3$	c		432.5	D − 8.17
$InI_3 \cdot NH_3$	c		87.6	D − 20.1
$InI_3 \cdot 2NH_3$	c		116.2	S $14.0_{HCl(22)}$
$InI_3 \cdot 5NH_3$	c		197.0	S $22.7_{HCl(22)}$
$InI_3 \cdot 7NH_3$	c		241.7	S $46.4_{HCl(22)}$
$InI_3 \cdot 9NH_3$	c		281.1	D − 7.7
InI_3 $15NH_3$	c		356.2	D − 7.4

Thallium

Atomic number 81 Standard state Tl (c) Atomic weight 204.39

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal mole*$^{-1}$
Tl	g	6p ($^2P^1_{1/2}$)	− 40.	
	liq.			F − 1 47
	c	I		T 0 05$^{226}_{\rightarrow II}$
	c	II	0.000	
Tl*	g	6p ($^2P^1_{3/2}$)	− 62 18	E^z − 22.18
	g	7s ($^2S_{1/2}$)	− 115.38	E^z − 75.38
Tl+	g	6s^2 ($^1S_0$)	− 181.70	I^z −110 24
	aq.		− 0 S	
Tl++	g	6s ($^2S_{1/2}$)	− 651.7	I^z −186.7
Tl+++	g	5d^{10} ($^1S_0$)	−1338.	I^z −684 9
	aq.		− 28.	
Tl_2O	c		42.3	S − 3.08
Tl_2O_3	c		120	
TlOH	c		56.95	S − 3.15
	aq.		53.8	
TlF	g			V − 25 1^{298}
TlF	800		77.5	N 16.44$_{800}$
$TlHF_2$	800		152 6	
TlCl	g		16.4	V − 25 2^{806}
	liq.			F − 3.95^{450}
	c		48 62	
	aq.		38.3	S − 10 3
TlCl*	g		− 71.8	E^z − 88 22
$TlCl_3$	c		82.4	S 8.4$_{300}$
	aq.		90.8	
$TlCl_3 \cdot 4H_2O$	c		366.4	S − 2.12$_{300}$
TlBr	g		9.5	V − 25.2^{817}
	liq.			F − 3.6^{456}
	c		41.5	
TlBr*	g		− 73.4	E^z − 82.9
$TlBr_3$	aq.		58.1	
$TlBr_3 \cdot 4H_2O$	c		333 9	S − 2.25$_{300}$
$TlBr_2Cl$	aq.		69.0	
$TlBr_2Cl \cdot 4H_2O$	c		345.5	S − 2.90
TlI	g		0.7	V − 25.3^{824}
	c		31.1	
Tl_2S	c		22.0	
Tl_2SO_4	c		221.8	S − 7.95$^{20}_{3200}$
	3200		213.8	
	800		213.9	
	200		214.25	

Thallium

Formula	State	Description	*Qf, kcal. mole*$^{-1}$	*Q, kcal. mole*$^{-1}$
Tl_2Se	c		18.	
Tl_2Te	c		7.	
TlN_3	c		− 54.7	
$TlNO_3$	c	I		T $0.76^{145}{}_{\rightarrow II}$
	c	II		T $0.24^{75}{}_{\rightarrow III}$
	c	III	58.2	S − 10.0_{200}
	aq		48 2	
$TlCl\ 3NH_3$	c		102.9	D − 7.1
$TlBr\ 3NH_3$	c		95 2	D − 7.1
$TlI{\cdot}3NH_3$	c		84.3	D − 7.1
$Tl_2SO_4{\cdot}10NH_3$	c			D − 13.3
$TlC_2H_3O_2$	aq.	thallous acetate	117.0	
TlC_2H_5O	c	thallous alcoholate	56.8	
	C_2H_5OH		56.3	S − 0.53
TlCNO	c		− 25.7	D − 52.5

Zinc

Atomic number 30 Standard state Zn (c) Atomic weight 65.38

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Zn	g	$4s^2$ ($^1S_0$)	− 27.4	V − 24.8^{911}
	liq.			F − 1.70^{419}
	c		0.000	
Zn*	g	4s4p ($^3P^1_0$)	− 119.38	E^s − 91.98
	g	($^3P^1_1$)	− 119.92	E^s − 92.52
	g	($^3P^1_2$)	− 120.03	E^s − 93.63
	g	4p ($^1P^1_1$)	− 160.83	E^s −133.43
Zn^+	g	4s ($^2S_{1/2}$)	− 244.54	I^s −215.69
Zn^+ *	g	4p ($^2P^1_{1/2}$)	− 382.55	E^s −138.01
	g	($^2P^1_{3/2}$)	− 385.04	E^s −140.50
Zn^{++}	g	$3d^{10}$ ($^1S_0$)	− 658.46	I^s −412.47
	aq.		36.3	
Zn^{+++}	g	$3d^9$ (^2D)	−1570.	I^s −910.
Zn_2	g		− 48.2	D^s − 5.67
ZnO	c	unfused	83.5	
	c	fused	85.2	
ZnH	g	$^2\Sigma$	− 55.4	D^s − 23.05
ZnH*	g	$^2\Pi_{1/2}$	− 121.7	
	g	$^2\Pi_{3/2}$	− 122.6	
	g	$^2\Sigma_1$	− 142.9	D^4 − 28.9
ZnH^+	g	$^2\Sigma$	− 223.1	D^s − 67.5
$Zn(OH)_2$	c	"crystalline"	155.8	
	c	ppt.	153.5	
$ZnO_2{\cdot}2H_2O$	c		253.7	S $14.85_{H_2SO_4(220)}$
$Zn(OH)_2{\cdot}H_2O$	c	ppt.	221.9	
$ZnO{\cdot}\frac{1}{2}H_2O_2$	c		108.6	S $15.5_{H_2SO_4(200)}$
$Zn_2O_5{\cdot}2H_2O$	c		369.7	S $48.1_{H_2SO_4(200)}$
$Zn_2O_5{\cdot}3H_2O$	c		439.7	S $46.5_{H_2SO_4(200)}$
ZnF_2	aq.		192.3	
$ZnCl_2$	c		99.55	S 15.72_{400}
	400		115.27	
	200		114.88	
	100		114.05	
	50		112.55	
	20		10.37	
	10		109 06	
	5		107.20	
	C_2H_5OH		109.4	S $9.8_{230C_2H_5OH}$
$ZnCl_2{\cdot}3ZnO{\cdot}5H_2O$	c		705.4	S $61.5_{HCl(aq.)}$
$ZnCl_2{\cdot}4ZnO{\cdot}11H_2O$	c		1204.3	S $76.6_{HCl(aq.)}$
$ZnCl_2{\cdot}5ZnO{\cdot}8H_2O$	c		1083.8	S $95.6_{HCl(aq.)}$
$ZnCl_2{\cdot}8ZnO{\cdot}10H_2O$	c		1478.7	S $148.5_{HCl(aq.)}$
$ZnBr_2$	c		78.4	S 15.0_{400}
	400		93.4	

Zinc

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$ZnBr_2\ 4ZnO{\cdot}13H_2O$	c		1320.	S $78.0_{HBr(aq.)}$
ZnI	g		− 6.	
ZnI*	g		− 91.7	E^2 − 85.74
ZnI_2	c		49.8	S 11.6^{25}_{650}
	aq.		61.4	
$ZnI_2\ 5ZnO{\cdot}11H_2O$	c		940.2	S $115.6_{HI(aq.)}$
ZnS	c	zinc blend	44.	
	c	ppt.	44.3	
$ZnSO_4$	c		233.4	S 18.54_{400}
	400		251.95	
	200		251.94	
	100		251.92	
	50		251 87	
	20		251.63	
$ZnSO_4\ H_2O$	c		310.3	S 10.0_{400}
$ZnSO_4\ 6H_2O$	c		663.0	S − 0.84_{400}
$ZnSO_4{\cdot}7H_2O$	c		734.8	S − 4.28_{400}
ZnS_2O_4	aq.		198.	
ZnS_2O_6	400		317.0	
$ZnS_2O_6\ 6H_2O$	c		729 5	S − 2.24_{400}
ZnSe	c		34.	
ZnTe	c		33.	
ZnN_6	c		− 50.8	
$Zn(NO_3)_2$	400		134.7	
	200		134.87	
	50		134.86	
	20		134.81	
	15		134.57	
	10		133.66	
	3		132.	
$Zn(NO_3)_2{\cdot}3H_2O$	c		345.	F − 8.3^{44}
$Zn(NO_3)_2\ 6H_2O$	c		550.9	S − 5.85_{400}
$ZnF_2{\cdot}2H_2O{\cdot}\frac{1}{2}NH_3$	c			
$ZnF_2{\cdot}2H_2O\ 3NH_3$	c			D − 11.2
$ZnCl_2{\cdot}NH_3$	c		135.3	D − 25.
$ZnCl_2\ NH_3{\cdot}\frac{1}{2}H_2O$	c		180.8	S $13.75_{HCl(100)}$
$ZnCl_2\ 2NH_3$	c		165.6	D − 19.2
$ZnCl_2{\cdot}4NH_3$	c		211.3	D −118.
$ZnCl_2{\cdot}5NH_3{\cdot}H_2O$	c		294.1	S $46.9_{HCl(aq.)}$
$ZnCl_2{\cdot}6NH_3$	c		255.3	D − 10.7
$ZnCl_2{\cdot}8NH_4Cl\ ZnO$	c		777.5	S $9.5_{HCl(100)}$
$ZnCl_2\ 10NH_3$	c		327.3	D − 7.1
$3ZnCl_2\ 6NH_4Cl{\cdot}H_2O$	c		831.1	S $6.5_{HCl(100)}$
$3ZnCl_2{\cdot}ZnO{\cdot}10NH_4Cl$	c		913.2	S $16.2_{HCl(aq.)}$
$6ZnCl_2\ ZnO{\cdot}12NH_3$	c		1347.4	S $95.6_{HCl(100)}$

Zinc

Formula	State	Description	Qf, kcal mole^{-1}	Q, kcal. mole^{-1}
$ZnBr_2 \cdot NH_3$	c		122.9	D — 24 1
$ZnBr_2$ $2NH_3$	c		153 8	D — 19.2
$ZnBr_2$ $4NH_3$	c		202 8	D — 11.82
$ZnBr_2 \cdot 6NH_3$	c		246.7	D — 11.02
$ZnI_2 \cdot NH_3$	c		82.4	D — 22.
$ZnI_2 \cdot 2NH_3$	c		112.5	D — 19.4
$ZnI_2 \cdot 4NH_3$	c		166 0	D — 15.4
ZnI_2 $6NH_3$	c		209.8	D — 10.9
$ZnSO_4 \cdot \frac{1}{2}NH_3$	c		251.4	D — 25.
$ZnSO_4$ NH_3	c		268.	D — 22.4
$ZnSO_4 \cdot 2NH_3$	c		298.	D — 18.9
$Zn(NH_4)_2(SO_4)_2 \cdot 2H_2O$	c		661.7	
$Zn(NH_4)_2(SO_4)_2 \cdot 6H_2O$	c		954.5	S — 13.2
$ZnSO_4$ $3NH_3$	c		324.	D — 15.5
$ZnSO_4$ $4NH_3$	c		349.	D — 13.8
$ZnSO_4$ $5NH_3$	c		371.	D — 10 8
$ZnCO_3$	c	zinc carbonate	193.3	
$ZnC_2O_4 \cdot 2H_2O$	c	zinc oxalate	373.2	
$Zn(C_2H_5)_2$	liq.	zinc ethyl	10.0	S 78.0
$Zn(CHO_2)_2$	c	zinc formate	231.3	S $4.0^{15}{}_{300}$
	250		235 3	
$Zn(CHO_2)_2$ $2H_2O$	c		374 4	S — $2.4^{13}{}_{600}$
$Zn(C_2H_3O_2)_2$	c	zinc acetate	261.1	S $9.8_{/20}$
	400		270 9	
	200		270.02	
	100		268.95	
	50		267.75	
$Zn(C_2H_3O_2)_2$ H_2O	c		332.3	S $7.0^{23}{}_{800}$
$Zn(C_2H_3O_2)_2$ H_2O	c		403.7	S $4.2^{10}{}_{500}$
$Zn(C_2H_3O_3)_2$	c	zinc glycollate	350 0	S — 0.6
	aq.		349.4	
$Zn(C_2H_3O_3)_2 \cdot 2H_2O$	c		490.2	S — 4.1
$Zn(CN)_2$	c	zinc cyanide	— 16.2	S $3.4^{12}{}_{HCl\,(aq.)}$
$Zn(CN)_4^{--}$	aq.		— 79.4	
$2Zn(CN)_2$ ZnO	c	basic zinc cyanide	39.9	S $25.6^{19}{}_{HCl\,(aq.)}$
$Zn(CHO_2)_2 \cdot 2NH_3$	c	zinc formate ammine	279.	D — 13.
$Zn(CHO_2)_2 \cdot 2\frac{1}{2}NH_3$	c		290.	D — 10.6
$Zn(CHO_2)_2 \cdot 4NH_3$	c		322.	D — 10.5
$Zn(CHO_2)_2 \cdot 6NH_3$	c		360.	D — 8.3
$ZnSiO_3$	c		282.6	S $85.5_{HF\,(4.44)}$
Zn_2SiO_4	gls.		340.4	S $99.5_{HF\,(4.44)}$
	c		349.4	S $90.5_{HF\,(4.44)}$
$2ZnI_2 \cdot PbI_2$	c		141.2	S $23.50^{18}{}_{1000}$

Cadmium

Atomic number 48 Standard state Cd (c, II, hexagonal) Atomic weight 112.41

Formula	State	Description	Qf, *kcal, mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
Cd	g	$5s^2$ ($^1S_0$)	− 26.8	
	liq.			F − 1.50^{321}
	c	I		T $0.055^{37\ 5\to11}$
	c	II, hexagonal	0 000	
Cd*	g	5s5p ($^3P^1_0$)	−112.53	E^z − 85.73
	g	($^3P^1_1$)	−114 07	E^z − 87.26
	g	($^3P^1_2$)	−117.41	E^z − 90 61
	g	($^1P^1_1$)	−151.18	E^z −124.38
Cd^+	g	5s ($^2S_{1/2}$)	−234 75	I^z −206.50
Cd^+ *	g	5p ($^2P^1_{1/2}$)	−360.47	E^z −125 72
	g	($^2P^1_{3/2}$)	−367.47	E^z −132 72
Cd^{++}	g	$4d^{10}$ ($^1S_0$)	−624.44	I^z −388 24
	aq.		17.6	
Cd_2	g		− 6.7	D^z − 46.0
CdO	c		65.2	
CdH	g	$^2\Sigma$	− 62 3	D^z − 15.47
CdH*	g	$^2\Sigma_1$	−113.0	
CdH^+	g	$^2\Sigma$	−232.1	
$Cd(OH)_2$	c	ppt.	133 6	
CdF_2	1200		172.5	
$CdCl_2$	liq.			F $10\ 5^{566}$
	c		93.0	S 3.09_{400}
	400		96.06	
	200		95.89	
	100		95.73	
	50		95.60	
	20		95.01	
	10		93.37	
$CdCl_2 \cdot H_2O$	c		163.81	S 0.63_{400}
$CdCl_2\ 2\frac{1}{2}H_2O$	c		269.98	S − 2.94_{400}
$CdCl_2\ 4H_2O$	c		463.2	
$CdCl_2\ 2HCl\ 7H_2O$	c		655.8	S − 2.3^{11}
$CdCl_2\ CdO\ H_2O$	c		236.2	S $13.4^{15}{}_{HCl(aq)}$
CdBr	g		− 7.	D^z − 60
CdBr*	g		− 96.6	E^z − 89.55
$CdBr_2$	liq.			F − 5.0^{680}
	c		75.8	S 0.44_{400}
	400		76.2	
$CdBr_2 \cdot 4H_2O$	c		357.0	S − 7.29_{400}
$CdBr_2 \cdot CdO\ H_2O$	c		217.7	S $14.3^{16}{}_{HBr(aq)}$
CdI	g		− 20.	D^z − 32.
CdI*	g		−104.1	E^z − 84.07
CdI_2	g		4.0	V − 28.7^{700}

Cadmium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
CdI_2	liq.			F — 4.0^{400}
	c		48.40	S — 0.96_{400}
	$140CH_3OH$			S $4.31^{13}{}_{140CH_3OH}$
	$144C_2H_5OH$			S $6.65^{13}{}_{144C_2H_5OH}$
	400		47.44	
$CdI_2\ CdO\ H_2O$	c		180.7	S $25.8^{13}{}_{HI\,(aq.)}$
CdS	c		34.6	
$CdSO_4$	c		222.22	S 10.68_{400}
	400		232.906	
	200		232.70	
	100		232.553	
	50		232.352	
	30 6		231.828	
	20.6		231.494	
	15.6		231.128	
	13.6		230.194	
$CdSO_4\ H_2O$	c		295.23	S 6.05_{400}
$CdSO_4 \cdot 2\frac{2}{3}H_2O$	c		412.72	S 2.54_{400}
CdS_2O_6	aq.		298 0	
$CdSO_4\ 2\frac{1}{2}H_2SO_4$	c		766.2	S — 4.7
$CdSO_4\ 2HCl$	c		287.	D — 10.
$CdSe$	c		25.	
$CdTe$	c		16.	
CdN_6	c		−106.2	D — 35.1
$Cd(NO_3)_2$	c		77 (?)	
	400		115.67	
$Cd(NO_3)_2 \cdot H_2O$	c		179 87	S 4.18_{400}
$Cd(NO_3)_2 \cdot 4H_2O$	c		394.23	S — $5\ 04_{400}$
$CdCl_2\ NH_3$	c		122.0	D — 18 1
$CdCl_2\ 2NH_3$	c		149.5	D — 16.5
$CdCl_2\ 4NH_3$	c		192.8	D — 10.7
$CdCl_2 \cdot 4NH_4Cl$	c		394.4	S — 13.75^{15}
$CdCl_2\ 6NH_3$	c		235.1	D — 10.2
$CdCl_2 \cdot 10NH_3$	c		308.5	D — 7.4
$CdCl_2 \cdot NH_4Cl \cdot \frac{1}{2}H_2O$	c		206.6	S — 5.36
$CdBr_2 \cdot NH_3$	c		104.8	D — 18.1
$CdBr_2\ 2NH_3$	c		131 9	D — 16.9
$CdBr_2\ 6NH_3$	c		219.3	D — 10.7
$CdBr_2\ 12NH_3$	c		330.6	D — 7.6
$CdBr_2 \cdot NH_4Br \cdot \frac{1}{2}H_2O$	c		177.4	S — 7.2^{16}
$CdI_2 \cdot 2NH_3$	c		98.0	D — 16.6
$CdI_2\ 6NH_3$	c		191.0	D — 11.7
$CdI_2\ NH_4I \cdot \frac{1}{2}H_2O$	c		134.5	S — 7.88^{15}
$CdSO_4\ NH_3$	c		250.8	D — 17.6
$CdSO_4 \cdot 2NH_3$	c		277.7	D — 16.0

Cadmium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$CdSO_4\ 5NH_3$	c		346 9	*D* — 12.1
$CdSO_4\ 6NH_3$	c		369.	*D* — 11.2
CdSb	c		2 7	
Cd_3Sb_2	c		4 0	
$CdCO_3$	c		178.6	
$Cd(CN)_2$	c		— 35 3	*S* $8.3^{20}{}_{H_2SO_4(aq)}$
$Cd(ONC)_2$	c	cadmium fulminate	— 36 3	*D* — 44.5
$Cd(CN)_2\ CdO\ 5H_2O$	c		467 2	*S* $12.6_{H_2SO_4(aq)}$
$2CdI_2\ PbI_2$	c		128.4	*S* $8.30^{15}{}_{1000}$

Mercury

Atomic number 80 Standard state Hg (liq) Atomic weight 200.61

Hg	g	$6s^2$ ($^1S_0$)	— 14 60	*V* — 14 60
	liq.		0 000	
	c			*F* — $0\ 55^{-40}$
Hg*	g	$6s6p$ ($^3P^1_0$)	— 121.77	
	g	($^3P^1_1$)	— 126.80	
	g	($^3P^1_2$)	— 139 99	
	g	($^1P^1_0$)	— 168.52	
Hg^+	g	$5d^{10}6s$ ($^2S_{1/2}$)	— 255.69	I^s —239.64
Hg^+ *	g	$5d^96s^2$ ($^2D_{5/2}$)	— 356.79	E^s —101.10
	g	($^2D_{3/2}$)	— 399 60	E^s —113.91
	g	$5d^{10}6p$ ($^2P^1_{1/2}$)	— 402 26	E^s —146 57
	g	($^2P^1_{3/2}$)	— 428 20	E^s —172 51
Hg^{++}	g	$5d^{10}$ ($^1S_0$)	— 687.81	I^s —430.66
	aq.		— 41.6	
Hg_2	g		— 27.8	
Hg_2^{++}	aq.		— 40.	
HgO	c	red	21.6	
HgO	c	yellow ppt.	20.8	
Hg_2O	c		21.6	
HgH	g		— 57.1	D^s — 8.5
HgH*	g	$^2\Pi_{1/2}$	— 128.1	E^s — 70.97
	g	$^3\Pi_{3/2}$	— 138.6	E^s — 81.46
HgH^+	g	$^1\Sigma$	— 272.3	D^s — 34.4
HgCl	g		— 10.	
HgCl*			— 123.0	E^s —113.0
$HgCl_2$	g		33 3	*V* — 14.6^{382}
	liq.			*F* — 4.1^{277}

Mercury

Formula	State	Description	Qf, kcal mole^{-1}	Q, kcal mole^{-1}
$HgCl_2$	c		53 1	S — 3 32$_{10}$
	aq.		50 1	
$HgCl_4^{--}$	aq		130 9	
Hg_2Cl	c		63 15	
$HgCl_2\ HgO$	c		75 6	
$HgCl_2\ 2HgO$	c		97.1	
$HgCl_2\ 3HgO$	c		119 1	
$HgCl_2\ 4HgO$	c		140 9	
HgBr	g		— 16	.
$HgBr_2$	g		21 6	V — 11 6^{08}
	liq.			F — 4 5^{26}
	c		40 70	S — 2 1
	aq		38 3	
$HgBr_4^{--}$	aq		99 1	
Hg_2Br_2	c		49 2	
$HgBr_2\ HgO$	c		63 0	
$HgBr_2\ 2HgO$	c		84 8	
$HgBr_2\ 3HgO$	c		106 7	
HgI	g		— 21	
HgI_2	g		5 0	V — 15 0^{60}
	liq			F — 1 6^{56}
	c	I, yellow	24 65	T 0 65$^{127\to II}$
	c	II, red	25 3	
HgI_4^{--}	aq		55 4	
Hg_2I_2	c	yellow	28 87	
HgS	c	red	11 0	
	c	black	10 7	
$HgSO_4$	c		166 6	
$HgSO_4\ 4H_2SO_4$	100		1016 2	
Hg_2SO_4	c		176.5	
$(HgO)_3SO_3$	c		218 9	S 43 1$_{6HCl(aq)}$
HgSe	c		8 0	
Hg_2N_6	c		— 100	
$Hg(NO_3)_2$	aq.		56 6	
$Hg(NO_3)_2{\cdot}\frac{1}{2}H_2O$	c		91 5	S — 1 1$_{HNO_3(aq)}$
$Hg_2(NO_3)_2$	aq		58 3	
$Hg_3(NO_3)_2\ HNO_3$	100		106 4	
$Hg_3(NO_3)_2\ 2H_2O$	c		206 5	S 33 5$_{KI(aq)}$
$Hg(NO_3)_2\ 2HgO\ H_2O$	c		244.6	S 3 8$_{HNO_3(aq)}$
$(Hg_2N)_2O$	c	Millon's oxide	— 77.0	S 151 0$_{KCN(aq)}$
	aq		— 73 4	S 3 6
Hg_2NOH	c	Millon's hydroxide	— 2 8	S 74 $_{KCN(aq)}$
$Hg_2NOH\ 1\frac{1}{2}H_2O$	c		104 0	S 70.1$_{KCN(aq)}$
$Hg_2NOH\ 2H_2O$	c	Millon's base	189.0	S 68 9$_{KCN(aq)}$
$Hg_2NOH\ 4H_2O$	c		326 4	S 68.3$_{KCN(aq)}$
$HgF_2\ 2NH_4$	c			

Mercury

Formula	State	Description	Q_f, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
$HgF_2\ 4NH_3$	c			D − 11.5
$HgF_2{\cdot}5NH_3$	c			D − 8.6
$HgCl_2\ 2NH_3$	c		108.5	S $34.5_{HCl\,(aq.)}$
$HgCl_2\ 8NH_3$	c		222.9	D − 8.1
$HgCl_2\ 9\frac{1}{2}NH_3$	c		250.1	D − 7.2
Hg_2NCl	c	Millon's chloride	− 6.	
$Hg_2NCl\ \frac{1}{2}H_2O$	c		31.2	
$Hg_2NCl\ H_2O$	c		68 4	
$Hg_2NCl{\cdot}\frac{1}{2}NH_3$	c		5.6	S $60.7_{KCN\,(aq.)}$
$Hg_2Cl_2\ 2NH_3$	c		113.5	D − 14.3
$Hg_2NCl{\cdot}NH_3$	c		15 8	S $54\ 6_{KCN\,(aq.)}$
$Hg_2NCl{\cdot}NH_4Cl$	c		141.5	S $54.5_{KCN\,(aq.)}$
$Hg_2NCl\ 3NH_4Cl$	c		289.6	S $48\ 8_{KCN\,(aq.)}$
$Hg_2NCl\ \frac{1}{2}HgCl_2$	c		24 0	S $81.1_{KCN\,(aq.)}$
$HgBr_2\ 2NH_3$	c		95 0	S $20\ 4_{KCN\,(140)}$
$HgBr_2\ 2NH_4Br$	aq		161.	
$HgBr_2\ 8NH_3$	c		207 5	D − 7.8
Hg_2NBr	c	Millon's bromide	− 14.9	S $60\ 5_{KCN\,(aq.)}$
$Hg_2NBr\ NH_4Br$	c		57 0	S $50.2_{KCN\,(aq.)}$
$Hg_2NBr\ 3NH_4Br$	c		188.6	S $44.3_{KCN\,(aq.)}$
$Hg_2NBr\ \frac{1}{2}HgBr_2$	c		− 1.8	S $65.6_{KCN\,(aq.)}$
$Hg_2NBr{\cdot}\frac{1}{2}HgBr_2$	c		10.9	
$HgI_2\ \frac{3}{4}NH_3$	c		43.3	
$HgI_2\ 2NH_3$	c		71 8	S $13.8_{KCN\,(aq.)}$
$HgI_2\ 8NH_3$	c		145.8	D − 7.8
$Hg_{100}Bi_1$	liq		− 3.7	
HgC_2O_4	c	mercuric oxalate	160.2	S $7.0^{9}{}_{4HCl\,(100)}$
$Hg(CH_3)_2$	liq		− 37.8	
$Hg(C_2H_5)_2$	liq		− 15 4	
$Hg(C_2H_3O_2)_2$	c	mercuric acetate	198 0	S − 4.0_{140}
	aq.		191.0.	
$HgH_2(C_2H_3O_2)_4$	aq.	mercuric biacetate	431 7	
$Hg_2(C_2H_3O_2)_2$	c	mercurous acetate	203.3	S $36.6_{KI\,(aq.)}$
$Hg(C_2H_3O_2)_2\ HgO$	c		219 0	
$HgCl_2\ CH_3OH$	c		113.7	D − 11.7^{20}
$Hg(CN)_2$	c		− 61.8	S − 3.0
	aq.		− 64 8	
$Hg(CN)_4^{--}$	aq.		124.7	
$HgC_2N_2O_2$	c		− 64.1	D −117.7
$Hg(CN)_2{\cdot}\frac{1}{3}HgO$	c		− 52.0	S $0.1_{HCl\,(aq.)}$
$Hg(CN)_2{\cdot}HgO$	c		− 39.2	S $13.6_{HCl\,(aq.)}$
$Hg(CN)_2\ NH_4CN$	400		− 61.0	
$Hg(CN)_2{\cdot}2NH_4CN$	600		− 59.	
$Hg(CN)_2{\cdot}HgCl$	c		− 8.9	S − 5.4^{14}
$Hg(CN)_2\ NH_4Cl$	500		6.6	
$Hg(CN)_2{\cdot}NH_4Cl{\cdot}\frac{1}{2}H_2O$	c		65.4	S − 7.55^{15}

Mercury

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$Hg(CN)_2 NH_4Br$	500		− 4.0	
$Hg(CN)_2 NH_4Br H_2O$	c		74.8	S − 10.48[16]
$Hg(CN)_2 NH_4I$	500		− 17.6	
$Hg(CN)_2 \cdot NH_4I \cdot \frac{1}{2}H_2O$	c		11 8	S − 12.25
$Hg(SCN)_2$	c		− 52.0	
$Hg_{50}Sn$	liq.		− 2 54	
$Hg_{100}Sn$	liq		− 2.54	
$HgPb_2$	c		− 0 05	
$Hg_{100}Pb$	liq.		− 2 51	
$Hg_{200}Pb$	liq.		− 2.63	
$Hg_{1000}Pb$	liq.		− 2.66	
$Hg_{\infty}Pb$	liq.		− 2.70	
Hg_5Tl_2	c		2 50	
$Hg_{7\ 2}Tl$	liq.		− 2.94	
$Hg_{8\ 1}Tl$	liq.		− 3 44	
$Hg_{9\ 8}Tl$	liq.		− 4.56	
$Hg_{16\ 2}Tl$	liq.		− 5.06	
$Hg_{21\ 6}Tl$	liq.		− 5 48	
$Hg_{31\ 6}Tl$	liq.		− 5 85	
$Hg_{54\ 5}Tl$	liq.		− 6.47	
$Hg_{32}Zn$	liq.		− 2 25	
$Hg_{65}Zn$	liq.		− 2 31	
$HgBr_2 ZnBr_2$	4400		132 6	
$HgBr_2 2ZnBr_2$	4800		228.6	
$2HgBr_2 \cdot ZnBr_2$	8400		170 5	
$Hg(CN)_2 ZnCl_2$	1000		− 14 7	
$Hg(CN)_2 \cdot ZnCl_2 \cdot 7H_2O$	c		477.2	S − 13.4[15]
$ZnBr_2 \cdot Hg(CN)_2$	1000		− 35 6	
$ZnBr_2 Hg(CN)_2 \cdot 8H_2O$	c		532.4	S − 20 8
$Hg_{55}Cd$	liq.		0 50	
$HgCd_3$	c		0.74	
$HgCd$	c		1.96	
Hg_3Cd	c		3.99	
$Hg_{3\ 5}Cd$	c		4.27	
Hg_4Cd	c		3.92	
$Hg_{19}Cd$	c		0.5002	
$HgBr_2 \cdot CdBr_2$	4400		115.9	
$HgBr_2 2CdBr_2$	4800		193 3	
$2HgBr_2 CdBr_2$	8400		153.0	
$Hg(CN)_2 \cdot CdCl_2$	660		31.5	
$Hg(CN)_2 \cdot CdCl_2 2H_2O$	c		177.5	S − 9.3[15]
$Hg(CN)_2 CdBr_2$	660		12.0	
$2Hg(CN)_2 \cdot CdBr_2$	1100		− 52.8	
$Hg(CN)_2 \cdot CdBr_2 3H_2O$	c		229.6	S − 12.5[14]
$2Hg(CN)_2 CdI_2$	1100		− 80.1	
$2Hg(CN)_2 \cdot CdI_2 8H_2O$	c		489 2	S − 22.3[15]

Copper

Atomic number 29 Standard state Cu (c) Atomic weight 63.57

Formula	State	Description	*Qf, kcal mole*$^{-1}$	*Q, kcal. mole*$^{-1}$
Cu	g	$3d^{10}4s$ ($^2S_{1/2}$)	− 81.2	
	liq.			F − 3.2^{1083}
	c		0 000	
Cu*	g	$3d^94s^2$ ($^2D_{3/2}$)	−113.09	E^z − 31.89
	g	($^2D_{5/2}$)	−119 91	E^z − 38.71
	g	$3d^{10}4p$ ($^2P^1_{1/2}$)	−168.13	E^z − 86 93
	g	($^2P^1_{3/2}$)	−168.83	E^z − 87.63
Cu^+	g	$3d^{10}$ ($^1S_0$)	−162.23	I^z −177.38
Cu^+ *	g	$3d^94s$ ($^3D_3$)	−224.65	E^z − 62.42
	g	($^3D_2$)	−227.26	E^z − 65 03
	g	($^3D_1$)	−230.54	E^z − 68.31
	g	($^1D_1$)	−236 96	E^z − 74.73
Cu^{++}	g	$3d^9$ ($^2D_{5/2}$)	−629 51	I^z −465 83
	aq.		− 15.1	
CuO	liq.			F − $13\ 3^{1336}$
	c		38 5	
Cu_2O	liq.			F − 18.4^{1236}
	c		42.5	
CuH	g	$^1\Sigma$	− 62.3	D^z − 69 9
	c		− 5.12	S $8.93_{CuCl_2(aq)}$
CuH*	g	$^1\Sigma$	−128.65	E^z − 66 35
$Cu(OH)_2$	c	blue ppt.	106.70	
	c	green ppt.	106.96	S $14.46_{HNO_3(aq)}$
$3CuO\ H_2O$	c	brown	180.4	S $15.76_{HNO_3(aq)}$
CuF_2	aq.		141.7	
CuCl	c		34 3	S − $6.41^{25}{}_{500}$
	HCl(aq.)		27.9	
$CuCl_2^-$	aq.		67.7	
$CuCl_2$	c		53.4	S 11.12_{600}
	800		61 6	
	400		64.5	
	200		64.0	
	100		63.55	
	50		62.84	
	30		61.96	
	20		61.13	
	10		59.49	
	$200C_2H_5OH$		58.43	
	$100C_2H_5OH$		58.31	
	$50C_2H_5OH$		58.12	
	$40C_2H_5OH$		58.05	
	$30C_2H_5OH$		57.91	
$CuCl_2 \cdot 2H_2O$	c		197.0	S 3.71_{200}
Cu_2Cl_2	g			V − $19\ 2^{1300}$

Copper

Formula	State	Description	Qf, kcal. $mole^{-1}$	Q, kcal. $mole^{-1}$
Cu_2Cl_2	liq.			F — 7.74^{430}
	c	= 2 CuCl (c)	68.6	
$CuClO_4$	aq.		28.2	
$Cu(ClO_3)_2$	400		24.3	
$Cu(ClO_4)_2$	aq.		64.9	
$CuO \cdot CuCl_2$	c		90.	
Cu_2OCl_2	c		121 3	
$CuCl_2 \cdot 3CuO$	c		168.6	S $54.9_{HCl(aq)}$
$CuCl_2 \cdot 3CuO \cdot 4H_2O$	c	atacamite	464.1	S. $33\ 0_{HCl(aq)}$
$HCuCl_2$	aq.		67.7	
CuBr	c		26.7	
$CuBr_2$	c		34 0	S $8\ 25^{20}_{400}$
	aq.		42 2	
$CuBr_2 \cdot 4H_2O$	c		317.2	S — 1.
Cu_2Br_2	g			V — $18\ 8^{1000}$
	c	= 2 CuBr (c)	53.4	
$CuBr_2 \cdot 3Cu(OH)_2$	c		374.2	S $32\ 1_{HBr(aq)}$
CuI	g		— 8.	
	c		17 8	
CuI_2	c		4 8	
	aq.		11.7	
Cu_2I_2	g			V — $18\ 9^{1300}$
	c	= 2 CuI (c)	35.6	
CuS	c		11 6	
Cu_2S	c	I		T $1.05^{250}{\rightarrow}II$
	c	II		T $1\ 31^{91}{\rightarrow}III$
	c	III	18.97	
$CuSO_4$	c		184.7	S 15.90_{800}
	800		200 64	
	200		200.6	
	100		200 52	
	60		200.48	
$CuSO_4 \cdot H_2O$	c		259.7	S 9.33_{800}
$CuSO_4 \cdot 3H_2O$	c		402.1	S 3.61_{800}
$CuSO_4 \cdot 5H_2O$	c		545.34	S — 2.80_{800}
CuS_2O_6	aq.		265.1	
$CuS_2O_6\ 5H_2O$	c		611.9	S — 4.89_{400}
Cu_2SO_4	c		179.6	
	aq.		191.2	
$3CuO \cdot CuSO_4$	c		302.	
$CuSO_4 \cdot 3CuO \cdot 4H_2O$	c		389.8	S $48.0_{H_2SO_4(aq)}$
$CuSO_4 \cdot 2HCl$	c		245.	D — 8.2
CuSe	c		19.	
Cu_2Se	c	I		T $1.12^{110}{\rightarrow}II$
	c	II	14.5	S 112. bromine water

Copper

Formula	State	Description	*Qf, kcal. mole*$^{-1}$	*Q, kcal. mole*$^{-1}$
$CuSeO_4$	400		130.2	
$CuSeO_4 \cdot 5H_2O$	c		474 8	*S* — 2.66
Cu_2Te	c		6.0	
CuN_3	c		— 56 8	
$Cu(NO_3)_2$	c		73.1	S 10.47^{8}_{250}
	200		83.4	
	100		83.45	
	50		83.58	
	20		83.61	
	15		83.42	
	12		83.14	
	10		82.67	
$Cu(NO_3)_2\ 3H_2O$	c		291.1	S — 2.5^{15}
$Cu(NO_3)_2\ 6H_2O$	c		504.3	S — 10.71_{400}
$Cu(NO_3)_2\ 3CuO \cdot 3H_2O$	c		415.5	S $34.0_{HNO_3(aq.)}$
$Cu4NH_3^{++}$	aq.		80.1	
$Cu6NH_3^{++}$	aq.		120.6	
$Cu8NH_3^{++}$	aq.		163 3	
$Cu12NH_3^{++}$	aq.		237 2	
$Cu(NO_3)_2 \cdot 2NH_3$	c		139.5	
$Cu(NO_3)_2 \cdot 4NH_3$	c		196.2	D — 17.4
	aq.		178.8	S — 17.4
$Cu(NO_3)_2 \cdot 6NH_3$	c		255.2	D — 9.8
$CuCl \cdot NH_3$	c		62.2	D — 16.7
$CuCl \cdot 1\frac{1}{2}NH_3$	c		74.0	D — 12.6
$CuCl_2\ 2NH_3$	c		120.0	S $7.7_{HCl(aq)}$
$CuCl_2 \cdot 2NH_3 \cdot \frac{1}{4}H_2O$	c		136.1	S $2.6_{12NH_3(aq.)}$
$CuCl_2\ 2NH_4Cl$	c		201.6	S 4.5^{15}_{550}
$CuCl_2 \cdot 2NH_4Cl\ 2H_2O$	c		349.1	S — 6.2
$CuCl \cdot 3NH_3$	c		104.5	D — 9.5
$CuCl_2 \cdot 3\frac{1}{2}NH_3$	c		153.1	D — 14.1
$CuCl_2\ 4NH_3$	aq.		159.7	
$CuCl_2 \cdot 4NH_3 \cdot 2H_2O$	c		311.0	S — $12.4_{2NH_3(aq.)}$
$CuCl_2\ 5NH_3$	c		191.7	D — 12.2
$CuCl_2\ 5NH_3 \cdot \frac{1}{2}H_2O$	c		224.1	S — 9.3
$CuCl_2 \cdot 5NH_3\ 1\frac{1}{2}H_2O$	c		292.7	S — 9.5
$CuCl_2\ 6NH_3$	c		217.	D — 15.
	aq.		200.7	
$CuCl_2\ 10NH_3$	c		284.7	D — 7.6
$Cu(ClO_3)_2 \cdot 4NH_3$	c			D — 15.6
$Cu(ClO_3)_2 \cdot 6NH_3$	c			D — 9.8
$Cu(ClO_4)_2 \cdot 4NH_3$	c			D — 20.0
$Cu(ClO_4)_2 \cdot 6NH_3$	c			D — 11.6
$CuBr \cdot NH_3$	c		52.3	D — 14.6
$CuBr \cdot 1\frac{1}{2}NH_3$	c		64.3	D — 13.1

Copper

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$CuBr\ 3NH_3$	c		95.0	*D* − 9.4
$CuBr_2{\cdot}2NH_3$	c		98.0	*S* $4.8_{HCl\,(20)}$
$CuBr_2{\cdot}3\frac{1}{2}NH_3$	c		133 4	*D* − 15.6
$CuBr_2{\cdot}5NH_3$	c		173.1	*D* − 12.9
$CuBr_2\ 6NH_3$	c		193.2	*D* − 9.1
$CuBr_2\ 10NH_3$	c		268.2	*D* − 7.8
$CuI\ \frac{1}{2}NH_3$	c		30.6	*D* − 15.5
$CuI\ NH_3$	c		44.0	*D* − 14.7
$CuI{\cdot}2NH_3$	c		66.0	*D* − 11.30
$CuI\ 3NH_3$	c		87.6	*D* − 10 4
$CuI_2\ 2NH_3$	c		67.7	
$CuI_2\ 3\frac{1}{2}NH_3$	c		102.6	*D* − 15.2
$CuI_2\ 5NH_3$	c		142 8	*D* − 13.2
$CuI_2{\cdot}10NH_3$	c		242 8	*D* − 7.0
$Cu(IO_3)_2\ 5NH_3$	c			*D* − 12.7
$CuSO_4\ NH_3$	c		215.0	*S* $22.0_{27\,NH_3\,(aq\,)}$
$CuSO_4{\cdot}2NH_3$	c		215.3	*S* $11\ 0_{56\,NH_3\,(aq\,)}$
$CuSO_4{\cdot}4NH_3$	c		297.1	*S* − $1.87_{24\,NH_3\,(aq\,)}$
	aq.		292.4	
$CuSO_4{\cdot}4NH_3{\cdot}1\frac{1}{2}H_2O$	c		403 9	*S* − $7.1_{2\,NH_3\,(aq\,)}$
$CuSO_4{\cdot}5NH_3$	c		322.9	
$CuSO_4\ 6NH_3$	c		323.6	
	aq.		333.1	
$CuSO_4{\cdot}8NH_3$	aq.		372.7	
$CuSO_4{\cdot}12NH_3$	aq		451.1	
$CuS_2O_6{\cdot}4NH_3$	c			*D* − 19.3
$CuS_2O_6\ 5NH_3$	c			*D* − 10.4
$CuS_4O_6\ 4NH_3$	c			*D* − 13.0
$CuSO_4\ (NH_4)_2SO_4$	c		462.1	*S* 9.85^{14}
$CuSO_4\ (NH_4)_2SO_4\ 2H_2O$	c		597.1	
$CuSO_4{\cdot}(NH_4)_2SO_4\ 6H_2O$	c		892.8	*S* − 10.6
CuP_2	c		1.0	
Cu_3Sb	c		2.5	
$Cu(CHO_2)_2$	c	cupric formate	182.2	*S* $0.52^{15}{}_{603}$
	aq.		182.7	
$Cu(CHO_2)_2\ 4H_2O$	c		464.0	*S* − $7.8^{10}{}_{500}$
$Cu(C_2H_3O_2)_2$	c	cupric acetate	216.4	*S* $2.4^{16}{}_{320}$
	aq.		218.8	
$Cu(C_2H_3O_2)_2\ H_2O$	c		463.2	*S* 0.17_{400}
$Cu(C_2H_3O_3)_2$	c	cupric glycollate	299.3	*S* − 1.62
	aq		297.7	
$CuCO_3\ Cu(OH)_2$	c		192.1	
$CuCl_2\ 2CH_3OH$	c		164.1	*D* − 13.45
$Cu_2Cl_2\ CO\ 2H_2O$	c		227.3	
	aq.		223.9	

Copper

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$Cu(C_2H_5SO_4)_2$	aq.	cupric ethyl-sulfate	428.4	
CuCN	aq.		− 20.9	
CuONC	c	cuprous fulminate	23.2	
$CuC_2O_4\ 5NH_3$	c	cupric oxalate ammine		*D* − 10 8
$Cu(CHO_2)_2\ 4NH_3$	c	cupric formate ammine		*D* − 11 7
$Cu(C_2H_3O_2)_2\ 4NH_3$	c	cupric acetate ammine		*D* − 12 2
$Cu(SCN)_2{\cdot}4NH_3$	c			*D* − 13 7
$Cu(SCN)_2\ 6NH_3$	c			*D* − 8 9
Cu_3Sn	c		8.0	
Cu_2Zn_3	c		16.	
Cu_4Cd_3	c		3.0	
$CuSO_4\ Tl_2SO_4\ 6H_2O$	c			*D* − 11 8

Silver

Atomic number 47 Standard state Ag (c) Atomic weight 107.880

Ag	g	$4d^{10}5s\ (^2S_{1/2})$	− 68 0	
	liq.			*F* − 2.7[961]
	c		0 000	
Ag*	g	$4d^{10}5p\ (^2P^1_{1/2})$	−152.13	*E*[2] − 84.13
	g	$(^2P^1_{3/2})$	−154 71	*E*[2] − 86 74
Ag^+	g	$4d^{10}\ (^1S_0)$	−243 40	*I*[2] −173 96
	aq.		− 25.2	
Ag^+ *	g	$4d^9\ (^2D_{5/2})5s(^3D_3)$	−354.89	*E*[2] −111.49
	g	$(^1D_2)$	−355 01	*E*[2] −111.64
	g	$4d^9\ (^2D_{3/2})5s\ ^3D_1$	−367.86	*E*[2] −124.46
	g	$^1D_2$	−366.78	*E*[2] −123 38
Ag^{++}	g	$4d^9\ (^2D_{5/2})$	−748.	*I*[2] −504.
Ag^{+++}	g	$4d^8$	−1533.	*I*[2] −785.
Ag_2O	c		6.95	
Ag_2O_2	c		5.95	
AgH	g		− 64.	
AgF	c		48.7	*S* 4.3[10]
	amorp.	red	48.7	*S* 4.3[16]
	400		53.0	
$AgF{\cdot}H_2O$	c		120.5	*S* 0.85[10]
$AgF{\cdot}2H_2O$	c		191.25	*S* − 1.5[10]

Silver

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$AgF \cdot 4H_2O$	c		331.45	S — 4.9^{13}
Ag_2F	c		50 3	S 2.75
$AgHF_2$	aq.		130.6	
AgCl	g		— 26.5	V — $44\ 3^{1300}$
	liq.			F — 3.1^{450}
	c		30 30	
AgCl*	g		— 116.4	E^s — 89.89
Ag_2Cl	c	(?)	30.7	
$AgClO_3$	c		1.8	S . — 7.52_{600}
	aq.		— 5.7	
$AgClO_4$	c		12 2	S $2.17^{12}{}_{1000}$
	aq.		11.4	
AgBr	g		— 27 2	V — 40.8^{1100}
	liq.			F — 2.4^{434}
	c	ppt.	23.81	
AgI	g		— 33 5	V — 38.6^{1000}
	c	I, cubic		T $1.27^{247}{}_{\rightarrow II}$
	c	II, hexagonal	14.94	
$AgI_3{}^{---}$	aq.		43 9	
$3AgI \cdot HI \cdot 7H_2O$	c		539 0	S — 2.1
Ag_2S	c	I		T $0\ 95^{175}{}_{\rightarrow II}$
	c	II	5 5	
Ag_2SO_4	c		170 1	
	aq.		165.6	
$Ag(S_2O_3)_2{}^{---}$	aq.		284	
$Ag_2S_2O_6$	aq.		230 0	
$Ag_2S_2O_6 \cdot 2H_2O$	c		377.1	S — $10\ 36_{4.0}$
$Ag_2SO_4 \cdot 2HCl$	c		244.	D — $15.^{300}$
Ag_2Se	c	I		T $1\ 66^{133}{}_{\rightarrow II}$
	c	II	1.	
Ag_2SeO_4	c		95 9	S 89.1 bromine water
AgN_3	c		— 67.3	
$AgNO_2$	c		11.6	S — 8.8
	aq.		2 8	
$AgNO_3$	liq.			F — 2.76^{212}
	c	I		T $0.57^{159}{}_{\rightarrow II}$
	c	II	29.4	S — 5.46
	200		23.96	
$Ag_2N_2O_2$	c		— 29.1	
$Ag(NH_3)_2{}^+$	aq.		24.6	
$Ag_2O \cdot HNO_3 \cdot 2H_2O$	liq.		19.9	
$AgNO_2 \cdot 3NH_3$	c			D — 18.7
$AgNO_3 \cdot NH_3$	c		59.9	
$AgNO_3 \cdot 2NH_3$	c		84.8	S — $9\ 05^{16}{}_{1000}$
	aq.		75.7	
$AgNO_3 \cdot 3NH_3$	c		105.5	S — $10.44^{12}{}_{1000}$

Silver

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$AgNO_3\,3NH_3$	aq.		95.1	
$Ag(NH_3)_2OH$	aq.		198.2	
$AgCl\,NH_3$	c		53 6	*D* — 11.2
$AgCl\,1\frac{1}{2}NH_3$	c		64 8	*D* — 10.6
$AgCl_3{\cdot}NH_3$	c		96.9	*D* — 9.3
$AgClO_4\,2NH_3$	c		76.8	*S* — 10.71
	aq		66.1	
$AgClO_4\,3NH_3$	c		96.9	*S* — 11.18
	aq.		85.7	
$AgBr\,NH_3$	c		45.5	*D* — 10.6
$AgBr\,1\frac{1}{2}NH_3$	c		55.9	*D* — 9.95
$AgBr\,3NH_3$	c		85.3	*D* — 8.6
$AgBrO_3\,3NH_3$	c			*D* — 8.45
$AgI{\cdot}\frac{1}{2}NH_3$	c		26.2	*D* — 11.6
$AgI{\cdot}NH_3$	c		36.0	*D* — 8 6
$AgI{\cdot}1\frac{1}{2}NH_3$	c		45.1	*D* — 6.9
$AgI{\cdot}2NH_3$	c		54.1	*D* — 6.8
$AgI\,3NH_3$	c		71.9	*D* — 6.7
AgP_2	c		— 2.6	
Ag_2C_2	c		— 83.6	
Ag_2CO_3	c		119 9	
$Ag_2C_2O_4$	c	silver oxalate	159.6	
$AgC_2H_3O_2$	c	silver acetate	96.8	*S* — 4.40
	aq.		92.4	
$Ag_2C_2{\cdot}AgCl$	c		— 50 0	*S* $11.8_{HCl(aq.)}$
$2Ag_2C_2{\cdot}AgCl$	c		— 130.2	*S* $23.3_{HCl(aq.)}$
$Ag_2C_2{\cdot}AgI$	c		— 67.3	*S* $12.65_{HCl(aq.)}$
$Ag_2C_2\,2AgI$	c		— 51.1	*S* $13.85_{HCl(aq.)}$
$2Ag_2C_2{\cdot}Ag_2SO_4$	c		14.0	*S* $39\,3_{HCl(aq.)}$
$AgCN$	c	silver cyanide	— 33.4	
$Ag(CN)_2^-$	aq.		— 61.75	
$Ag(CN)_3^{--}$	aq.		— 98.0	
$Ag_2C_2{\cdot}AgNO_3$	c		— 49.5	*S* $24.4_{HCl(aq.)}$
$AgCN{\cdot}NH_3$	c	silver cyanide ammine	8.0	*D* — 14 0
Ag_2CN_2	c	silver cyanamide	— 50 0	*S* $19.25_{HCl(aq.)}$
$AgCNO$	c	silver cyanate	23.6	
$AgONC$	c	silver fulminate	— 42 8	
$AgCl\,CH_3NH_2$	c		50.	*D* — 12.2
$AgBr\,CH_3NH_2$	c		43.5	*D* — 13.6
$AgI{\cdot}CH_3NH_2$	c		36.2	*D* — 14.0
$AgSCN$	c		— 21.8	*S* — 21.3
	aq.		— 43.1	
$AgI{\cdot}PbI_2$	c			*T* — 2.6
Ag_2Hg_4	c		0.7	
$AgI{\cdot}CuI$	c	(?)		*T* — 2.9
$AgI{\cdot}2CuI$	c	(?)		*T* — 8.7

Gold

Atomic number 79 Standard state Au (c) Atomic weight 197.2

Formula	State	Description	*Qf*, *kcal, mole*$^{-1}$	*Q, kcal. mole*$^{-1}$
Au	g	$5d^{10}6s$ ($^2S_{1/2}$)	− 92.	
	liq.			*F* − 3.12^{1063}
	c		0 000	
Au*	g	$5d^96s^2$ ($^2D_{5/2}$)	−118.08	E^2 − 26 08
	g	($^2D_{3/2}$)	−153 01	E^2 − 61.02
	g	$5d^{10}6p$ ($^2P^1_{1/2}$)	−198 35	E^2 −106.36
	g	($^2P^1_{3/2}$)	−209 22	E^2 −117 22
Au^+	g	$5d^{10}$ ($^1S_0$)	−305.42	I^2 −211 97
Au_2O_3	c		− 11.	
AuH	g		− 44 3	
$Au(OH)_3$	c	ppt	100 6	*S* $36.9_{4HBr(aq.)}$
AuCl	c		8 3	*S* $4\ 5_{HCl(aq.)}$
$AuCl_2$	c		18 1	*S* $6\ 7_{HCl(aq.)}$
$AuCl_3$	c		28.3	
	aq.		32.75	*S* $4\ 45_{400}$
$AuCl_4^-$	aq.		76.7	
$AuCl_3{\cdot}2H_2O$	c		171 2	*S* − 1.69_{600}
$HAuCl_4$	aq.		76 7	
$HAuCl_4\ 3H_2O$	c		285 1	*S* − 3 55
$HAuCl_4\ 4H_2O$	c		356.0	*S* − 5.83_{400}
AuBr	c		3.4	
$AuBr_2$	c	(?)	5 6	*S* $6\ 7_{HBr(aq.)}$
$AuBr_3$	c		14.5	*S* − 3.76_{200}
	aq.		10 8	
$AuBr_4^-$	aq.		47.1	
$HAuBr_4$	aq		47.1	
$HAuBr_4\ 5H_2O$	c		400.3	*S* − 11.40_{1000}
AuI	c		− 0 2	
$AuCl\ NH_3$	c		43 8	*S* $29.2_{KCN(aq.)}$
$AuCl\ 2NH_3$	c		68 9	*S* $23.3_{KCN(aq.)}$
$AuCl\ 6NH_3$	c		141.5	*D* − 7.2
$AuBr\ NH_3$	c		36 1	*S* $25.9_{KCN(aq.)}$
$AuBr\ 2NH_3$	c		60 1	*D* − 12 2
$AuBr\ 3NH_3$	c		79 3	*D* − 8 3
$AuBr\ 4NH_3$	c		98.4	*D* − 8.1
$AuBr\ 6NH_3$	c		136 2	*D* − 7.95
$AuI{\cdot}NH_3$	c		26.4	*S* $20\ 1_{KCN(aq.)}$
$AuI{\cdot}2NH_3$	c		46.4	*D* − 9.1
$AuI{\cdot}3NH_3$	c		66.3	*D* − 8.9
$AuI\ 6NH_3$	c		123.1	*D* − 8.0
$AuI\ 8NH_3$	c		157.6	*D* − 6.3
$Au(CN)_2^-$	aq.		− 57.5	
$AuHg_{100}$	liq.		− 2.0	
$AuAgCl_2$	c		38 5	
$AuAgCl_4$	c		57.1	*D* − 18.2

Platinum

Atomic number 78 Standard state Pt (c) Atomic weight 195.23

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
Pt	g	$5d^9$ $(^2D_{3/2})6s(^3D_3)$	−127.	
	liq.			F − 5 3^{1755}
	c		0.000	
Pt*	g	$5d^9$ $(^2D_{5/2})6s(^3D_2)$	−129.21	E^z − 2.21
	g	$5d^86s^2$ (J = 4)	−129.35	E^z − 2 35
	g	$5d^{10}$ $(^1S_0)$	−144 48	E^z − 17.48
Pt^+	g		−334 2	I^z −205.8
$Pt(OH)_2$	c		87 5	
PtCl	c		17.	D − 34.
$PtCl_2$	c		34.	D − 34.
$PtCl_3$	c		50	D − 32.
$PtCl_4$	c		62.6	D − 25 2
	aq		82.0	
$PtCl_4\ 5H_2O$	c		425.7	S − 1.84$_{400}$
$PtCl_4^{--}$	aq.		122.0	
$PtCl_6^{--}$	aq		165 6	
H_2PtCl_4	aq.		122 0	
H_2PtCl_6	aq		165.6	
$HPtCl_5{\cdot}2H_2O$	c		248 5	S 14 34$_{HCl(aq.)}$
$H_2PtCl_6{\cdot}6H_2O$	c		571.5	S 4 31$_{500}$
$PtBr_4$	c		40.6	S 9 8$_{1000}$
	aq		50 4	
$PtBr_4^{--}$	aq		90.2	
$PtBr_6^{--}$	aq.		115 9	
H_2PtBr_6	aq		115.9	
$H_2PtBr_6\ 9H_2O$	c		733 8	S − 2 86
PtI_4	c		18.	S 7 3$_{2NaI(aq.)}$
PtI_6^{--}	aq.		52.4	
PtS	c		16.	
PtS_2	c		21.	
$Pt(NH_3)_4(OH)_2$	aq.		209.1	
$PtCl_2\ 2NH_3$	c		119.6	D − 31.3
$(NH_4)_2PtCl_4$	c		193 3	S − 8.42
	aq.		184 9	
$Pt(NH_3)_4Cl_2$	c		183.	
	aq.		178 9	
$Pt(NH_3)_4Cl_2\ H_2O$	c		256 0	S − 8.76
$PtCl_2{\cdot}5NH_3$	c		204.3	
$PtI_2{\cdot}2NH_3$	c		x	
$PtI_2{\cdot}4NH_3$	c		x+54.1	D − 16.1
$PtI_2{\cdot}6NH_3$	c		x+94.6	D − 9.3
$PtCl_2(NH_3)_4SO_4$	aq.		311 4	
$AgPtCl_6$	c		129.9	
$AgPtBr_6$	c		97.3	

Iridium

Atomic number 77 Standard state Ir (c) Atomic weight 193 1

Formula	State	Description	Qf, kcal $mole^{-1}$	Q, kcal $mole^{-1}$
Ir	g	$5d^9$ ($^2D_{5/2}$)	−120.	
Ir	c		0.000	
Ir*		$5d^9$ ($^2D_{3/2}$)	−128.07	E^2 − 8.07
IrO_2	c		50	
H_2IrI_6				D −67.4
IrF_6	g		121 5	
	liq.		130.	
IrCl	c		20.5	
$IrCl_2$	c		40.6	
$IrCl_3$	c		60 5	
$IrCl_6^{--}$	aq.		152.5	
$IrCl_6^{---}$	aq.		186 8	

Osmium

Atomic number 76 Standard state Os (c) Atomic weight 191.5

Os	g		−125.	
	c		0 000	
OsO_4	g		80.1	
	liq.			F − 3.41[40]
	c		93 6	

Rhenium

Atomic number 75 Standard state Re (c) Atomic weight 186.31

Re	c		0 000
ReO_3	c		83.
Re_2O_7	c		297 5
ReO_4^-	∞		224 2
$HReO_4$	∞		224.2
	25600		223.6
	12800		223.3
	6400		223 0
	4700		222.7

Palladium

Atomic number 46 Standard state Pd (c) Atomic weight 106 7

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal mole*$^{-1}$
Pd	g	$4d^{10}$ ($^1S_0$)	−110.	
	liq			F − 3 65^{1549}
	c		0.000	
Pd*	g	$4d^9$ ($^2D_{5/2}$)5s($^3D_3$)	−128 69	E^2 − 18.69
	g	($^3D_2$)	−132 08	E^2 − 22 08
	g	$4d^9$ ($^2D_{3/2}$)5s($^3D_1$)	−138 73	E^2 − 28.73
	g	($^1D_2$)	−143.37	E^2 − 33 37
Pd+	g	$4d^9$ ($^2D_{5/2}$)	−302 3	I^1 −191.83
Pd+ *	g	($^2D_{3/2}$)	−312.3	E^2 − 10.00
Pd++	g	$4d^8$ ($^3F_4$)	−761.	I^2 −457.
PdO	c		21.4	
Pd_2H	c		8 86	
$Pd(OH)_2$	c		90 7	
$Pd(OH)_4$	c		155 0	
$PdCl_2$	c		44 2	
$PdCl_4$--	aq		127.5	
$PdCl_6$--	aq		156.5	
H_2PdCl_4	aq		127.5	
H_2PdCl_6	aq.		156 5	
$PdBr_2$	c		24.9	
$PdBr_4$	aq		85.5	
PdI_2	c		15 1	
PdI_2 H_2O	c		86 5	
$PdCl_2$ $2NH_3$	c		106.1	
$PdCl_2$ $4NH_3$	c		159 1	
PdI_2 $2NH_3$	c		71.0	
PdI_2 $4NH_3$	c		118 7	
$Pd(CN)_2$	c		− 51 7	

Rhodium

Atomic number 45 Standard state Rh (c) Atomic weight 102 91

Rh	g	$4d^8$ (^3F)5s($^4F_{9/2}$)	−115.	
	c		0 000	
Rh*	g	$4d^8$ (^3F)5s($^4F_{7/2}$)	−119 36	E^1 − 4.36
	g	($^3F_{5/2}$)	−122.40	E^2 − 7 40
	g	($^4F_{3/2}$)	−124.89	E^2 − 9 89
Rh+	g	$4d^8$ (^3F)	−194.	I^1 −178.
RhO	c		25.	D − 58.
Rh_2O	c		21.	D − 41.
Rh_2O_3	c		78.	D - 56.
RhCl	c		16.	D − 32.
$RhCl_2$	c		40.	D − 36.
$RhCl_3$	c		60.	D − 40.
$RhCl_6$---	aq.		205.5	

Ruthenium

Atomic number 44 Standard State Ru (c) Atomic weight 101.7

Formula	State	Description	Qf, kcal, mole^{-1}	Q, kcal. mole^{-1}
Ru	g	$4d^7(^4F)5s$ ($^5F_5$)	−120	
	c		0 000	
Ru*	g	($^5F_4$)	−123.39	E^z − 3.39
	g	($^5F_3$)	−125 95	E^z − 5.95
	g	($^5F_2$)	−127.72	E^z − 7.72
	g	($^5F_1$)	−128.84	E^z − 8.84
Ru^+	g		−294.	I^z −173.
RuO_2	c		52 5	
$RuCl_3$	c		63.	

Masurium

Atomic number 43 Standard state Ma (c) Atomic weight (98?)

Nickel

Atomic number 28 Standard state Ni (c, III) Atomic weight 58.69

Ni	g	$3d^8s^2$ ($^3F_4$)	− 85 0	
	liq.			F − 4.3^{1452}
	c	I (?)		T $0\ 0^{1130}{}_{\rightarrow II}$
	c	II		T $0.12^{360}{}_{\rightarrow III}$
	c	III	0.000	
Ni*	g	$3d^94s$ ($^3D_3$)	− 85.58	E^z − 0.583
	g	($^3D_2$)	− 87.51	E^z − 2.505
	g	$3d^84s^2$ ($^3F_3$)	− 88.79	E^z − 3.792
	g	$3d^94s$ ($^3D_1$)	− 89.88	E^z − 4.878
	g	$3d^84s^2$ ($^3F_2$)	− 91.31	E^z − 6.310
	g	$3d^94s$ ($^1D_2$)	− 94.71	E^z − 9.707
	g	$3d^{10}$ ($^1S_0$)	−126 93	E^z − 41.93
Ni^+	g	$3d^9$ ($^2D_{5/2}$)	−261.7	I^z −175.30
Ni^+ *	g	($^2D_{3/2}$)	−266 0	E^z − 4.290
	g	$3d^84s$ ($^4F_{9/2}$)	−285.6	E^z − 23.89
	g	($^4F_{7/2}$)	−288.3	E^z − 26.56
	g	($^4F_{5/2}$)	−290.5	E^z − 28.80
	g	($^4F_{3/2}$)	−292.1	E^z − 30.56
Ni^{++}	g	$3d^8$ (^3F)	−681.6	I^z −418.
	aq.		15.2	
NiO	c		58.4	
$Ni(OH)_2$	c	ppt.	129.8	

Nickel

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$Ni(OH)_2$	c	ppt.	163.2	
NiF_2	c		157.5	
	aq.		171.4	
$NiCl_2$	c		75 0	*S* 19.17_{400}
	800		94.23	
	400		94.17	
	200		94 06	
	100		93.86	
	50		93.55	
	20		92.48	
$NiCl_2 \cdot 2H_2O$	c		220.6	*S* 10.3_{400}
$NiCl_2 \cdot 4H_2O$	c		363.5	*D* − 13.5
$NiCl_2 \cdot 6H_2O$	c		505.6	*S* -1.16_{400}
$NiBr_2$	c		53.4	*S* 18.9
	aq.		72.4	
$NiBr_2 \cdot 3H_2O$	c		277.3	*S* 0.2
NiI_2	c		22.4	*S* 19 4
	aq.		41.8	
NiS	c		20.4	
$NiSO_4$	c		216.	
	200		231.1	
$NiSO_4 \cdot 7H_2O$	c		713 9	*S* -4.25_{400}
NiS_2O_6	aq.		295.5	
$NiS_2O_6 \cdot 6H_2O$	c		708.1	*S* − 2.42
NiSe	c		14.	*S* $101.2_{\text{bromine water}}$
NiTe	c		11.	
$NiN_6 \cdot H_2O$	c		− 31.7	
$Ni(NO_3)_2$	c		101 5	*S* 11.8_{280}
	200		113.3	
	6		110.2	
$Ni(NO_3)_2\ 6H_2O$	c		531.0	*S* -7.47_{400}
$Ni(NO_2)_2 \cdot 5NH_3$	c			*D* − 13.8
$Ni(NO_3)_2 \cdot 6NH_3$	c			*D* − 17.0
$NiF_2 \cdot H_2O \cdot \frac{1}{2}NH_3$	c			
$NiF_2 \cdot H_2O \cdot NH_3$	c			*D* − 12.8
$NiF_2 \cdot H_2O \cdot 5NH_3$	c			*D* − 11.5
$NiCl_2 \cdot NH_3$	c		107.8	*S* $17.8_{HCl(aq.)}$
$NiCl_2 \cdot 2NH_3$	c		137.7	*S* $19.5_{HCl(aq)}$
$NiCl_2\ 6NH_3$	c		239.1	*S* $44.3_{HCl(aq)}$
$Ni(ClO_3)_2 \cdot 6NH_3$	c			*D* − 17.5
$Ni(ClO_4)_2 \cdot 6NH_3$	c			*D* − 19.1
$NiBr_2 \cdot NH_3$	c		85.2	*D* − 20.8
$NiBr_2 \cdot 2NH_3$	c		116.6	*D* − 20.4
$NiBr_2 \cdot 6NH_3$	c		221.7	*D* − 15.4
$NiI_2 \cdot 2NH_3$	c		83.7	*D* − 19.7

Nickel

Formula	State	Description	Qf, *kcal mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
$NiI_2 \cdot 6NH_3$	c		191 2	D − 15.9
$Ni(IO_3)_2 \cdot 5NH_3$	c			D − 12.7
$NiSO_4 \cdot \frac{1}{2}NH_3$	c		234	D − 25.
$NiSO_4 \cdot 2NH_3$	c		278 6	D − 18 8
$NiSO_4 \cdot 4NH_3$	c		333 4	D − 16 4
$NiS_2O_6 \cdot 5NH_3$	c			D − 15 0
$NiSO_4 \cdot 6NH_3$	c		384.7	D − 14.7
$NiSO_3O_6 \cdot 6NH_3$	c			D − 16.8
$NiSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$	c	-dihydrate		D − 15.4
$NiS_4O_6 \cdot 6NH_3$	c			D − 14 7
$Ni(H_2PO_2)_2 \cdot 6NH_3$	c			D − 13 3
NiC_3	c		− 9.2	
$Ni(CO)_4$	liq.			V − 6.92[40]
$Ni(C_2H_3O_2)_2$	aq.	nickel acetate	251.1	
$NiBr_2 \cdot 3CH_3OH$	c		237 3	D − 12.7
$Ni(CN)_2$	c	ppt.	−232.	
$Ni(CN)_4^{--}$	aq.		− 80 4	
$Ni(CHO_2)_2 \cdot 4NH_3$	c	nickel formate ammine		D − 15 1
$Ni(C_2H_3O_2)_2 \cdot 4NH_3$	c	nickel acetate ammine		D − 12.7
$Ni(CNS)_2 \cdot 6NH_3$	c			D − 10.8
$2NiI_2 \cdot PbI_2$	c		85 2	S 40.2
$2NiI_2 \cdot PbI_2 \cdot 3H_2O$	c		341.7	S − 11.1
$NiBr_2 \cdot HgBr_2$	aq.		112 4	
$NiBr_2 \cdot 2HgBr_2$	aq.		150.0	

Cobalt

Atomic number 27 Standard state Co (c, III) Atomic weight 58.94

Formula	State	Description	*Qf*, *kcal mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
Co	g	$3d^74s^2$ ($^4F_{9/2}$)	− 85.	*V* − $74.^{2375}$
	liq.			*F* − $3\ 95^{1480}$
	c	I		*T* $0.12^{1150}{}_{\rightarrow II}$
	c	II		*T* $0.06^{460}{}_{\rightarrow III}$
	c	III	0 000	
Co*	g	$3d^74s^2$ ($^4F_{7/2}$)	− 87 32	E^z − 2.32
	g	($^4F_{5/2}$)	− 89 00	E^z − 4 00
	g	($^4F_{3/2}$)	− 90 15	$E^{z'}$ − 5 15
	g	$3d^84s$ ($^4F_{9/2}$)	− 94.91	E^z − 9 91
	g	($^4F_{7/2}$)	− 97 36	E^z − 12 36
	g	($^4F_{5/2}$)	− 98 35	E^z − 13.35
	g	($^4F_{3/2}$)	− 99 45	E^z − 14 45
Co^+	g	$3d^8$ ($^3F_4$)	−266 0	I^z −179 6
	g	($^3F_3$)	−268.7	E^z − 2.71
	g	($^3F_2$)	−270 5	E^z − 4 55
Co^{++}	g	$3d^7$ (^4F)	−866 0	I^z −399.
	aq.		16 5	
CoO	c		57 5	
Co_3O_4	c		196.5	
$Co(OH)_2$	c		131 5	
$Co(OH)_3$	c		177 0	
CoF_2	liq.			*Qf* $161.^{700}$
	aq.		172.8	
$CoCl_2$	c		76 9	*S* 18.41_{400}
	400		95.40	
$CoCl_2\ 2H_2O$	c		222 3	*S* $9\ 85^{23}{}_{400}$
$CoCl_2\ 6H_2O$	c		508 5	*S* − 2.85_{400}
$CoBr_2$	c		55 0	*S* 18.4
	aq.		73.43	
$CoBr_2\ 6H_2O$	c		484 9	*S* − 1.28
CoI_2	c		21 2	*S* 18.8
	aq.		42.97	
CoS	c	ppt.	22 3	
Co_2S_3	c		40 0	
$CoSO_4$	c		216.7	
	400		231.7	
	200		231 6	
$CoSO_4\ 6H_2O$	c		643 3	
$CoSO_4{\cdot}7H_2O$	c		713.9	*S* − $3\ 57_{800}$
CoSe	c		12.	*S* $74.0_{\text{bromine water}}$
CoTe	c		11.	*S* $115.9_{\text{bromine water}}$
$Co(NO_3)_2$	c		102.8	*S* $11\ 88_{300}$
	aq.		114.7	

Cobalt

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$Co(NO_3)_2\ 6H_2O$	c		529.8	S — 4.96_{400}
	liq.			F — 8.7^{56}
$[Co(NH_3)_5H_2O]^{+++}$	aq.		178.5	
$[Co(NH_3)_5NO_3]^{++}$	aq.		158.7	
$[Co(NH_3)_5NO_3](NO_3)_2$	aq.		256 9	
	c		271.8	S — 14.90^{75}
$[Co(NH_3)_5H_2O](NO_3)_3$	c		341.1	S — 15.38^{25}
	aq.		325.7	
$CoF_2\ H_2O\cdot\frac{1}{2}NH_3$	c			
$CoF_2\cdot H_2O\ NH_3$	c			D — 12.5
$CoF_2\cdot H_2O\cdot 5NH_3$	c			D — 10.5
$CoCl_2\cdot NH_3$	c		109.2	S $17.5_{HCl(aq)}$
$CoCl_2\ 2NH_3$	c	rose	138.8	S 19.6
$[Co(NH_3)_5Cl]^{++}$	aq.		146 5	
$[Co(NH_3)_5Cl]Cl_2$	c		237.9	S — $12\ 42^{25}$
	aq.		225.4	
$CoCl_2\ 6NH_3$	c		239 0	S 46.3
$Co(NH_3)_6Cl_3$	c	product unknown		D — 18.9
$[Co(NH_3)_5H_2O]Cl_3$	c		302.4	S — 6.46
	aq		295.9	
$CoBr_2\ NH_3$	c		87.6	D — $21.^{185}$
$CoBr_2\ 2NH_3$	c		120 2	D — 21.7^{165}
$CoBr_2\ 2NH_4Br$	aq.		193 9	
$[Co(NH_3)_5Br]^{++}$	aq.		137.2	
$[Co(NH_3)_5Br]Br_2$	c		207.1	S — 12.66
	aq.		194.4	
$CoBr_2\ 6NH_3$	c		230.	D — $14\ 0^{136}$
$[Co(NH_3)_5H_2O]Br_3$	c		273.7	S — 9.25^{25}
	aq.		264.5	
$CoI_2\cdot 2NH_3$	c		85 9	D — 19.9^{147}
$CoI_2\ 6NH_3$	c		188.6	D — 14.7
$CoSO_4\ \frac{1}{2}NH_3$	c		234.1	D — 24.
$CoSO_4\ 2NH_3$	c		279.7	D — 19.4
$CoSO_4\ (NH_4)_2SO_4\ 6H_2O$	c	-dihydrate		D — 14.8
$CoSO_4\ 3NH_3$	c		307 5	D — 16.8
$CoSO_4\ 4NH_3$	c		333.2	D — 14.78
$CoSO_4\ 6NH_3$	c		383.1	D — 13.98
Co_3C	c		11.3	
$CoCO_3$	c	ppt.	172 8	
$Co(C_2H_5SO_4)_2$	aq.		432.3	
$2CoI_2\cdot PbI_2$	c		84.3	S 41.5
$2CoI_2\ PbI_2\ 3H_2O$	c		341.6	S — 10.6
$CoBr_2\cdot HgBr_2$	4400		113.5	
$CoBr_2\ 2HgBr_2$	8400		151.	
$2CoBr_2\ HgBr_2$	4800		189.1	

Iron

Atomic number 26 Standard State Fe (c, IV, α) Atomic weight 55.84

Formula	State	Description		Qf, *kcal mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
Fe	g	$3d^64s^2$	($^5D_4$)	− 94.	V − 76.^{1600}
	liq.				F − 3.86^{1535}
	c	I, δ			T 0.11$^{1405}{}_{\rightarrow II}$
	c	II, γ			T 0.21$^{906}{}_{\rightarrow III}$
	c	III, β			T 0 37$^{325-785}{}_{\rightarrow IV}$
	c	IV, α		0 000	
Fe*	g	$3d^64s^2$	($^5D_3$)	− 95.18	E^z − 1.18
	g		($^5D_2$)	− 96.00	E^z − 2.00
	g		($^5D_1$)	− 96.53	E^z − 2.53
	g		($^5D_0$)	− 96 78	E^z − 2.78
	g	$3d^7(^4F)4s$	($^5F_5$)	−113.72	E^z − 19.72
	g		($^5F_4$)	−115 00	E^z − 21.00
	g		($^5F_3$)	−116 00	E^z − 22 00
	g		($^5F_2$)	−116.73	E^z − 22.73
	g		($^5F_1$)	−117.21	E^z − 23 21
	g		($^3F_4$)	−128 09	E^z − 34.09
	g		($^3F_3$)	−129 76	E^z − 35.76
	g		($^3F_2$)	−130 92	E^z − 36 92
Fe+	g	$3d^64s$	($^6D_{9/2}$)	−276 0	I^z −180.6
Fe+ *	g		($^6D_{7/2}$)	−277.1	E^z − 1.12
	g		($^6D_{5/2}$)	−277.9	E^z − 1 90
	g		($^6D_{3/2}$)	−278 5	E^z − 2 46
	g		($^6D_{1/2}$)	−278 8	E^z − 2.78
	g	$3d^7$	($^4F_{9/2}$)	−281.4	E^z − 5.35
	g		($^4F_{7/2}$)	−282 9	E^z − 6 92
	g		($^4F_{5/2}$)	−284 1	E^z − 8.08
	g		($^4F_{3/2}$)	−284 9	E^z − 8.87
	g	$3d^6(^5D)4s$	($^4D_{7/2}$)	−298.6	E^z − 22.65
	g		($^4D_{5/2}$)	−299.9	E^z − 23.89
	g		($^4D_{3/2}$)	−300.7	E^z − 24.71
	g		($^4D_{1/2}$)	−301.2	E^z − 25.18
Fe++	g	$3d^6$	(^5D)	−658.0	I^z −308.5
	aq.			20.6	
Fe+++	aq.			9.3	
FeO	c	I		64.3	
	c	II			T − 0.10$^{-90}{}_{\rightarrow I}$
Fe_2O_3	c			198.5	
Fe_3O_4	c	I			T 0.10$^{740}{}_{\rightarrow II}$
	c	II			T 0.58$^{485}{}_{\rightarrow III}$
	c	III		266.9	
	c	IV			T − 0.18$^{-160}{}_{\rightarrow III}$
$Fe(OH)_2$	c	ppt.		135.9	
$Fe(OH)_3$	c	ppt.		197.3	
FeF_2	1200			177.0	

Iron

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
FeF_2	liq.			Qf $158.^{800}$
FeF_3	liq.			Qf $233.^{700}$
	1200		243.3	
	150		242 5	
$FeCl_2$	g		40.	V $-$ 32.1^{800}
	c		81.9	S 17.90_{400}
	400	(solution acid)	99 76	
$FeCl_2 2H_2O$	c		227 8	S $8\ 7^{20}{}_{300}$
$FeCl_2 4H_2O$	c		370 5	S 2.75_{400}
$FeCl_3$	c		96.4	S 31.7
	1000		128 1	
	200		127 1	
	100		126 1	
	50		123.1	
	20		102 8	
Fe_2Cl_6	g		159 7	
	liq.			F $-$ 21 8
$FeCl_3 2\frac{1}{2}H_2O$	c		278 0	S 21.0_{1200}
$FeCl_3 6H_2O$	c		532 7	S $5.64^{21}{}_{1200}$
FeOCl	c		97 1	
$Fe(ClO_3)_2$	aq.		67.4	
$FeBr_2$	c		60 0	
	aq		78 0	
$FeBr_3$	aq.		95 2	
FeI_2	c		24 2	S 23.3
	aq.		47.5	
FeI_3	aq.		49 5	
FeS	liq.			F $2\ 8^{1195}$
	c		23 1	
FeS_2	c	pyrite	35 5	
	c	marcasite	35.5	
$FeSO_4$	c		221 3	S $14.90^{14}{}_{110}$
	100		235 98	
	200		235 94	
$FeSO_4 H_2O$	c		297.0	S $7.54^{14}{}_{110}$
$FeSO_4 4H_2O$	c		508 1	S $1.60^{14}{}_{110}$
$FeSO_4 \cdot 7H_2O$	c		719 0	S $-$ 4.51_{400}
$Fe_2(SO_4)_3$	1200		653.2	
	400		653 0	
	300		652.8	
	150		652.2	
	50		648 2	
$Fe(HSO_4)_3$	600		695.1	
FeSe	c		13.2	
FeTe	c		8.	S $268.2_{\text{bromine water}}$

Iron

Formula	State	Description	*Qf*, *kcal mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
Fe_4N	c		− 1 1	
$FeNO^{--}$	aq.		9 6	
$Fe(NO_3)_2$	aq.		118.8	
$Fe(NO_3)_3$	800		156 3	
	200		157.4	
$Fe(NO_3)_3\,9H_2O$	c		780.7	*S* − 9.1
$FeF_2\,H_2O\,\frac{1}{2}NH_3$	c			
$FeF_2\,H_2O\,NH_3$	c			*D* − 12.4
$FeF_2\,H_2O\,5NH_3$	c			*D* .− 9.8
$FeNOCl_2$	aq		88.9	
$FeCl_2\,NH_3$	c		113 6	*D* − 20 76
$FeCl_2\,2NH_3$	c		141.1	*D* − 19.48
$FeCl_2\,6NH_3$	c		246 6	*D* − 14 66
$FeCl_2\,10NH_3$	c		319 5	*D* − 7 25
$FeBr_2{\cdot}NH_3$	c		91.8	*D* − 20 78
$FeBr_2\,2NH_3$	c		122 6	*D* − 19 87
$FeBr_2\,6NH_3$	c		219.8	*D* − 13.34
$FeBr_2\,6NH_3$	c			*D* − 11 2
$FeI_2\,2NH_3$	c		87.1	*D* − 20.16
$FeI_2\,6NH_3$	c		188 9	*D* − 14 50
$FeNOSO_4$	aq.		221 8	
$NH_4Fe(SO_4)_2$	aq.		166 2	
$NH_4Fe(SO_4)_2{\cdot}12H_2O$	c		1303 3	*S* − 16 6
$FeSO_4\,NH_3$	c		252 8	*D* − 20 5^{300}
$FeSO_4\,2NH_3$	c		281 6	*D* − 17.9
$(NH_4)_2Fe(SO_4)_2\,6H_2O$	c		935 0	*S* − 9.8
$FeSO_4\,3NH_3$	c		306 7	*D* − 14 1^{121}
$FeSO_4\,4NH_3$	c		331 3	*D* − 13.6^{110}
$FeSO_4\,6NH_3$	c		378 6	*D* − 12 7^{83}
Fe_3C	c		− 5 2	
$FeCO_3$	c		172 8	
$Fe(CO)_5$	g		180.0	
	liq.		189 8	
	c			*F* − 3.25^{-20}
$Fe_2(C_2O_4)_3$	300	ferric oxalate	610.1	
	100		610.4	
$Fe(HC_2O_4)_3$	aq.	ferric bioxalate	597.3	
$Fe(C_2H_3O_2)_3$	1800	ferric acetate	357.1	
	600		358.3	
	300		358.6	
$Fe(CN)_6^{---}$	aq.		−146 7	
$Fe(CN)_6^{----}$	aq.		−121.6	
$Fe_4(Fe(CN)_6)_3$	c		−319.	
$FeCO(CN)_5^{---}$	aq.		− 42.9	
$HFe(CN)_6^{--}$	aq.		−146.6	

Iron

Formula	State	Description	Qf, kcal mole	Q, kcal. mole^{-1}
$HFe(CN)_6^{---}$	aq.		−121.7	
$H_2Fe(CN)_6^{--}$	aq.		−147.4	
$H_2Fe(CN)_6^{--}$	aq.		−121.9	
$H_3Fe(CN)_6^{-}$	aq		−122.2	
$H_3Fe(CN)_6$	aq.		−148.2	
$H_4Fe(CN)_6$	c		−122 9	S $0.4^{10}{}_{200}$
	aq.		−122 3	
$(NH_4)_4Fe(CN)_6$	aq.		4.2	
$(NH_4)_4Fe(CN)_6\ 3H_2O$	c		216.1	S − $6\ 8^{14}$
$H_3FeCO(CN)_5$	aq.		− 43 3	
$H_3FeCO(CN)_5\ H_2O$	c		19.9	C 808 3
Fe_2Si	c		− 20	
$FeSiO_3$	c		273 5	
$2FeI_2{\cdot}PbI_2$	c		90 0	S 46 9
$2FeI_2{\cdot}PbI_2\ 3H_2O$	c		352.2	S − 10.2
$Zn_2Fe(CN)_6$	c		− 40 0	

Manganese

Atomic number 25 Standard state Mn (c, III) Atomic weight 54 93

Mn	g	$3d^54s^2$ $(^6S_{5/2})$	− 74.	
	liq.			F − 3.6^{1260}
	c	I		T $0.25^{1044}{}_{\rightarrow II}$
	c	II		T $0\ 16_{\rightarrow III}$
	c	III	0.000	
Mn*	g	$3d^6(^5D)4s$ $(^6D_{9/2})$	−121.98	E^z − 47.98
	g	$(^6D_{7/2})$	−122 60	E^z − 48.60
	g	$(^6D_{5/2})$	−123 01	E^z − 49.01
	g	$(^6D_{3/2})$	−123.45	E^z − 49.45
	g	$(^6D_{1/2})$	−123.64	E^z − 49.64
	g	$3d^54s(^7S)4p$ $(^8P^1{}_{9/2})$	−143 97	E^z − 69 97
	g	$(^8P^1{}_{7/2})$	−144.00	E^z − 69.00
	g	$(^8P^1{}_{5/2})$	−144.04	E^z − 69.04
Mn^+	g	$3d(^6S)4s$ $(^7S_3)$	−246.08	I^z −170.63
Mn^{++}	g	$3d^5$ $(^6S_{5/2})$	−607.5	I^z −361.0
	aq.		49.2	
Mn^{+++}	aq.		25.	
MnO	c	I	96.5	
	c	II		T − $0.15^{-56}{}_{\rightarrow I}$
MnO_2	c	I	123.	
	c	ppt.	115.5	
	c	II		T − $0.08^{-180}{}_{\rightarrow I}$

Manganese

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
MnO_4^-	aq.		122.3	
Mn_2O_3	c		233.	
Mn_3O_4	c		345.0	
$HMnO_4$	aq.		122.3	
$Mn(OH)_2$	c	ppt.	163.4	
$Mn(OH)_3$	c	ppt.	221.	
MnF_2	1200		205 9	
MnF_3	aq.		260.	
MnF_3 3HF	aq.		486 8	
$MnCl_2$	c		112.7	*S* $16\ 00_{3.0}$
	100		128.3	
	400		128.7	
$MnCl_2 \cdot 2H_2O$	c		257.2	*S* 8.20_{300}
$MnCl_2$ $4H_2O$	c		400.7	*S* 1.54_{400}
H_2MnCl_6	aq.		215.	
$MnBr_2$	c		91.	
	aq.		106.	
$MnBr_2 \cdot H_2O$	c		160.0	*D* − 11.2
$MnBr_2 \cdot 4H_2O$	c		363.4	*D* − 10.0
$MnBr_3$	aq.		109.0	
MnI_2	c		49 8	*S* 26.2
	aq.		76.0	
MnI_2 H_2O	c		120.2	*D* − 12.6
$MnI_2 \cdot 2H_2O$	c		190 0	*D* − 12 0
MnI_2 $4H_2O$	c		329.6	*D* − 12.0
MnI_2 $6H_2O$	c		465.	*D* − 10.0
MnS	c	ppt.	47.0	
$MnSO_4$	c		251.2	*S* 13.80_{400}
	400		265 0	
	200		264.97	
	100		264.90	
	50		264.72	
	20		264.19	
$MnSO_4 \cdot H_2O$	c		321 5	*S* 7.80_{400}
$MnSO_4$ $6H_2O$	c		602.9	*S* $0\ 04_{400}$
$MnSO_4 \cdot 7H_2O$	c		745.3	
MnS_2O_6	aq.		329.4	
MnS_2O_6 $6H_2O$	c		741.5	*S* − 1.93_{400}
$Mn_2(SO_4)_3$	c		635.	*S* 32.1
	aq.		657.	
MnSe	c		26.3	
MnN_6	c		− 94.0	
Mn_3N_2	c		56.6	*S* $273.4_{H_2SO_4\ (50)}$
$Mn(NO_3)_2$	c		134.9	*S* 12.93^{14}_{280}
	400		147.8	

Manganese

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal mole*$^{-1}$
$Mn(NO_3)_2$	6		145 7	
	3		145.1	
$Mn(NO_3)_2\ 3H_2O$	c		356 8	F — 5 6[35]
$Mn(NO_3)_2\ 6H_2O$	c		564 2	S — 6 15$_{400}$
	liq.		555 9	F — 8.26[26]
$MnF_2\ H_2O\ \frac{1}{2}NH_3$	c			
$MnF_2\ H_2O\ NH_3$	c			D — 12.2
$MnF_2\ H_2O{\cdot}5NH_3$	c			D — 9.6
$MnCl_2\ NH_3$	c		145 3	D — 21.7
$MnCl_2{\cdot}2NH_3$	c		175 1	D — 18 8
$MnCl_2\ 2NH_4Cl\ 2H_2O$	c		413.5	S — 5.70
$MnCl_2\ 6NH_3$	c		268.9	D — 12 6
$MnBr_2\ NH_3$	c		123.7	D — 21.95
$MnBr_2{\cdot}2NH_3$	c		155.1	D — 20 4
$MnBr_2\ 2NH_4Br$	400		226 34	
$MnBr_2\ 6NH_3$	c		256 1	D — 14 3
$MnI_2{\cdot}2NH_3$	c		93 4	D — 21 7
$MnI_2\ 6NH_3$	c		201 8	D — 16.15
$MnSO_4{\cdot}\frac{1}{2}NH_3$	c		262.5	D — 19 7
$MnSO_4{\cdot}NH_3$	c		276 6	D — 17 3
$MnSO_4{\cdot}2NH_3$	c		304 8	D — 17 2
$MnSO_4{\cdot}(NH_4)_2SO_4\ 2H_2O$	c		688.1	
$MnSO_4{\cdot}(NH_4)_2SO_4\ 6H_2O$	c		964.0	S — 9 7
$MnSO_4\ 5NH_3$	c		374 8	D — 12 4
$MnSO_4{\cdot}6NH_3$	c		397 5	D — 11.7
$Mn_2(PO_4)_3$	c	ppt.	736	
Mn_3C	c		23.	
$MnCO_3$	c		218.	
	c	ppt.	207.8	
MnC_2O_4	c	manganese oxalate	241.8	S 2.73$_{HNO_3(9)}$
$MnC_2O_4\ 2H_2O$	c		384.7.	S — 3.50$_{HNO_3(9)}$
$MnC_2O_4{\cdot}3H_2O$	c		454.7	S — 5 06$_{HNO_3(9)}$
$Mn(CHO_2)_2$	c	manganeseformate	244.1	S 4.3$^{24}{}_{300}$
	aq.		248.4	
$Mn(CHO_2)_2{\cdot}2H_2O$	c		388.0	S 2.9$^{24}{}_{500}$
$Mn(C_2H_3O_2)_2$	c	manganese acetate	272.0	S 12.2$^{17}{}_{300}$
	aq.		284.2	
$Mn(C_2H_3O_2)_2{\cdot}4H_2O$	c		556.1	S 1.6$^{16}{}_{600}$
$MnSiO_3$	gls.		292.8	S 61.6$_{HF(1\ 44)}$
	c		301.3	S 53.1$_{HF(4\ 44)}$
$MnBr_2{\cdot}2HgBr_2$	aq.		183.9	
$MnBr_2{\cdot}HgBr_2$	aq.		146.2	
$2MnBr_2{\cdot}HgBr_2$	aq.		255.1	
$2MnI_2{\cdot}PbI_2$	c		150.0	S 43.9[15]
$2MnI_2{\cdot}PbI_2{\cdot}3H_2O$	c		407.5	S — 8.5[15]

Chromium

Atomic number 24 Standard state Cr (c) Atomic weight 52.01

Formula	State	Description	Qf, kcal, mole^{-1}	Q, kcal. mole^{-1}
Cr	g	$3d^5(^6S)4s\ (^7S_3)$	− 88.	
	liq.			F − 3.65^{1600}
	c		0.000	
Cr*	g	$3d^5(^6S)4s\ (^5S_2)$	− 109.62	E^z − 21.62
	g	$3d^44s^2\ (^5D_0)$	− 110 06	E^z − 22.06
	g	$(^5D_1)$	− 110 21	E^z − 22.24
	g	$(^5D_2)$	− 110.57	E^z − 22.57
	g	$(^5D_3)$	− 111.05	E^z − 23.05
	g	$(^5D_4)$	− 111.61	E^z − 23.64
Cr^+	g	$3d^5\ (^6D_{7/2})$	− 244.7	I^z − 155.27
Cr^+ *	g	$3d^44s\ (^6D_{1/2})$	− 278.8	E^z − 34.06
	g	$(^6D_{3/2})$	− 279 0	E^z − 34.26
	g	$(^6D_{5/2})$	− 279 3	E^z − 34.59
	g	$(^6D_{7/2})$	− 279.7	E^z − 35.03
	g	$(^6D_{9/2})$	− 280 3	E^z − 35.58
Cr^{++}	g	$3d^4\ (^5D)$	− 629.	I^z − 382.
Cr^{++} *	g	$(^3F_2)$	− 683.	E^z − 54.1
	g	$(^3F_3)$	− 683 1	E^z − 54.2
	g	$(^3F_4)$	− 683.4	E^z − 54.5
$[Cr]^{+4}$	aq.		42.8	
Cr^{+++}	g	$3d^3\ (^4F)$	−1255.	I^z − 635.
$[Cr]^{+++}$	aq		64.6	
Cr^{+++} *	g	$3d^3\ (^2G)$	−1298.	E^z − 42.7
Cr^{++++}	g	$3d^2\ (^3F)$	−2461.	I^z −1162.
Cr^{+++++}	g	$3d\ (^2D)$	−4132.	I^z −1670.
CrO	g		− 59.	D^z − 87.2
CrO_3	c		139.3	
	80		141.8	
	50		141.75	
	25		141.65	
	10		141.10	
	4		140.66	
	3.3		140.32	
CrO_4^{--}	aq.		207.9	
Cr_2O_3	c		273.	
$Cr_2O_7^{--}$	aq.		350.4	
$Cr_3O_{10}^{---}$	aq.		494.	
Cr_7H_2	c		− 3.7	
CrO·OH	c		180.	
$[CrOH]^{++}$	aq.		102.7	
H_2CrO_4	aq.		210.2	
$[Cr](OH)_3$	c	ppt.	249.3	
$[CrOH](OH)_2$	c	ppt.	245.1	
$[Cr(OH)_2]OH$	c	ppt.	241.0	

Chromium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$Cr_2O_3\ 2H_2O$	c		439.	
CrF_2	c		152.	
CrF_3	c		231.	
$[Cr]F_3$	aq.		296 6	
$H_3[Cr]F_6$	aq.		531.2	
$CrCl_2$	c		103.1	S 18.6
	aq.		121.7	
$CrCl_2 \cdot 3H_2O$	c	light green	321 5	S 5.3
$CrCl_2 \cdot 4H_2O$	c	dark green	392 2	S 2.0
$[CrCl_2]^+$	aq.		134.1	
$[CrCl_3]Cl$	c	rose	143 0	S 30.6
	aq.	green	173 6	
$[Cr]Cl_3$	aq.	purple	183.0	
$[Cr(H_2O)_4Cl_2]Cl$	c	green	438.7	S 8.4
$[Cr(H_2O)_4Cl_2]Cl \cdot 2H_2O$	c	green	583 9	S — 0.04_{150}
$[Cr(H_2O)_6]Cl_3$	c	purple	581.2	S 12 0
$[Cr(H_2O)_4Cl_2]Cl\ 6H_2O$	c	green	857 2	S 0.0
CrO_2Cl_2	g		126.1	V — 8 5
	liq.		134 6	S 16.6
$[CrOH]Cl_2$	aq.		181 6	
$[Cr(OH)_2]Cl$	aq.		194 4	
$[CrBr_2]Br$	aq		138.4	
$[Cr]Br_3$	aq.		149 9	
$[CrBr_2(H_2O)_4]Br\ 2H_2O$	c	green	548 0	S 0 68
$[Cr(H_2O)_6]Br_3$	c	purple	545.8	S 14.35
CrI_2	c		63 7	S 5.72
	aq.		69 4	
$[CrSO_4]^+$	aq.		266.4	
$Cr_2(SO_4)_3$	aq.	"modified," hydrolyzed to form $[Cr_2(SO_4)_2](OH)_2$	753.4	
$[Cr_2(SO_4)_3]$	aq.		757.4	
$[Cr_2(SO_4)_2]SO_4$	aq.	green	760 9	
$[Cr_2SO_4](SO_4)_2$	aq.	green	767.8	
$[Cr]_2(SO_4)_3$	aq.	purple	772.3	
$Cr_2(SO_4)_3\ 6H_2O$	c	green	1282 2	S 13.4
$[Cr(H_2O)_6]_2(SO_4)_3 \cdot 2H_2O$	c	purple	1707.9	S 10.18
$[Cr(H_2O)_6]_2(SO_4)_3 \cdot 3H_2O$	c	purple	1777.7	S 8.3
$[Cr(H_2O)_6]_2(SO_4)_3\ 5H_2O$	c	purple	1917.0	S 6.3
CrN	c		29.5	
$(NH_4)_2CrO_4$	c		276.9	S — 5.8_{500}
	aq.		271.1	
$(NH_4)_2Cr_2O_7$	c		423.6	S — 12.90^{16}_{540}
	600		410.7	
$CrCl_2 \cdot 3NH_3$	c		175.2	D — 13.1

Chromium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$CrCl_2\,6NH_3$	c		241.4	D − 11.1
Cr_3C_2	c		140.	
$PbCrO_4$	c		221.4	
$2CrI_2\,PbI_2$	c		160.2	S 20.4
$2CrI_2{\cdot}PbI_2{\cdot}3H_2O$	c		388.0	S − 2.3

Molybdenum

Atomic number 42 Standard state Mo (c) Atomic weight 96.0

Mo	g	$4d^5(^6S)5s\ (^7S_3)$	−160.	
	c		0.000	
Mo*	g	$4d^5(^6S)5s\ (^5S_2)$	−190.65	E^z − 30.65
	g	$4d^45s^2\ (^5D_0)$	−191.22	E^z − 31.22
	g	$(^5D_1)$	−191.72	E^z − 31.72
	g	$(^5D_2)$	−192.61	E^z − 32.61
	g	$(^5D_3)$	−193.74	E^z − 33.74
	g	$(^5D_4)$	−195.15	E^z − 35.15
Mo^+	g	$4d^4(^5D)5s(^6D)$	−331.	I^z −169.56
MoO_2	c		130.	
MoO_3	c		176.5	
	aq.		178.0	
MoO_4	aq.		163.4	
MoO_4^{--}	aq.		243.5	
MoO_5	aq.		145.0	
H_2MoO_4	c	$MoO_3\,H_2O$	247.0	D − 18.76
	aq.		246.4	
$H_2MoO_4{\cdot}H_2O$	c	$MoO_3{\cdot}2H_2O$	319.4	D − 14.70
MoF_6	c			V − 8.30[17 5]
	liq.			F − 2.1
$PbMoO_4$	c		262.1	D − 33.1
$CuMoO_4$	c		241.5	D − 26.5
$FeMoO_4$	c		254.3	D − 13.5
$Fe_2(MoO_4)_3{\cdot}xH_2O$	c		698.7+68.37x	

Tungsten

Atomic number 74 Standard state W (c) Atomic weight 184.0

Formula	State	Description	*Qf, kcal. mole*$^{-1}$	*Q, kcal, mole*$^{-1}$
W	g	$5d^46s^2$ ($^5D_0$)	− 210.	
	c		0.000	
W*	g	$5d^46s^2$ ($^5D_1$)	− 214.75	E^z − 4 75
	g	($^5D_2$)	− 219.47	E^z − 9.47
	g	($^5D_3$)	− 223.75	E^z − 13.75
	g	($^5D_4$)	− 227.71	E^z − 17.71
	g	$5d^56s$ ($^7S_3$)	− 218.40	E^z − 8.40
WO_2	c		130.5	
WO_3	c		195.7	
WO_4^{--}	aq.		266.3	
W_2O_5	c		324.	
H_2WO_4	c		284.5	
	aq.		284.4	
$WO_3 \cdot H_2O_2$	aq.		331.0	
$WO_3 \cdot 2H_2O_2$	aq.		377.2	
$WO_3 \cdot 3H_2O_2$	aq.		424.6	
WF_6	liq.			V − 6.25
	c			Vs − 8.72[3]
WS_2	c		84.	
$CuWO_4$	c		246.3	
$CuWO_4 \cdot 2H_2O$	c		389.9	
$FeWO_4$	c		269.7	
$FeWO_4 \cdot 3H_2O$	c		482.3	
$Fe_2(WO_4)_3 \cdot 8H_2O$	c		1339.8	

Uranium

Atomic number 92 Standard state U (c) Atomic weight 238.14

Formula	State	Description	Qf, *kcal.. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
U	g		− 220.	
	c		0.000	
UO_2	c		256.6	
UO_2^{++}	aq.		243.	
UO_3	c		291.6	
U_3O_8	c		845.2	
$UO_3 \cdot \frac{1}{2}H_2O$	c		325.9	
$UO_3\ H_2O$	c		364.9	S $14.85_{HNO_3\,(110)}$
$UO_3 \cdot 1\frac{1}{2}H_2O$	c		401 1	
$UO_3 \cdot 2H_2O$	c		435 8	S $12.38_{HNO_3\,(110)}$
$UO_4 \cdot 2H_2O$	c		426.0	S $0.1_{H_2SO_4\,(100)}$
UF_6	liq.			V -10.4^{42}
UCl_3	c		213.	
UCl_4	c		251.	
UO_2Cl_2	aq.		321.8	
$UO_2Cl_2\ H_2O$	c		384.0	S 6.0_{1000}
UO_2Br_2	aq.		300.	
UO_2SO_4	c		427.	
	aq.		455.0	
$UO_2SO_4 \cdot 3H_2O$	c		655.6	S 5.1_{1000}
$U(SO_4)_2$	c		428.	
U_3N_4	c		274.	
$UO_2(NO_4)_2$	c		322.2	S 19.0^{12}_{220}
	aq.		341.2	
$UO_2(NO_3)_2 \cdot H_2O$	c		397 7	S 11.87_{220}
$UO_2(NO_3)_2 \cdot 2H_2O$	c		473.0	S 5.05^{12}_{220}
$UO_2(NO_3)_2 \cdot 3H_2O$	c		544.4	S 1.85^{12}_{220}
$UO_2(NO_3)_2\ 6H_2O$	c		756.8	S $-\ 5.45^{12}_{220}$
UC_2	c		29.	
$UO_2(C_2H_3O_2)_2$	aq.		479.1	
$UO_2(C_2H_3O_2)_2 \cdot 2H_2O$	c		620 2	S $-\ 4.3_{1000}$
$UO_2(C_2H_3O_2)_2\ NH_4C_2H_3O_2\ 6H_2O$	c		1042.3	S $-\ 3.8_{1000}$
UO_2CrO_4	aq.		450.5	
$UO_2CrO_4 \cdot 5\frac{1}{2}H_2O$	c		832.8	S $-\ 6.3_{1000}$

Vanadium

Atomic number 23 Standard state V (c) Atomic weight 50 95

Formula	State	Description		*Qf*, *kcal mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
V	g	$3d^34s^2$	($^4F_{3/2}$)	− 85.	
	c			0 000	
V*	g	$3d^34s^2$	($^4F_{5/2}$)	− 85 39	E^z − 0 391
	g		($^4F_{7/2}$)	− 85.92	E^z − 0 921
	g		($^4F_{9/2}$)	− 86 57	E^z − 1 574
	g	$3d^4(^5D)4s$	($^6D_{1/2}$)	− 91.01	E^z − 6.013
	g		($^6D_{3/2}$)	− 91.13	E^z − 6.130
	g		($^6D_{5/2}$)	− 91.32	E^z − 6.320
	g		($^6D_{7/2}$)	− 91 58	E^z − 6.580
	g		($^6D_{9/2}$)	− 91.90	E^z − 6.903
V^+	g	$3d^4$	($^5D_0$)	− 242 1	I^z − 155.7
V^+ *	g		($^5D_1$)	− 242 2	E^z − 0.103
	g		($^5D_2$)	− 242 4	E^z − 0 304
	g		($^5D_3$)	− 242 7	E^z − 0 594
	g		($^5D_4$)	− 243 1	E^z − 0.966
	g	$3d^3(^4F)4s$	($^5F_1$)	− 249.5	E^z − 7.415
	g		($^5F_2$)	− 249.8	E^z − 7 649
	g		($^5F_3$)	− 250 1	E^z − 7 995
	g		($^5F_4$)	− 250 6	E^z − 8 501
	g		($^5F_5$)	− 251 1	E^z − 9.003
V^{++}	g	$3d^3$	($^4F_{3/2}$)	− 579.8	I^z − 326 2
V^{++} *	g		($^4F_{5/2}$)	− 580.2	E^z − 0 413
	g		($^4F_{7/2}$)	− 580 7	E^z − 0.965
	g		($^4F_{9/2}$)	− 581.5	E^z − 1.66
V^{+++}	g	$3d^2$	($^3F_2$)	−1190	I^z − 609.
V^{+++} *	g		($^3F_3$)	−1190 9	E^z − 0.91
	g		($^3F_4$)	−1192.1	E^z − 2 07
V^{++++}	g	3d	($^2D_{3/2}$)	−2303	I^z −1113.
V^{++++} *	g		($^2D_{5/2}$)	−2304 8	E^z − 1.76
V^{+++++}	g	$3s^2$	($^1S_0$)	−3785.	I^z −1480
VO_3^-	aq.			257.6	
VO_4^-	aq			243.9	
VO_5^-	aq.			229.9	
V_2O_2	c			195.	
V_2O_3	c			330.	
V_2O_4	c			383.	
V_2O_5	c			437.	
VCl_2	c			147.	
VCl_3	liq.			187.	
VCl_4	liq.			165.	
$VOCl_3$	c			200.	
NH_4VO_3	c			283.5	S $6.15^{16}_{NaOH(aq.)}$

Columbium

Atomic number 41 | Standard state Cb (c) | Atomic weight 93.3

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal mole*$^{-1}$
Cb	c		0.000	
Cb_2O_5	c		442.	

Tantalum

Atomic number 73 | Standard state Ta (c) | Atomic weight 181.4

Ta	c		0.000	
Ta_2O_5	c		199	

Protoactinium

Atomic number 91 | Standard state Pa (c) | Atomic weight (232?)

Titanium

Atomic number 22 | Standard state Ti (c) | Atomic weight 47.90

Ti	g	$3d^24s^2$	($^3F_2$)	− 100.	
	c			0 000	
Ti*	g		($^3F_3$)	− 100 18	E^z − 0.484
	g		($^3F_4$)	− 101.10	E^z − 1.101
	g	$3d^3(^4F)4s$	($^5F_1$)	− 118 66	E^z − 18 660
	g		($^5F_2$)	− 118.79	E^z − 18.785
	g		($^5F_3$)	− 118.96	E^z − 18 963
	g		($^5F_4$)	− 119 20	E^z − 19.195
	g		($^5F_5$)	− 119.48	E^z − 19.480
	g	$3d^24s'$	($^1D_2$)	− 120.65	E^z − 20 65
	g		($^1P_0$)	− 124 02	E^z − 24.02
	g		($^3P_1$)	− 124.18	E^z − 24 18
	g		($^3P_2$)	− 124.49	E^z − 24.49
Ti^+	g	$3d^24s$	($^4F_{3/2}$)	− 258.5	I^z −156.97
Ti^+ *	g		($^4F_{5/2}$)	− 258.8	E^z − 0 267
	g		($^4F_{7/2}$)	− 259.1	E^z − 0 692
	g		($^4F_{9/2}$)	− 259.6	E^z − 1.119
	g	$3d^3$	($^4F_{3/2}$)	− 261.1	E^z − 2 585
	g		($^4F_{5/2}$)	− 261.3	E^z − 2.801
	g		($^4F_{7/2}$)	− 261.6	E^z − 3.095
	g		($^4F_{9/2}$)	− 262.0	E^z − 3.461
Ti^{++}	g	$3d^2$	($^3F_2$)	− 573.1	I^z −313.1
Ti^{++} *	g		($^3F_3$)	− 573.6	E^z − 0.523
	g		($^3F_4$)	− 574.3	E^z − 1.201
Ti^{+++}	g	3d	($^2D_{3/2}$)	1221.	I^z −645.
Ti^{+++} *	g		($^2D_{5/2}$)	1222.1	E^z − 1.091

Titanium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Ti^{++++}	g	$3s^23p^6$ ($^1S_0$)	2215.5	I^s — 993.0
TiO_2	c	rutile I		T $0.75^{778}{}_{\rightarrow II}$
	c	rutile II		T $0.30^{840}{}_{\rightarrow III}$
	c	rutile III	218.0	
	c	anatase I		T $0.38^{785}{}_{\rightarrow II}$
	c	anatase II		T $0.26^{600}{}_{\rightarrow III}$
	c	anatase III		
	amorp.		214.1	
	amorp	hydrated ppt.	210 0	
TiF_6^{--}	aq.		557.5	
H_2TiF_6	aq.		558.4	
$TiCl_3$	c	brown		S 48 6
	c	violet		S 45 8
$TiCl_4$	g		172 4	V — 8.62^{136}
	liq.		181.4	S 57.86_{2C06}
	c			F — $2\ 23^{-30}$
	aq.	hydrolyzed	239 3	
$TiCl_4 \cdot H_2S$	c		195 6	D — 8.86
$TiCl_4 \cdot 2H_2S$	c		208 3	D — 7.49
$TiBr_4 \cdot H_2S$	c			D — 8.57
$TiBr_4 \cdot 2H_2S$	c			D — 7.20
$TiCl_4\ PH_3$	c		202 4	
$TiCl_4 \cdot 2PH_3$	c		215 5	D — 10.8
$TiBr_4\ PH_3$	c			D — 16.0
$TiBr_4 \cdot 2PH_3$	c			D — 11.8
TiC	c		110.	

Zirconium

Atomic number 40 — Standard state Zr (c) — Atomic weight 91.22

Zr	g	$4d^25s^2$ ($^3F_2$)	— 110.	
	c		0.000	
Zr*	g	($^3F_3$)	— 111.62	E^s — 1.62
	g	($^3F_4$)	— 113.53	E^s — 3 53
	g	($^3P_0$)	— 121.94	E^s — 11.94
	g	($^3P_1$)	— 122.46	E^s — 12.46
	g	($^3P_2$)	— 121.91	E^s — 11.91
	g	$4d^3(^4F)5s$ ($^5F_1$)	— 123.86	E^s — 13.86
	g	($^5F_2$)	— 124.30	E^s — 14.30
	g	($^5F_3$)	— 124.92	E^s — 14.92
	g	($^5F_4$)	— 125.77	E^s — 15.77
	g	($^5F_5$)	— 126.76	E^s — 16.76
Zr^+	g	$4d^3(^1F)5s$ ($^4F_{3/2}$)	— 270.0	I^s —159.6
	g	($^4F_{5/2}$)	— 270.9	E^s — 0.896

Zirconium

Formula	State	Description		Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Zr^{+}	g		($^4F_{7/2}$)	− 272.2	E^s − 2.17
	g		($^4F_{9/2}$)	− 273.8	E^s − 3.77
	g	$4d^3$	($^4F_{3/2}$)	− 277.3	E^s − 7.32
	g		($^4F_{5/2}$)	− 278.2	E^s − 8.24
	g		($^4F_{7/2}$)	− 279.4	E^s − 9.39
	g		($^4F_{9/2}$)	− 280.7	E^s − 10.70
Zr^{++}	g	$4d^2$	($^3F_2$)	− 594.	I^s −322.
Zr^{+++}	g	4d	($^2D_{3/2}$)	−1148.	I^s −553.
Zr^{++++}	g	$4p^6$	($^1S_0$)	−1930.	I^s −780.2
ZrO^{++}	aq.			198.3	
ZrO_2	c	monoclinic		258 1	
	c	ppt.		253.	
$ZrO(OH)_2$	c			337.	
$Zr(OH)_4$	c			411.0	
$Zr(OH)_4 \cdot H_2O$	c			482.7	
$Zr(OH)_4 \cdot 2H_2O$	c			544.0	
$ZrCl_4$	g			242.	V − 26.0[339]
	c			268.9	
$ZrOCl_2$	aq.			272.5	
$ZrOCl_2 \cdot 2H_2O$	c			393.2	S 16.0
$ZrOCl_2 \cdot 3\frac{1}{2}H_2O$	c			502.8	S 9.0
$ZrOCl_2 \cdot 6H_2O$	c			683.6	S 0.7
$ZrOCl_2 \cdot 8H_2O$	c			822.5	S − 3.0
$ZrBr_4$	c				Vs − 26.5[356]
$ZrOBr_2$	aq.			250.6	
$ZrOBr_2\ 3\frac{1}{2}H_2O$	c			480.9	S 9.01
$ZrOBr_2\ 8H_2O$	c			799.6	S 2.01
ZrI_4	c				Vs − 29 5[431]
$ZrOSO_4$	aq.			409.1	
$ZrOSO_4 \cdot 4H_2O$	c			672.2	S 10.4
$ZrOSO_4 \cdot SO_3$	c			519.4	S 32.8
$ZrOSO_4 \cdot H_2SO_4$	c			600.0	S 20.6
$ZrO(NO_3)_2$	aq.			291.7	
$ZrO(NO_3)_2 \cdot 2H_2O$	c			426.2	S 2.17
$ZrO(NO_3)_2 \cdot 3H_2O$	c			497.3	S − 0.5
$ZrO(NO_3)_2 \cdot 3\frac{1}{2}H_2O$	c			532.9	S − 1.92
$ZrO(NO_3)_2 \cdot 6H_2O$	c			707.8	S − 5.90
ZrC	c			44.	

Hafnium

Atomic number 72 Standard state Hf (c) Atomic weight 178.6

Hf	c		0.000	
HfO_2	c	monoclinic	271.5	

Thorium

Atomic number 90 Standard state Th (c) Atomic weight 232.12

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Th	g		− 177.	
	c		0.000	
Th^{++++}	aq.		238.5	
ThO_2	c		293.	
ThH_4	c		− 42.8	D − 21.4
$Th(OH)_4$	c	"soluble"	336.1	S 39.1$_{HCl(15)}$
	c	"insoluble"	325.1	S 50.2$_{HCl(15)}$
$ThCl_4$	c		335.	S 56.7^{15}
	aq.		392.	
$ThCl_4 2H_2O$	c		487 2	S 41.1
$ThCl_4 4H_2O$	c		639 2	S 26.23
$ThCl_4 7H_2O$	c		856 0	S 14.7
$ThCl_4 8H_2O$	c		927.6	S 11.45
$ThOCl_2$	c		336.	S 28 15
$ThCl_3OH \cdot H_2O$	c		398.8	S 47.6
$ThBr_4$	c		281 5	S 70 2
	aq		351.7	
$ThBr_4 \cdot 7H_2O$	c		807.8	S 22 55
$ThBr_4 \cdot 10H_2O$	c		1025 7	S 9 84
$ThBr_4 \cdot 12H_2O$	c		1170 0	S 2 3
$ThOBr_2$	c		319 0	S 28 0
ThI_4	aq		291 7	
$ThOI_2$	c		289 5	S 21 5
$ThOI_2 \cdot 3\frac{1}{2}H_2O$	c		425 6	S 10 03
ThI_3OH $10H_2O$	c		1008.1	S 8 14
$ThOSO_4$	c		517.	
$Th(SO_4)_2$	c		632.	
	aq.		667 9	
$Th(SO_4)_2 \cdot 4H_2O$	c		936.1	S 5.0
$Th(SO_4)_2 \cdot 8H_2O$	c		1222 1	S − 7.5
Th_3N_4	c		301 1	
$ThCl_4 \cdot 2NH_4Cl$	c		491 5	S 39.8
$ThCl_4$ $2NH_4Cl$ $10H_2O$	c		1221 1	S − 3 9
$ThCl_4 \cdot 4NH_3$	c	α	458.8	S 61.7$_{HCl(aq.)}$
$ThCl_4$ $6NH_3$	c	α	511.8	S 73.1$_{HCl(aq)}$
$[Th(NH_3)_6]Cl_4$	c	β	548.9	S 35.3$_{HCl(aq.)}$
$ThCl_4$ $7NH_3$	c	α	521 3	S 82.75$_{HCl(aq)}$
$[Th(NH_3)_6]Cl_4 \cdot NH_3$	c	β	581.9	S 34.15$_{HCl(aq)}$
$[Th(NH_3)_6]Cl_4$ $6NH_3$	c	β	684 4	S 93.7$_{HCl(aq)}$
$ThCl_4$ $12NH_3$	c	α	638 4	S 139.7$_{HCl(aq)}$
$ThCl_4 \cdot 18NH_3$	c	α	747.1	S 214 2$_{HCl(aq.)}$
$[Th(NH_3)_6]Cl_4 \cdot 12NH_3$	c	β	789.4	S 171.9$_{HCl(aq)}$
ThC_2	c		45.	

Boron

Atomic number 5 Standard state B (c) Atomic weight 10.82

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
B	g	2p $(^2P^1_{1/2})$	− 115.	
	c		0 000	
B*	g	2p $(^2P^1_{3/2})$	− 115.04	E^s − 0.04
	g	3s $(^2S_{1/2})$	− 228.99	E^s − 113.99
B^+	g	$2s^2$ $(^1S_0)$	− 307.4	I^s − 190.97
B^+ *	g	2s2p $(^3P^1_0)$	− 413.0	E^s − 105.57
	g	$(^3P^1_1)$	− 413.0	E^s − 105.59
	g	$(^3P^1_2)$	− 413.0	E^s − 105.64
B^{++}	g	2s $(^2S_{1/2})$	− 885.8	I^s − 576.89
B^{+++}	g	$1s^2$ $(^1S_0)$	− 1557.1	I^s − 870.92
B^{++++}	g	1s $(^2S_{1/2})$	− 7512.	I^s −5954.
B^{+++++}	g	$(^1S_0)$	− 15313.0	I^s −7809.6
BO	g	$^2\Sigma^+$	− 35.	D^s − 138.
BO_2^-	aq.		174.2	
BO_3^{---}	aq.		215.3	
B_2O_3	gls.		279.9	S 7.3
	aq.		287.2	
$B_4O_7^{--}$	aq.		637.6	
BH	g	$^1\Sigma^+$	− 87.	D^s − 79.6
B_2H_6	g			V − 3.1
HBO_2	c		178.2	D − 13.3
H_3BO_3	c		251.6	S − 5.39_{400}
	aq.		246.2	
$H_2B_4O_7$	c		641.7	D − 12.3
$H_2B_6O_{10}$	c		927.0	D − 13 3
BF_3	g		256.9	S − 24.5
	liq.			V − 4.68^{-101}
	aq.		281.4	
BF_4^-	aq.		358.0	
HBF_4	aq.		358.0	
BCl_3	g		88.3	
	liq.		94.6	
BBr_3	g		35.0	V − 7.75
	liq.		42.8	S 83.8^{11}_{400}
B_2H_5Br	liq.			V − 6.25
B_2S_3	c		40.	S 58.0
NH_4BO_2	1320		206.1	
	200		205.88	
NH_4BO_2	aq.		230.4	
$NH_4BO_2 \cdot H_2O$	c		307.8	S − 9.03
$(NH_4)_2HBO_3$	300		296.4	
$(NH_4)_3BO_3$	aq.		316.7	
$B(CH_3)_3$	liq.			V − 4.85

Aluminum

Atomic number 13 Standard state Al (c) Atomic weight 26.97

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Al	g	$3s^23p$ ($^2P^1_{1/2}$)	− 55.	
	liq.			F − 2.3[659]
	c		0 000	
Al*	g	$3s^23p$ ($^2P^1_{3/2}$)	− 55.32	E^s − 0.32
	g	$3s^24s$ ($^2S_{1/2}$)	− 127.17	E^s − 72.17
Al+	g	$3s^2$ ($^1S_0$)	− 193.9	I^s − 137.45
Al+ *	g	$3s3p$ ($^3P^1_0$)	− 300.4	E^s − 106.45
	g	($^3P^1_1$)	− 300.5	E^s − 106.63
	g	($^3P^1_2$)	− 300 9	$E^{s'}$ − 106.98
Al++	g	($^2S_{1/2}$)	− 627.7	I^s − 432.32
Al++ *	g	$3p$ ($^2P^1_{1/2}$)	− 780.5	E^s − 152.82
	g	($^2P^1_{3/2}$)	− 781.2	E^s − 153.70
Al+++	g	$2p^6$ ($^1S_0$)	−1282.3	I^s − 653.2
	aq.		126.3	
Al++++	g	$2p^5$	−4120.	I^s −2835.
Al_2O_3	g		260.	V − 116.[2700]
	c		380.0	
AlH	g		− 35.0	D^s − 71.0
$Al(OH)_3$	c		304.9	
AlF_3	c		329.	S 31.
	aq.		360.2	
AlF_6---	aq.		591.	
H_3AlF_6	aq.		589.6	
$AlF_3 \cdot \frac{1}{2}H_2O$	c		375.4	S $25.6_{HF\,(4\,75)}$
$AlF_3 \cdot 3\frac{1}{2}H_2O$	c	"soluble"	601.2	S − 1.7
	c	"insoluble"	601.7	S $4.44_{HF\,(4\,75)}$
$AlCl_3$	g		133.	D − 40.
	liq.			F − 8.49[192]
	c		166.8	S 77.9
	600		244.7	
$AlCl_3\,6H_2O$	c		641.7	S 13.2^{18}_{450}
Al_2Cl_6	g		306.1	
$AlBr_3$	liq.			F − 2.7[98]
	c		126.7	S 85.3^{9}_{3000}
	aq.		212.0	
AlI_3	liq.			F − 3.8[191]
	c		77.2	S 89.0^{9}_{2200}
	aq.		166.2	
Al_2S_3	c		140.5	S 75.0
$Al_2(SO_4)_3$	c		770.	D − 17.
	aq.		896.	
$Al_2(SO_4)_3 \cdot 6H_2O$	c		1250.	S 56.
$Al_2(SO_4)_3 \cdot 18H_2O$	c		2120.	S 8.2
$AlCl_3 \cdot \frac{1}{2}SO_2$	c		208.8	S 75.3
$AlCl_3 \cdot SO_2$	c		248.8	S 74.7
$AlCl_3 \cdot \frac{1}{2}H_2S$	c		174.4	S 75.3^{15}_{5000}
$AlCl_3 \cdot H_2S$	c		181.4	D − 9.2
$AlBr_3 \cdot H_2S$	c		141.7	D − 9.72[20]

Aluminum

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$AlI_3 \cdot H_2S$	c		106.1	*D* — 9.1[11]
$AlI_3 \cdot 4H_2S$	c		129.3	*D* — 6.3[-74]
AlN	c		80.	
$AlF_3 \cdot 2NH_4F \cdot 1\frac{1}{2}H_2O$	c		691.5	*S* — 8.54[16]
$AlCl_3 \cdot NH_3$	c		216.0	*S* 54.5[15]
$AlCl_3 \cdot NH_4Cl$	c		255.3	*S* 60.47[15]$_{800}$
$AlCl_3 \cdot 3NH_3$	c		282.7	*S* 30.3[15]
$AlCl_3 \cdot 5NH_3$	c		342.8	*S* 9.05[15]$_{2300}$
$AlCl_3 \cdot 6NH_3$	c		364.9	*S* 6.35[15]$_{2500}$
$AlCl_3 \cdot 7NH_3$	c		386.1	*D* — 10.2
$AlCl_3 \cdot NH_4Cl\ 6NH_3$	c		454.5	*S* — 2.7
$AlCl_3 \cdot 14NH_3$	c		517.5	*D* — 7.8$_{\text{heptammine}}$
$AlBr_3 \cdot NH_3$	c		177.0	*S* 66.9$^{0}{}_{HBr\,(20)}$
$AlBr_3 \cdot 3NH_3$	c		249.6	*S* 57.7$^{0}{}_{HBr\,(20)}$
$AlBr_3 \cdot 5NH_3$	c		310.6	*S* 60.2$^{0}{}_{HBr\,(20)}$
$AlBr_3\ 6NH_3$	c		335.9	*D* — 16.2
$AlBr_3 \cdot 7NH_3$	c		357.5	*D* — 10.7
$AlBr_3\ 9NH_3$	c		396.4	*D* — 8.4
$AlBr_3 \cdot 14NH_3$	c		516.3	*D* — 7.72
$AlI_3 \cdot NH_3$	c		119.9	*S* 78.9$^{0}{}_{HI\,(20)}$
$AlI_3 \cdot 3NH_3$	c		204.0	*S* 58.0$^{0}{}_{HI\,(20)}$
$AlI_3\ 5NH_3$	c		282.0	*S* 42.0$^{0}{}_{HI\,(20)}$
$AlI_3 \cdot 6NH_3$	c		306.8	*S* 50.3$^{0}{}_{HI\,(20)}$
$AlI_3 \cdot 7NH_3$	c		329 7	*D* — 11.7
$AlI_3\ 9NH_3$	c		368.5	*D* — 8.6
$AlI_3 \cdot 13NH_3$	c		443.4	*D* — 7.74
$AlI_3 \cdot 20NH_3$	c		574.6	*D* — 7.67
NH_4AlSO_4	c		531.	
$NH_4AlSO_4 \cdot 5H_2O$	c		912.	
$NH_4AlSO_4\ 9H_2O$	c		1208.2	*D* — 12.0
$NH_4AlSO_4 \cdot 12H_2O$	c		1417.6	*S* — 9.2
$AlCl_3 \cdot PH_3$	c		179.0	*D* — 9.9
$AlBr_3 \cdot PH_3$	c		143 3	*D* — 14.3
$AlI_3 \cdot PH_3$	c		94.2	*D* — 14.7
Al_4C_3	c		60.	
Al_2SiO_5	c	andalusite	617.0	*S* 90.1$_{HF\,(4\,44)}$
	c	disthene	617.4	*S* 89.7$_{HF\,(4\,44)}$
	c	sillimanite	623.7	*S* 80.4$_{HF\,(4\,44)}$
$3Al_2O_3 \cdot 2SiO_2$	c	mullite	1804	*S* 83.7$_{HF\,(4\,44)}$
$2AlCl_3 \cdot 3PbI_2$	c		236 0	*S* 222.0[15]
$2AlCl_3 \cdot 3PbI_2 \cdot 10H_2O$	c		1126 7	*S* 15.0[15]
$AlCl_3 \cdot \frac{1}{2}ZnCl_2$	c		237.2	*S* 94.0
AlCu	c		68.	*S* 181.$_{\text{bromine water}}$
$AlCu_3$	c		23.	*S* 303.$_{\text{bromine water}}$
Al_2Cu	c		84.	*S* 366.$_{\text{bromine water}}$
$AlCl_3 \cdot AgCl$	c		199.2	*S* 75.7[22]
Al_3Fe	c		25.0	*S* 371.$_{HCl\,(8)}$
AlCo	c		32.	*S* 106.$_{HCl\,(8)}$
Al_3Co	c		86.	*S* 565.9$_{HCl\,(8)}$

Scandium

Atomic number 21 Standard state Sc (c) Atomic weight 45.10

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Sc	g	$3d4s^2$ ($^2D_{3/2}$)	− 70.	
	c		0.000	
Sc*	g	$3d4s^2$ ($^2D_{5/2}$)	− 70.48	E^z − 0.479
	g	$3d^24s$ ($^4F_{3/2}$)	− 102.79	E^z − 32.79
	g	($^4F_{5/2}$)	− 102.90	E^z − 32.90
	g	($^4F_{7/2}$)	− 103 05	E^z − 33.05
	g	($^4F_{9/2}$)	− 103.24	E^z − 33.24
Sc+	g	3d4s ($^3D_1$)	− 225.	I^z −154.
Sc+ *	g	($^3D_2$)	− 225.2	E^z − 0 19
	g	($^1D_2$)	− 225.5	E^z − 0.51
	g	(^1D)	− 232 2	E^z − 7 23
	g	$3d^2$ ($^3F_2$)	− 238.7	
	g	($^3F_3$)	− 238 9	E^z − 13 90
	g	($^3F_4$)	− 239.1	E^z − 14.20
Sc++	g	3d ($^2D_{3/2}$)	− 522.	I^z −296.
	g	($^2D_{5/2}$)	− 522 6	E^z − 0.56
Sc+++	g	($^1S_0$)	−1022.	I^z −568 5
Sc_2O_3	c		410.	
$ScCl_3$	c		200.	

Yttrium

Atomic number 39 Standard state Y (c) Atomic weight 88.92

Y	g	$4d5s^2$ ($^2D_{3/2}$)	− 90.	
	c		0 000	
Y*	g	$4d5s^2$ ($^2D_{5/2}$)	− 91.51	E^z − 1.510
	g	$5s^25p$ ($^2P^1_{1/2}$)	− 119.97	E^z − 29 97
	g	($^2P^1_{3/2}$)	− 122 34	E^z − 32 34
	g	$4d^2(^3F)5s$ ($^4F_{3/2}$)	− 121.14	E^z − 31 14
	g	($^4F_{5/2}$)	− 121.51	E^z − 31.51
	g	($^4F_{7/2}$)	− 122.11	E^z − 32.11
	g	($^4F_{9/2}$)	− 122.83	E^z − 32.83
Y+	g	$5s^2$ ($^1S_0$)	− 241.	I^z −150.
Y+ *	g	4d5s ($^3D_1$)	− 243.4	E^z − 2.392
	g	($^3D_2$)	− 244.0	E^z − 2 975
	g	($^1D_2$)	− 250.4	E^z − 9.38
Y++	g	4d ($^2D_2$)	− 526.	I^z −284.
Y++ *	g	($^2D_3$)	− 528.1	E^z − 2.06
Y+++	g	$4p^6$	−1008.	I^z −470.5
	aq.	(estimated)	130.	
Y_2O_3	c		440.	
$Y(OH)_3$	c	ppt.	336.7	
YCl_3	c		240.	S 45.36^{16}_{200}
	aq.		285.4	
$Y_2(SO_4)_3$	aq.		974.1	
$Y_2(SO_4)_3 \cdot 8H_2O$	c		1510.4	S 10.68^{20}_{1200}

Lutecium

Atomic number 71 Standard state Lu (c) Atomic weight 175.0

Ytterbium

Atomic number 70 Standard state Yb (c) Atomic weight 173.04

Thulium

Atomic number 69 Standard state Tm (c) Atomic weight 169 4

Erbium

Atomic number 68 Standard state Er (c) Atomic weight 165.20

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
Er	c		0.000	
Er^{+++}	aq.	(estimated)	150.	
$Er(OH)_3$	c	ppt.	326.8	
$Er(C_2H_3O_2)_3$	aq.	erbium acetate	503.9	
$Er(C_2H_3O_2)_3 \cdot 4H_2O$	c		776 0	S $1\ 36^{20}{}_{1500}$

Holmium

Atomic number 67 Standard state Ho (c) Atomic weight 163.5

Dysprosium

Atomic number 66 Standard state Dy (c) Atomic weight 162.46

Terbium

Atomic number 65 Standard state Tb (c) Atomic weight 159.2

Gadolinium

Atomic number 64 Standard state Gd (c) Atomic weight 157.3

Europium

Atomic number 63 Standard state Eu (c) Atomic weight 152.0

Samarium

Atomic number 62 Standard state Sm (c) Atomic weight 150.43

Sm	c		0.000	
Sm^{+++}	aq.	(estimated)	160.	
Sm_2O_3	c		430.	S $94.6_{HCl(aq)}$
$SmCl_3$	c		241.0	S 37.4
	aq.		278.4	
$SmCl_3 \cdot NH_3$	c		272.6	D − 20.7^{375}
$SmCl_3 \cdot 2NH_3$	c		300.0	D − 16.4^{240}
$SmCl_3\ 3NH_3$	c		326 0	D − 15.1^{200}
$SmCl_3 \cdot 4NH_3$	c		350.7	D − 13.7^{155}
$SmCl_3 \cdot 5NH_3$	c		373.7	D − 12.1^{105}
$SmCl_3 \cdot 8NH_3$	c		440.2	D − 11.2^{76}
$SmCl_3\ 9\frac{1}{2}NH_3$	c		471.6	D − $10\ 0^{40}$
$SmCl_3\ 11\frac{1}{2}NH_3$	c		491.9	D − 9.2^{15}

Illinium

Atomic number 61 Standard state Il (c) Atomic weight (146?)

Neodymium

Atomic number 60 Standard state Nd (c) Atomic weight 144 27

Formula	State	Description	Qf, kcal mole^{-1}	Q, kcal mole^{-1}
Nd	c		0 000	
Nd^{+++}	aq		164	
Nd_2O_3	c	"high temperature"	435	
Nd_2O_3	c	"low temperature"	427	S $105\ 5_{HCl(aq.)}$
$NdCl_3$	c		246 7	S $35\ 5_{2000}$
$NdCl_3$	aq		282 2	
$NdCl_3 \cdot 6H_2O$	c		684 8	S $7\ 6^{15}{}_{2000}$
NdI_3	c		155 4	S $48\ 9^{19}{}_{2000}$
	aq		204 3	
Nd_2S_3	c		262 7	S $75\ 8^{18}{}_{HCl(110)}$
$Nd_2(SO_4)_3$	c		931 5	S $36\ 5_{400}$
	aq		968	
$Nd_2(SO_4)_3\ 5H_2O$	c		1301 6	S 8 3
$Nd_2(SO_4)_3\ 8H_2O$	c		1508 2	S 6 7
$NdCl_3\ NH_3$	c		277 8	D — $20\ 2^{360}$
$NdCl_3\ 2NH_3$	c		305 7	D — $16\ 9^{255}$
$NdCl_3\ 4NH_3$	c		355 0	D — $13\ 7^{157}$
$NdCl_3\ 5NH_3$	c		378 4	D — $12\ 5^{117}$
$NdCl_3\ 8NH_3$	c		144.9	D — $11\ 2^{79}$
$NdCl_3\ 11NH_3$	c		506.2	D — $9\ 5^{26}$
$NdCl_3\ 12NH_3$	c		525 6	D — $8\ 4^{-10}$

Praseodymium

Atomic number 59 Standard state Pr (c) Atomic weight 140.92

Pr	c		0 000	
Pr^{+++}	aq		170.	
PrO_2	c		231.5	S $42.9_{HNO_3(6)}$
Pr_2O_3	c		439 4	S $106.2_{HCl(aq.)}$
Pr_6O_{11}	c		1376.	S $270.6_{HNO_3(6)}$
$PrCl_3$	c		254 9	S 33.5_{2500}
	aq.		288.4	
$PrCl_3\ H_2O$	c		327.9	S $28.9^{17}{}_{2000}$
$PrCl_3\ 7H_2O$	c		761.7	S 5.3
$Pr(NO_3)_3$	aq.		317.9	

Cerium

Atomic number 58 Standard state Ce (c) Atomic weight 140.13

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
Ce	c		0 000	
Ce^{++++}	aq		165.	
CeO_2	c		233.4	
Ce_2H_3	c		169	
$Ce_2(OH)_3OOH$	c		398 6	
$CeCl_3$	c		261 5	*S* 31 5
	aq		283.	
$Ce(SO_4)_2$	c		424.	*D* −103 5
$Ce_2(SO_4)_3$	aq		977.	
$Ce_2(SO_4)_3\ 4\frac{1}{2}H_2O$	c		1260.4	*S* 16.1
CeN	c		78.2	*S* $119.2_{HCl(20)}$
$CeCl_3\ 2NH_3$	c		306.2	*D* − $11\ 4^{100}$
$CeCl_3\ 4NH_3$	c		349 0	*D* − $10\ 4^{67}$
$CeCl_3\ 8NH_3$	c		428.5	*D* − $8\ 9^{20}$
$CeCl_3\ 12NH_3$	c		503 9	*D* − 7.9^{-12}
$CeCl_3\ 20NH_3$	c		650.9	*D* − 7.4^{-30}
$CeHg_4$	c		23 2	
$CeZn_4$	c		49.	
$CeAl_4$	c		22	*S* $620._{HCl(20)}$
Ce_3Al	c		39	*S* $596.5_{HCl(20)}$

Lanthanum

Atomic number 57 Standard state La (c) Atomic weight 138.92

La	g	$5d6s^2$ ($^2D_{3/2}$)	− 90.	
	c		0 000	
La*	g	$5d6s^2$ ($^2D_{5/2}$)	− 93 00	E^s − 3.00
	g	$5d^2(^3F)6s$ ($^4F_{3/2}$)	− 97.59	E^s − 7.59
	g	($^4F_{5/2}$)	− 98.57	E^s − 8.57
	g	($^4F_{7/2}$)	− 99.95	E^s − 9.95
	g	($^4F_{9/2}$)	− 101 73	E^s − 11.73
La^{+++}	aq.		165 9	
La_2O_3	c		457.0	
La_2H_3	c		160.	*S* $333._{HCl(aq)}$
$LaCl_3$	c		253.1	*S* $31\ 3^{16}{}_{1200}$
	aq.		284 4	
LaS_2	c		148.3	*S* $31.8_{HCl(aq)}$
La_2S_3	c		351.4	*S* $71.8_{HCl(9\ 4)}$
$La_2(SO_4)_3$	aq.		972.	
$La_2(SO_4)_3\ 8H_2O$	c		1514.9	*S* 4.0_{2400}
LaN	c		72.8	*S* $127.1_{HCl(20)}$
$LaAl_4$	c		20.	

Actinium

Atomic number 89 Standard state Ac (c) Atomic weight (227.?)

Beryllium

Atomic number 4 Standard state Be (c) Atomic weight 9.02

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Be	g	$2s^2$ ($^1S_0$)	− 75.	
	liq.			F − 2.5^{1280}
	c		0.000	
Be*	g	2s2p ($^3P^1_0$)	− 137.58	E^z − 62.577
	g	($^3P^1_1$)	− 137.58	E^z − 62.578
	g	($^3P^1_2$)	− 137.59	E^z − 62.585
Be^+	g	2s ($^2S_{1/2}$)	− 290.51	I^z − 214.06
Be^+ *	g	2p ($^2P^1_{1/2}$)	− 380 40	E^z − 90.90
	g	($^2P^1_{3/2}$)	− 380.41	E^z − 90.91
Be^{++}	g	$1s^2$ ($^1S_0$)	− 800.0	I^z − 380.41
	aq.		85.	
Be^{+++}	g	1s ($^2S_{1/2}$)	−4333 6	I^z −3532.2
Be^{++++}	g		−9333 1	I^z −4998.1
BeO	g		− 12 6	
	c		135.0	
BeII	g		− 52.6	
BeII$^+$	g		− 661.	
BeII$^+$ *	g		− 861.	E^z − 200.
$Be(OH)_2$	c	ppt.	206.8	
BeF_2	aq.		240.8	
H_2BeF_4	aq.		392 6	
$BeCl_2$	g		83.0	
	liq.			F − 3.0^{405}
	c		112.6	S 51.1
	aq.		163.7	
	C_2H_5OH		150.	S $37.4_{C_2H_5OH}$
$BeBr_2$	g		48.	
	c		79.4	S $55.7_{HCl(6)}$
	aq.		142.	
BeI_2	g		11.	
	c		39.4	S $62.5_{HCl(aq.)}$
	aq.		112.	
$BeSO_4$	c		281.	
	aq.		299.1	
$BeSO_4 \cdot H_2O$	c		354.	D − 23.4
$BeSO_4\ 2H_2O$	c		427.9	S $8.0^{15}{}_{1000}$
$BeSO_4 \cdot 4H_2O$	c		571.5	S 1.10_{400}
$BeBr_2\ 2H_2S$	c		107.7	
$BeI_2 \cdot 2H_2S$	c		64.0	
$Be(NO_3)_2$	aq.		183.4	
$BeCl_2 \cdot 2NH_3$	c		234.5	D − 18.2
$BeCl_2 \cdot 4NH_3$	c		292.8	S $28.3_{HCl(6)}$
$BeCl_2\ 6NH_3$	c		330.7	D − 8.04
$BeCl_2 \cdot 12NH_3$	c		442.0	D − 7.8

Beryllium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$BeBr_2 \cdot 4NH_3$	c		165.6	S 33 7$_{HCl(9)}$
$BeBr_2 \cdot 6NH_3$	c		304.7	D — 8.8
$BeBr_2 \cdot 10NH_3$	c		379.9	D — 7.85
$BeI_2 \cdot 4NH_3$	c		231.2	S 34.8$_{HCl(aq)}$
$BeI_2 \cdot 6NH_3$	c		272.5	D — 8 9
$BeI_2 \cdot 13NH_3$	c		404.0	D — 7.9

Magnesium

Atomic number 12 Standard state Mg (c) Atomic weight 24.32

Mg	g	$3s^2$ ($^1S_0$)	— 36.3	
	liq.			F — 1 70^{600}
	c		0.000	
Mg*	g	3s3p ($^3P^1_0$)	— 98.51	E^x — 62 21
	g	($^3P^1_1$)	— 98.56	E^x — 62 26
	g	($^3P^1_2$)	— 98 68	E^x — 62.38
Mg^+	g	3s ($^2S_{1/2}$)	— 213 31	I^x — 175 56
Mg^+ *	g	3p ($^2P^1_{1/2}$)	— 314.86	E^x — 101.55
	g	($^2P^1_{3/2}$)	— 315.10	E^x — 101.79
Mg^{++}	g	$2p^6$ ($^1S_0$)	—* 559.98	I^x — 345.22
	∞		110.23	
Mg^{+++}	g	$2p^5$ ($^2P^1_{3/2}$)	—2414.	I^x —1853
	g	($^2P^1_{1/2}$)	—2420.	E^x — 6 05
Mg^{++++}	g	$2p^4$ ($^3P_2$)	—4931.	I^x —2515 6
MgO	c		146.1	
MgH	g	$^2\Sigma$	— 55.7	
MgH*	g	$^2\Pi$	— 109.4	
MgH^+	g	$^1\Sigma^+$	— 222.5	
$Mg(OH)_2$	c	ppt.	218.7	
	c	brucite	223 9	D — 19.4
MgF	g		— 95.	
MgF_2	c	ppt.	263.8	
$MgCl_2$	c		153.3	S 35.9$_{800}$
	∞		189 60	
	6400		189.43	
	3200		189.37	
	1600		189.30	
	800		189.22	
	400		189.13	
	200		189.02	
	100		188.81	

Magnesium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$MgCl_2$	50		188.53	
	20		187.61	
	10		185.29	
$MgCl_2 \cdot 2H_2O$	c		305.5	S 20.4_{400}
$MgCl_2 \cdot 4H_2O$	c		452.6	S 10.0_{400}
$MgCl_2 \cdot 6H_2O$	c		596.4	S 2.94_{400}
	liq.			F $-$ 9.6^{120}
$MgCl_2 \cdot MgO$	c		421.1	S $14.5_{HCl(aq.)}$
$MgCl_2 \cdot MgO \cdot 6H_2O$	c		810.2	S $36._{HCl(aq.)}$
$MgCl_2 \cdot MgO \cdot 16H_2O$	c		1507.9	S $22.0_{HCl(aq)}$
$MgO \cdot HCl$	c		194.1	
$MgBr_2$	c		123.9	S 43.3
	∞		167.57	
	6400		167.41	
	3200		167.35	
	1600		167.29	
	800		167.22	
	400		167.16	
$MgBr_2 \cdot H_2O$	c		200.0	D $-$ 18.3
$MgBr_2 \cdot 6H_2O$	c		558.	D $-$ 11.7
MgI_2	c		86.8	S 49.8
	∞		136.97	
	6400		136.82	
	3200		136.77	
	1600		136.71	
	800		136.65	
	400		136.61	
MgS	c		82.2	S $38.0^{13}_{HCl(aq.)}$
	aq.		108.	
$MgSO_3$	c		240.0	S $16.88^{12}_{HCl(220)}$
$MgSO_3 \cdot 3H_2O$	c		460.8	S $1.17_{HCl(220)}$
$MgSO_3 \cdot 6H_2O$	c		672.7	S $-$ $5.63_{HCl(220)}$
$MgSO_4$	c		304.95	S 20.30_{400}
	∞		326.03	
	6400		325.52	
	3200		325.42	
	1600		325.30	
	800		325.25	
	400		325.25	
	200		325.18	
	100		325.11	
	50		325.07	
	20		324.79	
$MgSO_4 \cdot H_2O$	c		380.4	S 13.3_{400}
$MgSO_4 \cdot 2H_2O$	c		451.03	S 11.05_{400}

Magnesium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$MgSO_4 \cdot 4H_2O$	c		594.6	S 4.24$_{400}$
$MgSO_4 \cdot 6H_2O$	c		735.7	S − 0.10$_{400}$
$MgSO_4 \cdot 7H_2O$	c		807.8	S − 3.85$_{400}$
MgS_2O_6	aq.		390.1	
$MgS_2O_6 \cdot 6H_2O$	c		803.3	S − 2.97$_{400}$
$Mg(HS)_2$	aq.		117.4	
Mg_3N_2	c		116.	
$Mg(NO_3)_2$	∞		208.610	
	550000		208.587	
	62000		208.558	
	11300		208 485	
	5500		208.442	
	2460		208.385	
	1375		208.343	
	555		208.278	
	400		208.27	
	200		208.22	
	100		208.21	
	50		208.25	
	20		208.26	
	15		208.11	
	12		207.85	
$Mg(NO_3)_2 \cdot 6H_2O$	c		622.5	S − 4.22$_{400}$
	liq.			F − 9.7^{90}
$Mg(NH_3)_2^{++}$	aq.		148.5	
$MgCl_2 \cdot NH_3$	c		185.0	D − 20.8
$MgCl_2 \cdot 2NH_3$	c		215.6	D − 19.7
	aq.		227.5	
$MgCl_2 \cdot 6NH_3$	c		312.7	D − 13.3
$MgBr_2 \cdot NH_3$	c		156.7	D − 21.7
$MgBr_2 \cdot 2NH_3$	c		187.7	D − 20.1
$MgBr_2 \cdot 6NH_3$	c		292.4	D − 15.2
$MgI_2 \cdot 2NH_3$	c		154.3	D − 22.7
$MgI_2 \cdot 6NH_3$	c		267.0	D − 17.2
$3MgSO_3 \cdot (NH_4)_2SO_3 \cdot 6H_2O$	c		1381.9	S 8.9$_{HCl(aq.)}$
$3MgSO_3 \cdot (NH_4)_2SO_3 \cdot 18H_2O$	c		2233.5	S − 22.3$_{HCl(aq.)}$
$MgSO_4 \cdot (NH_4)_2SO_4 \cdot 4H_2O$	c		936.2	
$MgSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$	c		1024.4	S − 9.7
$Mg_3(PO_4)_2$	c	ppt.	915.8	
	aq.		926.	
$MgHPO_4$	aq.		415.	
$MgNH_4PO_4 \cdot 6H_2O$	c		901.4	
$Mg_3(AsO_4)_2$	c	ppt.	731.3	
	aq.		749.	
$MgHAsO_4$	aq.		323.	

Magnesium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$Mg(H_2AsO_4)_2$	aq.		541.	
$MgNH_4AsO_4\,6H_2O$	c		763 9	
$MgCO_3$	c		268.	
$MgCO_3{\cdot}H_2O$	c		339 8	
$MgCO_3\,3H_2O$	c		480.8	
$Mg(C_2H_3O_2)_2$	∞	magnesium acetate	346.12	
$Mg(C_2H_3O_3)_2$	c	magnesium glycollate	415.0	S 4.4
	aq		419.4	
$Mg(C_2H_3O_3)_2{\cdot}2H_2O$	c		557.7	S − 1 5
$MgCl_2\,6CH_3OH$	c		517.	D − 12.
$MgCN_2$	c	magnesium cyanamide	61.	C 179.2
$Mg(CN)_2$	aq		40.4	
$Mg(NO_3)_2\,6CH_3OH$	c			D − 13 77
$MgSiO_3$	c		347.5	
Mg_2Sn	c		59.	
$2MgI_2{\cdot}PbI_2$	c		206 9	S 110.5[15]
$MgZn_2$	c		13 1	
MgCd	c	I		T $0.28^{243}{}_{\rightarrow II}$
	c	II	9 2	S $123.7_{HCl(8)}$
$MgHg_4$	c		17.3	
$MgBr_2{\cdot}HgBr_2$	4400		207.4	
$MgBr_2\,2HgBr_2$	4200		245.0	
$2MgBr_2\,HgBr_2$	4800		376.5	
$Mg(CN)_2\,Hg(CN)_2$	600		− 11 9	
$Mg(CN)_2\,2Hg(CN)_2$	900		− 75.6	
$MgCl_2\,2Hg(CN)_2$	1000		59 3	
$MgCl_2\,2Hg(CN)_2\,6H_2O$	c		479 9	S − 10 3[16]
$MgBr_2\,2Hg(CN)_2$	1000		38.5	
$MgBr_2\,2Hg(CN)_2\,8H_2O$	c		601 5	S − 16 0[14]
$MgI_2{\cdot}2Hg(CN)_2$	1000		12.7	
$MgI_2\,2Hg(CN)_2\,8H_2O$	c		579.6	S − 20.0[15]
$MgMoO_4$	c		329 9	
$MgWO_4$	c		345 2	
Mg_4Al_3	c		49.0	S $779._{HCl(8)}$
MgCe	c		13.0	S $260.5^{25}{}_{HCl(20)}$
Mg_3Ce	c		17.0	S $477.3^{25}{}_{HCl(20)}$
$Mg_7B_{16}O_3Cl_2$	c	borocite		T − 1.3^{285}

Calcium

Atomic number 20 Standard state Ca (c, II) Atomic weight 40.08

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
Ca	g	$4s^2$ ($^1S_0$)	− 47.8	
	liq.			F − 9.6^{800}
	c	I		T $0\ 10^{400}{}_{\rightarrow II}$
	c	II	0.000	
Ca*	g	4s4p ($^3P^1{}_0$)	− 90.95	E^z − 43 15
	g	($^3P^1{}_1$)	− 90 10	E^z − 43 30
	g	($^1P^1{}_1$)	− 91 40	E^z − 43.60
Ca^+	g	4s ($^2S_{1/2}$)	− 189 61	I^z − 140 36
Ca^+ *	g	3d ($^2D_{3/2}$)	− 228 47	E^z − 38 86
	g	($^2D_{5/2}$)	− 228.63	E^z − 39 02
	g	4p ($^2P_{1/2}$)	− 261 33	E^z − 71 72
	g	($^2P_{3/2}$)	− 261 96	E^z − 72 35
Ca^{++}	g	$3p^6$ ($^1S_0$)	− 463 63	I^z − 272.57
	∞		129.71	
Ca^{+++}	g	$3p^5$ ($^2P^1{}_{3/2}$)	−1642.2	I^z −1176.1
CaO	g		29.	
	liq.			F − $28.^{2570}$
	c		151.7	
	c	prepared at 1000°	151 8	
CaO_2	c		156 4	S $18\ 9_{HCl\,(100)}$
$CaO_2\ 8H_2O$	c		719.0	
CaH	g		− 55 3	D^z − 43.5
CaH_2	c		46.	S $82.7_{HCl\,(aq\ )}$
$Ca(OH)_2$	c		236 0	
	∞		239 06	
	800		238.7	
$Ca(OH)_2{\cdot}H_2O_2$	c		291.2	
CaF	g		− 3.	
CaF_2	c		290.2	
	∞		286.14	
CaCl	c	(?)	96.9	S $72.2_{HCl\,(aq\ )}$
$CaCl_2$	c	fused	190.6	S $18\ 0_{200}$
	∞		209.117	
	6400		208.954	
	3200		208.898	
	1600		208.835	
	800		208.771	
	400		208.688	
	200		208.6	
	100		208.501	
	50		208.363	
	20		208.78	
	10		206.15	

Calcium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$CaCl_2$	6		204.2	
$CaCl_2 \cdot H_2O$	c		265.2	S 11.7_{400}
$CaCl_2 \cdot 2H_2O$	c		333.4	S 10.0_{400}
$CaCl_2 \cdot 4H_2O$	c		480.2	S 1.85_{400}
$CaCl_2 \cdot 6H_2O$	c		623.45	S $-$ 4.56_{400}
	liq.		614.4	
$CaCl_2 \cdot 2CaO$	c		505.4	S $99.5^{13}_{HCl(aq)}$
$CaCl_2 \cdot 3CaO$	c		656.	S $147.3^{13}_{HCl(aq)}$
$CaCl_2\ 3CaO \cdot 3H_2O$	c		910.5	S $97.7^{13}_{HCl(aq)}$
$CaCl_2 \cdot 3CaO \cdot 16H_2O$	c		1833.8	S $63.4^{13}_{HCl(aq.)}$
$CaOCl_2$	c		177.9	S 9.83
	aq.		187.8	
$CaOCl_2 \cdot H_2O$	c		248.6	S 7.53
$Ca(ClO)_2$	aq.		180.2	
$CaBr_2$	c		162.22	S 24.5_{400}
	∞		187.08	
	6400		186.95	
	3200		186.88	
	1600		186.83	
	800		186.77	
	400		186.72	
$CaBr_2 \cdot 6H_2O$	c		598.2	S $-$ 1.09_{400}
$CaBr_2\ 3CaO\ 3H_2O$	c		888.5	S $97.7^{16}_{HBr(aq.)}$
$CaBr_2 \cdot 3CaO \cdot 16H_2O$	c		1811.6	S $93.5^{20}_{HBr(aq.)}$
CaI_2	c		128.48	S 27.70_{400}
	∞		156.48	
	6400		156.34	
	3200		156.30	
	1600		156.26	
	800		156.21	
	400		156.18	
$CaI_2 \cdot 8H_2O$	c		701.6	S 1.74^{20}
$CaI_2 \cdot 3CaO \cdot 16H_2O$	c		1781.2	S $63.4_{HI(aq)}$
CaS	c		113.4	S $26.3^{11}_{HCl(aq.)}$
	aq.		119.8	
$CaSO_3 \cdot 2H_2O$	c		418.7	
$CaSO_4$	c	"insoluble"	340.7	
	c	"soluble"	340.4	
	∞		345.54	
	6400		344.97	
	3200		344.86	
	1600		344.75	
	800		(344.71)	
$CaSO_4 \cdot \frac{1}{2}H_2O$	c		376.11	
$CaSO_4 \cdot 2H_2O$	c		482.46	S $-$ 0.84_{800}

Calcium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
CaS_2O_3	800		275.2	
	350		275.05	
	230		275.01	
	116		274.87	
	34		274.60	
CaSe	c		81.8	S $34.8_{HCl(200)}$
CaN_6	c		− 75.8	
Ca_3N_2	c		109.5	S $342.7_{HCl(aq.)}$
$CaN_2O_2 \cdot 4H_2O$	c		405.4	
$Ca(NO_3)_2$	c		224.04	S 3.94_{400}
	∞		228.12	
	6400		227.98	
	3200		227.96	
	1600		227.94	
	800		227.94	
	400		227.98	
	200		228.24	
	100		228.29	
	4		228.3	
	200 C_2H_5OH		231.5	S $7.41^{25}_{C_2H_5OH}$
$Ca(NO_3)_2 \cdot H_2O$	c		295.8	
$Ca(NO_3)_2 \cdot 2H_2O$	c		368.07	S − 3.35_{400}
$Ca(NO_3)_2 \cdot 3H_2O$	c		437.41	S − 4.32_{400}
$Ca(NO_3)_2 \cdot 4H_2O$	c		509.59	S − 8.13_{400}
	liq.		501.8	
$Ca(NH_2)_2$	c		91.5	S $101.7^{14}_{HCl(aq)}$
$Ca(NO_3)_2 \cdot Ca(OH)_2$	c		461.2	S $33.2_{HNO_3(aq.)}$
$Ca(NO_3)_2 \cdot Ca(OH)_2\ 2\frac{1}{2}H_2O$	c		552.2	S $24.8_{HNO_3(aq.)}$
$CaCl_2 \cdot NH_3$	c		218.5	D − 17.
$CaCl_2 \cdot 2NH_3$	c		244.5	D − 15.0
$CaCl_2 \cdot 4NH_3$	c		287.0	D − 10.1
$CaCl_2\ 8NH_3$	c		370.4	D − 9.8
$CaBr_2 \cdot NH_3$	c		191.9	D − 18.6
$CaBr_2 \cdot 2NH_3$	c		219.9	D − 17.0
$CaBr_2 \cdot 6NH_3$	c		310.5	D − 11.7
$CaBr_2 \cdot 8NH_3$	c		351.9	D − 9.8
$CaI_2 \cdot NH_3$	c		159.2	D − 19.7
$CaI_2 \cdot 2NH_3$	c		189.2	D − 19.0
$CaI_2 \cdot 6NH_3$	c		289.0	D − 14.0
$CaI_2 \cdot 8NH_3$	c		327.7	D − 8.4
$CaSO_4 \cdot (NH_4)_2SO_4 \cdot H_2O$	c		694.5	S − 2.16
$2CaSO_4 \cdot (NH_4)_2SO_4$	c		964.7	S 4.38
$5CaSO_4 \cdot (NH_4)_2SO_4 \cdot H_2O$	c		2070.1	S 2.32
$Ca_3(PO_4)_2$	c		983.	
	aq.		984.	

Calcium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$Ca_3(PO_4)_2$	colloid	in water	977.	
$CaHPO_4$	aq.		434.	
$CaHPO_4\,2H_2O$	c		571.7	
$Ca(H_2PO_4)_2$	aq.		744.	
$Ca(H_2PO_4)_2\,H_2O$	c		813.	
$Ca(H_2PO_4)_2\,H_2O\,NH_3$	c		835.6	D — 11.6
$Ca(H_2PO_4)_2\,H_2O\,2NH_3$	c		855.6	D — 9.1
$Ca(H_2PO_4)_2\,H_2O\,4NH_3$	c		892 8	D — 7.6
$Ca_3(AsO_4)_2$	c	ppt.	794.	
	aq		808.	
$CaHAsO_4$	aq.	ppt.	343.	
$Ca(H_2AsO_4)_2$	aq.	ppt.	560.	
CaC_2	c		14.5	S $60.8_{HCl(100)}$
$CaCO_3$	c	calcite, I	289 5	S $3.24^{25}{}_{HCl(50)}$
	c	aragonite, II	289 51	T — $0.04^{25}{}_{\rightarrow I}$
CaC_2O_4	c	ppt , calcium oxalate	333.1	
$Ca(CHO_2)_2$	c	calcium formate	328.3	S $0.66^{16}{}_{360}$
	400		329.0	
$Ca(HCO_3)_2$	aq.	calcium bicarbonate	460.2	
$Ca(C_2H_3O_2)_2$	c	calcium acetate	358 0	S $7.0^{16}{}_{440}$
	∞		365.64	
$Ca(C_2H_3O_2)_2\,H_2O$	c		427.5	S $5.86^{17}{}_{440}$
$Ca(C_2H_4O_3)_2$	c	calcium glycollate	443 2	S — 1.62
	aq.		441.6	
$Ca(C_2H_3O_4)_2\,3H_2O$	c		653 8	S — 7.06
$Ca(C_2H_7O_3)_2\,5H_2O$	c		791.0	S — 7.6
$Ca(C_2H_5O)_2$	c	calcium alcoholate	229.0	S $40.27^{15}{}_{HCl(110)}$
$Ca(C_2H_5O)_2\,2C_2H_5OH$	c		372.1	S $36.8_{HCl(110)}$
$3CaO\,4C_2H_5OH$	c		780 5	S $92.9_{HCl(aq.)}$
$CaCl_2\,3C_2H_5OH$	c		405.8	D — 14.6
$CaCl_2{\cdot}4C_2H_5OH$	c		474.9	D — 12.
$CaCl_2{\cdot}(CH_3)_2CO$	c			D — 11.4
$CaBr_2{\cdot}3C_2H_5OH$	c		380.2	D — 15.5
$CaBr_2{\cdot}4C_2H_5OH$	c		451.9	D — 14.6
$CaCN_2$	c		85.	S 161.2
$Ca(CN)_2$	aq.		60.2	
$Ca(NO_3)_2\,2CH_3OH$	c		344.1	D — 11.4
$3CaO{\cdot}Ca(CN)_2{\cdot}15H_2O$	c		1608.0	S $94.0^{15}{}_{HCl(aq.)}$
$CaSi$	c		87.	

Calcium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$CaSi_2$	c		220.	
$CaSiO_3$	c	II, wollastonite	377.9	$T - 1.26_{.I}$
	c	I, pseudowollastonite	376.6	
$CaSiO_4$	gls.		537.	
$CaSn_3$	c		52.	
$CaI_2\ 2PbI_2$	c		223.4	S $16\ 61^{15}{}_{300}$
$CaI_2\ 2PbI_2\ 7H_2O$	c		713.3	S 5 3
$CaZn_4$	c		29 5	S $219.5_{HCl(20)}$
$CaZn_{10}$	c		48.	S $381._{HCl(20)}$
Ca_2Zn_3	c		40.	S $307.8_{HCl(20)}$
Ca_4Zn	c		32.	S $512._{HCl(20)}$
$CaCd_3$	c		30.	S $159.6_{HCl(8)}$
$CaBr_2\ HgBr_2$	1400		226.9	
$CaBr_2\ 2HgBr_2$	8400		264.5	
$Ca(CN)_2\ Hg(CN)_2$	900		8.4	
$Ca(CN)_2\ 2Hg(CN)_2$	900		54.85	
$CaCl_2\ 2Hg(CN)_2$	1000		79 5	
$CaCl_2\ 2Hg(CN)_2\ 6H_2O$	c		504.3	S $14\ 6^{15}$
$CaBr_2\ 2Hg(CN)_2$	1000		58.4	
$CaBr_2\ 2Hg(CN)_2\ 7H_2O$	c		556 8	S 19.8^{15}
$CaI_2\ 2Hg(CN)_2$	1000		32 2	
$CaI_2\ 2Hg(CN)_2\ 6H_2O$	c		464.8	S 22.4
$Ca(CN)_2\ AgCN$	1000		68.8	
$Ca(CN)_2\ 2AgCN$	500		7 5	
$CaO\ Fe_2O_3$	c		399.	
$Ca_2Fe(CN)_6$	aq		138 1	N 56 4
$Ca_2Fe(CN)_6\ 12H_2O$	c		963 2	S $-\ 4\ 6^{10}$
$CaH_2Fe(CN)_6$	aq.		8 1	N 28 4
$CaWO_4$	c		387.	
$CaO\ B_2O_3$	c		462 7	S $22\ 5_{HCl(aq)}$
$CaO\ 2B_2O_3$	c		751.5	S $20\ 9_{HCl(aq)}$
$2CaO\ B_2O_3$	c		632 2	S $51.0_{HCl(aq)}$
$3CaO\ B_2O_3$	c		797 8	S $83.35_{HCl(aq)}$
$CaAl_3$	c		51.	S $454._{HCl(8)}$
$CaO{\cdot}Al_2O_3$	gls.		620.	
$2CaO{\cdot}Al_2O_3$	gls.		857.	
$3CaO{\cdot}Al_2O_3$	gls.		1098.	
$3CaCl_2\ 4AlCl_3$	c		1457.8	S 146.8
$3CaO{\cdot}Al_2O_3{\cdot}2SiO_2$	c		1292.	
$CaO{\cdot}Al_2O_3\ 6SiO_2$	c		3287.	S $286._{HF(4\ 44)}$
Ca_3Mg_4	c		43.	S $800._{HCl(8)}$
$CaCl_2{\cdot}2MgCl_2{\cdot}2H_2O$	c		701.0	S 22.3
$CaCO_3{\cdot}MgCO_3$	c	dolomite	559.7	

Strontium

Atomic number 38 Standard state Sr (c) Atomic weight 87.63

Formula	State	Description	Qf, kcal, mole^{-1}	Q, kcal. mole^{-1}
Sr	g	$5s^2$ ($^1S_0$)	− 47.	
	liq.			F − 1.4^{750}
	c		0 000	
Sr*	g	5s5p ($^3P^1_0$)	− 87.76	E^s − 40.759
	g	($^3P^1_1$)	− 88.29	E^s − 41.291
	g	($^3P^1_2$)	− 89.41	E^s − 42.414
	g	5s5d ($^1D_1$)	− 98.70	E^s − 51.697
	g	($^3D_2$)	− 98.87	E^s − 51.866
	g	($^3D_3$)	− 99.15	E^s − 52.152
Sr^+	g	5s ($^2S_{1/2}$)	− 179.19	I^s −130.74
Sr^+ *	g	4d ($^2D_2$)	− 212.63	E^s − 41.44
	g	($^2D_3$)	− 213.43	E^s − 42.238
Sr^{++}	g	$4p^6$ ($^2S_{1/2}$)	− 425.59	I^s −252.95
	∞		130 04	
SrO	g		− 3.0	Vs -140.0^{120}
	c		140.8	S $30.0^{15}{}_{1100}$
SrO_2	c		153.3	S $22.23^{15}{}_{HCl(900)}$
$SrO_2\,9H_2O$	c		789.2	S $1.74^{15}{}_{HCl(200)}$
Sr_2O	c		153.6	S $174.9^{15}{}_{HCl(aq)}$
SrH_2	c		42.1	S $88.0^{7}{}_{HCl(200)}$
$Sr(OH)_2$	c		228 7	S 10.5_{1100}
	∞		239 36	
	800		239 2	
$Sr(OH)_2{\cdot}H_2O$	c		302.1	S $5.26^{15}{}_{1100}$
$Sr(OH)_2{\cdot}8H_2O$	c		800 5	S − $14.27^{15}{}_{1100}$
SrF	g		− 27.	D − 77.
SrF_2	c		289 0	
SrCl	c	(?)	106.5	S $63.0^{15}{}_{HCl(100)}$
$SrCl_2$	c		197.87	S 11.15_{400}
	∞		209.41	
	6400		209.25	
	3200		209.20	
	1600		209.13	
	800		209.07	
	400		209.02	
	200		209.0	
	100		208.987	
	50		208.978	
$SrCl_2{\cdot}H_2O$	c		271.4	S $6.0^{17}{}_{400}$
$SrCl_2{\cdot}2H_2O$	c		343.2	S 2.51_{400}
$SrCl_2{\cdot}6H_2O$	c		626.7	S − 7.51_{400}
$Sr(ClO)_2$	aq.		179.9	N 17.8
$SrCl_2{\cdot}SrO{\cdot}H_2O$	c		436.7	S $39.3^{22}{}_{HCl(100)}$
$SrCl_2{\cdot}SrO{\cdot}9H_2O$	c		1006.2	S $16.72^{22}{}_{HCl(100)}$

Strontium

Formula	State	Description	*Qf*, *kcal, mole*$^{-1}$	*Q, kcal. mole*$^{-1}$
$SrBr_2$	c		171.0	*S* 16.1_{400}
	∞		187.38	
	6400		187.23	
	3200		187.19	
	1600		187.14	
	800		187.09	
	400		187.06	
$SrBr_2 \cdot H_2O$	c		246.5	*S* 8.9_{400}
$SrBr_2 \cdot 2H_2O$	c		317.6	*S.* 6.2_{400}
$SrBr_2 \cdot 4H_2O$	c		460.5	*S* 0.0_{400}
$SrBr_2 \cdot 6H_2O$	c		603 7	*S* − 6.45_{400}
$SrBr_2 \cdot SrO\ 3H_2O$	c		552 7	*S* $38\ 5_{HBr(aq)}$
$SrBr_2 \cdot SrO\ 9H_2O$	c		984.8	*S* $16\ 45^{20}{}_{HBr(aq)}$
SrI_2	c		136 1	*S* 20.6
	∞		156.78	
	6400		156.64	
	3200		156.60	
	1600		156.57	
	800		156.54	
	400		156.52	
$SrI_2 \cdot H_2O$	c		212.5	*S* 12.4
$SrI_2 \cdot 2H_2O$	c		283.1	*S* 10.17^{19}
$SrI_2 \cdot 6H_2O$	c		371.5	*S* − 4.73
SrS	c		113.1	*S* $27.0_{HCl(aq)}$
	aq.		120.3	
$SrSO_4$	c		345.3	
	∞		345.8	
	6400		345.2	
	3200		345.1	
	1600		345 0	
	800		344.9	
	400		344.8	
SrS_2O_6	aq.		410.2	
$SrS_2O_6 \cdot 4H_2O$	c		693.0	*S* − 9.25_{400}
$Sr(HS)_2$	aq.		137.9	
$SrI_2 \cdot 2SO_2$	c		300.2	*D* − 11.1
$SrI_2 \cdot 4SO_2$	c		463.5	*D* − 10.7
SrSe	c		83.4	*S* 33.6
	aq.		104.6	
SrN_6	c		− 49.0	
Sr_3N_2	c		92.2	*S* $361.6_{HCl(200)}$
SrN_2O_2	aq.		126.4	
$SrN_2O_2 \cdot 5H_2O$	c		474.0	
$Sr(NO_3)_2$	c		233.2	*S* − 4.7_{400}
	∞		228.420	

Strontium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$Sr(NO_3)_2$	550000		228.403	
	21000		228 348	
	5550		228 313	
	2000		228 304	
	1000		228.340	
	400		228 52	
	200		228 78	
	100		228 91	
	50		229 90	
	20		231.16	
$Sr(NO_3)_2\,4H_2O$	c		514 3	S — 12 3_{400}
$Sr(NH_2)_2$	c		82 8	S 110 $8^{7}{}_{HCl\,(200)}$
$Sr\,6NH_3$	c		123 3	D — 9.6
$SrCl_2{\cdot}NH_3$	c		220 3	D — 11 5
$SrCl_2\,2NH_3$	c		241 7	D — 10 5
$SrCl_2\,8NH_3$	c		370 0	D — 10 4
$SrBr_2\,NH_3$	c		198 3	D — 16.8
$SrBr_2\,2NH_3$	c		222 0	D — 12 8
$SrBr_2\,8NH_3$	c		375 5	D — 10 9
$SrI_2\,NH_3$	c		165 4	D — 18 3
$SrI_2\,2NH_3$	c		191 9	D — 15 5
$SrI_2\,6NH_3$	c		286 1	D — 12 8
$SrI_2\,8NH_3$	c		330 0	D — 11 0
$SrSO_4\,(NH_4)_2SO_4$	c		627 6	S — 3 20
$Sr_3(PO_4)_2$	c	ppt.	980	
	aq.		985.	
$SrHPO_4$	aq.		434.	
$Sr(H_2PO_4)_2$	aq		745	
$Sr_3(AsO_4)_2$	c	ppt	797.	
	aq.		809.	
$SrHAsO_4$	aq		343.	
$Sr(H_2AsO_4)_2$	aq.		560.	
$SrCO_3$	c		290.1	
$SrC_2O_4\,2\frac{1}{2}H_2O$	c	strontium oxalate hydrate	503 1	
$Sr(CHO_2)_2$	c	strontium formate	328 0	S 0 $62^{15}{}_{600}$
	aq.		329 6	
$Sr(CHO_2)_2{\cdot}2H_2O$	c		470 7	S — $5.46^{11}{}_{600}$
$Sr(HCO_3)_2$	aq	strontium bicarbonate	459.7	
$Sr(C_2H_3O_2)_2$	c	strontium acetate	359.7	S $5.56^{12}{}_{500}$
	∞		365.93	
	400		365 3	
$Sr(C_2H_3O_2)_2\,\frac{1}{2}H_2O$	c		394.2	S $5.26^{12}{}_{200}$

Strontium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal mole*$^{-1}$
$Sr(C_2H_3O_3)_2$	c	glycollate	444.3	*S* — 1.2
	aq		443.1	
$SrBr_2\ 1\frac{1}{2}CH_3OH$	c		257.8	*D* — 9.14
$Sr(CN)_2$	aq.		60.2	
$Sr(CN)_2\ 4H_2O$	c		338 6	$S - 4.15^{8}_{200}$
$SrSiO_3$	gls.		364.	
$SrI_2\ 2PbI_2$	c		222 9	*S* 17.55
$SrI_2\ 2PbI_2\ 7H_2O$	c		714 3	$S\ 4.70^{15}$
$SrHg_\infty$	liq		59 5	
$SrBr_2\ HgBr_2$	4400		227 3	
$SrBr_2\ 2HgBr_2$	8400		265.0	
$2SrBr_2\ HgBr_2$	4800		416 8	
$Sr(CN)_2\ Hg(CN)_2$	600		8 0	
$Sr(CN)_2\ 2Hg(CN)_2$	900		55 2	
$SrCl_2\ 2Hg(CN)_2$	1000		79 8	
$SrCl_2\ 2Hg(CN)_2\ 6H_2O$	c		505 8	$S - 15\ 8^{15}$
$SrBr_2\ 2Hg(CN)_2$	1000		58 9	
$SrBr_2\ 2Hg(CN)_2\ 6H_2O$	c		487 7	$S - 18.6^{15}$
$SrI_2\ 2Hg(CN)_2$	1000		32 6	
$SrI_2\ 2Hg(CN)_2\ 7H_2O$	c		533 0	$S - 21\ 8$
$Sr(CN)_2\ AgCN$	600		34 1	
$Sr(CN)_2\ 2AgCN$	500		6 6	
$Sr_3(FeCO(CN)_5)_2$	c		266.5	$S\ 39.9^{13}_{5300}$
	aq		306 4	
$Sr_3(FeCO(CN)_5)_2\ 4H_2O$	c		547 5	$S\ 32.4^{13}_{5700}$
$Sr(CN)_2{\cdot}Ni(CN)_2$	aq.		95.7	
$SrWO_4$	c		393	
$3SrCl_2\ 4AlCl_3$	c		1277 0	$S\ 328.8^{21}_{1600}$

Barium

Atomic number 56 Standard state Ba (c) Atomic weight 137.36

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Ba	g	$6s^2$ ($^1S_0$)	− 49.	
	liq.			F − 1.40^{660}
	c		0.000	
Ba*	g	6s5d ($^3D_1$)	− 74.72	E^z − 25.717
	g	($^1D_2$)	− 75.23	E^z − 26.234
	g	($^3D_3$)	− 76 32	E^z − 27.319
	g	($^1D_2$)	− 81.44	E^z − 32 437
	g	6s6p ($^3P^1_0$)	− 83 92	E^z − 34 919
	g	($^3P^1_1$)	− 84.74	E^z − 35.739
	g	($^3P^1_2$)	− 87.47	E^z − 38.473
Ba^+	g	6s ($^2S_{1/2}$)	− 160.10	I^z −119.645
Ba^+ *	g	($^2D_{3/2}$)	− 173.97	E^z − 13.874
	g	($^2D_{5/2}$)	− 176.25	E^z − 16.155
	g	6p ($^2P^1_{1/2}$)	− 217.78	E^z − 57 68
	g	($^2P^1_{3/2}$)	− 223.58	E^z − 62.49
Ba^{++}	g	$5p^6$ ($^1S_0$)	− 391.16	I^z −229.61
	∞		128.36	
BaO	g		40.	V − 90.0^{1200}
	c		133.	
BaO_2	c		152.4	S 22.0$^{13}{}_{HCl(330)}$
BaO_2H_2O	c		223.4	S 19.1$_{HCl(aq)}$
$BaO_2{\cdot}10H_2O$	c		855.1	S 2.72
Ba_2O	c		149.	S 176.4$^{15}{}_{HCl(aq)}$
BaH_2	c		40.8	S 87.6$^{7}{}_{HCl(aq.)}$
$Ba(OH)_2$	c		225.9	S 11.60$_{660}$
	∞		237.68	
	400		237.43	
$Ba(OH)_2H_2O$	c		298 6	S 7.06$^{15}{}_{660}$
$Ba(OH)_2{\cdot}8H_2O$	c		798.9	S − 14.50$^{15}{}_{660}$
$BaO_2{\cdot}H_2O_2$	c		208.1	S 11.8$^{12}{}_{HCl(aq.)}$
BaF_2	c		287.9	
	∞		284.76	
	1600		284.4	
$BaCl_2$	c		205.28	S 2.07$_{400}$
	∞		207.73	
	6400		207.57	
	3200		207.52	
	1600		207.46	
	800		207.40	
	400		207.350	
	200		207.3	
	100		207.272	
	50		207.308	
$BaCl_2{\cdot}H_2O$	c		278.27	S − 1.55$_{400}$

Barium

Formula	State	Description	Qf, *kcal, mole*$^{-1}$	^{s}Q, *kcal. mole*$^{-1}$
$BaCl_2 \cdot 2H_2O$	c		349.0	S — 4.92_{400}
$Ba(ClO)_2$	aq.		180.	
$Ba(ClO_2)_2$	c		157.8	
$Ba(ClO_3)_2$	c		176.6	S — $6.7^{10}{}_{800}$
	∞		169.86	
	1600		169.9	
$Ba(ClO_3)_2 \cdot H_2O$	c		248.8	S — 11.24_{600}
$Ba(ClO_4)_2$	c		210.2	S — $1.8^{10}{}_{800}$
	∞		207.36	
	800		208.2	
$Ba(ClO_4)_2 \cdot 3H_2O$	c		423.0	S — 9.4
$BaCl_2 \cdot BaO \cdot 3H_2O$	c		578.5	
$BaCl_2 \cdot BaO \cdot 5H_2O$	c		727.6	
$BaCl_2 \cdot BaO \cdot 8H_2O$	c		931.6	
$BaBr_2$	c		180.41	S 4.98_{400}
	∞		185.70	
	6400		185.56	
	3200		185.51	
	1600		185.46	
	800		185.42	
	400		185.39	
$BaBr_2 \cdot H_2O$	c		254.9	D — 16.70
$BaBr_2 \cdot 2H_2O$	c		326.31	S — 4.18_{400}
$Ba(BrO)_2$	aq.		176.	
$Ba(BrO_3)_2$	∞		150.76	
	800		151.6	
$Ba(BrO_3)_2 \cdot H_2O$	c		235.0	S — 15.06
$BaBr_2 \cdot BaO \cdot 2H_2O$	c		485.2	S $33.8_{HBr(aq.)}$
$BaBr_2 \cdot BaO \cdot 5H_2O$	c		704.7	S $18.5^{20}{}_{HBr(aq.)}$
BaI_2	c		144 6	S 10.29^{16}
	∞		155.10	
	6400		154.96	
	3200		154.93	
	1600		154.90	
	800		154.87	
	400		154.86	
$BaI_2 \cdot H_2O$	c		220.8	D — 18.8
$BaI_2 \cdot 2H_2O$	c		291.7	D — 13.5
$BaI_2 \cdot 2\frac{1}{2}H_2O$	c		326.6	D — 12.9
$BaI_2 \cdot 7H_2O$	c		640.30	S — 6.85_{400}
$Ba(IO_3)_2$	c		246.5	S — $4.6_{K_2SO_4(aq.)}$
	∞		237.36	
$Ba(IO_3)_2 \cdot H_2O$	c		317.0	
$BaI_2 \cdot BaO \cdot 2H_2O$	c		455.0	S $33.3^{20}{}_{HI(aq.)}$
$BaI_2 \cdot BaO \cdot 9H_2O$	c		955.1	S $11.8^{20}{}_{HI(aq.)}$

Barium

Formula	State	Description	Qf, kcal, mole^{-1}	Q, kcal. mole^{-1}
BaS	c		111.2	S $27.2^{10}_{HCl(aq)}$
	∞		118.36	
	800		118.6	
$BaSO_3$	c	ppt	282.5	
$BaSO_4$	c		349.4	
	∞		344.16	
BaS_2O_6	aq.		408.7	
$BaS_2O_6 \cdot 2H_2O$	c		552.4	S $-$ 6.93_{400}
BaS_2O_8	aq.		451.7	
$BaS_2O_8\ 4H_2O$	c		746 9	S $-$ 11.8
$Ba(HS)_2$	aq.		136.2	N 15.75
$Ba(HSO_3)_2$	aq.		426.0	
$BaSO_4 \cdot H_2SO_4$	c		548.0	S 14.25_{2260}
$BaSO_4 \cdot 2H_2SO_4 \cdot H_2O$	c		800.2	S 24.25_{2260}
BaS_4O_6	aq.		400.7	
$BaS_4O_6 \cdot 2H_2O$	c		544.4	S $-$ 7.0^{17}_{800}
$BaI_2 \cdot 2SO_2$	c		309 3	D $-$ 11.34
$BaI_2\ 4SO_2$	c		471.0	D $-$ 9.91
BaSe	c		81.3	S $33.9_{HCl(aq)}$
$BaSeO_4$	c		277.8	
$Ba(N_3)_2$	c		19 5	S $-$ 7.8
	aq		11.7	
Ba_3N_2	c		90.7	S $358.0^{8}_{HCl(aq.)}$
$Ba(NO_2)_2$	c		184.6	S $-$ 5.68^{12}_{800}
	aq		178.9	
$Ba(NO_2)_2\ 2H_2O$	c		255.9	S $-$ 8.6^{12}_{800}
$Ba(NO_3)_2$	c		236.9	S $-$ 9.47_{400}
	∞		226.740	
	550000		226.728	
	21200		226.705	
	5500		226.733	
	1900		226.839	
	1380		226.875	
	800		227.049	
	400		227.27	
	200		227.90	
BaNH	c		53.6	S $106.5^{8}_{HCl(200)}$
$Ba(NH_2)_2$	c		78 8	S $113.1^{8}_{HCl(200)}$
$Ba(NH_3)_6$	c		74.7	D $-$ 8.8
$BaCl_2 \cdot 8NH_3$	c		364.5	D $-$ 8.92
$BaBr_2 \cdot NH_3$	c		203.4	D $-$ 12.0
$BaBr_2 \cdot 2NH_3$	c		226.1	D $-$ 11.8
$BaBr_2 \cdot 4NH_3$	c		269.7	D $-$ 10.8
$BaBr_2 \cdot 8NH_3$	c		355.2	D $-$ 10.4
$BaI_2 \cdot 2NH_3$	c		193.3	D $-$ 13.4

Barium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$BaI_2 \cdot 4NH_3$	c		237.9	*D* − 11.3
$BaI_2 \cdot 6NH_3$	c		282.0	*D* − 11.1
$BaI_2 \cdot 8NH_3$	c		325.4	*D* − 10.7
$BaI_2 \cdot 9NH_3$	c		346 3	*D* − 10.0
$BaI_2 \cdot 10NH_3$	c		365.0	*D* − 7.7
$Ba_3(PO_4)_2$	c	ppt.	992.	
	colloid	in water	975.	
	∞		980.	
$Ba(HPO_2)_2$	aq.		414.0	
$Ba(HPO_2)_2 \cdot H_2O$	c		482.1	*S* 0.29_{400}
$BaH_2P_2O_6$	aq.			*N* 35.4
$BaHPO_4$	aq.		432.	
$Ba(H_2PO_4)_2$	aq.		743.	
$Ba_3(AsO_4)_2$	c	ppt.	817.7	
	aq.		804.	
$BaHAsO_3$	aq.		285.4	
$BaHAsO_4$	aq.		343.0	
$Ba(H_2AsO_3)_2$	aq.		466.	
$Ba(H_2AsO_4)_2$	aq.		558.	
$BaCO_3$	c		290.9	
$BaC_2O_4 \cdot H_2O$	c	ppt., barium oxalate hydrate	397.4	
$BaO \cdot BaCO_3$	c		424.	*D* − 63.2
$Ba(HCO_2)_2$	c	barium formate	330.4	*S* − $2\ 44^{8}_{500}$
	aq.		328.0	
$Ba(HCO_3)_2$	aq.	barium bicarbonate	460.	
$Ba(C_2H_3O_2)_2$	c	barium acetate	358.5	*S* 5.24^{11}_{600}
	∞		364.25	
	800		363.7	
$Ba(C_2H_3O_2)_2 \cdot 3H_2O$	c		569.4	*S* − 0.82
$Ba(C_2H_3O_3)_2$	c	barium glycollate	446.1	*S* − 5.08
	aq.		441.0	*N* 27.8
$Ba(C_2H_5O)_2$	c	barium alcoholate	220.6	*S* 19.76^{19}
$3BaO \cdot 4CH_3OH$	c		714.5	*S* $112.04_{HCl(aq.)}$
$3BaO \cdot 4C_2H_5OH$	c		737.5	*S* 49.07
$Ba(C_2H_5SO_4)_2$	aq.	barium ethyl sulfate	543.8	
$Ba(C_2H_5SO_4)_2 \cdot 2H_2O$	c		685.5	*S* − 4.97_{600}
$Ba(CN)_2$	c		57.4	*S* 1.8^{9}
	aq.		58.9	*N* $6\ 3^{7}$
$Ba(CN)_2 \cdot H_2O$	c		129.7	*S* − 2.1^{5}
$Ba(CN)_2 2H_2O$	c		200.5	*S* − 4.7^{7}
$Ba(CNO)_2$	c	barium cyanate	213.	*S* − 14.9

Barium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$Ba(CNO)_2$	aq.		198.	
$Ba(CH_2NO_2)_2$	aq.	pseudo salt of nitromethane	172.6	
$BaSiO_3$	gls.		363.	
$BaSiF_6$	c		678 2	
	aq.		672.4	
$BaI_2 \cdot 2PbI_2$	c		230.4	S 8.30[15]
$BaI_2 \cdot 2PbI_2 \cdot 7H_2O$	c		725.6	$S.$ − 8.29[15]
$BaBr_2 \cdot HgBr_2$	1400		225 7	
$BaBr_2 \cdot 2HgBr_2$	8400		263.2	
$2BaBr_2 \cdot HgBr_2$	1800		413.4	
$Ba(CN)_2 \cdot Hg(CN)_2$	600		6.7	
$Ba(CN)_2 \cdot 2Hg(CN)_2$	900		− 56.5	
$BaCl_2\ 2Hg(CN)_2$	1000		78.2	
$BaCl_2 \cdot 2Hg(CN)_2 \cdot 5H_2O$	c		437.2	S − 17.1[15]
$BaBr_2 \cdot 2Hg(CN)_2$	1000		57.2	
$BaBr_2 \cdot 2Hg(CN)_2 \cdot 6H_2O$	c		488.4	S − 21.0[15]
$BaI_2 \cdot 2Hg(CN)_2$	900		30 7	
$BaI_2 \cdot 2Hg(CN)_2 \cdot 4H_2O$	c		326.2	S − 22 0[15]
$Ba(CN)_2 \cdot AgCN$	1200		32.9	
$Ba(CN)_2 \cdot 2AgCN$	500		5.2	
$BaPtCl_6$	c		284.9	S $9.06^{19}{}_{5000}$
	aq.		294.0	
$BaPtCl_6 \cdot 6H_2O$	c		705.3	S − $1.06^{16}{}_{4000}$
$Ba_2Fe(CN)_6$	aq.		134.9	V 55.7[12]
$Ba_2Fe(CN)_6 \cdot 6H_2O$	c		556.6	S − 11.4[14]
$BaH_2Fe(CN)_6$	aq.		7 6	N 29.2
$Ba_3(FeCO(CN)_5)_2$	c		283.3	S $16.9^{15}{}_{10000}$
	aq.		300.2	N 84.6
$Ba_3(FeCO(CN)_5)_2 \cdot 11H_2O$	c		1059.2	S − 6.9_{12000}
$BaHFeCO(CN)_5$	aq.		85.7	N 28.2
$Ba(H_2FeCO(CN)_5)_2$	aq.		42.3	N 28 2
$Ba(CN)_2 \cdot Ni(CN)_2$	aq.		48.0	
$BaCrO_4$	c		342.2	
$BaMoO_4$	c		370.	
$BaWO_4$	c		402.	
$BaCl_2 \cdot 2AlCl_3$	c		543.2	S 153.5
$3BaCl_2 \cdot 4AlCl_3$	c		1291.3	S 309.4

Radium

Atomic number 88 Standard state Ra (c) Atomic weight 225.97

Lithium

Atomic number 3 Standard state Li (c) Atomic weight 6.940

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
Li	g	2s ($^2S_{1/2}$)	− 39.0	
	liq.			F − 0.76^{186}
	c		0 000	
Li*	g	2s ($^2P^1_{1/2}$)	− 81.40	E^z − 42.399
	g	2s ($^2P^1_{3/2}$)	− 81.40	E^z − 42.400
Li^+	g	$1s^2$ ($^1S_0$)	− 163.25	I^z − 123.796
	∞		66.628	
Li^{++}	g	1s ($^2S_{1/2}$)	−1901.6	I^z −1736.86
Li^{+++}	g		−4714.1	I^z −2811.1
Li_2	g		− 50.8	
Li_2O	c		142.3	S 31.5_{200}
$Li_2O \cdot \frac{3}{4}H_2O$	c		220 9	S 4.23_{200}
Li_2O_2	c		151.9	S 7.1_{110}
	aq.		159.	
LiH	g		− 33.0	D^z − 57.0
	c		21 59	S 31.14_{200}
LiH*	g		− 107 5	E^z − 74.8
LiOH	c		116 55	S $4\ 55_{200}$
	∞		121 288	
	6400		121.218	
	3200		121.233	
	1600		121.211	
	800		121.182	
	400		121.147	
	200		121.1	
	100		121.045	
	50		120.965	
	25		120.845	
$LiOH \cdot \frac{1}{2}H_2O$	c		125.44	S 4.21_{200}
$LiOH \cdot H_2O$	c		188.70	S 0.77_{200}
$Li_2O_2 \cdot H_2O_2\ 3H_2O$	c		414.	S − 4.5
LiF	g		82.	V − $52.^{1500}$
	liq.			F − 6.0^{870}
	c		145.57	S − 0.89_{400}
	∞		144.828	
	6400		144.788	
	3200		144.772	
	1600		144.750	
	800		144.719	
	400		144.678	
	200		144.624	
	100		144.552	
$LiHF_2$	400		219.93	
LiCl	g		51.	V − 37.2^{1200}

Lithium

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
LiCl	liq.			F — 5.0^{614}
	c		97.65	S 8.49_{200}
	∞		106.315	
	6400		106.277	
	3200		106.262	
	1600		106.242	
	800		106.215	
	400		106.183	
	200		106.140	
	100		106.084	
	50		106.003	
	25		105.865	
	20		105.795	
	15		105.67	
	12		105.54	
	10		105.39	
	8		105.16	
	6		104.68	
	5		104.30	
	4		103.63	
	3		102.54	
	48 CH_3OH	in methanol	108.55	S 10.9_{48CH_3OH}
	24 CH_3OH		108.15	
	7.9 CH_3OH		107.05	
	4.7 CH_3OH		105.55	
	70 C_2H_5OH	in ethanol	108.89	S $11.29_{70\ C_2H_5OH}$
	35 C_2H_5OH			S $11.5^{12}{}_{35\ C_2H_5OH}$
	16.9 C_2H_5OH			S $11.2^{12}{}_{16\ 9\ C_2H_5OH}$
	5.4 C_2H_5OH			S $9.1^{12}{}_{5\ 4\ C_2H_5OH}$
$LiCl \cdot H_2O$	c		170.23	S 4.28_{200}
$LiCl\ 2H_2O$	c		241.98	S — 0.90_{200}
$LiCl\ 3H_2O$	c		313.4	D — 13.6
LiClO	aq.		92.5	
$LiClO_3$	∞		87.38	
$LiClO_4$	∞		106.13	
LiBr	g		39.0	V — 36.5^{1200}
	liq.			F — 4.0^{549}
	c		83.76	S 11.39_{200}
	∞		95.298	
	6400		95.264	
	3200		95.254	
	1600		95.240	
	800		95.221	
	400		95.195	
	200		95.154	

Lithium

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
LiBr	100		95.103	
	50		95.033	
	25		94.903	
	20		94.84	
	15		94.73	
	12		94.62	
	10		94.50	
	8		94.31	
	6		93.92	
	5		93.54	
	4		92.83	
	3		91.47	
$LiBr \cdot H_2O$	c		158.37	S 5.27_{200}
$LiBr \cdot 2H_2O$	c		229.99	S 2.02_{200}
$LiBr \cdot 3H_2O$	c		302.0	D — 14.2
LiBrO	aq.		87.9	
$LiBrO_3$	∞		77.83	
LiI	g		23.	V — 34.3^{1000}
	c		65.08	S 14.83_{200}
	∞		79.998	
	6400		79.968	
	3200		79.959	
	1600		79.948	
	800		79.936	
	400		79.923	
	200		79.907	
	100		79.878	
$LiI \cdot \frac{1}{2}H_2O$	c		104.1	D — 10.1
$LiI \cdot H_2O$	c		141.44	S 6.83_{200}
$LiI \cdot 2H_2O$	c		213.31	S 3.33_{200}
$LiI \cdot 3H_2O$	c		285.28	S — 0.27_{200}
$LiIO_3$	∞		121.13	
Li_2SO_4	c	I		T $6.8^{568}{}_{\rightarrow II}$
	c	II	342.35	S 6.10_{200}
	∞		349.056	
	6400		348.872	
	3200		348.807	
	1600		348.736	
	800		348.656	
	400		348 586	
	200		348.446	
$Li_2SO_4 \cdot H_2O$	c		413.66	S 3.30_{400}
$LiHSO_4$	aq.		279.6	
$LiI \cdot SO_2$	c		145.8	D — 9.7
$LiI \cdot 2SO_2$	c		226.2	D — 9.4

Lithium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
Li_2Se	c		84.9	S 10.4_{500}
	aq.		95.3	
$Li_2Se{\cdot}9H_2O$	c		722.3	S — 12.2_{3000}
$LiHSe$	aq.		40 2	
Li_3N	c		46.4	S 131.1
$LiNO_3$	liq.			F — 6.1^{250}
	c		115.352	S 0.333_{200}
	∞		115.818	
	6400		115.782	
	3200		115.769	
	1600		115.753	
	800		115.733	
	400		115.710	
	200		115.685	
	100		115.661	
	50		115.638	
	25		115.613	
	10		115.58	
	3		115.3	
	385 C_2H_5OH	in ethanol	119 8	S $4\ 45_{385\ C_2H_5OH}$
$LiNO_3{\cdot}3H_2O$	c		328.8	
$LiNH_2$	c		42 6	
$Li(NH_3)_4$	liq		78.6	
Li_2NH	c		52.7	
$LiCl{\cdot}NH_3$	c		120.1	S 5.16_{330}
$LiCl\ 2NH_3$	c		142.4	S 2.67_{440}
$LiCl\ 3NH_3$	c		164 0	S $0\ 45_{550}$
$LiCl\ 4NH_3$	c		183 5	S 0.10_{660}
$LiCl\ 5NH_3$	c		202.4	D — 8.0
$LiBr{\cdot}NH_3$	c		107.6	S $7\ 00_{280}$
$LiBr{\cdot}2NH_3$	c		130.8	S 3.26_{440}
$LiBr{\cdot}3NH_3$	c		153.2	S 0.29_{550}
$LiBr\ 4NH_3$	c		174.4	S — 1.50_{660}
$LiBr{\cdot}5NH_3$	c		193.4	D — 8.1
$LiBr{\cdot}6\frac{1}{2}NH_3$	c		220.2	D — 6 9
$LiI{\cdot}NH_3$	c		92.0	D — 16.0
$LiI\ 2NH_3$	c		116.7	D — 13.8
$LiI{\cdot}3NH_3$	c		139.8	D — 12 2
$LiI{\cdot}4NH_3$	c		162.3	D — 11.6
$LiI\ 5NH_3$	c		181.3	D — 8 1
$LiI{\cdot}5\frac{1}{2}NH_3$	c		190 4	D — 7 2
$LiI{\cdot}7NH_3$	c		217.5	D — 7.1
Li_2C_2	c		13.9	S 37.2
Li_2CO_3	c		290.1	S 3.15_{220}
	∞		293.76	

Lithium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
Li_2CO_3	2000		293 50	
$LiCHO_2$	aq.	formate	166.4	
$LiHCO_3$	2000	bicarbonate	231.43	
$LiCH_3O$	60 CH_3OH	in methanol	112.6	
LiC_2H_5O	60 C_2H_5OH	in ethanol	118.7	
$LiC_2H_3O_2$	∞	lithium acetate	184.571	
$Li_2C_2O_4$	aq.		328 9	
LiCN	aq.		31.73	*N* 2.8$_{221}$
LiCNO	aq.		101.5	
$LiCl{\cdot}CH_4NH_2$	c		117.6	*S* 6.56$_{330}$
$LiCl{\cdot}2CH_3NH_2$	c		136.6	*D* − 11.7
$LiCl\ 3CH_3NH_2$	c		154.5	*D* − 10.6
$LiCl\ 4CH_3NH_2$	c		171 3	*D* − 9.5
$LiBr\ CH_3NH_2$	c		105 6	*D* − 14 5
$LiBr\ 2CH_3NH_2$	c		126.1	*D* − 13.2
$LiBr\ 3CH_3NH_2$	c		146 3	*D* − 12.9
$LiBr{\cdot}4CH_3NH_2$	c		163 7	*D* − 10.1
$LiBr\ 5CH_3NH_2$	c		179 9	*D* − 8 9
$LiI\ CH_3NH_2$	c		88.7	*D* − 16.3
$LiI\ 2CH_3NH_2$	c		109.1	*D* − 13 1
$LiI{\cdot}3CH_3NH_2$	c		127.9	*D* − 11.5
$LiI{\cdot}3\frac{1}{2}CH_3NH_2$	c		136.1	*D* − 9 1
$LiCl\ (CH_3)_2NH$	c		114 6	*D* − 8 7
$LiCl\ 2(CH_3)_2NH$	c		130.6	*D* − 7.8
$LiCl\ 3(CH_3)_2NH$	c		146.4	*D* − 7.6
$LiBr\ \frac{1}{2}(CH_3)_2NH$	c		92 9	*D* − 10 2
$LiBr\ (CH_3)_2NH$	c		101.9	*D* − 9.9
$LiBr\ 2(CH_3)_2NH$	c		117.9	*D* − 7.8
$LiBr\ 3(CH_3)_2NH$	c		133.7	*D* − 7.6
$LiBr\ 4(CH_3)_2NH$	c		148 7	*D* − 6.8
$LiBr\ 5(CH_3)_2NH$	c		163.1	*D* − 6.2
$LiI\ \frac{1}{2}(CH_3)_2NH$	c		76.0	*D* − 13.5
$LiI\ (CH_3)_2NH$	c		85 9	*D* − 11 5
$LiI\ 1\frac{1}{2}(CH_3)_2NH$	c		95 0	*D* − 10.0
$LiI{\cdot}2(CH_3)_2NH$	c		103.5	*D* − 8.9
$LiI{\cdot}3(CH_3)_2NH$	c		118.3	*D* − 6.6
$LiI\ 5(CH_3)_2NH$	c		147.1	*D* - 6.2
$LiCl\ C_2H_5NH_2$	c		124 5	*S* 7.5$_{330}$
$LiCl\ 2C_2H_5NH_2$	c		148.6	*S* 9.5$_{330}$
$LiCl\ 3C_2H_5NH_2$	c		172.2	*S* 11.8$_{550}$
Li_2SiO_3	gls.		374.	
Li_2SiF_6	c		677.3	*S* 2.0$_{600}$
	aq.		679.3	
$2LiI{\cdot}PbI_2$	c		140.83	*S* 60.90$_{1600}$

Lithium

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
$2LiI \cdot PbI_2 \cdot 4H_2O$	c		489.13	S — 13.92_{1750}
LiIIg	c		20.8	
$LiHg_2$	c		25.0	
$LiHg_3$	c		26.8	
$LiHg_{99}$	liq.		19.6	
$LiBr \cdot HgBr_2$	4500		134.8	
$2LiBr \cdot HgBr_2$	4600		231.2	
$4LiBr \cdot HgBr_2$	4900		423.3	
$8LiBr \cdot HgBr_2$	5900		805 4	
$LiCN \cdot Hg(CN)_2$	550		− 26.1	
$2LiCN \cdot Hg(CN)_2$	660		11.0	
$LiCl \cdot Hg(CN)_2$	550		41 5	
$2LiCl\ Hg(CN)_2$	660		147.7	
$LiBr \cdot Hg(CN)_2$	550		30 9	
$LiBr \cdot Hg(CN)_2\ 3\frac{1}{2}H_2O$	c		279.3	S — 9.1
$2LiBr \cdot Hg(CN)_2$	660		126.4	
$LiI \cdot Hg(CN)_2$	550		17.9	
$LiI \cdot Hg(CN)_2\ 3\frac{1}{2}H_2O$	c		267 5	S — 10.3
$2LiI \cdot Hg(CN)_2$	660		98 8	
$LiCl \cdot ThCl_4 \cdot 8H_2O$	c		1019.6	S 25.5
$2LiCl\ ThCl_4$	c		535 0	S 69.3

Sodium

Atomic Number 11 Standard state Na (c) Atomic weight 22.997

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
Na	g	$2p^6 3s$ ($^2S_{1/2}$)	− 25.9	
	liq.			F − 0.630^{98}
	c		0.000	
Na*	g	$2p^6 3p$ ($^2P^1_{1/2}$)	− 74.17	E^z − 48.271
	g	($^2P^1_{3/2}$)	− 74.22	E^z − 48.320
Na^+	g	$2p^6$ ($^1S_0$)	145.35	I^z − 118.00
	∞		57.479	
Na^{++}	g	$2p^5$ ($^2P^1_{3/2}$)	−1231 3	I^z −1084.5
Na^{++} *	g	($^2P^1_{1/2}$)	−1235 2	E^z − 3.90
Na^{+++}	g	$2P^4$	−2865.8	I^z −1633.02
Na_2	g	$^1\Sigma^+_g$	− 33.4	
Na_2*	g	$^1\Sigma^+_u$	− 76.1	E^z − 42.72
	g	$^1\Pi_u$	− 91.2	E^z − 57.79
Na_2O	c		99 45	S 56.3$_{200}$
Na_2O_2	c		119.2	
Na_3O	c		101 6	
NaH	c		14.	
	g	Σ	− 25.3	D^z − 51.6
NaH*	g	Σ	− 91.6	E^z − 66.3
NaOH	c	I		T 0.99$^{300}_{\rightarrow II}$
	c	II	101.96	S 10.10$_{200}$
	∞	$Na^+(\infty)$+ $OH^-(\infty)$	112.139	
	6400		112.101	
	3200		112.089	
	1600		112 076	
	800		112.063	
	400		112.053	
	200		112.061	
	100		112.1	
	50		112.184	
	25		112 312	
	20		112.351	
	18		112.361	
	15		112.371	
	12		112 348	
	10		112.282	
	8		112.14	
	6		112.55	
	5		113.02	
	4		113.86	
	3		115.34	
$NaOH \cdot \frac{1}{2}H_2O$	c		138.15	S 8.1$_{100}$
$NaOH \cdot \frac{3}{2}H_2O$	c		150.64	S 7.0$_{200}$

Sodium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$NaOH\ \frac{1}{4}H_2O$	c		156.94	S 6.4_{200}
$NaOH \cdot H_2O$	c		175.34	S 5.09_{200}
$NaHO_2$	aq.		94.5	
NaF	g		64.	V — $72.^{1300}$
	liq.			F — 7.8^{990}
	c		135.95	S — $0\ 40_{200}$
	∞	$Na^+(\infty)+F^-(\infty)$	135.679	
	6400		135 643	
	3200		135 629	
	1600		135 614	
	800		135.592	
	400		135.571	
	200		135.551	
	100		135.536	
$NaHF_2$	c		216.75	S — 6.0_{400}
	400		210.75	
NaCl	g		41.2	V — 43.5^{1200}
	liq.			F — 7.22^{800}
	c		98.330	S — 1.211_{200}
	∞	$Na^+(\infty)+Cl^-(\infty)$	97.166	
	6400		97.131	
	3200		97 121	
	1600		97.111	
	800		97.105	
	400		97.105	
	200		97.119	N 13.996_{201}
	100		97.171	
	50		97.286	
	25		97 496	
	20		97 581	
	15		97.701	
	12		97.792	
	10		97.850	
NaClO	800		83.4	
$NaClO_3$	c		83.60	
	∞	$Na^+(\infty)+ClO_3^-(\infty)$	78.23	
	6400		78.210	
	3200		78 207	
	1600		78.208	
	800		78.220	
	400		78.248	
	200		78.335	

Sodium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$NaClO_4$	c		101.13	S — 3.33_{400}
	∞	$Na^+(\infty)+$		
		$ClO_4^-(\infty)$	96.98	
	1600		97.28	
	800		97.58	
	400		98 05	
NaBr	g		32.9	V — $38.8^{1:50}$
	c		86.73	S — 0.60_{200}
	∞	$Na^+(\infty)+$		
		$Br^-(\infty)$	86.149	
	6400		86.117	
	3200		86.109	
	1600		86 103	
	800		86.099	
	400		86.104	
	200		86 129	N 13.923_{201}
	100		86 204	
	50		86.346	
	25		86 585	
	20		86.687	
	15		86.836	
	12		86 952	
	10		87.045	
	8		87.139	
	6		87.162	
$NaBr{\cdot}2H_2O$	c		227.46	S — 4.59_{200}
NaBrO	aq.		78.8	
$NaBrO_3$	∞	$Na^+(\infty)+$		
		$BrO_3^-(\infty)$	68.68	
	6400		68.661	
	3200		68.662	
	1600		68.667	
	800		68.683	
	400		68.720	
	200		68.82	
NaI	g		18.9	V — 38.6^{1100}
	c		69.28	S 1.55_{200}
	∞	$Na^+(\infty)+$		
		$I^-(\infty)$	70.849	
	6400		70.819	
	3200		70.811	
	1600		70.805	
	800		70.803	
	400		70.811	
	200		70.842	N 13.855_{201}

Sodium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
NaI	100		70.920	
	50		71.080	
	25		71.361	
	20		71.484	
	15		71.662	
	10		71.924	
	8		72.047	
	6		72.127	
	5		72.083	
	520 C_2H_5OH		73.67	S $4.39_{520\ C_2H_5OH}$
$NaI\ 2H_2O$	c		211.48	S − 3.90_{200}
$NaIO_3$	∞	$Na^+(\infty)+IO_3^-(\infty)$	111 98	
	6400		111.972	
	3200		111.980	
	1600		112.000	
	800		112.045	
	400		112.125	
	200		112 265	
	100		112 54	
Na_2S	liq.			F − 1.65^{320}
	c		89.8	S 15.2_{400}
	∞	$2Na^+(\infty)+S^{--}(\infty)$	104.96	
	1600		104.86	
	800		104.89	
	400		104.96	
	200		105.08	
	100		105.29	
	50		105.64	
	25		106.14	
	20		106 31	
$Na_2S{\cdot}4\frac{1}{2}H_2O$	c		417.54	S − 4.91_{400}
$Na_2S\ 5H_2O$	c		453.35	S − 6.54_{400}
$Na_2S\ 9H_2O$	c		736.94	S − 16.65_{400}
Na_2S_2	aq.		105.7	
Na_2S_3	aq.		107.2	
Na_2S_4	c		99.8	S 9.9_{600}
	aq.		109.7	
Na_2SO_3	c		261.2	S 2.7_{800}
	∞	$2Na^+(\infty)+SO_3^{--}(\infty)$	264.0	
	800		263.9	
$Na_2SO_3{\cdot}7H_2O$	c		753.7	S − 11.2_{800}
Na_2SO_4	liq.			F − 8.7^{885}

Sodium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
Na_2SO_4	c		330.48	*S* 0.26_{400}
	∞	$2Na^+(\infty)+SO_4^{--}(\infty)$	330.76	
	6400		330.638	
	3200		330.615	
	1600		330 610	
	800		330 633	
	400		330 735	
	200		330 985	
	100		331.450	
	50		332.115	
$Na_2SO_4 \cdot 10H_2O$	c		1033.20	*S* $-18\ 76_{400}$
$Na_2S_2O_3$	c		258.5	*S* 2.0_{440}
	aq.		260 5	
	5		262 5	
$Na_2S_2O_3 \cdot 5H_2O$	c	α	613.65	*S* -11.33_{400}
	c	β	612 35	*T* $1.3^{17\ 5}{}_{\rightarrow\alpha}$
$Na_2S_4O_5$	c		349 0	
	aq.		344.6	
$Na_2S_2O_6$	c		401 0	*S* -5.82_{400}
	aq.		395.2	
$Na_2S_2O_6\ 2H_2O$	c		543.8	*S* -11.68_{400}
$Na_2S_3O_6$	aq.		392.	
$Na_2S_3O_6\ 3H_2O$	c		606 7	*S* -9.6_{680}
$Na_2S_4O_6$	aq		387.3	
$Na_2S_4O_6\ 2H_2O$	c		533 0	*S* $-9\ 0_{500}$
NaHS	c		56 76	*S* 4.59_{400}
	∞	$Na^+(\infty)+HS^-(\infty)$	61.38	
	800		61.33	
	400		61.35	
	200		61.37	
	100		61.43	
	50		61.56	
	25		61.82	
	20		61.94	
	15		62.12	
	12		62.27	
	10		62.37	
	8		62.44	
	6		62.41	
	5		62 28	
	4		61.95	
$NaHS \cdot 2H_2O$	c		199.61	*S* -1.52_{400}
$NaHSO_3$	aq.		206.5	
$NaHSO_4$	c		269.04	*S* 1.25_{200}

Sodium

Formula	State	Description	Qf, *kcal mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
$NaHSO_4$	800		270.78	
	400		270.56	
	200		270.29	
	100		270 15	
	50		270.12	
	25		270 08	
	20		270 04	
	10		269 62	
$NaHSO_4 \cdot H_2O$	c		339 0	S — 0 3
$NaI \cdot 2SO_2$	c		231.2	D — 10 0
$NaI \cdot 4SO_2$	c		392 4	D — 9 6
Na_2Se	c		59 1	S 18.8_{1000}
	440		77 9	
$Na_2Se \cdot 4\frac{1}{2}H_2O$	c		393 1	S — $7\ 8_{2000}$
$Na_2Se \cdot 9H_2O$	c		703 9	S — $10\ 7_{2000}$
$Na_2Se\ 16H_2O$	c		1194 1	S — $22\ 3_{2000}$
Na_2SeO_3	800		238 2	
Na_2SeO_4	c		254.	
	∞	$2Na^+(\infty) + SeO_4^{--}(\infty)$	261.3	
	800		261.3	
NaHSe	4000		31 0	
$NaHSeO_3$	800		182 24	
$NaHSeO_4$	400		201 72	
Na_2TeO_4	c		308.	
	aq.		283 9	
$NaNO_2$	c		86.6	S — $3\ 55_{350}$
	aq.		83.0	
$NaNO_3$	c		111.72	S — 4.97_{200}
	∞	$Na^+(\infty) + NO_3^-(\infty)$	106.669	
	6400		106.639	
	3200		106.635	
	1600		106 638	
	800		106.651	
	400		106.684	
	200		106.755	
	100		106.915	
	50		107.189	
	25		107.629	
	20		107.804	
	18		107.889	
	15		108.049	
	12		108.239	
	10		108.389	
	8		108.564	

Sodium

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
$NaNO_3$	6		108.794	
	5		109.029	
$Na_2N_2O_2$	aq.		111.5	
$NaNH_2$	c		32.0	
$NaNH_3$	c		16.2	
$NaCl\ 5NH_3$	c		192.2	*D* — 7.8
$NaBr{\cdot}5\frac{1}{4}NH_3$	c		188.7	*D* — 8.5
$NaBr\ 5\frac{3}{4}NH_3$	c		197.7	*D* — 7.0
$NaI{\cdot}4\frac{1}{2}NH_3$	c		161.0	*D* — 9.4
$NaI\ 6NH_3$	c		188.7	*D* — 7.5
$Na_2SO_4\ (NH_4)_2SO_4\ H_2O$	c		690.9	*S* — 12.7
$NaPO_3$	c		288.7	*S* 4.0
	600		292.67	
Na_3PO_3	1000		388.81	
Na_3PO_4	c		457.	
	1600		470.0	
	800		471.0	
	400		471.6	
	200		471 9	
$Na_3PO_4{\cdot}12H_2O$	c		1305.7	*S* — $14\ 26_{660}$
$Na_4P_2O_6$	aq.			*N* $54.2^{11}{}_{1200}$
$Na_4P_2O_7$	c		755.2	*S* 11.92_{800}
	1600		767.1	
$Na_4P_2O_7{\cdot}10H_2O$	c		1462.5	*S* — 11.65_{800}
NaH_2PO_2	500		200.05	
NaH_2PO_3	c		286.42	*S* 0.90_{550}
	600		287.32	
$NaH_2PO_3{\cdot}2\frac{1}{2}H_2O$	c		463.53	*S* — 5.26_{550}
NaH_2PO_4	300		364.64	
$NaH_3P_2O_6$	aq.			*N* $15\ 1^{11}{}_{550}$
$NaH_3P_2O_7$	c		596.9	*S* 0 80
	1200		597.66	
$NaH_2PO_4{\cdot}H_3PO_4$	c		669.7	*S* 1.1
Na_2HPO_2	800		243.84	
Na_2HPO_3	c		335.33	*S* 9.30_{550}
	800		344.63	
$Na_2HPO_3{\cdot}5H_2O$	c		691.02	*S* — 4.54_{550}
Na_2HPO_4	c		414.85	*S* 5.65_{400}
	1600		420.06	
	800		420.26	
	400		420.5	
	200		420.82	
$Na_2HPO_4{\cdot}2H_2O$	c		557.62	*S* — 0.38_{400}
$Na_2HPO_4{\cdot}7H_2O$	c		910.69	*S* 11.60_{400}
$Na_2HPO_4{\cdot}12H_2O$	c		1263.68	*S* — 22.74_{400}
$Na_2H_2P_2O_5$	c		499.67	

Sodium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$Na_2H_2P_2O_5$	550		500.07	
$Na_2H_2P_2O_6$	aq.			N $30.1^{11}{}_{770}$
$Na_2H_2P_2O_7$	c		657.8	S — 2 2
	1200		655.6	
$Na_2H_2P_2O_7 \cdot 6H_2O$	c		1079.8	S — 14.0
$Na_3HP_2O_6$	q.			N $42.7^{11}{}_{990}$
$Na_3HP_2O_7$	c		706.1	S 6.9
	q		713.	
$Na_3HP_2O_7 \cdot H_2O$	c		780.2	S 1.2
$Na_3HP_2O_7 \cdot 6H_2O$	c		1130.2	S — 7 0
$NaNH_4HPO_4$	550		372 3	
$NaNH_4HPO_4 \cdot 4H_2O$	c		656.6	S — 10.8_{800}
$Na_2NH_4PO_4$	550		440.7	
$Na(NH_4)_2PO_4$	660		399.3	
Na_3AsO_3	500		314.30	
Na_3AsO_4	c		366.	
	500		381.65	
$Na_3AsO_4 \cdot 12H_2O$	c		1214 7	S — 12.6_{660}
NaH_2AsO_3	400		225.89	
NaH_2AsO_4	300		273 23	
Na_2HAsO_3	400		270 31	
Na_2HAsO_4	400		329 56	
Na_3SbO_4	c		349.	
	aq.		360.	
$3Na_2S \cdot Sb_2S_3$	aq		394.	
Na_3BiO_4	c		284.	
Na_2C_2	c		— 4.1	
Na_2CO_3	liq.			F — 9.1^{850}
	c	I		T' $0.4^{450 \to 11}$
	c	II	269.89	S $5\ 88_{200}$
	∞	$2Na^+(\infty) + CO_3^{--}(\infty)$	275.46	
	6400		275.37	
	3200		275.36	
	1600		275.36	
	800		275.40	
	400		275.52	
	200		275.77	
	100		276.19	
	50		276.83	
	25		277.59	
	20		277.83	
	18		277.94	
	15		278.13	
$Na_2CO_3 \cdot H_2O$	c		341.64	S 2.50_{200}
$Na_2CO_3 \cdot 7H_2O$	c		764.86	S — 10.50_{200}

Sodium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$Na_2CO_3\ 10H_2O$	c		975 38	S — 15.91_{200}
$Na_2C_2O_4$	c	sodium oxalate	314.7	S — 4.1_{400}
	600		310.58	
$NaHC_2$	c		— 25 1	
$NaCHO_2$	c	sodium formate	157.7	S — 0.41_{150}
	400		157.29	
$NaHCO_3$	c	sodium bicarbonate	226.4	S — 4.1_{300}
	1800		222.3	
$NaCH_3O$	60 CH_3OH		105.5	
$NaHC_2O_4$	c	sodium bioxalate	257.7	S — 5.3_{400}
	400		252 43	
$NaHC_2O_4{\cdot}H_2O$	c		330.1	S — 9.3_{400}
$NaC_2H_3O_2$	c	sodium acetate	171 34	S 3.90_{300}
	∞	$Na^+(\infty)+$ $C_2H_3O_2^-(\infty)$	175 425	
	6400		175 382	
	3200		175.363	
	1600		175.340	
	800		175.310	
	400		175.275	
	200		175 237	
	100		175.192	
	50		175.143	
	25		175 065	
	20		175.025	
	15		174.954	
	12		174.845	
	10		174.735	
	8		174 575	
	6		174.335	
	5		174.175	
	4		173.985	
	3		173 725	
	1100 C_2H_5OH		172.64	
$NaC_2H_3O_2{\cdot}3H_2O$	c		385.20	S — 4.85_{300}
$NaC_2H_3O_3$	c	glycollate	216.0	S — 2.46
	aq.		213.5	N 13 6
$NaC_2H_3O_3{\cdot}\frac{1}{2}H_2O$	c		251.2	S — 3.5
NaC_2H_5O	60 C_2H_5OH	methyl alcohol	111 9	
$NaC_2H_5O_2$	c	sodium glycol	150.1	
	aq.		156.1	
$NaC_3H_9O_3$	c	sodium methanol glycol	215.4	S 1.97
	aq.		213.4	

Sodium

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
$Na_2C_2H_2O_3$	c	bisodium glycollate	248.9	S 9.18
	aq		258.1	
$Na_2C_2H_2O_3\ 2H_2O$	c		395 2	S — 0 36
$NaC_2H_5SO_4$	aq	sodium ethyl sulfate	265 3	
$Na_2S_2O_3\ C_2H_2O_2$	aq	sodium glyoxal metabisulfite	594.8	
$Na_2S_2O_4\ C_2H_2O_2\ 2H_2O$	c		741 2	S — 9 66
NaCN	c		22 95	S — $0\ 37_{100}$
	200		22 58	
$NaCN\ \frac{1}{2}H_2O$	c		57 68	S — $0\ 91_{100}$
$NaCN\ 2H_2O$	c		163 73	S — $4\ 41_{100}$
NaCNO	c		96.7	S — 4.70_{1600}
	aq.		92 0	
$NaCN_2H$	aq.		35 0	
$NaC_2H_4NO_2$	c	sodium glycine	169 5	N 3 0
NaCNS	c		40 36	S — $1\ 80_{200}$
	∞	$Na^+(\infty)+CNS^-(\infty)$	38 53	
	6400		38 500	
	3200		38 490	
	1600		38 490	
	800		38 495	
	400		38 520	
	200		38 565	
	100		38 665	
	50		38 83	
	25		39 17	
	20		39 29	
	15		39 50	
	12		39 65	
	10		39 77	
	8		39.90	
	6		40 02	
	5		40 06	
	4		40 05	
	3		39.90	
	∞ C_2H_5OH	in ethyl alcohol	39 16	
	200 C_2H_5OH		39 24	
	100 C_2H_5OH		39.33	
	50 C_2H_5OH		39.49	
	10 C_2H_5OH		41.12	
	8 38 C_2H_5OH		41.43	

Sodium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal mole*$^{-1}$
Na_2SiO_4	gls.		374.	
	c		371.2	
Na_2SiF_6	c		669.	
	660		659.0	
$NaHSiF_6$	400		601.9	
NaSn	c		16.	
$NaSn_2$	c		20	
Na_2Sn	c		21.	
Na_4Sn	c		31.	
Na_4Sn_3	c		56.	
Na_2SnO_3	c		(?) 273.	
Na_6SnO_4	aq		453.6	
Na_2PbO_4	c		202 4	
$2NaI\ PbI_2$	c		104.49	S 79.04$_{1700}$
$2NaI{\cdot}PbI_2{\cdot}4H_2O$	c		481 94	
$2NaI\ PbI_2\ 6H_2O$	c		621 46	
$2Na_2S_2O_3\ PbS_2O_3$	c		676 7	S — 3.8$_{2700}$
	aq		672 9	
Na_2ZnO_2	c		187.	
$Na_2Zn(SO_4)_2$	c		567 0	S 15 9$_{360}$
$Na_2Zn(SO_4)_2\ 4H_2O$	c		866 6	S — 0 2$_{460}$
$NaCd_2$	c		8.5	
$NaCd_5$	c		12.5	
Na_2CdO_2	c		164.	
$NaHg_{27\ 5}$	liq.		19.75	
$NaHg_{50}$	liq.		19 91	
$NaHg_{100}$	liq.		20 0	
$NaHg_{200}$	liq.		20 05	
$NaHg_{400}$	liq.		20.07	
$NaHg_{\frac{1}{2}}$	c		3 7	
$NaHg_{\frac{3}{4}}$	c		7 4	
NaHg	c		11.0	
$NaHg_2$	c		18.5	
$NaHg_4$	c		22 2	
$NaBr\ HgBr_2$	4600		125 73	
$2NaBr\ HgBr_2$	4700		212.90	
$4NaBr{\cdot}HgBr_2$	5000		386.79	
$8NaBr\ HgBr_2$	5900		727 34	
$4Na_2S{\cdot}HgS$	aq.		538.9	
$NaCN\ Hg(CN)_2$	550		— 35.12	
$2NaCN{\cdot}Hg(CN)_2$	660		— 7.19	
$NaCl{\cdot}Hg(CN)_2$	550		32 49	
$2NaCl{\cdot}Hg(CN)_2$	660		129.69	
$NaCl{\cdot}Hg(CN)_2{\cdot}1\frac{1}{2}H_2O$	c		125 90	S — 7.95
$NaBr{\cdot}Hg(CN)_2$	550		21 89	

Sodium

Formula	State	Description	Qf, *kcal mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
$2NaBr\ Hg(CN)_2$	660		108.37	
$NaBr{\cdot}Hg(CN)_2\ 2H_2O$	c		170.53	S — 11.90
$NaI{\cdot}Hg(CN)_2$	550		8.76	
$2NaI{\cdot}Hg(CN)_2$	660		80.84	
$NaI\ Hg(CN)_2\ 2H_2O$	c		156 80	S — 11.30
$Na_2O{\cdot}CuO_2$	c		168.	
$Na_2CO_3\ CuCO_3$	c		418.5	
$Na_2CO_3\ CuCO_3\ 3H_2O$	c		632 91	
$Na_2O{\cdot}Ag_2O_2$	c		146.	
$Na_3Ag(S_2O_3)_2$	aq.		459	
$NaCN{\cdot}AgCN$	550		4 2	
$2NaCN{\cdot}AgCN$	220		20 2	
	330		19.8	
	1320		18.9	
Na_2PtCl_4	aq.		237 0	
Na_2PtCl_6	c		272 1	S 8.49_{800}
	aq.		280.6	
$Na_2PtCl_6{\cdot}2H_2O$	c		417.4	S — 0.10_{667}
$Na_2PtCl_6{\cdot}6H_2O$	c		701.4	S — 10.57_{900}
Na_2PtBr_4	aq.		205 2	S $9\ 94^{18}\ 7_{600}$
Na_2PtBr_6	c		221 3	
	aq.		231.2	
$Na_2PtBr_6\ 6H_2O$	c		649 9	S — $8.51^{19}{}_{600}$
Na_2PtI_6	aq.		167.4	
Na_2IrCl_6	aq.		267.5	
Na_2IrCl_6	aq.		359.2	
Na_2PdCl_4	aq.		242 5	
Na_2PdCl_6	aq.		271 5	
Na_2PdBr_4	aq		200 5	
Na_3RhCl_6	c		370 1	S $7.83^{19}{}_{6000}$
	aq.		377.9	
$Na_3RhCl_6{\cdot}12H_2O$	c		1218.9	S — $20.56^{17}{}_{5500}$
$2NaCN{\cdot}Ni(CN)_2$	aq.		34 4	
Na_2CoO_3	c		200.	
$2NaBr\ CoBr_2$	440		245.83	
$Na_3FeCO(CN)_5$	c		124.3	S 5.2_{1900}
	aq.		129.5	
$Na_3FeCO(CN)_5{\cdot}7H_2O$	c		615.5	S — 7.4_{5700}
Na_2MnO_4	c		270.	
$2NaBr{\cdot}MnBr_2$	440		278.34	
$Na_2SO_4{\cdot}MnSO_4$	c		583.6	S 12.8_{180}
$Na_2SO_4{\cdot}MnSO_4{\cdot}2H_2O$	c		730.1	S 3.1_{180}
Na_2CrO_4	c		319.8	S 2.50_{500}
	800		322 3	
	10		323.3	
$Na_2CrO_4{\cdot}4H_2O$	c		603.3	S — 7.50_{450}

Sodium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$Na_2CrO_4 \cdot 10H_2O$	c		1022 0	*S* — $16\ 0_{770}$
$Na_2Cr_2O_7$	1200		465.6	
Na_2MoO_4	c	I		*T* $11\ 6^{440}{}_{\rightarrow II}$
	c	II	364.	
	aq.		358.5	
Na_2WO_4	c	I		*T* $9\ 5^{579}{}_{\rightarrow II}$
	c	II	391.	
	aq.		381.3	
Na_2UO_4	c		500.	
$Na_2U_2O_7 \cdot 1\frac{1}{2}H_2O$	c		856.	
$(Na_2O_2)_2UO_4$	aq.		584.	
$(Na_2O_2)_2\ UO_4\ 9H_2O$	c		1213.	
$NaVO_3$	aq.		315.1	
$NaVO_4$	aq.		301.4	
$NaVO_5$	aq.		287.4	
Na_3VO_4	c		450.	
$2NaCl \cdot ThCl_4$	c		535.7	*S* 50 6
$NaCl \cdot ThCl_4 \cdot 10H_2O$	c		1178.4	*S* — 5.5
$NaBO_2$	300		231.7	
$NaBO_2$	aq.		257.1	
$NaBO_2 \cdot 4H_2O$	c		542 1	*S* — 11.56
$Na_2B_4O_7$	c		742 6	*S* 10.
	900		752.6	
$Na_2B_4O_7 \cdot 10H_2O$	c		1458.1	*S* — $25\ 8_{1600}$
Na_3BO_3	c		(?) 341.	
	600		387.7	
$NaAlO_2$	c		272.	
$3NaF \cdot AlF_3$	liq.			*F* — 16 64
	c	I		*T* 1 24$_{\rightarrow II}$
	c	II	758 47	
	3300		767.80	
$3NaF \cdot AlF_3\ 3\frac{1}{2}H_2O$	c		1020.04	
$NaCl \cdot AlCl_3$	c		270 5	*S* 71.31_{880}
$NaCl\ AlCl_3 \cdot 6NH_3$	c		461.4	*S* 6.2
$3NaCl \cdot AlCl_3$	c		470.4	*S* 65.65_{1330}
$3NaCl \cdot 2AlCl_3$	c		642.4	*S* 138.28_{2000}
$Na_2O\ Al_2O_3\ 3SiO_2$	c	natrolite	1179.9	
$Na_2O \cdot Al_2O_3 \cdot 4SiO_2$	c	dehydrated analcite	1365.9	
$Na_2SO_4 \cdot CaSO_4$	c		674.2	
$2Na_2SO_4 \cdot CaSO_4 \cdot 2H_2O$	c		144.7	
$NaSrPO_4 \cdot 9H_2O$	c		117.7	
$NaSrAsO_4 \cdot 9H_2O$	c		1026.0	
$NaBaPO_4 \cdot 9H_2O$	c		1116.3	
$NaBaAsO_4 \cdot 9H_2O$	c		1024.7	
NaLiICl	c	fresh melt	166.4	

Potassium

Atomic number 19 | Standard state K (c) | Atomic weight 39 096

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
K	g	4s $(^2S_{1/2})$	− 19 80	
	liq.			F − 0.574^{66}
	c		0 000	
K*	g	4p $(^2P^1_{1/2})$	− 56.40	E^7 − 36 596
	g	$(^2P^1_{3/2})$	− 56 90	E^7 − 37.102
K$^+$	g	$3p^6$ $(^1S_0)$	− 120 90	I^1 − 99 651
	∞		60 270	
K^{++}	g	$3p^5$ $(^2P^1_{3/2})$	− 852 91	I^2 − 730 59
K^{++}*	g	$(^2P^1_{1/2})$	− 859 10	E^2 − 6 16
	g	$3s3p^6$ $(^1S_{1/2})$	−1230 9	E^2 − 371 8
K^{+++}	g	$3p^4$ $(^3P_2)$	−1927 4	I^3 −1073.
K_2	g	A $^1\Sigma^+_g$	− 27.0	
K_2*	g	B $^1\Sigma^+_u$	− 60 2	E^2 − 33 2
	g	C $^1\Pi_u$	− 70 8	E^2 − 43 8
K_2O	c		86 2	
K_2O_3	c		126	
K_2O_4	c		135.	
KH	c		10	
KOH		I		T 1 52^{48}$_{.11}$
	c	II	102 02	S 12 78$_{.00}$
	∞	$K^+(\infty)$ + $OH^-(\infty)$	114.930	
	6400		114 892	
	3200		114 878	
	1600		114.860	
	800		114 840	
	400		114 817	
	200		114.8	
	100		114.793	
	50		114.793	
	25		114.768	
	20		114.76	
	15		111 70	
	12		114.57	
	10		114.52	
	8		114.32	
	6		113.90	
	5		113 56	
	4		112.99	
	3		112.10	
$KOH \cdot \frac{1}{2}H_2O$	c		161.94	S 4 14$_{200}$
$KOH \cdot H_2O$	c		179 82	S 3.35$_{200}$
$KOH \cdot 2H_2O$	c		250.81	S 0.13$_{200}$
KF	g		84.3	V − 38.4^{1100}

Potassium

Formula	State	Description	Q_1, *kcal mole*$^{-1}$	Q, *kcal mole*$^{-1}$
KF	liq			F — 6.3_{880}
	c		134.51	S 3.85_{200}
	∞	$K^+(\infty)+F^-(\infty)$	138.470	
	6400		138.436	
	3200		138.423	
	1600		138.408	
	800		138.389	
	400		138.370	
	200		138.355	
	100		138.349	
	50		138.347	
	25		138.339	
	20		138.338	
	15		138.325	
	12		138.295	
	10		138.248	
	8		138.157	
	6		137.926	
	5		137.696	
	4		137.295	
	3		136.73	
$KF\,2H_2O$	c		277.06	S — 1.96_{-00}
$KF\,4H_2O$	c		418.00	S — 6.16_{200}
KHF_2	c		219.13	S — 5.98_{400}
	∞	$K^+(\infty)+HF_2^-(\infty)$	213.67	
	3200		213.62	
	1600		213.60	
	800		213.57	
	400		213.535	
	200		213.507	
	100		213.515	
	50		213.615	
	25		213.870	
KF 2HF	c		297.0	S — 8.0
KF 3HF	c		373.2	S — 8.6
KCl	g		52.4	
	liq			F — 6.4^{790}
	c		101.361	S — 4.449_{200}
	∞	$K^+(\infty)+Cl^-(\infty)$	99.957	
	6400		99.924	
	3200		99.915	
	1600		99.906	

Potassium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcWl. mole^{-1}
KCl	800		99 899	
	400		99 899	
	200		99.912	
	100		99.970	
	50		100.085	
	25		100 275	
	20		100.359	
	15		100.483	
	12		100.575	
KClO	800		86.2	
$KClO_3$	c		91.33	S — $10\ 17_{400}$
	∞	$K^+(\infty)+ ClO_3^-(\infty)$	81 020	
	6400		81.003	
	3200		81.003	
	1600		81.013	
	800		81.06	
	400		81.16	
	200		81 36	
	100		81.78	
$KClO_4$	c		112.71	S — 12.28_{800}
	∞	$K^+(\infty)+ ClO_4^-(\infty)$	99.77	
	1600		100.14	
	800		100.43	
	400		100.97	
	200		101.83	
KBr	g		44.0	
	c		94.07	S — 5.10_{200}
	∞	$K^+(\infty)+ Br^-(\infty)$	88 940	
	6400		88.912	
	3200		88.907	
	1600		88.904	
	800		88.906	
	400		88.923	
	200		88.971	
	100		89.060	
	50		89.215	
	25		89.472	
	20		89.580	
	15		89.742	
	12		89.883	
	10		90.014	
KBr_3	aq.		91.4	

Potassium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
KBrO	aq.		81.6	
$KBrO_3$	c		81.60	$S - 10.0_{400}$
	∞	$K^+(\infty)+$ $BrO_3^-(\infty)$	71.47	
	6400		71.456	
	3200		71.460	
	1600		71.475	
	800		71.52	
	400		71.63	
	200		71.84	
KI	g		30.0	$V - 37.6^{1000}$
	c		78 87	$S - 5.19_{200}$
	∞	$K^+(\infty)+$ $I^-(\infty)$	73.640	
	6400		73.612	
	3200		73.607	
	1600		73.605	
	800		73.609	
	400		73.630	
	200		73.677	
	100		73.772	
	50		73.955	
	25		74.281	
	20		74.425	
	15		74.647	
	10		75 004	
	8		75 210	
	6		75.485	
	200 CH_3OH	in methanol	78.12	$S - 0.75^{18\ 5}{}_{200CH_3OH}$
	200 C_2H_5OH	in ethanol	76 67	$S - 2.20^{17\ 6}{}_{200\ C_2H_5OH}$
	400 C_2H_5OH		76.88	$S - 1.99^{17\ 1}{}_{400\ C_2H_5OH}$
	590 C_2H_5OH		77.33	$S - 1.54_{590\ C_2H_5OH}$
	200 CH_3CN	in acetonitrile	76.2	$S - 2.7_{200\ CH_3CN}$
	475 CH_3CN		76 0	$S - 2.9_{475\ CH_3CN}$
	200 C_3H_6O	in acetone	83.06	
KI_3	c		78.9	
	aq.		72.4	
KIO_3	c		121.70	$S - 6.70_{400}$
	∞	$K^+(\infty)+$ $IO_3^-(\infty)$	114.770	
	6400		114.765	
	3200		114.780	
	1600		114.810	
	800		114.880	
	400		114.995	

Potassium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
KIO_3	200		115 19	
	100		115.59	
KIO_4	aq.		97 9	
K_3IO_5	aq		283.7	
KH_4IO_6	aq.		234 6	
$KIO_4 \cdot HIO_4$	c		181 0	S — $11\ 3_{870}$
	1600		169 67	
$K_2H_3IO_6$	aq.		302 5	
$K_3H_2IO_6$	aq.		352 1	
KI KCl	c	fresh melt	182 69	
K_2S	c		121.5	S 11
	∞	$2K^+(\infty) + S^{--}(\infty)$	110 54	
	400		110.54	
	200		110 58	
	100		110 67	
	50		110 84	
	25		110 97	
	20		110 91	
	15		110 61	
	12		110 27	
	10		109 78	
	8		108 97	
	7		108 24	
$K_2S\ 2H_2O$	c		243 46	S $3\ 8_{1600}$
$K_2S\ 5H_2O$	c		457 53	S — $5\ 16_{900}$
K_2S_2	c		112 0	S $3\ 2_{1200}$
	aq		115 2	
K_2S_4	c		114 1	S $1\ 34_{1110}$
	aq		115 1	
$K_2S_4\ \frac{1}{2}H_2O$	c		151.5	S — 1 9
$K_2S_4\ 2H_2O$	c		259 1	S — 7 3
K_2SO_3	c		267 7	S $1\ 8_{1.0}$
	aq		269 5	
$K_2SO_3 \cdot H_2O$	c		336 5	S $1.4_{2.0}$
K_2SO_4	c	I		T $2.57^{569\ .11}$
	c	II	342.66	S — $6\ 42_{100}$
	∞	$2K^+(\infty) + SO_4^{--}(\infty)$	336 340	
	6400		336.210	
	3200		336 183	
	1600		336.169	
	800		336 175	
	100		336 237	
	200		336.450	

Potassium

Formula	State	Description	Qf, *kcal mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
K_2SO_4	100		336.970	
$K_2S_2O_3$	c		270 5	S — $4\ 5_{1000}$
	aq.		266.0	
$K_2S_2O_5$	c		361.1	S — $11\ 0_{00}$
	aq		350.1	
$K_2S_2O_5 \cdot \frac{1}{2}H_2O$	c		391 5	S — 10.2_{500}
$K_2S_2O_6$	c		113 7	S — $13\ 0_{400}$
	aq		400 7	
$K_2S_2O_7$	c		475.4	S — $3\ 8_{00}$
	aq		471.6	
$K_2S_2O_8$	c		457 5	S — $13\ 7_{400}$
	aq		443 8	
$K_2S_3O_6$	c		411 2	S — $12\ 10_{000}$
	aq		298 8	
$K_2S_4O_6$	c		406 0	S — $13\ 18_{000}$
	aq		392 8	
$K_2S_5O_6$	c		398.	
	aq		390	
$K_2S_6O_6\ 1\frac{1}{2}H_2O$	c		505 2	S — $12\ 6_{000}$
KHS	c		63 31	S $0\ 80_{00}$
	∞	$K^+(\infty) +$ $HS^-(\infty)$	61 17	
	100		61.11	
	200		61 12	
	100		61.14	
	50		61 21	
	25		61.35	
	20		61 41	
	15		61 50	
	12		61 57	
	10		61 62	
	8		61.67	
	6		61 69	
	5		61.61	
	4		61 52	
	3		61 24	
$KHS \cdot \frac{1}{2}H_2O$	c		80 58	S $0\ 62_{000}$
$KHSO_3$	aq.		209 3	
$KHSO_4$	c	I		T $0.19^{180}{}_{\rightarrow II}$
	c	II		T $0\ 096^{164}{}_{\rightarrow III}$
	c	III	276 85	S — 3.75_{200}
	800		273 75	
	400		273.37	
	200		273.1	
	100		272.97	

Potassium

Formula	State	Description	Q_f, kcal. mole^{-1}	Q, kcal. mole^{-1}
$KHSO_4$	50		272.94	
	25		272 99	
	20		272 02	
$KI{\cdot}4SO_2$	c		401.4	D — 9 7
K_2Se	c		74.4	S $8\ 8_{1800}$
	aq		83 2	
$K_2Se\ 9H_2O$	c		717.7	S — $19\ 2_{4000}$
$K_2Se\ 14H_2O$	c		1061 0	S — $20\ 6_{4000}$
$K_2Se\ 19H_2O$	c		1411 9	S — 29.7_{3400}
K_2SeO_4	∞	$2K^+(\infty)+SeO_4^{--}(\infty)$	266 9	
	440		266 85	
$KHSe$	aq.		34 0	
$KHSeO_4$	220		201 4	
K_2TeO_3	aq.		261.6	
K_2TeO_4	220		289.4	
KNO_2	aq		85.8	
KNO_3	liq.			F — $2\ 57^{333}$
	c	I		T $1.17^{128}{}_{\rightarrow II}$
	c	II		T $0\ 62^{126}{}_{\rightarrow III}$
	c	III	118.093	S — 8.400_{200}
	∞	$K^+(\infty)+NO_3^-(\infty)$	109.460	
	6400		109 429	
	3200		109.431	
	1600		109.442	
	800		109.477	
	400		109 550	
	200		109.693	N 14.165_{201}
	100		109.925	
	50		110 345	
	25		110.99	
	20		111.26	
$K_2N_2O_2$	aq.		117.0	
KNH_2	c		17.4	D — 6.4
$KBr{\cdot}4NH_3$	c		166.6	D — 7.15
$KI\ 4NH_3$	c		153 4	D — 7.65
$KI\ 6NH_3$	c		190.0	D — 7.35
KPO_3	aq.		295.5	
K_3PO_3	aq.		397.2	
K_3PO_4	aq.		478.4	
KH_2PO_2	aq.		202.8	
KH_2PO_3	aq.		290.1	
KH_2PO_4	c		362.7	S 4.7_{180}
	aq.		367 4	

Potassium

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
KH_3PO_7	aq.		600.5	
K_3HPO_2	aq.		249 4	
K_2HPO_3	aq.		350 2	
K_2HPO_4	aq.		425 6	
$K_2H_2P_2O_5$	aq.		505.7	
$K_2H_2P_2O_7$	aq.		661 1	
$K_3HP_2O_7$	aq.		721 4	
$K_4P_2O_7$	aq.		778.3	
KH_2AsO_3	aq.		228.7	
KH_2AsO_4	c		271 2	S 4 8_{800}
	aq.		276 0	
K_2HAsO_3	aq.		275 9	
K_2HAsO_4	aq.		335.1	
K_3AsO_3	aq.		322.7	
K_3AsO_4	aq		390 0	
K_3SbO_4	aq		368.4	
K_2CO_3	liq			F — 6 1^{880}
	c		274 46	S 6 63_{400}
	∞	$2K^+(\infty)$ + $CO_3^{--}(\infty)$	281 04	
	6400		280 980	
	3200		280 980	
	1600		280 985	
	800		281 010	
	400		281.090	
	200		281 240	
	100		281.440	
	50		281.660	
	25		281.815	
	20		281.860	
	15		281.875	
	10		281.840	
$K_2CO_3 \cdot \frac{1}{2}H_2O$	c		310 97	S 4.31$_{400}$
$K_2CO_3\ 1\frac{1}{2}H_2O$	c		384 03	S — 0 38_{400}
$K_2C_2O_4$	c	potassium oxalate	320 8	S — 4.56$_{400}$
	400		316.2	
$K_2C_2O_4 \cdot H_2O$	c		392 1	S — 7.52$_{800}$
$5(K_2CO_3 \cdot 1\frac{1}{2}H_2O) \cdot 4KHCO_3$	c		2836.	
$KCHO_2$	c	potassium formate	160.7	S — 0.66$_{320}$
	aq.		160.0	
$KHCO_3$	c	potassium bicarbonate	230.2	S — 5.2
	2000		225.07	

Potassium

Formula	State	Description	Q_f, kcal mole^{-1}	Q, kcal mole^{-1}
KCH_3O	60 CH_3OH		108 5	
KHC_2O_4	aq	potassium binoxalate	255 3	
$KC_2H_3O_2$	c	potassium acetate	171 67	S 3 35$_{200}$
	∞	$K^+(\infty)+C_2H_3O_2^-(\infty$	178 216	
	6400		178.178	
	3200		178 163	
	1600		178 113	
	800		178 111	
	400		178 074	
	200		178 023	
	100		177.951	
	50		177 844	
	25		177 686	
	20		177 616	
	15		177 494	
	12		177 369	
	10		177 241	
	8		177 051	
	6		176 721	
	5		176 451	
$KC_2H_3O_3$	c	potassium glycollate	218.0	S − 1 64
	aq.		216 3	N 13.7
$KC_2H_3O_3 \cdot \frac{1}{2}H_2O$	c		255 2	S − 4 7
KC_2H_5O	200 C_2H_5OH		117 0	
$K_2S_2O_5 \cdot C_2H_2O_2$	aq	potassium glyoxal metabisulfite	363.4	
$K_2S_2O_5 \cdot C_2H_2O_2 \cdot H_2O$	c		445.2	S − 13.40
KCN	c		28 5	S − 3 0
	200		25 50	
	63		25 58	
$KCNO$	c		100.0	S − 5.24$_{440}$
	aq.		94 8	
KCN_2H	aq.		37.8	
$KCNH_2O_2$	aq	pseudo salt of nitromethane	80.3	N 7.0
$KC_2NH_2O_3$	c	potassium oxamate	221.0	S − 7 0^{12}
	aq		214 0	N 13.65
$KCNS$	c		47.40	S − 6.00$_{200}$

Potassium

Formula	State	Description	Q_f, *kcal mole*$^{-1}$	Q, *kcal mole*$^{-1}$
KCNS	∞	$K^+(\infty) + CNS^-(\infty)$	41 320	
	6400		41 290	
	3200		41.280	
	1600		41 285	
	800		41.300	
	400		41.330	
	200		41 400	
	100		41 520	
	50		41 73	
	25		42 09	
	20		42 26	
	15		42 49	
	10		42 86	
	8		43 10	
	6		43 12	
	5		43 63	
	4		43 89	
	3		44 17	
	2		44 50	
$KCNS\ \frac{1}{2}SO_2$	c		83 4	D — 11 3
$KCNS\ SO_2$	c		118 8	D — 9 9
K_2SiF_6	c		681	
	aq		664 5	
K_2SnCl_6	c		360 21	S — $3\ 30_{400}$
	600		356 91	
$K_2SnCl_4\ H_2O$	c		363 2	S — $13\ 46_{600}$
$KCl{\cdot}PbCl_2\ \frac{1}{3}H_2O$	c		214.17	
$KCl\ 2PbCl_2$	c		277 92	
$2KI{\cdot}PbI_2$	c		200 05	S — $10\ 98_{1700}$
$2KI\ PbI_2\ 2H_2O$	c		311 41	S — 15.61_{1500}
$4KI{\cdot}3PbI_2$	c	fresh melt	439 18	S — 19.23_{1400}
$4KI\ 3PbI_2{\cdot}6H_2O$	c		861.76	S — 31.61_{1600}
$K_2SO_4\ PbSO_4$	c		566 46	
$KCl{\cdot}ThCl_4\ 9H_2O$	c		1103 9	S 3.30
$2KCl{\cdot}ThCl_4$	c		552.13	S 39.67
$K_2Zn(SO_4)_2$	c		580 31	S 7.98_{800}
$K_2Zn(SO_4)_2{\cdot}2H_2O$	c		724 47	S 0.56_{600}
$K_2Zn(SO_4)_2\ 6H_2O$	c		1010.48	S — 11.97_{800}
$2KCN{\cdot}Zn(CN)_2$	c		49.8	S — 15.0_{400}
KHg	c		11.0	
KHg_3	c		26 0	
KHg_{10}	c		33 0	
KHg_{100}	liq.		26 0	
$KCl{\cdot}HgCl_2$	c		166.02	S — 9.5_{770}

Potassium

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
$KCl\ HgCl_2$	550		150 50	
$KCl{\cdot}HgCl_2\ H_2O$	c		230.22	$S - 11.35_{800}$
$KCl{\cdot}2HgCl_2$	990		200 53	
$2KCl\ HgCl_2$	c		265.70	$S - 14.88_{930}$
	300		251.92	
	660		250.82	
$2KCl\ HgCl_2{\cdot}H_2O$	c		335.67	$S - 16.48_{800}$
$4KCl\ HgCl_2$	880		451.20	
$4KCl\ 3HgCl_2$	c		585 30	$S - 33.52$
	1760		551.78	
$4KCl{\cdot}3HgCl_2{\cdot}3H_2O$	c		796.09	$S - 39.2$
$KBr{\cdot}HgBr_2$	c		134.52	
	4600		128.58	
$KBr\ HgBr_2\ H_2O$	c		206 23	
$2KBr{\cdot}HgBr_2$	c		230.12	
	4800		128.64	
	300		220.34	
$4KBr{\cdot}HgBr_2$	4800		398.55	
$6HBr{\cdot}HgBr_2$	5000		576.94	
$8KBr{\cdot}HgBr_2$	5900		755.66	
$KI\ HgI_2$	c		106.36	
$KI{\cdot}HgI_2\ H_2O$	c		174.55	
$2KI\ HgI_2$	c		185 99	$S - 9.88_{900}$
	900		176.11	
$3KI{\cdot}HgI_2$	330		250.84	
$4KI{\cdot}HgI_2$	440		325.02	
$6KI{\cdot}HgI_2$	660		473.58	
$KCN{\cdot}Hg(CN)_2$	550		− 32.2	
$KCN\ 2Hg(CN)_2$	990		− 96.8	
$2KCN{\cdot}Hg(CN)_2$	c		12.4	$S - 13.8_{650}$
	660		− 1.4	
$4KCN{\cdot}Hg(CN)_2$	880		49.9	
$8KCN\ Hg(CN)_2$	1320		152.1	
$16KCN\ Hg(CN)_2$	2200		356.4	
$KCl{\cdot}Hg(CN)_2$	c		44.1	$S - 8.8_{720}$
	550		35.3	
$KCl{\cdot}Hg(CN)_2{\cdot}H_2O$	c		114.0	$S - 10.3_{760}$
$KCl{\cdot}2Hg(CN)_2$	1000		− 29.4	
$2KCl{\cdot}Hg(CN)_2$	660		135.4	
$4KCl{\cdot}Hg(CN)_2$	880		335.6	
$8KCl{\cdot}Hg(CN)_2$	1320		735.6	
$KBr{\cdot}Hg(CN)_2$	c		36.36	$S - 11.6$
	550		24.76	
$KBr\ Hg(CN)_2{\cdot}1\frac{1}{2}H_2O$	c		139.82	
$KBr{\cdot}2Hg(CN)_2$	1000		− 39.95	

Potassium

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal mole*$^{-1}$
$2KBr{\cdot}Hg(CN)_2$	660		111 11	
$4KBr\ Hg(CN)_2$	880		292 78	
$8KBr{\cdot}Hg(CN)_2$	1320		649.62	
$KI{\cdot}Hg(CN)_2$	c		23.6	S — 11 9
	550		11.7	
$KI\ Hg(CN)_2\ \frac{1}{2}H_2O$	c		41.1	
$KI\ 2Hg(CN)_2$	1000		— 52.8	
$2KI{\cdot}Hg(CN)_2$	660		86 56	
$4KI\ Hg(CN)_2$	880		234.92	
$8KI{\cdot}Hg(CN)_2$	1320		530 44	
$KCl\ CuCl_2$	c		162.4	
$2KCl\ CuCl$	c		214.78	
$2KCl\ CuCl_2$	c		266 2	
$2KCl\ CuCl_2{\cdot}2H_2O$	c		407 5	
$K_2Cu(SO_4)_2$	c	α, prepared below 130°	527.0	S 9.67_{800}
	c	β, prepared at 180-200°	530.4	S $6\ 23_{800}$
	c	fused	528.3	S $8\ 37_{800}$
$K_2Cu(SO_4)_2\ 2H_2O$	c		675.5	S — $1\ 17_{800}$
$K_2Cu(SO_4)_2\ 6H_2O$	c		960 4	
$K_2Cu(CO_4)_2$	c	II	424	
	c	IV	426.1	
	c	V	426.6	
$KCl\ AgCl$	c		134.5	
$KBr\ AgBr$	c		117.5	
$3KBr{\cdot}AgBr{\cdot}\frac{1}{2}H_2O$	c		338.6	
$KI{\cdot}AgI$	c		92.0	
$KI{\cdot}AgI\ \frac{1}{4}H_2O$	c		110.7	
$2KI{\cdot}AgI\ \frac{1}{2}H_2O$	c		206.8	
$3KI{\cdot}AgI$	c		250.7	
$3KI\ AgI\ \frac{1}{2}H_2O$	c		283.8	
$3KI\ 2AgI\ H_2O$	c		334.2	
$KCN{\cdot}AgCN$	c		6.9	S — 8 3
	500		— 1.4	
$2KCN{\cdot}AgCN$	1320		24.80	
	330		25.65	
	220		26.05	
$KCN{\cdot}AuCN$	aq.		4.8	
K_2PtCl_4	c		254.7	
	aq.		242.4	S — 12.15_{800}
K_2PtCl_6	c		299.6	
	aq.		286.2	
K_2PtBr_4	c		221.3	S — $10.58^{19\ 4}{}_{800}$
	aq.		210.7	

Potassium

Formula	State	Description	Qf, *kcal. mole*$^{-1}$	Q, *kcal. mole*$^{-1}$
K_2PtBr_6	c		248.2	
	aq.		236.0	S — $12.21^{20}{}_{2000}$
K_2PtI_6	aq.		172.9	
K_2IrCl_6	c		286.1	
	aq.		273.	S — $13.1^{15}{}_{5400}$
K_3IrCl_6	c		375.5	S — $7.9^{10}{}_{5500}$
	aq		367.6	
$KReO_4$	c		298.37	S — 13.88_{3600}
	∞	$K^+(\infty)+$ $ReO_4^-(\infty)$	284.5	
	14200		284.48	
	7200		284.46	
	3600		284.49	
K_2PdCl_4	c		261.6	S — $13.64^{19}{}_{800}$
	aq.		248.0	
K_2PdCl_6	c		292.	
	aq.		277.	
K_2PdBr_4	c		218.3	S — 12.3
	aq.		206.	
K_3RhCl_6	aq.		386.3	
$2KCN\cdot Ni(CN)_2$	aq.		40.3	
$K_2CO_3\cdot CoCO_3$	c		451.9	
$K_2CO_3\cdot CoCO_3\cdot 4H_2O$	c		736.8	
$KFe(SO_4)_2$	600		495 14	
$K_2Fe(SO_4)_2$	440		527.29	
$K_2Fe(SO_4)_2\cdot 4H_2O$	c		837.	
$K_2Fe(SO_4)_2\cdot 6H_2O$	c		937.	S 10.3_{200}
$K_3Fe(SO_4)_3$	660		830.03	
$K_3Fe(CN)_6$	c		48.5	
	aq.		34.1	
$K_4Fe(CN)_6$	c		131.9	
	aq.		119.5	
$K_4Fe(CN)_6\cdot 3H_2O$	c		340.3	
$K_3FeCO(CN)_5$	c		143.1	S — 5.1_{2000}
	aq.		138.0	
$K_3FeCO(CN)_5\cdot 3\frac{1}{2}H_2O$	c		388.2	S — 10.9_{2500}
$KH_3Fe(CN)_6$	aq.		− 87.2	
$KH_3Fe(CN)_6$	aq.		− 61.7	
$K_2HFe(CN)_6$	aq.		− 26.1	
$K_3H_2Fe(CN)_6$	aq.		− 1.4	
$K_3HFe(CN)_6$	aq.		59.1	
$KMnO_4$	c		192.9	S — 10.4_{500}
	400		182.5	
$K_2Mn(SO_4)_2$	c		594.9	S 6.34_{600}
$K_2Mn(SO_4)_2\cdot 2H_2O$	c		740.8	S — 2.87_{600}

Potassium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal mole*$^{-1}$
$K_2Mn(SO_4)_2\,4H_2O$	c		881.1	S — $6\,38_{600}$
K_2CrO_4	c	I		T $2.45^{664}{}_{\rightarrow II}$
	c	II	333.4	S — 5.25_{540}
	2185		328.53	
	1945		328 49	
	1722		328.44	
	440		328.0	
	21.47		326.80	
$K_2Cr_2O_7$	c		488.5	S — $16\,69_{400}$
	1600		470 69	
	800		471.25	
	400		471.8	
	200		427.31	
	100		472 87	
$KCl{\cdot}CrO_3$	c		246 4	S — $4\,65_{490}$
$K_2Cr_2O_7\,CrO_3$	c		599.	S $13\,3_{180}$
$KCr(SO_4)_2$	c		500.	
	600		554.93	
$KCr(SO_4)_2\,H_2O$	c		581.	
$KCr(SO_4)_2\,2H_2O$	c		659.	
$KCr(SO_4)_2{\cdot}6H_2O$	c		958.	
$KCr(SO_4)_2\,12H_2O$	c		1384 9	S — $9\,56_{600}$
KNH_4CrO_4	c		305 3	S — $5\,25_{385}$
	330		300.0	
K_2MoO_4	880		364 0	
$2KCl\,UO_2Cl_2{\cdot}2H_2O$	c		656 3	S $2\,0^{19}{}_{2000}$
KVO_3	c		321.8	S — 3 9
	aq.		317 9	
KVO_4	c		308.2	S — 4.0
	aq.		304.2	
KVO_5	aq.		290.2	
$3KF\,AlF_3$	c		777.57	
	3800		773.77	
$3KF{\cdot}AlF_3{\cdot}3\frac{1}{2}H_2O$	c		1033.39	
$KCl\,AlCl_3$	c		283 8	S 60.82_{900}
$3KCl{\cdot}AlCl_3$	c		496.9	S 47.49_{1330}
$3KCl{\cdot}2AlCl_3$	c		675.7	S 113.42_{2000}
$KAl(SO_4)_2$	c		569.	
	600		617.53	
$KAl(SO_4)_2{\cdot}H_2O$	c		723.	
$KAl(SO_4)_2{\cdot}2H_2O$	c		473.4	S — 2.4
$KAl(SO_4)_2{\cdot}3H_2O$	c		796.	
$KAl(SO_4)_2\,12H_2O$	c		1448.1	S — 10.10_{800}
$KCl{\cdot}AlCl_3{\cdot}6NH_3$	c		648.	
$K_2O{\cdot}Al_2O_3{\cdot}4SiO_2$	c	leucite	1379.6	

Potassium

Formula	State	Description	Qf, *kcal mole*$^{-1}$	Q, *kcWl. mole*$^{-}$
$K_2O\ Al_2O_3\ 4SiO_2$	gls.		1368 2	
$K_2O{\cdot}Al_2O_3{\cdot}6SiO_2$	c	adularia	1810 6	
$K_2O\ Al_2O_3\ 6SiO_2$	c	microcline	1784 4	
$K_2O{\cdot}Al_2O_3\ 6SiO_2$	gls		1747.	
$KCl{\cdot}MgCl_2$	c	fresh melt	260.7	
$KCl{\cdot}MgCl_2\ 6H_2O$	c		702 0	
$2KCl{\cdot}MgCl_2$	c	fresh melt	364 5	
$4KCl{\cdot}MgCl_2$	c	fresh melt	575 3	
$K_2Mg(SO_4)_2$	c	prepared below 150°	650 05	S 11 53_{500}
$K_2Mg(SO_4)_2$	c	fresh melt	654.71	S 6 92_{800}
$K_2Mg(SO_4)_2\ 2H_2O$	c		797.70	S 0.68_{600}
$K_2Mg(SO_4)_2\ 4H_2O$	c		945.4	
$K_2Mg(SO_4)_2\ 5H_2O$	c		991 58	S − 8 09_{800}
$K_2Mg(SO_4)_2\ 6H_2O$	c		1081.83	S − 10.02_{800}
$2KCl{\cdot}CaCl_2$	c	fresh melt	401 8	
$K_2SO_4\ CaSO_4\ H_2O$	c		757 5	
$K_2SO_4{\cdot}5CaSO_4\ H_2O$	c		2131 1	
$KCaFeCO(CN)_6{\cdot}5H_2O$	c		− 933.	
$K_2SO_4{\cdot}SrSO_4$	c		688.1	
KLiICl	c	fresh melt	176.6	
NaK	liq		2.1	
NaK_2	liq		5 3	
NaK_3	liq.		5 6	
Na_2K	liq.		0 4	
$KCl{\cdot}NaCl$	c	fresh melt	202 01	
KNaICl	c	fresh melt	176.59	
Na_2KPO_4	330		474 6	
3KCNS NaCNS	c		180 6	

Rubidium

Atomic number 37 Standard state Rb (c) Atomic weight 85.44

Formula	State	Description	*Qf*, *kcal mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
Rb	g	$4p^6 5s\ (^2S_{1/2})$	− 18 9	*V* − 18.2^{400}
	liq			*F* − 0.53^{39}
	c		0 000	
Rb*	g	$4p^6 5p\ (^2P^1_{1/2})$	− 44.68	E^2 − 35.781
	g	$(^2P^1_{3/2})$	− 45.39	E^2 − 36.486
Rb^+	g	$4p^6\ (^1S_0)$	− 116.25	I^1 − 95.90
	∞		61.04	
Rb^{++}	g	$4p^5\ (^2P^1_{3/2})$	− 749.3	I^2 −631.56
Rb_2O	c		82.9	*S* 80.0_{3000}
Rb_2O_2	c		107.	
Rb_2O_4	c		137.	
RbH	c		12.	
RbOH	c	II	101.3	*S* 14.4_{200}
	c	I		*T* $1.70^{245\to 11}$
	∞	$Rb^+(\infty)+OH^-(\infty)$	115.7	
	200		115.7	
	3 18		112 9	
$RbOH\ \frac{153}{1000}H_2O$	c		149.8	*S* 7.78_{110}
$RbOH{\cdot}H_2O$	c		180.2	*S* 3.87_{110}
$RbOH\ 2H_2O$	c		253.0	*S* − 0.56_{110}
RbF	g		79 8	*V* − 40.2^{1300}
	c		133.24	*S* 5.91_{110}
	∞	$Rb^+(\infty)+F^-(\infty)$	139.240	
	6400		139.218	
	3200		139.211	
	1600		139.202	
	800		139.189	
	400		139.173	
	200		139.157	
	100		139.150	
$RbF{\cdot}\frac{1}{2}H_2O$	c		158.08	*S* 3.86_{110}
$RbF\ 1\frac{1}{2}H_2O$	c		242 27	*S* − 0.56_{110}
$RbHF_2$	c		219.7	*S* − 5.17_{110}
	aq.		214.4	
RbCl	g		53.6	*V* − 37.7^{1200}
	c		105.08	*S* − 4.35_{200}
	∞	$Rb^+(\infty)+Cl^-(\infty)$	100.727	
	6400		100 704	
	3200		100 696	
	1600		100.691	
	800		100.688	
	400		100.698	
	200		100.733	

Rubidium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
RbCl	100		100 847	
RbBr	g		45 0	
	c		95 83	S — 5.86_{110}
	∞	$Rb^+(\infty)+Br^-(\infty)$	89.710	
	6100		89.690	
	3200		89.686	
	1600		89 684	
	800		89 690	
	400		89 720	
	200		89.800	
	100		89 970	
RbI	g		31.2	V — $36\ 7^{1106}$
	c		81.03	S — $6\ 5_{200}$
	∞	$Rb^+(\infty)+I^-(\infty)$	74 410	
	6400		74 391	
	3200		74.388	
	1600		74 388	
	800		74 395	
	400		74 432	
	200		74 530	
	100		74.730	
Rb_2S	c		88.	S 21 6
	∞	$2Rb^+(\infty)+S^{--}(\infty)$	112 08	
Rb_2SO_4	c		344 18	S — 6.43_{200}
	∞	$2Rb^+(\infty)+SO_4^{--}(\infty)$	337 880	
	6400		337 760	
	3200		337 743	
	1600		337.741	
	800		337 770	
	400		337 850	
	200		338.050	
$RbHSO_4$	c		277.6	S — 3.58_{200}
	aq		274 1	
$RbI\ 4SO_2$	c		405 0	D — 10.1
$RbNO_3$	c	II	119.24	S — 8.91_{400}
	c	I		T $1.05^{164\to II}$
	∞	$Rb^+(\infty)+NO_3^-(\infty)$	110.230	
	6400		110.201	
	3200		110.206	
	1600		110.220	
	800		110.257	
	400		110.339	

Rubidium

Formula	State	Description	*Qf*, *kcal. mole*$^{-1}$	*Q*, *kcal. mole*$^{-1}$
$RbNO_3$	200		110 495	
	100		110 750	
$RbBr\ 3NH_3$	c		150.0	*D* — 7.1
$RbI{\cdot}6NH_3$	c		191.7	*D* — 7.5
Rb_2CO_3	c		273.66	*S* 9.13_{220}
	∞	$2Rb^+(\infty)+CO_3^{--}(\infty)$	282.58	
	2000		282.54	
	220		282.79	
	5.76		281 58	
$Rb_2CO_3{\cdot}H_2O$	c		348.11	*S* 3.05_{220}
$Rb_2CO_3\ 1\frac{1}{2}H_2O$	c		385.38	*S* — $.03_{220}$
$Rb_2CO_3\ 3\frac{1}{2}H_2O$	c		525.56	*S* — $3\ 48_{220}$
$RbHCO_3$	c		230.44	*S* — $4\ 60_{220}$
	2000		225.84	
$3Rb_2CO_3\ 2RbHCO_3\ 4\frac{1}{2}H_2O$	c		1615.4	*S* — 7.7
$RbCNS$	c		56.	*S* — 14.
	aq.		42.1	
$RbCNS{\cdot}\frac{1}{2}SO_2$	c		96.8	*D* — 10.6
$2RbI{\cdot}PbI_2$	c		109 55	*S* 81.08_{1900}
$2RbI{\cdot}PbI_2\ 4H_2O$	c		490.80	*S* — 26.69_{2000}
$2RbCl\ CuCl_2$	c		269 0	*S* — 3.06_{800}
$2RbCl\ CuCl_2\ 2H_2O$	c		413.3	*S* — 10.65_{800}
$2RbCl\ ThCl_4$	c		565.2	*S* 28.1
$2RbCl\ ThCl_4\ 9H_2O$	c		1207.7	*S* 1.0
$4RbCl{\cdot}ThCl_4$	c		782.9	*S* 11.82
$RbAl(SO_4)_2$	c		567.	
$RbAl(SO_4)_2{\cdot}H_2O$	c		646.	
$RbAl(SO_4)_2\ 2H_2O$	c		722	
$RbAl(SO_4)_2\ 3H_2O$	c		796.	
$RbAl(SO_4)_2{\cdot}12H_2O$	c		1450.	

Cesium

Atomic number 55 | Standard state Cs (c) | Atomic weight 132.91

Formula	State	Description	Qf, kcal mole^{-1}	Q, kcal mole^{-1}
Cs	g	$5p^66s$ ($^2S_{1/2}$)	− 18 8	
	liq.		− 0 5	F − 0 50^{6}
	c		0 000	
Cs*	g	$5p^66p$ ($^2P^1_{1/2}$)	− 50 62	E^z − 31 82
	g	($^2P^1_{3/2}$)	− 52 20	E^z − 33 397
Cs^+	g	$5p^6$ ($^1S_0$)	− 109 65	I^z − 89 40
	∞		62 01	
Cs^{++}	g	$5p^5$ ($^2P_{3/2}$)	− 649 8	I^z − 538 7
Cs_2O	c		82 1	S 83 2$_{3109}$
Cs_2O_4	c		163 5	
CsH	c		12.	
CsOH	c	II	100 2	S 16 56$_{110}$
	c	I		T 1 76$^{22d}_{\rightarrow II}$
	∞	$Cs^+(\infty)+OH^-(\infty)$	116 7	
	200		116 7	
	2 16		113 36	
$CsOH\ H_2O$	c		180 69	S 1 48$_{110}$
CsF	g		81.	V − 36^{1200}
	c		131.68	S 8 51$_{110}$
	∞	$Cs^+(\infty)+F^-(\infty)$	110 24	
	800		110 20	
	200		110 19	
	100		110 19	
$CsF\ \frac{2}{3}H_2O$	c		181 41	S 1 34$_{110}$
$CsF\ 1\frac{1}{2}H_2O$	c		241 65	S 1 10$_{110}$
$CsHF_2$	c		219.1	S − 3 62$_{110}$
	aq		215 1	
CsCl	g		55.1	
	c	I		T 1 3$^{452}_{\rightarrow II}$
	c	II	106 32	S − 4 51$_{200}$
	∞	$Cs^+(\infty)+Cl^-(\infty)$	101 727	
	6400		101.706	
	3200		101 702	
	1600		101 703	
	800		101 712	
	400		101 732	
	200		101.801	
	100		101.912	
	50		102 097	
	25		102 427	
CsBr	g		47 8	V − 36.4^{1000}
	c		97 65	S − 6.60$_{110}$
	∞	$Cs^+(\infty)+Br^-(\infty)$	90.710	
	6400		90.692	

Cesium

Formula	State	Description	*Qf*, *kcal, mole*$^{-1}$	*Q, kcal. mole*$^{-1}$
CsBr	3200		90.690	
	1600		90 691	
	800		90.700	
	400		90 740	
	200		90.85	
	100		91.05	
CsI	g		37.5	
	c		83 90	*S* — 8.12_{110}
	∞	$Cs^+(\infty)+I^-(\infty)$	75.410	
	6400		75.393	
	3200		75.392	
	1600		75 393	
	800		75 403	
	400		75.455	
	200		75 57	
	100		75.78	
CsI_3	c		91.9	*D* — 17 5
CsI_4	c		92 3	*D* — 15 8
Cs_2S	c		87.	*S* 27 3
	∞	$2Cs^+(\infty)+S^{--}(\infty)$	114 08	
Cs_2SO_4	c		344.85	*S* — $4\ 70_{200}$
	∞	$2Cs^+(\infty)+SO_4^{--}(\infty)$	339 880	
	6400		339 787	
	3200		339.780	
	1600		339.795	
	800		339 843	
	400		339 940	
	200		340 15	
$CsHSO_4$	c		279.7	*S* — 3.55_{200}
	aq.		275.0	
$CsI\ 4SO_2$	c		410	*D* — 10 6
$CsNO_3$	c	II	121.10	*S* — 9.74_{400}
	c	I		*T* $0\ 83^{154}{}_{\rightarrow II}$
	∞	$Cs^+(\infty)+NO_3^-(\infty)$	111 230	
	6400		111.202	
	3200		111.210	
	1600		111.227	
	800		111.266	
	400		111.358	
	200		111.521	
	100		111.795	
	50		112.238	

Cesium

Formula	State	Description	Qf, kcal. mole^{-1}	Q, kcal. mole^{-1}
$CsNO_3$	25		112.980	
Cs_2CO_3	c		272.76	S 12.06_{220}
	∞	$2Cs^+(\infty)+CO_3^{--}(\infty)$	284.58	
	2000		284.54	
	220		284.82	
	7.59		284.58	
$Cs_2CO_3 \cdot 3\frac{1}{2}H_2O$	c		527.57	S -3.45_{220}
$CsHCO_3$	c		231.0	S -4.17_{220}
	2000		226.8	
$5Cs_2CO_3 \cdot 2CsHCO_3 \cdot 11H_2O$	c		256.8	S $-8.$
$5Cs_2CO_3\ 2CsHCO_3\ 17\frac{1}{2}H_2O$	c		3100.	S $-26.$
$CsCNS \cdot \frac{1}{2}SO_2$	c			D -10.1
$2CsCl \cdot CuCl_2$	c		272.7	S -4.8_{1000}
$2CsCl \cdot CuCl_2 \cdot 2H_2O$	c		413.6	S -9.0_{1000}
$2CsCl\ ThCl_4$	c		562.5	S 32.9
$2CsCl \cdot ThCl_4 \cdot 8H_2O$	c		1139.4	S 3.0
$4CsCl \cdot ThCl_4$	c		777.2	S 21.6
$CsLiICl$	c	melt	181.36	
$CsNaICl$	c	melt	181.91	
$CsKICl$	c	melt	187.49	
$CsAl(SO_4)_2$	c		569.	
$CsAl(SO_4)_2 \cdot H_2O$	c		647.	
$CsAl(SO_4)_2 \cdot 2H_2O$	c		723.	
$CsAl(SO_4)_2 \cdot 3H_2O$	c		797.	
$CsAl(SO_4)_2 \cdot 12H_2O$	c		1451.	

Element 87

Atomic number 87 Standard state M (c) Atomic weight (223?)

Helium

He (g). The values for the energy states of gaseous monatomic helium are from Hansen and Thorsen,[1] Hylleraas,[1] and Bacher and Goudsmit.[1]

He (liq.). Vapor pressure data were reported by Dana and Onnes,[1, 2] Keesom, Weber, and Ngaard,[1] Keesom, Weber, and Schmidt,[1] Onnes,[1, 2] Onnes and Weber,[1, 3] and Spangenberg.[1] We have utilized the data of Dana and Onnes.[1, 2].

He (c.) Simon and Steckel[1] reported values for the heat of fusion of helium at pressures from 1120 to 1860 kg per cm.[2] He (c) is not stable at 1 atmosphere. See also van Laar.[11]

He_2 (g). The values for the energy states and the energy of dissociation of gaseous diatomic helium are from Weizel,[1, 2, 3, 4, 5] Weizel and Pestel,[1] Weizel and Füchtbauer,[1] Imanishi,[1, 2] Curtis,[1] Curtis and Harvey,[1] and Mulliken.[6] See also Jevons.[1]

Neon

Ne (g). The values for the energy states of gaseous monatomic neon are from Paschen,[5] Hansen and Thorsen,[1] de Bruin,[3] Russell, Compton, and Boyce,[1] Compton, Boyce, and Nickerson,[1] Bleakney,[1] and Bacher and Goudsmit.[1]

Ne (liq.). Vapor pressure data for liquid neon were reported by Cath and Onnes,[1] Crommelin,[5] Onnes and Crommelin,[2] Crommelin and Gibson,[1] Clusius,[1] Verschaffelt,[2] and Mathias, Crommelin, and Onnes.[3]

Ne (c). Verschaffelt[2] measured the vapor pressure of solid neon.

Argon

A (g). The values for the energy states of gaseous monatomic argon are from Meissner,[1] Saunders,[3] Compton, Boyce, and Russell,[1] Compton, Boyce, and Nickerson,[1] Bleakney,[1] and Bacher and Goudsmit.[1]

A (liq.). Eucken[2, 3] measured directly the heat of vaporization, obtaining $V = -1\,501$ at $-185.6°$. This value is in agreement with the value -1.54 calculated from the vapor pressure data of Born,[1] Crommelin,[1, 2, 3] and Mathias, Crommelin, and Onnes.[3, 4]

A (c). Eucken and Hauch[1] measured the heat of fusion. See also Eucken.[2, 3]

$A \cdot 5\,H_2O$ (c). According to Villard[8] and de Forcrand,[68] argon forms a well-defined pentahydrate. The latter's data on the dissociation pressure from 0 to 8° yield a value for the heat of the reaction of dissociating the solid hydrate into gaseous argon and liquid water.

Krypton

Kr (g). The values for the energy states of gaseous monatomic krypton are from Meggers, de Bruin, and Humphreys,[1] Bleakney,[1] Deb and Dutt,[1] Dejardin,[1] and Bacher and Goudsmit.[1]

Kr (liq.). The vapor pressure data of Peters and Weil[1] yield $V = -2.31$ at the boiling point, $-151.0°$. Other vapor pressure data were reported by Ramsey,[1, 3] Ramsey and Travers,[1] and Patterson, Cripps, and Whytlaw-Gray.[1]

Kr (c). We have estimated the heat of fusion of krypton.

Kr · 5 H_2O (c). According to Villard[8] and de Forcrand[68] there is a well-defined pentahydrate of krypton. The latter computed the heat of dissociation into gaseous krypton and liquid water from his data on the dissociation pressure at temperatures from 0 to 12°.

XENON

Xe (g). The values for the energy states of gaseous monatomic xenon are from Meggers, de Bruin, and Humphreys,[1] Deb and Dutt,[1] and Bacher and Goudsmit.[1]

Xe (liq.). The vapor pressure data of Peters and Weil[1] yield $V = -3.27$ at the boiling point, $-108.6°$. Other vapor pressure data were reported by Ramsey and Travers[1] and Patterson, Cripps, and Whytlaw-Gray.[1]

Xe (c). We have estimated the heat of fusion.

Xe · 6 H_2O (c). According to de Forcrand,[70] there is a well defined hexahydrate. His data on the dissociation pressure at temperatures from 1.5 to 23.5° yield a value for the heat of dissociation of the solid hydrate into gaseous xenon and liquid water.

RADON

Rn (g). The values for the energy states of gaseous monatomic radon are from Rasmussen[1] and Bacher and Goudsmit.[1]

Rn (liq.). We have estimated the heat of vaporization.

Rn (c). We have estimated the heat of fusion.

OXYGEN

O_2 (g). The standard state is taken to be the naturally existing mixture of oxygen molecules containing the atoms, O^{16}, O^{17}, and O^{18}. The values for the energy states of gaseous diatomic oxygen are from Mulliken[6] and Jevons.[1]

O_2 (liq.), O_2 (c). We have selected Giauque and Johnston's[1] accurate calorimetric values for the heats of transition, fusion, and vaporization of oxygen. These and the earlier calorimetric data of Eucken,[2, 3] Alt,[1] Barschall,[1] and Keesom,[1] as well as the vapor pressure data of Cath,[1] Holst,[4] Onnes and Braak,[1] Onnes and Crommelin,[1] and von Siemens,[1] are in substantial agreement.

O_2 (aq.). From the data of Winkler[1, 2, 6, 9, 10] and Cassuto[1] on the solubility of oxygen in water at various temperatures we have calculated $S = 3.85$. Washburn and Strachan[1] computed $S = 3.0$.

O (g). The value for the energy of dissociation of the normal oxygen molecule into normal oxygen atoms is 5.09 ± 0.03 volt-electrons. This

value is from Herzberg,[2] Wigner and Witmer,[1] Birge,[2, 3, 5] and Birge and Sponer.[1] See also Henri,[1] Mecke,[5] Kondratjew,[1] Baxter,[1] Jenckel,[1] Eucken,[1] and Warburg.[1] Copeland[1] and Rodebush and Troxel[1] made direct calorimetric measurements of the energy of recombination of oxygen atoms on a palladium surface, but their values, though identical, are about 12 per cent higher than the accepted value and may indicate a systematic error. See also Reisenfeld and Schumacher,[1] Reisenfeld and Wassmuth,[1] and Kassel.[1, 2]

The values for the energy states of gaseous monatomic oxygen are from Frerichs,[1, 2] Paschen,[8] Bowen,[1, 2, 8] Kaplan,[1] Sommer,[1] McLennan and Crawford,[1] Hopfield,[1] Russell,[5] Fowler,[1] Fowler and Hartree,[1] Laporte and Young,[2] Edlen and Ericson,[1] and Bacher and Goudsmit.[1]

O^{--} (g). The electron affinity of the oxygen atom may be evaluated by extrapolation of the square root of the ionization potentials of F^-, Ne, and Na^+, but adequate data for F^- are not available The only other method which presents itself is by way of the reaction MO (c) $= M^{++}$ (g) $+ O^{--}$ (g). Using the values for the lattice energies as given by Sherman,[2] and taking the values for the heats of formation for MO (c) and M^{++} (g) from our tables, we have calculated the following values for the heat of formation of O^{--} (g) from the data on the various metallic oxides: −224.9, MgO; −226 8, CaO; −224 6, SrO; −222.6, BaO; −226 2, Li_2O; −204, NiO; −231.0, ZnO; −187.4, CdO; −260, SnO_2. We have selected as a mean, the value −225, which gives for the electron affinity of the oxygen atom, O (g) $+ 2\theta = O^{--}$ (g), Q = 166. Senftleben[1] gave −40 for the electron affinity, but his calculation via OH^- is very uncertain; Lande's[1] data lead to 265, which is apparently in error.

O_3 (g). Berthelot[3a, 13i] and Mulder and Van der Muelen[1, 2] measured the heat of the reaction between O_3 (g) and As_2O_3 (aq.). Combining their data with those of Thomsen for the reaction between O_2 (g) and As_2O_3 (aq.), we have computed the following values for *Qf* of O_3 (g): Berthelot, 32 5 ± 1 5; Mulder and Van der Meulen, 33.7 ± 2 0. Recent determinations of this quantity have been made by direct catalytic decomposition. Van der Meulen, using a platinum catalyst, obtained 35.9; the data of Kailan and Jahn,[3] and Jahn[3] (cf. Woods[1]), who passed ozone over soda lime, lead to 34.50 ± 0.2. This latter value may be accepted with considerable confidence inasmuch as Kailan and Jahn[3] have shown that the use of platinum as a catalyzer results in high values, probably due to oxidation of the catalyst. See also Rideal and Kunz,[1] and Born and Gerlach.[1]

O_3 (liq.). Spangenberg[1] determined the heat of vaporization of liquid ozone.

O_3 (aq.). The heat of solution of ozone was computed from the data of Fischer and Tropsch[1] and Rothmund[1] on the solubility of ozone in water at various temperatures.

O_4 (g). The existence of O_4 was first postulated by Lewis[3] in order to explain the anomalous magnetic properties of oxygen. and his expres-

sion for the equilibrium constant gives for O_4 (g), $Qf = 0.13$. Wulf[1] found bands in the absorption spectra of oxygen which he assigned to the O_4 molecule. If, following Kondratjew,[1] it is assumed that the band at 47,500 cm^{-1} is associated with the reaction, O_4 (g) (normal) $= O_3$ (g) (normal) $+ O$ (g) (^1D), then for O_4 (g), $Qf = 1.2$.

HYDROGEN

H_2 (g). The standard state of hydrogen is taken to be the naturally existing mixture of diatomic hydrogen molecules containing atoms of protium (H^1) and deuterium (H^2), the molecules being in equilibrium at 18° with respect to the ortho and para rotational states. See Dennison,[1] Bonhoeffer and Harteck,[1] Giauque,[1] Elbe and Simon,[1] Davis and Johnston,[1] and Johnston and Long.[1] For H^1H^1 at 18°, 0.2508 of the molecules are in the para rotational states and 0.7492 in the ortho, which is very nearly the high temperature distribution of 1 to 3. The number of atoms of H^2 in natural hydrogen is about 1 in 5000.

The values for the energy states of gaseous diatomic hydrogen are from Richardson[3, 4, 5] and Richardson and Das.[1, 2] See also Sandeman,[1] Dieke and Hopfield,[1] Hori,[3] Schaafsma and Dieke,[1] Richardson and Davidson,[1, 2, 3, 4, 5] Finkelnburg and Mecke,[1, 2] Mulliken,[6] Jevons,[1] and Burrau.[1]

H_2 (liq.). The calorimetric determinations of the heat of vaporization by Simon and Lange,[1] Keesom,[1] Onnes and Keesom,[1] Mathias, Crommelin, and Onnes,[1] Dewar,[3] and Eucken[2, 3] are in substantial agreement, as are values calculated from vapor pressure data by Dewar,[3] de Forcrand,[61, 62] Cederberg,[1] Onnes and Keesom,[1] Van Laar,[2, 5] Eucken, Karwat, and Fried,[1] Simon,[5, 6] Eucken and Fried,[2] Crommelin and Onnes,[2] Keesom,[1] and Onnes and Martinez.[1]

H_2 (c). For the heat of fusion we have taken Simon and Lange's[1] value, which is in agreement with the earlier values of Keesom and Onnes,[1] but not with that of Dewar.[3] These data are presumably for the 1 to 3 mixture of para and ortho hydrogen.

H_2 (aq.). The heat of solution is computed from the solubility-temperature data of Turnofejen[1] and Winkler.[9]

H (g). The International Critical Tables (see Bichowsky[1]) value for the heat of formation of monatomic hydrogen was taken from Witmer[1] and Dieke and Hopfield,[1] who gave $D^z = 4.35$ volt-electrons. It has since been shown that the last line of Witmer's Lyman band is spurious, and the slightly higher value of 4.47 volt-electrons is obtained. The calorimetric data of Bichowsky and Copeland[1] yield $D^z = 4.47 \pm 0.15$ volt-electrons. Richardson and Davidson[5] carefully reviewed all the data on the energy of dissociation of hydrogen and concluded that $D^z = 4.46 \pm 0.04$ volt-electrons.

See Bacher and Goudsmit[1] for a discussion of the energy states of gaseous monatomic hydrogen.

H^- (g). The electron affinity of the hydrogen atom can be determined in several ways. Extrapolation of the ionization potentials of Be^{++}, Li^+, and He to H^- yields a value of 1.40 volt-electrons. The electron affinity can also be calculated from the lattice energy of the ionic LiH crystal. Assuming that the repulsive force varies as $1/r^5$ for both Li^+ and H^-, we have calculated for the lattice energy of LiH, the value 218.2. Hylleraas,[4] using a similar method, obtained 217. Hylleraas[4] also calculated this quantity by means of the new quantum mechanics, obtaining 218.6. This last calculation gives atomic distances in LiH in exact accord with the known density.

H^+ (aq.). It is conventional to take the heat of formation of aqueous hydrogen ion as zero at infinite dilution. This value, of course, has no relation to the actual heat of formation of H^+ (aq.), which quantity could be determined if the heat of solution of H^+ (g) were known. Though we have no accurate knowledge of the heat of solution of H^+ (g), its value can be estimated in several ways. The method of Latimer[1] requires a knowledge of the absolute potential of the hydrogen electrode and the entropy of H^+ (aq.); while that of Born requires a knowledge of the effective diameter, r, of the hydrogen ion and the dielectric constant, d, of water, which values are used in the formula $S=e^2/2r(1-1/d)$. The values obtained by these methods are, respectively, $S=257$ and 225; and the absolute value of Qf for H^+(aq.) becomes -108 and -140, respectively. See also Fajans[3, 4]. However, for practical reasons, we arbitrarily take, for H^+ (∞), $Qf=0$.

H_2O (liq.). At the time of the compilation of the thermochemical values for the International Critical Tables by Bichowsky,[1] the heat of formation of water had been measured by a large number of investigators: Despretz,[2] Dulong,[2] Grassi,[1] Abria,[2] Favre and Silbermann,[1] Andrews,[4, 14] Thomsen,[3, 15] von Than,[1, 2, 3] Schuller and Wartha,[1] Berthelot,[69] Berthelot and Matignon,[8] Mixter,[2, 3] and Rümelin.[1] The first six of these investigations must be designated as pioneering studies, while those of von Than,[1, 2, 3] Berthelot,[69] Berthelot and Matignon,[8] and Rümelin[1] must be withdrawn from consideration for the following reasons: Five experiments were reported by von Than,[1, 2, 3] who used an ice calorimeter and obtained an average deviation of about ± 0.05 per cent in the combustion experiments; but, unfortunately, his calibration data (energy equivalent of the calorimeter) are so few and so lacking in accuracy as to make the high precision of the combustion experiments practically valueless. Berthelot[69] reported the result of but one experiment. Berthelot and Matignon[8] performed four experiments with an average deviation of about ± 0.9 per cent. The six results given by Rümelin[1] have an average deviation of about ± 0.5 per cent.

There remain to be considered the data of Thomsen[3, 15] who burned oxygen in hydrogen in a flame at constant pressure in a calorimeter at room temperature; of Schuller and Wartha,[1] who burned oxygen in hydrogen in a flame at constant pressure in an ice calorimeter; and of

Mixter,[2, 3] who exploded oxygen and hydrogen at constant volume in a bomb calorimeter. The best of these three sets of data are those of Schuller and Wartha,[1] to which an accuracy of about ±0.09 per cent may be attached. The data of these three investigations were reviewed by Lewis,[2] Roth,[10] and Bichowsky,[1] who recommended the following values for the heat of formation of liquid water from gaseous hydrogen and oxygen (corrected to 18°): Lewis, 68.33; Roth, 68.39; Bichowsky, 68.38. Complete details of a recalculation of the calorimetric data of Thomsen,[15] Schuller and Wartha,[1] and Mixter[2, 3] are given in a report by Rossini.[1]

Recently, Rossini[1] determined with considerable accuracy (±0.015 per cent) the heat of formation of water, using a flame calorimeter at constant pressure and burning both oxygen in hydrogen and hydrogen in oxygen. His method was a substitution one, in which the energy from a measured amount of electrical energy was substituted for the energy from a measured amount of chemical reaction, the calorimeter serving as the comparator of the two kinds of energy. Rossini[1] reported 285,775±40 international joules per mole for the reaction at 25° and a constant pressure of 1 atmosphere. Corrected to 18°, and kilocalories, the value becomes 68.367±0.010. For the present tables, we have rounded off this value to 68.370.

H_2O (g). Values for the heat of vaporization of water were reported by Brix,[1] Regnault,[5, 7, 9] Andrews,[5] Favre and Silbermann,[3] Berthelot,[44] Schall,[1] Dieterici,[1] Griffiths,[2] Louguinine,[10] Smith,[3, 4, 5] Joly,[5] Henning,[1, 2, 4] Brown,[1] Richards and Mathews,[1, 2, 3] Carlton-Sutton,[1] Mathews,[3] Wrewsky,[2] Jakob,[1] Osborne, Stimson, and Fiock,[1] and Fiock and Ginnings.[1] The most accurate data are apparently those of the last two named investigations, whose data yield for 18°, $V = -10.571$. This value is in agreement with that obtained by Fiock[1] from a recalculation of the earlier data. See also Holborn, Scheel, and Henning.[1]

H_2O (c). Values for the heat of fusion of ice were reported by Black,[1] Laplace and Lavoisier,[1] la Provostaye and Desain,[1] Desain,[1] Regnault,[1, 5] Hess,[11] Person,[1, 3, 5] Leduc,[1] Bunsen,[3, 4] Smith,[4, 5] Behn,[2] Dieterici,[2] Zakrzewsky,[2] Bogojawlensky,[1] Noyes and Sammet,[1] Bridgman,[5] Dickinson and Osborne,[2] and Dickinson, Harper, and Osborne.[1] The data of the last two named investigations are the most accurate and yield the value −1.437 at 0°.

OH (g). The normal state of the OH molecule is $^2\pi$. The next higher electronic energy state is $^2\Sigma$, and its energy has been shown by Birge[1] and Jack[1] to be 92.26 above that of the normal level. Bonhoeffer and Reichardt,[1] in an ingenious study of the intensity of lines in the absorption spectra of partially dissociated H_2O, determined the concentration of gaseous OH in equilibrium in the mixture at various temperatures and pressures. Their data yield for the reaction, O_2 (g) $+2H_2O$ (g) $=4OH$ (g), $Q = -134$; whence, for OH (g), $Qf = -4.6$. By extrapolating the vibration levels of the $^2\Sigma$ state of OH, Bonhoeffer and Haber deduced $D^\circ = -70.6$ for the reaction, OH (g) ($^2\Sigma$) = H (g) (nor-

mal) + O (g) ($^2D_1$); whence, for OH (g), $Qf = 7.5$. Villars[1] gave, for OH (g) (normal) = O (g) ($^2D_1$) + H (g) (normal), $D^z = -138$, yielding for OH (g), $Qf = -17.3$; but his method is faulty. From spectroscopic data, Bates[1] found for the dissociation of normal OH into normal atoms of O and H, $D^z = -116.05$, whence, for OH (g), $Qf = 5.93$.

OH^- (g). The heat of formation of OH^- (g) can be estimated by the method of lattice energies. Using the approximate formula for the lattice energy, with rough estimates of the crystal constants of NaOH, KOH, and RbOH from their densities and molecular weights, we have calculated from the data on these substances, for OH^- (g), $Qf = -64$, -58, and -56, respectively. Lederle[1] calculated a value of -81.

OH^- (∞). The heat of formation of OH^- (∞) is calculable from a knowledge of the heat of neutralization of a strong acid and a strong base at infinite dilution in water. That is to say, the reaction, NaOH (∞) + HCl (∞) = NaCl (∞) + H_2O (liq.), is equivalent to the reaction OH^- (∞) + H^+ (∞) = H_2O (liq.). Rossini[4] critically reviewed the data on heats of neutralization and heats of dilution, and, utilizing the Debye-Huckel theory for extrapolating to infinite dilution, calculated the following heats of neutralization at 18° and infinite dilution in water: KCl, 13.689; KNO_3, 13.713; NaCl, 13.699; $NaNO_3$, 13.720; LiCl, 13.703; $LiNO_3$, 13.734. The average value is 13.710, whence for OH^- (∞), $Qf = 54.66$.

H_2O_2 (aq.). Thomsen[15] measured the heat of reaction of ($SnCl_2$ + 4HCl) (500) with H_2O_2 (600) and with other oxidizing agents. His recomputed data yield, for H_2O_2 (600), $Qf = 44.96$. Thomsen[15] also measured the heat of reaction of $KMnO_4$ (aq.) with H_2O_2 (aq.) and with other reducing agents, but these data are less accurate than the former, and the reactions are not as clear cut. Berthelot[30] measured the heats of reaction of BaO_2 (c) + HCl (aq.) and of $SnCl_4$ (aq.) + $BaCl_2$ (aq.) + $2H_2O$ (liq.); these data yield, for H_2O_2 (aq.), $Qf = 44.8$. Berthelot[62] also measured the heat of decomposition of H_2O_2 with Ag_2O as a catalyst, —these data yielding $Qf = 46.7$. Berthelot's[63] data on the reaction of H_2O_2 (aq.) + KI (aq.) must be disregarded because of the slowness of the reaction and because of side reactions. Favre and Silbermann[2] measured the decomposition of H_2O_2 with Pt as a catalyst, but their data are lacking in accuracy. Recently Matheson and Maass,[1] and Roth, Grau and Meichsner[1] independently measured the heat of decomposition of H_2O_2 (aq.) with MnO_2 as a catalyst. Their data yield the following values for the heat of formation of H_2O_2 in 0, 0.3, 1.8, 2.6, 6.3, 170, and 360 H_2O, respectively: 44.84, 44.91, 45.60, 45.63, 45.67, 45.68, and 45.75.

H_2O_2 (liq.). The foregoing data of Matheson and Maass[1] and of Roth, Grau, and Meichsner[1] yield, for the heat of solution of H_2O_2 (liq.) in water, $S_{200} = 0.88$; while the direct measurements of de Forcrand[32] yield $S_{200} = 0.46$.

H_2O_2 (g). Maass and Hiebert[1] measured the heat of vaporization of H_2O_2 (liq.) to be 11.61. This direct determination supersedes the value

of 12.3 which was calculated by Lewis and Randall[5] from the uncertain vapor pressure data of Wolffenstein[1] and Bruhl.[1]

H_2O_2 (c). The data of Maass and Hatcher[1] and Maass and Waldbauer[1] yield $F = -2.51$ at $-1.7°$.

Fluorine

F_2 (g). The energy states of the F_2 molecule are evaluated from the data of Gale and Monk[1] and Gale.[1] See Jevons.[1]

F_2 (liq.). Cady and Hildebrand,[1] from their own vapor pressure data, computed $V = -1.60^{-188}$. Henglein[1] estimated $V = -1.44$.

F_2 (c). Henglein[1] estimated $F = -0.34$.

F (g). The data of von Wartenberg, Sprenger, and Taylor,[1] who measured, spectroscopically, the convergence limit of the vibrational levels of F_2 (g), yield -62.6 for the energy of dissociation of normal F_2 (g) into normal fluorine atoms. Earlier estimates of this value were: Birge,[1] -70.0; Henglein,[1] -63.0; Villars,[1] -57. See also Franck.[2]

The values for the energy states of gaseous monatomic fluorine are from Dingle,[1, 2] de Bruin,[2] Bowen,[2] Turner,[3] and Laporte and Young.[1] See also Bacher and Goudsmit.[1]

F^- (g). Extrapolation of the ionization potentials of Ne and Na^+ gives 135 for the ionization energy of F^- (g), the negative of the electron affinity of F (g); but this method is known to give values that are too high. A more reliable value can be obtained by the method of lattice energies, utilizing the data on the alkali fluorides. We have computed values of the lattice energies of LiF, NaF, KF, RbF, and CsF which are identical with those given by Sherman[1] namely: 240.1, 215.0, 190.4, 181.8, and 172.8, respectively. Utilizing the remaining necessary data from our tables, we have computed, for F^- (g), the average value, $Qf = 66.3$. This is equivalent to an electron affinity of 98, which is identical with the value given by Lederle.[1] Older values were given by Henglein,[1] Lande,[1] and Turner.[3]

HF (g). von Wartenberg and Fitzner[1] measured the heat of the reaction between gaseous fluorine and hydrogen to give the gaseous associated molecule $(HF)_n$. According to present information, (see Simons and Hildebrand[1]) the association of gaseous hydrogen fluoride is such that, at 18° and a pressure of 745 mm. Hg, the mean molecule is $(HF)_{3.3}$. Utilizing the data of Simons and Hildebrand[1] on the reaction, 6 HF (g) $= (HF)_6$(g), von Wartenberg and Fitzner corrected their observed calorimetric data to give, for HF (g) (ideal), $Qf = 63.0$. Later, von Wartenberg and Schutza[1] and Ruff and Laass[1] reported, for HF (g) (ideal), $Qf = 64.5$ and 62.3, respectively.

HF (aq.). The earliest determination of the heat of formation of fluorine compounds was made by Berthelot and Moissan,[1] who measured the heat of reaction between fluorine and an aqueous alkaline solution of potassium sulfite; but their data are of historical interest only. Guntz[1] found the heat of solution of hydrogen fluoride to be 11.8; von Wartenberg and Fitzner[1] gave, for HF (g) (ideal) = HF (aq.), $Q = 11.56$. von

Wartenberg and Fitzner[1] also measured the heat of the reaction, $\frac{1}{2}F_2$ (g) $+$NaCl (c) $=$NaF (c) $+\frac{1}{2}Cl_2$ (g). Combining with this reaction the heat of formation of NaCl (c) and the heat of neutralization of HF (aq.), we have obtained, for HF (aq.), $Qf=77.0$. The heat of dilution of aqueous HF was measured by Guntz[1] and Peterson.[6]

HF (liq.). Guntz[1, 5] measured the heat of solution of liquid HF in water. He gave $S=4.6$, whence, for HF (liq.), $Qf=71.0$. Kolosovskii,[1] from vapor pressure data, computed $V=-6.3$, correcting an earlier calculation by Simons.[1] In a recent investigation, Fredenhagen[1] found $V=-6.05$ at 15°.

HF (c). Dahmlos and Jung[1] reported $F=-1.09$.

$(HF)_6$(g). Simons and Hildebrand[1] studied the equilibrium, 6HF (g) $=(HF)_6$(g), and concluded that $Q=40.0$. They assumed that no other molecular species exist in gaseous hydrogen fluoride.

F^- (aq.). From the values of the heats of formation of LiF (∞), NaF (∞), KF (∞), and of Li^+ (∞), Na^+ (∞), and K^+ (∞), we have computed, for F^- (∞), $Qf=78.21$, 78.13, and 78.23, respectively.

HF_2^- (aq.). From the values of the heats of formation of aqueous $LiHF_2$, $NaHF_2$, and KHF_2 at infinite dilution (assuming no dissociation of HF_2^-) we have obtained, for HF_2^- (∞), $Qf=153.67$, 153.37, and 153.40, respectively.

F_2O (g). von Wartenberg and Klinkott[1] found for the reaction, F_2O (g) $+2$KOH (4.67) $=2$KF (4.67) $+2H_2O$ (liq.) $+O_2$ (g), $Q=251.8 \pm 1.0$; whence, for F_2O (g), $Qf=-6.7$. von Wartenberg and Klinkott[1] also measured the heats of the reactions, F_2O (g) $+6$KI (aq.) $+2$HF (aq.) $=(4KF+3KI_3)$ (aq.) $+H_2O$ (liq.) and, at about the same concentration, $2Cl_2$ (g) $+6$KI (aq.) $=(2KI_3+4KCl)$ (aq.), finding, respectively, $Q=176.4$ and 103. Combination of these reactions leads to a value of -4.8 for the heat of formation of F_2O (g). von Wartenberg and Klinkott[1] also measured the heats of the reactions, F_2O (g) $+4$ HBr (aq.) $=2$ HF (aq.) $+2$ Br_2 (liq.) $+H_2O$ (liq.) and $2Cl_2$ (g) $+4$ HBr (aq.) $=4$ HCl (aq.) $+2$ Br_2 (liq.), finding, respectively, $Q=134.8$ and 49.1. These data give, for F_2O (g), $Qf=-5.7$. von Wartenberg and Klinkott[1] reported that Ruff measured the heat of the reaction, $2H_2$ (g) $+2$NaOH (aq.) $+F_2O$ (g) $=2$ NaF (aq.) $+3$ H_2O (liq.), and gave, from this source, $Qf=-4.6$.

Chlorine

Cl_2 (g). The standard state is taken as the equilibrium gas at 18°, containing the natural mixture of isotopes. The energy states of the diatomic chlorine molecule are evaluated from the data of Elliott,[1, 2] and the discussion of Mulliken.[6] See also Jevons.[1]

Cl_2 (liq.). The heat of vaporization of liquid chlorine was measured by Estreicher and Schneer,[3] Knietsch,[1] Pellaton,[1] Trautz and Gerwig,[1] Johnson and McIntosh,[1] Wohl,[2] and Eucken, Karwat, and Fried.[1] See also Harteck.[1]

Cl_2 (c). The heat of fusion of chlorine was investigated by Estreicher

and Staniewski,[1] Estriecher and Schneer,[1] Eucken and Karwat,[1] and Harteck.[2] See also Rideal.[1] We have taken Eucken and Karwat's[1] value, $F = -1.62$ at $-102°$.

Cl (g). The heat of dissociation of Cl_2 (g) into atoms can be determined in several ways. Pier[1] and Wohl,[2, 3] utilizing data on the instantaneous pressure developed in a closed bomb by explosion of $H_2 + Cl_2$, or $H_2O + Cl_2$, computed thermodynamically the heat of dissociation. Pier's[1] values were preliminary; Wohl[2, 3] reported $D = -57.0$. The values from the explosion method are in accord with those deduced from the data of Henglein,[1] Trautz and Geissler,[1] von Wartenberg and Wiegel,[1] and von Wartenberg and Henglein,[1] all of whom measured the vapor density of gaseous chlorine at various high temperatures. These data on the equilibrium, Cl_2 (g) $= 2$ Cl (g), yield $D = -54.0$ and -59.5. Trautz and Stackels[1] earlier value, -71.0, from vapor density data, is evidently in error. The most accurate value for the energy of dissociation of the normal diatomic chlorine molecule into two normal chlorine atoms is obtained from the spectroscopic data of Kuhn,[1] who interpreted a band limit at 4758 Angstrom units as the dissociation of Cl_2 (g) (normal) into Cl (g) ($^2P_1$) + Cl (g) ($^2P_2$). Correcting to the normal state gives $D = -56.9$. Kuhn's[1] interpretation of the band limit was corroborated by Senftleben and Germer.[1]

The values for the energy states of gaseous monatomic chlorine are from Kiess and de Bruin,[1] Muraka,[1, 2] Bowen,[4] Paschen,[7] and Bowen and Millikan.[1] See also Bacher and Goudsmit.[1]

Cl^- (g). Plotting the square root of the ionization potentials of A, K^+, and Ca^{++} against the atomic number, and extrapolating to Cl^-, yields -65 for the energy of ionization of Cl^- (g). This is equivalent to the negative of the electron affinity of Cl (g). The heat of the reaction, Cl (g) $+ \theta = Cl^-$ (g), can also be calculated by way of the lattice energies of LiCl, NaCl, KCl, RbCl, and CsCl. Using our own values for the auxiliary data, we have computed from these substances the following values for Cl^- (g): $Qf = 62.1$, 63.2, 61.2, and 63.7, respectively. Similar calculations, varying but slightly from the foregoing in the values obtained, were made by Lennard-Jones[1] and Sherman.[2] Lederle,[1] from data on the absorption spectra of gaseous KCl, PbCl, and CsCl, calculated the electron affinity of Cl (g), and his values yield, respectively, for Cl^- (g), $Qf = 60.4$, 61.6, and 60.2.

Cl^- (∞). Since we have adopted the convention of making $Qf = 0$ for H^+ (∞), the value for the heat of formation of Cl^- (∞) is identical with that for HCl (∞).

Cl_3 (g). The existence of this substance is still hypothetical and depends mostly on an interpretation of some rate of reaction experiments by Bodenstein and Plaut,[1] who assumed the reaction, 3 Cl_2 (g) $= 2$ Cl_3 (g), and gave $Q = -51$.

Cl_2 (aq.) (ideal). Chlorine gas dissolved in water is in part hydrolyzed to form HCl and HClO. In addition, aqueous chlorine solutions decom-

pose slowly, evolving gaseous HCl and O_2. One can, however, consider that this last reaction is negligible in the observed calorimetric experiment of dissolving chlorine gas in water, and make proper correction for the amount of the reaction, Cl_2 (aq.) $+H_2O$ (liq.) $=$ (HCl $+$ HClO) (aq.), which has occurred at the given temperature and concentration. Jakowkin[1] gave the equilibrium constant for this latter reaction, whence one can compute the amount of Cl_2 hydrolyzed and thence the correction which must be applied to the observed heat of solution in order to obtain the heat of the pure reaction without hydrolysis: Cl_2 (g) $=Cl_2$ (aq.) (ideal). Thomsen[15] found $S_{1000}=4.87$; Baker,[2] $S_?'=4.97$; Berthelot,[26, 67, 151] $S_?'=7.4$. According to Jakowkin's[1] data on the hydrolysis constant for 18°, the chlorine in Thomsen's solution was 40 per cent hydrolyzed. Making correction for this amount of hydrolysis, we have calculated, for Cl_2 (aq.) (ideal), $Qf=7.0$. Utilizing, instead of the calorimetrically observed heat of solution, a value obtained from the temperature coefficient of solubility for Cl_2 in water, Jakowkin[1] calculated, for Cl_2 (aq.) (ideal), $Qf=7.1$. On recalculating his data, we have obtained 7.0. Roth[12] reviewed all the foregoing data and recommended the value 6.9.

Cl_2 (CCl_4). Noyes and Tulley[1] measured the heat of solution of chlorine in carbon tetrachloride at 0°.

ClO_2 (g). From explosion experiments, Booth and Bowen[1] found for ClO_2 (g), $Qf=-23.5$. Mayer[4] interpreted a predissociation band in the spectra of chlorine dioxide as due to the reaction ClO_2 (g) $=$Cl (g) $+O_2$ (g), and gave $Q=3.6$; whence, for ClO_2 (g), $Qf=-25.15$. This is a verification of the values of the heats of formation of both Cl (g) and ClO_2 (g).

ClO_2 (aq.). Booth and Bowen[1] reported $S=6.60$.

ClO_2 (liq.). King and Partington[1] reported the heat of vaporization.

$HClO_2$ (aq.). The heat of solution of ClO_2 (g) in water is supposed to correspond to the reaction, 2 ClO_2 (g) $+H_2O$ (liq.) $=$ ($HClO_3+HClO_2$) (aq.). Anticipating the value of Qf for $HClO_3$ (aq.), we have obtained, for $HClO_2$ (aq.), $Qf=13.8$.

ClO_2^- (aq.). Assuming that aqueous $HClO_2$ is completely ionized, one finds, for ClO_2^- (aq.), $Qf=13.8$.

ClO (g). Finkelnburg and Schumacker,[1] from spectral data, gave for the reaction, ClO_2 (g) $=$ClO (g) $+$O (g) (^{1}D), $Q=-111$.

$Cl_2 \cdot 7H_2O$ (c). Even though a hydrate of chlorine has been known for over a century, there is still some uncertainty as to its composition. Roozeboom[3] believed the compound to be the octahydrate; de Forcrand,[38] the heptahydrate. de Forcrand[38] measured the heat of solution of a weighed amount of the hydrate in water, and, correcting for the variation of the composition of the compound from the supposed heptahydrate, obtained $S^3=-15.87$, -15.27, and -15.76. At the same temperature and concentration, de Forcrand found, for Cl_2 (g), $S^3=2.94$; whence, for Cl_2 (g) $+7H_2O$ (liq.) $=Cl_2 \cdot 7H_2O$ (c), $Q^3=18.6$. In somewhat rougher experiments, LeChatelier[3, 5] found for this latter reaction $Q=17.0$. From

the equilibrium data of Isambert,[4] LeChatelier,[5] and Roozeboom,[2, 4] de Forcrand[38] computed, for this reaction, $Q = 18.8$, 17.8, and 17.8, respectively. See also Tammann and Krige.[1] We have selected the value 18 0, giving more weight to the values from the equilibrium data.

HCl (g). Calorimetric determinations of the heat of formation of gaseous hydrogen chloride were made by Abria,[1] Favre and Silbermann,[1] Berthelot,[181], Thomsen,[15] Roth and Richter,[1] von Wartenberg and Hanisch,[1] and Rossini.[10] The values of Abria[1] and Favre and Silbermann,[1] 24.0 and 23.8 respectively, are now only of historical interest. The only information that we have been able to obtain concerning Berthelot's[181] work on this problem is that he quoted Thomsen's[15] value and wrote "J'ai obtenu le meme chiffre." Thomsen[15] burned chlorine in hydrogen at constant pressure in a flame calorimeter. The detailed data of his four calorimetric experiments have been recomputed and yield, for HCl (g), $Qf = 21.99 \pm 0.05$. Thomsen determined the amount of reaction in each experiment by absorbing the HCl and titrating with aqueous barium hydroxide.

von Wartenberg and Hanisch[1, 2] performed similar experiments and reported, for HCl (g), $Q = 21.90 \pm 0.01$ at 24°. The amount of reaction in each experiment was computed from the loss in weight of the chlorine bottle. Roth and Richter[1] reported the results of three series of calorimetric experiments on the combination of hydrogen and chlorine by explosion at constant volume at 21°: Series I, 21.82 ± 0.06, amount of reaction determined by titrating the hydrogen chloride formed; Series II, 22.02 ± 0.02, chlorine in excess, amount of reaction determined from volume, pressure, and temperature of the hydrogen used in the reaction; Series III, $21\ 87 \pm 0.03$, hydrogen chloride titrated. Roth and Richter[1] concluded that the third series was the most accurate and best represented the results of their work.

Rossini[10] burned chlorine in hydrogen at constant pressure in a flame calorimeter, using the apparatus with which he made the accurate measurements on the heat of formation of water. He reported, for HCl (g), $Qf^{25} = 22.063 \pm 0.012$; whence, at 18°, $Qf = 22.060 \pm 0.012$. The amount of reaction in each experiment was determined by absorbing the HCl formed in a soda-asbestos mixture. In the same paper, Rossini[10] made a detailed calculation of the heat of formation of gaseous HCl utilizing the thermodynamic relation $\Delta H = \Delta F + T\Delta S$. He obtained the value of ΔS, the entropy of formation, from the recently obtained accurate values of the entropies of H_2, Cl_2, and HCl from spectroscopic data by Giauque and coworkers; and the value of ΔF, the free energy of formation, from the electromotive force of cells giving the reactions, $\frac{1}{2}H_2$ (g) + AgCl (c) = Ag (c) + HCl (aq.) and Ag (c) + $\frac{1}{2}Cl_2$ (g) = AgCl (c), and the vapor pressure of HCl over aqueous HCl. In this manner Rossini[10] computed, for HCl (g), $Qf^{25} = 22.026 \pm 0.03$, which value is in accord, within its limits of uncertainty, with his directly measured calorimetric value. See also the discussion under HCl (aq.).

HCl (liq.). The heat of vaporization of HCl was measured by Elliott and McIntosh,[1] Steele, McIntosh, and Archibald,[1] Estreicher and Schneer,[1] and Giauque and Wiebe.[1] The value from Giauque and Wiebe[1] is accepted as being the most accurate. Tsurita[1] calculated $V = -2.38$. The vapor pressure of liquid HCl was measured by Faraday,[1] Ansdell,[1] McIntosh and Steele,[1] Briner,[4] Drozdowski and Pietrzak,[1] Cardoso and Germann,[1] and Henning and Stock.[1]

HCl (c, I). Giauque and Wiebe[1] and Eucken and Karwat[1] found, by direct measurement, $F = -0.504$ and -0.476, respectively. The data of Eucken and Donath,[1] Eucken and Karwat,[1] and Giauque and Wiebe,[1] on the vapor pressure of solid and liquid HCl in the neighborhood of the triple point, yield $F = -0.498$.

HCl (c, II). Giauque and Wiebe[1] and Eucken and Karwat[1] found, respectively, $T_{\rightarrow I} = -0\,284$ and $-0\,293$.

HCl^+ (g). Foote and Mohler[1] gave for the energy of ionization of HCl (g) to form HCl^+ (g) the value 14.0 volt-electrons; Barton[1] reported 13.8 volt-electrons. Other values were reported by Kemble,[1] Knipping,[1, 2] Franck,[1] Mackay,[1, 2] and Barker and Duffendack.[1]

HCl (aq.). The data on the heat of dilution of aqueous HCl in the dilute region (Richards and Rowe,[1] Richards, Mair, and Hall,[1] Muller,[1] von Steinwehr,[1] and Wrewskii and Savaritzkii[1]) were reviewed by Rossini,[5] who gave values from ∞ to $25\,H_2O$. The data of Wrewskii and Savaritzkii,[1] Thomsen,[15] and Berthelot,[17, 18] have been utilized to obtain values from 25 to $1\,H_2O$. Other data were given by Ellis,[1] Harned and Brumbaugh,[1] Tucker,[1] Richards, Rowe, and Burgess,[1] and Payn and Perman.[1]

The heat of solution of gaseous HCl in water was measured by Thomsen,[15] Berthelot and Louguinine,[1] and Wrewskii and Savaritzkii.[1] Their data yield for S_{200}: 17.20, 17.5, and 17.38, respectively. Combination of the last value with the heat of dilution from 200 to ∞H_2O, and with the heat of formation of the gas, yields, for HCl (∞), $Qf = 39.66$ (See Rossini[10]). Older data on the heat of solution of HCl were obtained by Favre and Silbermann,[1, 3] Favre,[6] and Abria.[2] See also Wilke and Kieninger[1] and Wrewskii and Faerman.[1]

The heat of formation of aqueous HCl can also be computed (see Rossini[10]) from the temperature coefficient of the electromotive force of certain cells and the heats of formation of silver chloride and mercurous chloride. Lewis and Randall,[2] Ellis,[1] and Harned and Brumbaugh[1] measured at a series of temperatures the electromotive force of cells in which the reaction was $\frac{1}{2}H_2\,(g) + HgCl\,(c) = Hg\,(liq.) + HCl\,(aq., m)$, and computed the heat of the reaction. Addition to this quantity of the heat of formation of HgCl (c), and the partial molal heat of dilution of HCl from the molality m to infinite dilution, yields values for the reaction, $\frac{1}{2}H_2\,(g) + \frac{1}{2}Cl_2\,(g) = HCl\,(\infty)$. From the foregoing data, we have obtained the average value, for HCl (∞), $Qf = 39.71$. In a similar manner Noyes and Ellis,[1] Harned and Brumbaugh,[1] and Butler and Rob-

ertson[1] obtained values for the heat of the reaction $\frac{1}{2}H_2$ (g) + AgCl (c) = Ag (c) + HCl aq., m). And from their data we have computed, for HCl (∞), the average value $Qf = 39.63$. See Rossini.[10]

HCl (C_2H_5OH). Berthelot[152] measured the heat of solution of gaseous HCl in ethyl alcohol.

HCl (CCl_4). Noyes and Tulley[1] measured the heat of solution of gaseous HCl in carbon tetrachloride.

HCl · 2 H_2O (c). Berthelot[47] measured the heats of solution of the solid and of the liquid in water. The difference in the observed heats of solution, for the same temperatures and concentration, gives the heat of the reaction, HCl · 2 H_2O (c) = HCl (2) + 2 H_2O (liq.), $Q = -2.5$. Vapor pressure data on the system HCl–H_2O were reported by Roozeboom.[3, 5]

HClO (aq.). Thomsen[15] measured the heats of the reactions:

(1), Cl_2 (g) + 2 NaOH (400) = (NaCl + NaClO) (800) + H_2O (liq.);
(2), NaOH (400) + HClO (400) = NaClO (800) + H_2O (liq.);
(3), NaOH (400) + HCl (400) = NaCl (800) + H_2O (liq.);
(4), NaCl (400) + NaClO (400) = (NaCl + NaClO) (800);
(5), NaCl (400) = NaCl (800); and
(6), NaClO (400) = NaClO (800).

Subtraction of (2) + (3) + (4) from (1) + (5) + (6) yields Cl_2 (g) + H_2O (liq.) = HCl (400) + HClO (400). Our recalculation of Thomsen's data on the above reactions yields, for HClO (400), $Qf = 29.76$. Thomsen also measured the heat of the reaction, HClO (400) + (2 HCl + 2 KI) (400) = (2 KCl + HCl) (800) + H_2O (liq.) + I_2 (c). From his data on this reaction, we have computed, for HClO (400), $Qf = 29.79$. Recently, Neumann and Muller[2] measured the heats of the reactions, Cl_2 (g) + 2 MOH (aq.) = (MCl + MClO) (aq.) + H_2O (liq.) and MOH (aq.) + HClO (aq.) = MClO (aq.) + H_2O (liq.), where M was Li, Na, K, $\frac{1}{2}$ Ca, $\frac{1}{2}$ Sr, and $\frac{1}{2}$ Ba, respectively. With these data one can compute the heat of the reaction Cl_2 (g) + MOH (aq.) = HClO (aq) + MCl (aq.). Utilized in this manner, the foregoing data of Neumann and Muller yield six values for the heat of formation of HClO (aq.), the average being 30.4. In view of the fact that Neumann and Muller did not give their experimental measurements of the heat of neutralization of MOH (aq.) + HCl (aq.), and reported no values for the pertinent heats of mixing and dilution, we have selected the value from Thomsen's data. The heat of dilution of aqueous HClO was measured by Neumann and Muller.[2]

Cl_2O (g). Thomsen[15] and Neumann and Muller[2] found for the heat of solution in water the values 9.44_{800} and 8.74_{2070}, respectively. Because we have selected the value of HClO (aq.) from Thomsen's data, we have also, to be consistent, taken his value for the heat of solution of Cl_2O (g) in water to form HClO (aq.). Recently, Gunther and Wekua[1] measured the heat of explosion of Cl_2O, their data yielding, for Cl_2O (g), $Qf = -25.1$. Our selected value is -18.2. The discrepancy may lie in a systematic error of the nature of the formation of ozone in the experiments of Gunther and Wekua.[1]

Cl_2O (aq.). As Goldschmidt[1] pointed out, solutions of aqueous HClO more concentrated than about HClO (50) contain appreciable amounts of free unhydrated Cl_2O, in the equilibrium, $2\,HClO\,(aq.) = H_2O\,(aq.) + Cl_2O\,(aq.)$. The data of Roth[12] and Goldschmidt[1] on the equilibrium constant at various temperatures yield -8.0 for the heat of the foregoing reaction.

$HClO_3$ (aq.). Thomsen[15] measured the heat of the reaction, $HClO_3\,(1200) + 3\,H_2SO_3\,(400) = (3\,H_2SO_4 + HCl)\,(2400)$, obtaining as the average from three experiments, $Q = 206.3$. From these data, we have calculated, for $HClO_3$ (aq.), $Qf = 24.6$. Berthelot[79] measured the heats of the reactions, $Ba(ClO_3)_2(200) + 6\,H_2SO_3$ (aq., satd.) $= BaSO_4(c) + (5\,H_2SO_4 + 2\,HCl)$ (aq.), and $Ba(ClO_3)_2\,(200) + H_2SO_4\,(400) + 2\,HClO_3\,(300) + BaSO_4$ (c). Thomsen[15] also measured the heat of this last reaction. From these data, we have computed, for $HClO_3$ (aq.), $Qf = 20.8$. This latter value we have taken as the best for aqueous $HClO_3$ because the reactions involved are clear cut and rapid, as contrasted with the reaction between chloric and sulfurous acids.

$HClO_4$ (aq.). Berthelot[79] measured the heat of neutralization of aqueous $HClO_4$ with KOH (660), his data yielding $N = 14.25_{1320}$. Taking the heat of formation of $KClO_4$ (aq.) as known, we have computed, for $HClO_4$ (660), $Qf = 39.6$. Berthelot[79, 80] measured the heat of dilution of aqueous $HClO_4$.

$HClO_4$ (liq.). Berthelot[79, 80] measured the heat of solution.

$HClO_4 \cdot H_2O$ (c). Berthelot[79, 80] measured the heat of solution.

ClO^- (aq.). The data on the heats of formation of aqueous LiClO, NaClO, and KClO, and of aqueous Li^+, Na^+, and K^+ yield, for ClO^- (aq.), $Qf = 25.77$, 25.92, and 25.93, respectively.

ClO_3^- (∞). From the data on the heats of formation of $NaClO_3$ (∞) and Na^+ (∞), we have obtained, for ClO_3^- (∞), $Qf = 20.75$.

ClO_4^- (∞). From the data on the heats of formation of $NaClO_4$ (∞), Na^+ (∞), $KClO_4$ (∞), and K^+ (∞), we have obtained, for ClO_4^- (∞), $Qf = 39.35$ and 39.60, respectively.

ClF (g). Fredenhagen and Krefft[1] observed that heat is evolved when Cl_2 and F_2 are mixed. Ruff and Laass[1] measured the heats of the reactions, $ClF\,(g) + H_2\,(g) = HCl\,(g) + HF\,(g)$ and $1/2\,F_2\,(g) + 1/2H_2\,(g) = HF\,(g)$; and their data yield, for ClF (g), $Qf = 25.7$.

ClF (liq.). Ruff and Laass[1] computed, from vapor pressure data, $V = -2.27$ at $-101°$.

Bromine

Br_2 (liq.). Standard state.

Br_2 (g). The heat of vaporization of liquid bromine was measured directly by Andrews,[5, 10] Berthelot and Ogier,[6] Le Chatelier,[4] Regnault,[7] and Thomsen.[15] Vapor pressure data were reported by Scheffer and Voogd,[1] Bouzat and Letuan,[1] Cuthbertson and Cuthbertson,[1] Isnardi,[1] Ramsey and Young,[1] and Roozeboom.[3, 5] All the foregoing data agree

with the equation given by Lewis and Randall[5]: $V=-10.45+0.0096$ $(t+273.1)$.

Br_2 (c). Regnault[2] measured directly $F=-2.53^{-7}$. This value is in accord with the heat of sublimation computed from the vapor pressure data on solid bromine of Braune,[1] Isnardi,[1] Ramsay and Young,[1] Cuthbertson and Cuthbertson,[1] Henglein,[2] and Henglein, Rosenberg, and Muchlinski.[1] See also Rideal.[1]

Br (g). Perman and Atkinson[1, 2] and Bodenstein and Cramer[1] measured the vapor density of bromine gas at various elevated temperatures, and computed values of the equilibrium constant for the reaction, Br_2 (g) $=2$ Br (g). Lewis and Randall[5] reviewed the work of Perman and Atkinson[1, 2] and deduced for this reaction: $Q=-41.60-0.0026$ $(t+273.1$. The data of Bodenstein and Cramer[1] yield $Q=-46.10-0.0026$ $(t+273.1)$. DeVries and Rodebush[1] gave $Q=-41.2$. None of these values compare in accuracy with that obtained from spectroscopic analysis. Kuhn[1] reported for the above reaction $D^z=-45.2$. Kuhn's interpretation of the spectroscopic data has been corroborated by Senftleben and Germer.[1] In a similar manner, Brown[3] recently deduced the accurate value $D^z=-45.24\pm0.07$.

The values for the energy states of gaseous monatomic bromine are from Kiess and de Bruin,[2] Turner,[1] and Deb.[1] See also Bacher and Goudsmit.[1]

Br^- (g). The electron affinity of Br (g) is calculable by the method of lattice energies. Selecting the crystal RbBr, because Rb^+ and Br^- have exactly the same nuclear structure, and taking the exponent of the repulsive term to be 10, we have computed, for the reaction, RbBr (c) $=Rb^+$ (g) $+Br^-$ g), $D^z=-151\ 2$; whence the electron affinity of Br (g) becomes 87.9. Using the lattice energies of the alkali bromides as calculated by Sherman,[1] we have computed the values 89.6, 85.6, 84.6, 83.6, and 89.6, respectively. Butkow,[1] from the spectra of gaseous TlBr, deduced the value 86.5. From data on the absorption spectra of the alkali halides, Lederle[1] obtained the value 82. See also Lennard-Jones.[2]

Br_2 (aq.). Bromine, like chlorine, is hydrolyzed in water. From the heat of the hydrolysis reaction, and the value given by Bray and Connolly[1] for the hydrolysis constant at 25°, we have computed K^{18} (hydrolysis) $=\dfrac{(H^+)\ (Br^-)\ (HBrO)}{(Br_2)}=2\ 2\times10^{-9}$. The heat of solution of liquid bromine in water was measured by Le Chatelier,[4] Berthelot,[98] Pickering,[8] and Thomsen.[15] The last three investigators used 1 mole of Br_2 per 200, 5400, and 700 moles of water, and, correcting their data for the amount of bromine hydrolyzed, we have computed $S=1.2$, -0.9, and 1.24. Berthelot[98] also measured the heat of solution of liquid bromine in dilute aqueous HCl, where the hydrolysis would be suppressed, finding $S=1.1$.

Br_2 (CCl_4), Br_2 ($CHCl_3$), Br_2 (CS_2). Pickering[8] measured the heat of solution of liquid bromine in carbon tetrachloride, chloroform, and carbon disulfide, respectively.

$Br_2 \cdot 10\ H_2O$ (c). The vapor pressure data of Tammann and Krige[1] for the system, $Br_2 \cdot 10\ H_2O$ (c) $-H_2O$ (c), yield $Q = -7.9$[-10] for the reaction $Br_2 \cdot 10\ H_2O$ (c) $= Br_2$ (g) $+ 10\ H_2O$ (c). This is in agreement with the data of Roozeboom.[3, 4]

HBr (aq.). Thomsen[15] measured the heat of the following reactions: $\frac{1}{2}\ Cl_2$ (g) $+$ KBr (200) $=$ (KCl $+ \frac{1}{2}\ Br_2$) (200); $\frac{1}{2}\ Br_2$ (liq.) $= \frac{1}{2}\ Br_2$ (aq.). We have recomputed Thomsen's data on these reactions, obtaining for, $\frac{1}{2}\ Cl_2$ (g) $+$ KBr (200) $=$ KCl (200) $+ \frac{1}{2}\ Br_2$ (liq), $Q = 10.94$, which is equivalent to the heat of formation of KCl (200) minus the heat of formation of KBr (200). By combining with this last equation the difference in the heats of neutralization of aqueous HCl and HBr with aqueous KOH, which is HCl (100) $+$ KBr (200) $=$ HBr (100) $+$ KCl (200), $Q = 0.024$, we have obtained, for $\frac{1}{2}\ Cl_2$ (g) $+$ HBr (100) $= \frac{1}{2}\ Br_2$ (liq.) HCl (100), $Q = 10.916$. From which we have computed, for HBr (100), $Qf = 28.47$. Berthelot[15i] measured the heat of the reaction between $\frac{1}{2}\ Br_2$ (liq.) and KI (aq.), which for several reasons is preferable to the reaction studied by Thomsen[15]; but there is apparently some considerable error in Berthelot's data on this reaction. Berthelot[45] also measured the heats of the reactions, Br_2 (liq) $+ SO_2$ (aq.) and I_2 (c) $+ SO_2$ (aq.), the difference between which gives the heat of the reaction $\frac{1}{2}\ Br_2$ (liq). $+$ HI (aq) $= \frac{1}{2}\ I_2$ (c) $+$ HBr (aq.); but his data on these reactions are lacking in accuracy.

Thomsen measured the heats of the reactions, KCl (200) $+ AgNO_3$ (400) $=$ AgCl (c) $+ KNO_3$ (600) and KBr (200) $+ AgNO_3$ (400) $=$ AgBr (c) $+ KNO_3$ (600), the difference of which gives KCl (200) $+$ AgBr (c) $=$ KBr (200) $+$ AgCl (c). Combining with this equation, the difference in the heats of formation of AgCl (c) and AgBr (c), the difference in the heats of neutralization of HCl (100) and HBr (100) with KOH (100), and the heat of formation of HCl (100), we have obtained, for HBr (100), $Qf = 28.63$. Utilizing, in a similar manner, the difference in the heats of reaction of KI (200) and of KBr (200) with $AgNO_3$ (200) as measured by Thomsen,[15] the difference in the heats of formation of AgI (c) and AgBr (c), the difference in the heats of neutralization of HI (100) and HBr (100) with KOH (100), and the heat of formation of HI (100), we have computed, for HBr (100), $Qf = 28.44$.

The heat of diluting aqueous HBr from 100 to ∞ H_2O has been computed from the following reactions whose heats are known: NaOH (∞) $+$ HBr (∞) $=$ NaBr (∞) $+ H_2O$ (liq.); NaOH (100) $+$ HBr (100) $=$ NaBr (201) $+ H_2O$ (liq.); NaOH (100) $=$ NaOH (∞); and NaBr (201) $=$ NaBr (∞). The values for the heat of dilution in the more concentrated solutions to 1 H_2O are taken from the data of Berthelot,[18] Roozeboom,[8] and Thomsen.[15]

HBr (g). For the heat of solution of gaseous HBr in water, the data of Thomsen yield $S = 19.89_{400}$; Berthelot found $S = 20.0_{760}$[15].

HBr (liq.). The heat of vaporization of liquid HBr was measured by Elliott and McIntosh,[1] Estreicher and Schneer,[1] Eucken and Karwat,[1]

and Giauque and Wiebe.[2] Vapor pressure data were reported by Maass and McIntosh,[1] Steele and Bagster,[1] Steel, McIntosh, and Archibald,[1] Eucken and Karwat,[1] and Giauque and Wiebe.[2] All these data are in accord, and we have selected the directly measured value of Giauque and Wiebe.[2]

HBr (c, I), HBr (c, II), HBr (c, III). The heat of fusion of HBr (c, I) and the heats of the two transitions of crystalline HBr were measured by Eucken and Karwat,[1] and by Giauque and Wiebe,[2] whose values we have selected. The vapor pressure of solid hydrogen bromide was measured by Henglein,[3] Maass and McIntosh,[1] Steele, McIntosh, and Archibald,[1] and Drozdowski and Pietrzak.[1]

$HBr \cdot H_2O$ (c). Roozeboom[6] reported −3 0 for the heat of fusion.

$HBr \cdot 2\,H_2O$ (c). Berthelot[18] reported 16 9 for the heat of the reaction HBr (g) $+2\,H_2O$ (liq) = $HBr \cdot 2\,H_2O$ (c), but no details of the experiments were reported. The vapor pressure data of Roozeboom[6] are in accord with Berthelot's value.

Br_3^- (aq.). Berthelot[105B, 151] measured the heat of solution of liquid bromine in aqueous KBr and in aqueous HBr at 12°, finding, respectively, 2.7 and 2.0. Correcting these data to 18°, we have obtained for the reaction, Br_2 (liq.) $+Br^-$ (aq.) $=Br_3^-$ (aq.), $Q=2.7\pm0\,4$; whence, for Br_3^- (aq.), $Qf=31.3$. Linhart[1] determined at various temperatures the equilibrium constant for the reaction, Br_2 (aq) $+Br^-$ (aq.) $=Br_3^-$ (aq.), and calculated $Q=1.30$; whence, for Br_3^- (aq.), $Qf=31.1$.

Br_5^- (aq.). Linhart[1] explained the activity of bromine dissolved in concentrated aqueous KBr as due to the existence of Br_5^- (aq.). This explanation also accounts for the thermal behavior of these solutions. Linhart's data on the temperature coefficient of the equilibrium constant yield, for Br_5^- (aq.), $Qf=35.7$. Berthelot's[151, 105B] calorimetric data lead to practically the same value.

BrO^- (aq.). From the values for the heats of formation of NaBrO (aq.), KBrO (aq.), Na^+ (∞), and K^+ (∞), we have calculated, for BrO^- (aq.), $Qf=21.2$ and 21 4, respectively.

HBrO (aq.). There are no data on the heat of neutralization of HBrO (aq.). Assuming that the heat of the reaction HBrO (aq.) $=H^+$ (aq.) $+BrO^-$ (aq.) is the same as that for HClO (aq.) $=H^+$ (aq.) $+ClO^-$ (aq.), we have computed, for HBrO (aq.), $Qf=25\,2$.

$HBrO_3$ (aq.). Thomsen[12, 15] measured the heat of the reaction, $HBrO_3$ (1250) + 3 ($SnCl_2$ + 2 HCl) (500) = (HBr + 3 $SnCl_4$) (2750) $+3\,H_2O$ (liq.), and found $Q=213.2$; whence we have computed, for $HBrO_3$ (1250), $Qf=11.30$.

BrO_3^- (aq.). From the values of Qf for $KBrO_3$ (∞) and K^+ (∞), we have obtained, for BrO_3^- (∞), $Qf=11.21$.

BrCl (g). From spectroscopic data, Jost[3] deduced values of the equilibrium constant at various temperatures, and computed for $\frac{1}{2}\,Br_2$ (g) $+\frac{1}{2}Cl_2$ (g) = BrCl (g), $Q=0.75$.

IODINE

I_2 (c). Standard state.

I_2 (g). Vapor pressure data on solid iodine were reported by Baxter and Grose,[1] Baxter, Hickey, and Holmes,[1] and Ramsay and Young.[1] Haber and Kerschbaum[1] measured the vapor pressure at low temperatures. Giauque[2] critically reviewed the data, and deduced for the heat of sublimation, $Vs = -16.069 + 0.0040\ (t+273.1)$, which gives at 18°, −14.91. Earlier calculations were made by Wohl,[3] Dewar,[1] and Nernst.[1]

I_2 (liq.). Vapor pressure data for liquid iodine were reported by Ramsay and Young,[1] Stelzner and Niederschulte,[1] and Rassow.[1] These data yield for the heat of vaporization, $V = -12.75 + 0.0056\ (t+273.1)$. Combination of this equation with that for the heat of sublimation gives for the heat of fusion of solid iodine, $F = -3.3 + 0.0016\ (t+273.1)$, or −4.0 at the melting point. See also Rideal.[1]

I_2 (aq.). From measurements of the temperature coefficient of solubility, Hartley and Campbell[1] computed $S = -5.0$. Sammet's[1] data yield $S = -4.9$, his own calculated value of −6.37 evidently being in error.

I_2 (C_2H_5OH). Pickering[8] and Waentig[1] reported for the heat of solution of solid iodine in ethyl alcohol −1.7 and −1.9, respectively. The solution is brown.

I_2 ($C_2H_5OC_2H_5$). Pickering[8] and Waentig[1] reported for the heat of solution of solid iodine in ether −1.6 and −2.0, respectively. The solution is brown.

I_2 (CS_2). Pickering[8] and Waentig[1] measured the heat of solution of solid iodine in carbon disulfide to be −5.0 and −5.2, respectively. The solution is purple.

I_2 ($CHCl_3$). Pickering[8] and Waentig[1] found $S = -6.0$ and −5.5, respectively, for the heat of solution of solid iodine in chloroform. The solution is purple.

I_2 (C_6H_6). Pickering[8] and Waentig[1] reported, for I_2 (c) in benzene, $S = -6.0$ and −4.7, respectively. The solution is purple.

I_2 (CCl_4). Pickering,[8] for I_2 (c) in carbon tetrachloride, found $S = -5.3$. The solution is purple.

I_2 (pyridine). Waentig[1] found $S = 17$ for the heat of solution of solid iodine in pyridine.

I (g). Density measurements on iodine vapor at high temperatures, which yield values of the equilibrium constant for the reaction, I_2 (g) = 2 I (g), were made by DeVries and Rodebush,[1] Weide and Bichowsky,[1] Braune and Ramstetter,[1] Starck and Bodenstein,[1] Bjerrum,[3] and Deville and Troost.[2] The computed heats of dissociation at 18° from the first five named investigations are, respectively, −31.6, −32, −33.6, −35.4, and −35.7. Lewis and Randall[5] calculated, from Starck and Bodenstein's[1] data, $D^z = -31.7$. Spectroscopic determinations of the energy of dissociation of the normal gaseous I_2 molecule to form 2 normal I atoms lead to much more accurate values than the foregoing ones. Kuhn,[1] Koenigsberger,[1] Gibson and Heitler,[1] and Brown[4] reported values from

spectroscopic data, the last named investigation giving $D^z = -35.40 \pm 0.03$. See also Senftleben and Germer[1] and Kondratjeiv and Leipunsky.[1]

The values for the energy states of gaseous monatomic iodine are from Evans[1] and Bacher and Goudsmit.[1]

I^- (g). Utilizing the data on the lattice energies of CsI and KI, we have computed for the reaction, $\frac{1}{2}I_2$ (c) $+\theta = I^-$ (g), $Q = 58.4$ and 52.4, respectively. Sherman[1] calculated for the same reaction, from the data on the alkali iodides, the values 56.4, 52.7, 51.1, 52.3, and 56.3. See also Lennard-Jones.[2] Recently Mayer[3] measured the electrical conductivity of gaseous cesium iodide and of potassium iodide, and deduced values of the equilibrium constant at various temperatures for the reaction MI (g) $= M^+$ (g) $+ I^-$ (g). For CsI (g) and KI (g), he calculated, respectively, $D^z = 94.8 \pm 0.5$ and -104.6 ± 0.5. Utilizing our values for CsI (g), Cs^+ (g), KI (g), and I^- (g), one obtains $Qf = 55.1$ and 52.3 respectively. From a study of the absorption spectra of some alkali iodides, Lederle[1] deduced the unaccountably low values of 48.2, 47.4, and 46.5.

HI (aq.). Thomsen[15] measured the heat of the reaction $\frac{1}{2}Cl_2$ (g) $+$ KI (200) $=$ KCl (200) $+ \frac{1}{2}I_2$ (c). We have recomputed the data of his three experiments, and have obtained, for the above reaction, $Q = 26.26$. Subtracting from the above equation, the difference in the heats of neutralization of HCl (100) and HI (100) with KOH (100), HCl (100) $+$ KI (200) $=$ KCl (200) $+$ HI (100), $Q = 0.110$, we have obtained for the reaction, $\frac{1}{2}Cl_2$ (g) $+$ HI (100) $=$ HCl (100) $+ \frac{1}{2}I_2$ (c), $Q = 26.15$; whence, for HI (100), $Qf = 13.23$. Thomsen[15] also measured the heats of the reactions, KCl (200) $+ AgNO_3$ (400) $=$ AgCl (c) $+ KNO_3$ (600) and KI (200) $+ AgNO_3$ (400) $=$ AgI (c) $+ KNO_3$ (600). From his data on these reactions, we have calculated, for KCl (200) $+$ AgI (c) $=$ KI (200) $+$ AgCl (c), $Q = -10.57$. Combining this equation with that for the difference in the heats of neutralization of HCl (100) and HI (100) with KOH (100), we have obtained, for the reaction, HCl (100) $+$ AgI (c) $=$ HI (100) $+$ AgCl (c), $Q = -10.46$. And using our values for HCl (100), AgI (c), and AgCl (c), one finds, for HI (100), $Qf = 13.56$.

A value for the heat of formation of aqueous HI can also be deduced from the following reactions, whose heats were measured by Thomsen[15]: KCl (200) $+ HgNO_3$ (200) $= \frac{1}{2}Hg_2Cl_2$ (c) $+ KNO_3$ (400) and KI (200) $+ HgNO_3$ (200) $= \frac{1}{2}Hg_2I_2$ (c) $+ KNO_3$ (400). The difference gives, for KCl (200) $+ \frac{1}{2}Hg_2I_2$ (c) $=$ KI (200) $+ \frac{1}{2}Hg_2Cl_2$ (c), $Q = -9.10$. Combining this with the difference in the heats of neutralization of HCl (100) and HI (100) with KOH (100) gives, for HCl (100) $+ \frac{1}{2}Hg_2I_2$ (c) $= \frac{1}{2}Hg_2Cl_2$ (c) $+$ HI (100), $Q = -8.99$. Using our values for the other three substances in this equation, we have obtained, for HI (100), $Qf = 13.25$. Utilizing in a similar manner, Thomsen's[15] data on the reaction of $Pb(NO_3)_2$ (aq.) with KCl (aq.) and KI (aq.), respectively, we have computed, for HI (100), $Qf = 13.21$.

HI (g). The heat of solution of gaseous hydrogen iodide in water was measured by Favre and Silbermann,[3] Berthelot and Louguinine,[1] and

Thomsen.[15] Only the data of Thomsen[15] are accurately specified as to temperature and concentration, and we have recomputed them to obtain $S_{200}=19.19$. This gives, for HI (g), $Qf=-5.91$. The data of Stegmuller,[1] who measured the temperature coefficient of the cell in which the reaction was $\frac{1}{2}H_2\,(g)+\frac{1}{2}I_2\,(g)=HI\,(g)$, yield $Q=1.70$; whence, for HI (g), $Qf=-5.76$. Haber[1] reported for the foregoing reaction $Q=0.096$, calculated from the equilibrium measurements of Bodenstein[1] at high temperatures; but Lewis and Randall[5] pointed out that neglect of the dissociation of I_2 introduced a false trend in the values of the equilibrium constant. Recently, Gunther and Wekua[1] measured the heat of the reaction, $\frac{1}{2}Cl_2\,(g)+HI\,(g)=HCl\,(g)+\frac{1}{2}I_2\,(c)$, to be $Q=27.97$, whence, for HI (g), $Qf=-5.91$.

HI (liq.). Cottrell[1] found for the heat of solution of liquid HI in water 14.78_{700}^{12}; whence, for HI (liq.), $Qf=-1.39$ and $V=-4.42$. The data on the heat of vaporization of liquid HI at the boiling point are: Giauque and Wiebe,[3] −4.72; Estreicher and Schneer,[1] −4.33; Elliott and McIntosh,[1] −4.50; and Eucken and Karwat,[1] −4.94.

HI (c, I), HI (c, II), HI (c, III). The heat of fusion of HI (c, I) and the heat of the two transitions were measured by Giauque and Wiebe[3] and Eucken and Karwat.[1] We have selected the values of the former.

I_3^- (aq.). Jones and Kaplan[1] determined the equilibrium constant for the reaction, $I_3^-\,(aq.)=I_2\,(aq.)+I^-\,(aq.)$, at 0° and 25°, finding $K=0.00072$ and 0.00140, respectively. From the temperature coefficient of the equilibrium constant, we have computed, for the above reaction, $Q=-4.22$, whence, for I_3^- (aq.), $Qf=12.6$. Pickering[8] measured the heat of solution of I_2 (c) in 7.6 KI (408), finding $Q=-1.1$. For this concentration, we have calculated from the value of the equilibrium constant that 0.1 of the iodine remains as I_2 (aq.). That is, for the reaction, $I_2\,(c)+0.9\,I^-\,(aq.)=0.1\,I_2\,(aq.)+0.9\,I_3^-\,(aq.)$, $Q=-1.1$. From this we have computed, for I_3^- (aq.), $Qf=12.5$.

HIO (aq.). Skrabal[1] estimated the following: $I_2\,(aq.)+OH^-\,(aq.)=HIO\,(aq.)+I^-\,(aq.)$, $Q=1.0$, and $OH^-\,(aq.)+I_3^-\,(aq.)=HIO\,(aq.)+2\,I^-\,(aq.)$, $Q=-5.9$. From these data we have computed, for HIO (aq.), $Qf=37.3$ and 34.6, respectively. From the temperature coefficient of the equilibrium constant, Angeleser and Popeser[1] calculated for the reaction, $I_2\,(aq.)+H_2O\,(liq.)=HIO\,(aq.)+HI\,(aq.)$, $Q=-11.7$; whence, for HIO (aq.), $Qf=38.3$. See also Berthelot.[46]

IO^- (aq.). This value is computed from that for HIO (aq.), assuming the heat of ionization to be the same as that for HClO (aq.).

HIO_3 (aq.). We have recomputed the data of Thomsen on the reactions, $KI\,(600)+3\,HClO\,(200)=(HIO_3+2\,HCl+KCl)\,(1200)$ and $(5\,HCl+5\,KI)\,(1000)+HIO_3\,(aq.)=3\,I_2\,(aq.)+3\,H_2O\,(liq.)+5\,KCl\,(1000)$, and have obtained, for HIO_3 (aq.), $Qf=54.61$ and 54.71, respectively Berthelot[42,45] and Skrabal and Buchta[1] also measured the heat of the latter reaction, and their data yield $Qf=54.8$ and 55.8, respectively. The data of Luther and Sammet,[1] who determined the temperature coefficient

of the equilibrium constant for the reaction, $6\,H^+\,(aq.)+IO_3^-\,(aq.)+5\,I^-\,(aq.)=3\,I_2\,(aq.)+3\,H_2O\,(liq.)$, yield, for HIO_3 (aq.), $Qf=55.4$. The data of Thomsen[15] on the reaction, $(6\,HCl+3\,SnCl_2)\,(aq.)+HIO_3\,(aq.)=3\,(SnCl_4+HI)\,(aq.)+3\,H_2O\,(liq.)$, yield, for HIO_3 (aq.), $Qf=53.8$. Berthelot[45] and Skrabal and Buchta[1] measured the heat corresponding to the reaction, $3\,I_2\,(c)+6\,OH^-\,(aq.)=IO_3^-\,(aq.)+5\,I^-\,(aq.)+3\,H_2O$ (liq.), and their data yield, for HIO_3 (aq.), $Qf=54.2$.

IO_3^- (aq.). We have computed the value of Qf for $IO_3^-\,(\infty)$ from the values for $KIO_3\,(\infty)$ and $K^+\,(\infty)$.

I_2O_5 (c). The data on the heat of solution of solid iodine pentoxide yield the following values: Ditte,[4] −1.90; Berthelot,[46] −1.62[12]; Thomsen,[15] −1.90. From Thomsen's data, and the reaction, $I_2O_5\,(c)+H_2O\,(liq.)=2\,HIO_3\,(aq.)$, we have computed, for I_2O_5 (c), $Qf=42\,73$.

HIO_3 (c). The data on the heat of solution of HIO_3 (c) in water yield the following values: Ditte,[4] −2.24; Berthelot,[46] −2.67[12]; Thomsen,[15] −2.17. Using Thomsen's value we have obtained, for HIO_3 (c) $Qf=56.77$.

$I_2O_5\cdot HIO_3$ (c). Berthelot[46] reported for $I_2O_5\cdot HIO_3$ (c), $S=-4.29$[12], and for $I_2O_5\ 2\,HIO_3$ (c), $S=-5.72$[12]. Our best present information is that only the former hydrate of I_2O_5 exists. Berthelot's $I_2O_5\cdot 2\,HIO_3$ (c) was probably a mixture.

H_5IO_6 (aq.). Thomsen[15] measured the heat of reduction of H_5IO_6 (aq.) with aqueous stannous chloride acidified with HCl, and his data yield, for H_5IO_6 (aq.), $Qf=183.0$.

H_5IO_6 (c). Thomsen[15] found $S=-1.38_{2000}$.

$H_4IO_6^-$ (aq.), $H_3IO_6^{--}$ (aq.), $H_2IO_6^{---}$ (aq.), HIO_6^{----} (aq.), IO_6^{-----} (aq.). Thomsen[15] measured the heat of neutralizing H_5IO_6 (aq.) with 1, 2, 3, and 5 moles of KOH (aq.). The data are extraordinary in that Thomsen found a much smaller heat for the first mole of KOH than for the second, which is quite contrary to the usual behavior. It is difficult to tell which ions really exist in the solution and the values for the foregoing ions are computed in a purely formal manner.

ICl (g). McMorris and Yost[1] studied the equilibrium, $\frac{1}{2}\,Cl_2\,(g)+\frac{1}{2}\,I_2\,(g)=ICl\,(g)$, at various temperatures, and deduced, for ICl (g), $Qf=-3.13$. The energy of dissociation of ICl (g) into normal iodine and chlorine atoms has been determined from spectroscopic data by Wilson,[3] Gibson and Ramsperger,[1] Patkowski and Curtis,[1] and Brown and Gibson.[1] The data of Brown and Gibson[1] are the most accurate and give, for ICl (g), $Qf=-3.46$.

ICl (liq.). McMorris and Yost,[1] from vapor pressure data on liquid ICl, computed $V=-9.49$; whence, for ICl (liq.), $Qf=6.03$. Thomsen[15] measured the heat of formation of ICl (liq.) and found $Qf=5.85$.

ICl (c, α). Berthelot[64, 140] measured directly the heat of formation of ICl (c, α), finding $Qf=6.9$; and also measured its heat of solution in aqueous sulfurous acid, which latter data lead to the value 6.6. The

data on the heat of fusion of ICl (c, α) are: Tanatar,[5] −2.32; Stortenbeker,[1] −2.66; Berthelot,[64,140] −2.43. These values, coupled with that for ICl (liq.), $Qf=6.03$, yield, for ICl (c, α), $Qf=8.35$, 8.69, and 8.46, respectively.

ICl_3 (c). For ICl_3 (c), Thomsen[15] reported $Qf=21.5$; Berthelot[64] found, by direct combination, $Qf=15.5$, and by the reaction with aqueous sulfurous acid, $Qf=17.1$.

IBr (g). From the data of Bodenstein and Schmidt[1] and Muller[13] on the equilibrium, $\frac{1}{2}Br_2\ (g)+\frac{1}{2}I_2\ (g)=IBr\ (g)$, we have computed, for IBr (g), $Qf=-9.6$. The spectroscopic data of Cordes and Sponer[1] on the energy of dissociation of IBr (g) into normal iodine and bromine atoms yield, for IBr (g), $Qf=-10.3$.

IBr (liq.). By direct measurement, Berthelot[64, 140] found $Qf=2.47$.

BrCl (g). We have estimated this value.

BrCl (liq.). We have estimated this value.

Element 85

X (c). Standard state.

Sulfur

S (c, rhombic). Standard State.

S (c, monoclinic). The heat of transformation of monoclinic to rhombic sulfur was measured by Bronsted,[3] Mitscherlich,[2] Tammann,[2, 3] Lewis and Randall,[1] Wigand,[1] and Mondain-Monval.[1, 4] Using Lewis and Randall's[5] values for the heat capacities, we have found that Bronsted's[3] data yield, for the transformation, $T=0.120-0.0005\ (t+273.1)-0.00000125\ (t+273.1)^2$; whence, at 18°, $T=-0.080$, and at 95°, the normal transition temperature, $T=-0.088$. Mondain-Monval[1, 4] found $T=-0.087$.

S (liq., μ), S (liq., λ). Liquid sulfur is a mixture of at least two forms, soluble S (λ) and insoluble S (μ). At the melting point there is 95 per cent of the former. Lewis and Randall[1] found, for the heat of fusion of rhombic sulfur, $F=-0.478^{112}$. For the heat of fusion of monoclinic sulfur, the following data were reported: Mondain-Monval,[4] -0.297^{119}; Person,[1] -0.30^{115}; Trautz,[6] -0.284^{119}; Iitaka,[1] -0.429^{119}; Wigand,[1] -0.334^{119}. At 119° liquid sulfur contains 4 per cent of S (μ). Taking Wigand's[1] value, we have computed, for S (c, monoclinic) = S (liq., λ), $F=-0.35^{119}$; and utilizing the heat capacity data of Lewis and Randall,[1] we have calculated, for S (liq., λ), $Qf=-0.33$.

For the heat of transformation, S (liq., λ) = S (liq., μ). Lewis and Randall[1] reported -0.416^{25}; Mondain-Monval,[4] -0.9^{160}; Berthelot,[1] -0.86^{185}. Taking Lewis and Randall's value, we have computed, for S (liq., μ), $Qf=-0.75$.

S_8 (CS_2). Berthelot[1, 130] measured the heat of solution of sulfur in carbon disulfide.

S (S_2Cl_2). The heat of solution of sulfur in liquid S_2Cl_2 was found

by Trautz[6] to be -1.3 to -3.0, and by Thomsen,[15] -0.83; the data on the variation of solubility with temperature yield -1.5.

S_8 (g), S_6 (g), S_2 (g). Sulfur gas is a mixture of S_8 and its dissociation products. The gas in equilibrium with the liquid at 150° is practically all S_8. Vapor pressure data on liquid sulfur were reported by Ruff and Graf,[1] Bodenstein,[4] Gruener,[1] and Mathies[1]; and these data were used by Preuner and Schupp[1] to compute $V = -20.0^{150}$. The vapor pressure data of West and Menzies[1] yield $V = -20.5^{150}$. Awbery[1] measured directly the heat of vaporization at the boiling point to be -20.2.

The isotherms of sulfur vapor indicate the existence of at least two molecular species in addition to S_8. Arbitrarily selecting the species as S_8, S_6, and S_2, we have interpreted the data of Mitscherlich[1] and Preuner and Schupp[1] to give the following values: $3\,S_8\,(g) = 4\,S_6\,(g)$, $Q = -29$; $S_6\,(g) = 3\,S_2\,(g)$, $Q \doteq -64$.

Data on the vapor pressure of sulfur above the boiling point were reported by Barus,[1, 2] Greuner,[1] Rassow,[1] Regnault,[6, 7] Ruff and Graf,[1] and Menzies.[1]

There is an indirect but more certain method of calculating the heat of formation of S_2 (g) than the foregoing. Lewis and Randall[3, 5] reviewed the equilibrium data of Preuner,[1] Preuner and Schupp,[1] and Randall and Bichowsky[1] on the reaction, $H_2\,(g) + \frac{1}{2}\,S_2\,(g) = H_2S\,(g)$, and concluded that $Q = -19.6$. Using our value of Qf for H_2S (g), we have obtained, for S_2 (g), $Qf = -28.6$. Lewis and Randall[5] also reviewed the equilibrium data leading to the reaction, S (c, rhombic) $+ H_2\,(g) = H_2S\,(g)$, and calculated, for S_2 (g), $Qf = -29.7$.

The energy states of the gaseous S_2 molecule are evaluated from the band spectral data of Christy and Naude.[1] The spectrum of S_2 has also been studied by Henri,[3] Henri and Teves,[1] Rosen,[1] and Kondratjew.[1] See also Jevons.[1]

S (g). From data on a bomb reaction involving the combustion of hydrogen sulfide, Budde[1] deduced for the reaction, $S_2\,(g) = 2\,S\,(g)$, $Q = -120.^{2450}$. However, Bjerrum[3] pointed out that Budde's results may be interpreted just as well by assuming that the heat absorbing side reaction is not the dissociation of S_2 but the reaction of sulfur with water. The foregoing value, therefore, is not a reliable one. Bjerrum[3] estimated, from Budde's[1] data, $D = -80$. From vapor density data, von Wartenberg[3] estimated $D = -90$. Nernst[4] found that S_2 is 80 per cent dissociated at 2200°. Computing the free energy change from this value and utilizing the entropy and heat capacity values given by Lewis and Randall,[1] we have obtained $D = -48$. The heat of formation of gaseous monatomic sulfur can be evaluated accurately from spectroscopic data. For the energy of dissociation of normal S_2 (g) into normal S atoms, Christy and Naudè,[1] reported the value 4.45 volt-electrons. See also Henri[3] and Kondratjew.[1]

The electronic energy states of the sulfur atom are evaluated from the data of Fowler,[3] Birge,[2] Hopfield,[2, 3] and Runge and Paschen.[1] See also

Frerichs[3] and Bacher and Goudsmit.[1] The energies of the sulfur atom in various stages of ionization are taken from Ingram,[1, 2] Millikan and Bowen,[1, 2] Bowen,[4] and Bowen and Millikan.[1, 2]

S^{--} (g). The electron affinity of the sulfur atom is calculated in the same manner as for the oxygen atom. Sherman[1] reported for the lattice energies of MgS, CaS, SrS, and BaS, the values 778.3, 721.8, 687.4, and 655.9, respectively. Lennard-Jones[1] and Taylor[1] gave for MgS and CaS, 784 and 728, respectively. Our individual values for the electron affinity of S (g), calculated from the foregoing values, are different from those computed by Sherman,[1] but our average value is the same as his, namely, -79.5 for the reaction, $S\ (g) + 2\theta = S^{--}\ (g)$.

SO_2 (g). Calorimetric determinations of the heat of formation of sulfur dioxide from solid sulfur and oxygen were made by Dulong,[2] Andrews,[14] Favre and Silbermann,[1] Hess,[7] Thomsen,[15] Berthelot,[45, 65] Giran,[6] Frost,[1] and Eckman and Rossini.[1] The first four investigations are of historical interest only.

Thomsen[15] burned solid sulfur in a stream of oxygen gas at constant pressure in his calorimeter. The appreciable amounts of sulfur trioxide which were formed along with the sulfur dioxide in Thomsen's experiments were determined by weighing, and a heat correction was applied. The amount of sulfur dioxide was determined by absorbing it in strong chromic acid solution and weighing. Thomsen's data yield $Q = 71.08$ and 71.72 for the heats of combustion of solid rhombic and solid monoclinic sulfur, respectively, in oxygen to form gaseous sulfur dioxide. These values, incidentally, give much too large (about 7 times) a value for the heat of transition of monoclinic to rhombic sulfur.

Berthelot[45, 65] burned rhombic sulfur in oxygen in a bomb at constant volume. The amounts of sulfur dioxide along with the lesser amounts of sulfur trioxide were absorbed and determined by titration with iodine exactly equivalent to the amount of sulfur burned. In another series, Berthelot used aqueous potassium hydroxide to absorb the products of combustion, titrating afterwards with iodine. His data from the two series of experiments yield, respectively, $Q = 69.4$ and 69.1, for the reaction, $S\ (c, \text{rhombic}) + O_2\ (g) = SO_2\ (g)$. Ferguson[1] reviewed Berthelot's data and discarded the results of his second series on the grounds of unreliability of the analytical method.

Giran[6] determined the heat of combustion of sulfur in a bomb at constant volume with various pressures of oxygen. The observed heats of combustion varied linearly from 70.4 at 2.5 atmospheres to 81.1 at 45 atmospheres. Extrapolation to zero pressure yields $Q = 69.5$.

Frost[1] carried out experiments on two reactions: $S\ (c, \text{rhombic}) + \frac{2}{5} KIO_3\ (aq.) + O_2\ (g) + \frac{4}{5} H_2O\ (liq.) = I_2\ (c) + \frac{4}{5} H_2SO_4 (aq.) + \frac{1}{5} K_2SO_4\ (aq.)$, and $SO_2\ (liq.) + \frac{2}{5} KIO_3\ (aq.) + \frac{4}{5} H_2O\ (liq.) = I_2\ (c) + \frac{4}{5} H_2SO_4\ (aq.) + \frac{1}{5} K_2SO_4\ (aq.)$. The difference gives the reaction, $S\ (c, \text{rhombic}) + O_2\ (g) = SO_2\ (liq.)$. For the first reaction Frost[1] found at constant volume $Q = 133.2^{23.9}$, $132.7^{26.2}$, and $132.4^{24.3}$, using about 0.03 mole of sulfur in

each experiment. Frost[1] found that these results showed a trend much greater than the calorimetric error, and selected $Q=134$. For the second reaction Frost[1] found, at constant volume, $Q=60.06$, 60.01, and 60.03. Thus for the third reaction above these data yield $Q=74.6$ at constant pressure. Taking the heat of vaporization of liquid sulfur dioxide as $-6\,0$, we have obtained from these data, for SO_2 (g), $Qf=68.6$.

Eckman and Rossini[1] made a careful determination of the heat of formation of gaseous sulfur dioxide under conditions which completely favored a pure reaction,—no sulfur trioxide being formed. This was accomplished by burning oxygen gas in an excess of sulfur vapor at constant pressure in a calorimeter. The reaction took place in a flame where the stream of oxygen gas entered the chamber containing the sulfur vapor. The amount of reaction was determined from the mass of sulfur which disappeared, and, as a check, from the amount of sulfur dioxide formed by absorbing it in a sodium hydroxide-asbestos mixture and weighing. Their data yield, for SO_2 (g), $Qf=70\,92\pm0.05$.

SO_2 (liq.). Vapor pressure data were reported by Faraday,[3] Young,[2] Cardoso and Fiorentino,[1] Henning and Stock,[1] Mund,[1], Mills,[1] Bergstrom,[2, 3] Burrell and Robertson,[1] Regnault,[7] Pictet,[1] and Blumcke.[1] See also Antione.[3] The heat of vaporization of liquid sulfur dioxide was measured directly by Eucken,[2, 3] Estreicher and Schneer,[1] Chappuis,[2] Estreicher,[2] Mathias,[1] Schneer,[1] Cailletet and Mathias,[1, 2] and Smith.[1] The last named found $V=-6\,07$[-10].

SO_2 (c). Vapor pressure data on solid and liquid sulfur dioxide were reported by Bergstrom,[2, 3] Burrell and Robertson,[1] and Steele and Bagster.[1] These data yield for the heats of sublimation and vaporization of the solid and liquid near the melting point, $-8\,56$ and $-6\,64$, respectively; whence $F=-1\,9$ at the melting point.

SO_2 (aq.). From the vapor pressure data of Lindner[1, 2] on aqueous solutions of sulfur dioxide, Bichowsky[3] deduced the following values for the heat of solution of SO_2 (g) in water: $6\,68_{00}$; $6\,90_{200}$; 6.97_{290}; 7.70_{1500}; 9.13_{6600}. These values are in fair agreement with the recent data of Stiles and Felsing,[1] who measured directly the heat of solution, and gave $Q=0.911+1.1053 \log n$, where n is the number of moles of water per mole of SO_2. Ramstetter and Hantke[1] reported $S=8.02_{40}$. Values computed from the vapor pressure data of Maass and Maass[1] are in accord with those of Stiles and Felsing.[1] Data on the solubility of SO_2 in water were reported by Hudson,[1] Roozeboom,[1] Burrell and Robertson,[1] McCrae and Wilson,[1] Freeze,[1] and Oman.[1] The old direct calorimetric data of Berthelot,[92] de Forcrand,[4] and Favre and Silbermann[3] are now of historical interest only. Thomsen[15] measured the heat of solution of SO_2 (liq.) in water to be 1.444_{210} and 1.564_{310}.

SO_3^{--} (aq.). From the various values for Na_2SO_3 (aq.) and K_2SO_3 (aq.), we have computed, for SO_3^{--} (aq.), $Qf=148.2$, 149.2, and 150.7, respectively.

$S_2O_8^{--}$ (aq.). Berthelot[63, 107] measured the heat of the reaction,

BaS_2O_8 (aq.) $+H_2SO_4$ (220) $=BaSO_4$ (c) $+H_2S_2O_8$ (aq.). From our values for the last three substances, we have computed, for BaS_2O_8 (aq.), $Qf=451.7$; whence, taking for Ba^{++} (aq.), $Qf=128.4$, one finds for $S_2O_8^{--}$ (aq.), $Qf=323.3$.

HSO_3^- (aq.). From the values of the heats of formation of $NaHSO_3$ (aq.) and $KHSO_3$ (aq.), we have calculated, for HSO_3^- (aq.), $Qf=148.8$ and 149.4, respectively.

$S_2O_5^{--}$ (aq.). We have taken equal to zero the heat of the reaction, 2 HSO_3^- (aq.) $=H_2O$ (liq.) $+S_2O_5^{--}$ (aq.).

$SO_2 \cdot 7\ H_2O$ (c). The solid hydrate of SO_2 is now usually accepted as having 7 moles of water. The dissociation pressure of this compound was measured at various temperatures by Villard[2, 10] and Roozeboom.[4] The data of the latter yield, for $SO_2 \cdot 7\ H_2O$ (c) $=SO_2$ (g) $+7\ H_2O$ (c), $Q=-7.78$ at 0°.

SO (g). The band spectra of sulfur dioxide indicate the existence of a diatomic molecule. From a study of the predissociation limits in sulfur dioxide, Henri[2] and Henri and Wolff[1] deduced the following: SO_2 (g) $=SO$ (g) $+O$ (g), $Q=-112.5$; SO (g) $=S$ (g) $+0$ (g), $Q=-148$. These values yield for SO (g), $Qf=17.5$ and 23, respectively. Martin[1] carefully reinvestigated these spectra, and concluded that the normal state of SO is $^3\Sigma$ and that it dissociates into a normal S atom and a normal O atom with $D^0=-118\,2$. Hence, for SO (g), $Qf=-6.3$.

H_2S (g). Thomsen[15] determined the heat of formation of H_2S (g) by burning it in oxygen in his flame calorimeter. The reaction is not a clear cut one, there being a considerable quantity of sulfuric acid spray formed along with the SO_2 and H_2O. For H_2S (g), Thomsen[15] reported $Qf=2.73$. We have carefully recomputed his calorimetric and analytical data and have deduced for the reaction, H_2S (g) $+\frac{3}{2}\ O_2$ (g) $=H_2O$ (liq.) $+SO_2$ (g), $Q=134.10$ whence, for H_2S (g) $Qf=5.2$. Thomsen[15] also measured the heat of the reaction I_2 (c) $+HI$ (aq.) $+H_2S$ (g) $=3$ HI (aq.) $+S$ (solid). The sulfur precipitated was the usual plastic form, the heat of inversion of which into rhombic sulfur we have taken as 0.3 (following the discussion of Pollitzer[1]). For the above reaction, Thomsen[15] found $Q=21.6$, whence we have computed, for H_2S (g), $Qf=5.5$. Pollitzer[1] measured the equilibria in the reaction, I_2 (c) $+H_2S$ (g) $=2$ HI (g) $+S$ (c, rhombic), at various temperatures, and gave $Q=17.20$; whence, for H_2S (g), $Qf=5.4$. Another value for the heat of formation of hydrogen sulfide is obtained from the equilibrium data on the reaction, S (c, rhombic) $+H_2$ (g) $=H_2S$ (g), which are discussed by Lewis and Randall.[5] These last data yield, for H_2S (g), $Qf=5.0$.

H_2S (liq.). By direct measurement, Estreicher and Schneer[1] found $V=-4.49^{-61.4}$; Elliott and McIntosh[1] gave $V=-4.68$. The vapor pressure data of Cailletet and Bordet,[1] Regnault,[6] Maass and McIntosh,[2] Steele and Bagster,[1] and Steele, McIntosh, and Archibald[1] yield $V=-4.5$.

H_2S (c). The vapor pressure data of Maass and McIntosh[2] yield

-4.95 for the heat of sublimation of H_2S (c). See also Steele, McIntosh, and Archibald.[1]

$H_2S \cdot 6\,H_2O$ (c). The vapor pressures of this solid hydrate in the presence of a solution of H_2S in H_2O and of H_2O in H_2S, which two liquid solutions are immiscible, were measured by Cailletet and Bordet,[1] McLauchlan,[1] Scheffer,[1, 6] Scheffer and Meyer,[1, 2] and Schrienemaker.[1] de Forcrand and Fonzes-Diacon[1] computed, from the foregoing data, $Q = -16.5$ for the reaction $H_2S \cdot 6\,H_2O$ (c) $= 6\,H_2O$ (liq.) $+ H_2S$ (g).

H_2S (aq.). Thomsen[15] found, by direct measurement, the heat of solution of H_2S (g) in water to be 4.75. The solubility data of Scheffer[1, 6] and Winkler[7] yield 4.56 and 4.86, respectively.

S^{--} (aq.). From the values of the heats of formation of Na_2S (∞), Na^+ (∞), K_2S (∞), and K^+ (∞), we have computed, for S^{--} (∞), $Qf = -9.86$ and -10.14, respectively.

S_2^{--} (aq.), S_3^{--} (aq.), S_4^{--} (aq.). From the values of Qf for the aqueous polysulfides of sodium, we have obtained the values for these ions.

HS^- (aq.). From the values of Qf for NaHS (∞), Na^+ (∞), KHS (∞), and K^+ (∞) we have found, for HS^- (∞), assuming no dissociation, $Qf = 3.95$ and 3.85, respectively.

H_2S_5 (liq.). Sabatier[1] found for the reaction, H_2S_5 (liq.) $= H_2S$ (g) $+ 4$ S (solid), $Q = 2.7$. Assuming that the sulfur formed was rhombic, one finds, for H_2S_5 (liq.), $Qf = 2.6$.

H_2S_2 (liq.). We have estimated for the reaction, H_2S_2 (liq) $+ 3$ S (c) $= H_2S_5$ (liq.), $Q = 3$; whence, for H_2S_2 (liq.), $Qf = -0.4$. This value lies between those for H_2S (liq.) and H_2S_5 (liq.).

H_2S_2 (g). Butler and Maass[1] measured the heat of vaporization of liquid H_2S_2.

H_2S_2 (c). Butler and Maass[1] measured the heat of fusion.

H_2SO_4 (aq.). Thomsen[15] measured the heat of reaction of gaseous chlorine with aqueous sulfur dioxide to form a mixture of aqueous hydrochloric and sulfuric acids. We have recomputed in detail the data of Thomsen's three experiments on this reaction, and have obtained, for SO_2 (2400) $+ Cl_2$ (g) $+ 2H_2O$ (liq.) $= 2HCl$ (800) $+ H_2SO_4$ (800), $Q = 73.84 \pm 0.10$; whence, anticipating the value for the heat of dilution, one finds, for H_2SO_4 (200), $Qf = 210.3$. Berthelot,[45, 135, 136] measured the heat of reaction of liquid bromine with aqueous sulfur dioxide, and also that of solid bromine with aqueous sulfur dioxide. His data yield, respectively, for H_2SO_4 (200?), $Qf = 212.6$ and 210.3. Mixter[15] measured in a bomb calorimeter the heat of reaction of rhombic sulfur with sodium peroxide, S (c, rhombic) $+ 3Na_2O_2$ (c) $= Na_2SO_4$ (c) $+ 2\,Na_2O$ (c), and found $Q = 168.6$. Utilizing our values for the heats of formation of Na_2O_2 (c), Na_2O (c), the heat of solution of Na_2SO_4 (c) in 400 H_2O, the heat of neutralization of H_2SO_4 (200) with 2NaOH (100), and the heat of formation of NaOH (100), we have computed, for H_2SO_4 (200), $Qf = 210.4$. Utilizing the data obtained by Frost[1] on the reaction between liquid SO_2 and aqueous KIO_3, which has been discussed under the section on SO_2 (g), we have computed,

for H_2SO_4 (200), $Qf=213.7$. This value is given little weight because of the large heats of mixing involved. Roth, Grau, and Meichsner[1] recently measured the heat of reaction of aqueous hydrogen peroxide with gaseous sulfur dioxide, and the heat of decomposition of aqueous hydrogen peroxide into water and oxygen. Combining their data on these two reactions, we have computed, for SO_2 (g) $+H_2O$ (liq.) $+\frac{1}{2}O_2$ (g) $=H_2SO_4$ (800), $Q=73.09$; whence for H_2SO_4 (200), $Qf=211.6$. The data of Hess[7, 9] are of historical interest only.

The heat of dilution of aqueous sulfuric acid was measured by many investigators. The data of Favre and Silbermann,[3] Favre and Quaillard,[1] Thomsen,[15] Pfaundler,[5] Pickering,[9] and Rümelin,[1] were summarized by Brönsted.[7] The values deduced by Brönsted[7] have been experimentally verified and extended by Grau and Roth,[1] who reported values from 1 to 20,000 H_2O. Other data are given by Naudè,[2] Berthelot,[48, 111] Muller,[7] and Mathias.[1] See also Bose,[2] Wilson,[1] and Porter.[2] The value of Qf for H_2SO_4 (∞) is taken as equal to that for SO_4^{--} (∞).

H_2SO_4 (liq.). Brönsted[7] and Grau and Roth[1] measured the heat of solution of liquid sulfuric acid in water and of water in liquid sulfuric acid. Their data yield, respectively, for H_2SO_4 (liq.), $Qf=193.73$ and 193.75. For the heat of solution of liquid sulfuric acid, Berthelot[48] found 16.92_{150} and Thomsen[15] 17.85_{1600}.

H_2SO_4 ($C_2H_5OC_2H_5$). Hantzsch[1] measured the heat of solution of liquid sulfuric acid in diethyl ether.

H_2SO_4 (c). The data on the heat of fusion of solid sulfuric acid are: Berthelot,[3, 6, 132] -0.86; Pickering,[13] -2.35; Hantzsch,[2] -2.258; Knietsch (see Hantzsch[2]), -2.24; Brönsted,[7] $-2.55^{10.5}$.

$H_2SO_4 \cdot H_2O$ (c). The data on the heat of fusion of the hydrate are: Berthelot,[3, 6, 132] -3.680; Hammerl,[3] -3.420, -3.536; Pickering,[13] -3.92; Brönsted,[7] $-4.290-0.0188\,t$. Brönsted's[7] data yield $F=-4.45$ at the melting point, 8.60°

SO_4^{--} (aq.) From the values of the heats of formation of Li_2SO_4 (∞), Li^+ (∞), Na_2SO_4 (∞), Na^+ (∞), K_2SO_4 (∞), and K^+ (∞), we have computed, for SO_4^{--} (∞), $Qf=215.71$, 215.76, and 215.94, respectively.

SO_3 (liq.). The data on the heat of solution of liquid sulfur trioxide in water are: Thomsen,[15] 39.17_{1600}; Giran,[3] 39.4_{400}; Grau and Roth,[2] 41.18_{3000}.

SO_3 (g). Berthelot[66] found for the heat of solution of gaseous sulfur trioxide in water, $S=49.2_{200}$?, whence, for SO_3 (g), $Qf=93.9$. Giran[3] reported, for the heat of vaporization of liquid sulfur trioxide, $V=-9.4$; Grau and Roth[2] found $V=-10.0\pm0.4$. From the latter value we have computed, for SO_3 (g), $Qf=94.2$. The vapor pressure data of Berthout,[1] Smits and Schoenmaker,[1, 2] and Grau and Roth[2] yield, respectively, $V=-10.37$, -10.40, and -10.22. The average of these values yields, for SO_3 (g), $Qf=93.9$. From a study of predissociation in the absorption spectra of gaseous sulfur trioxide, Dutt[1] deduced SO_3 (g) $=SO_2$ (g)

+O (g) (^{3}P), $D^z = -86.7$ and $SO_3(g) = SO_2(g) + O(g)$ ($^1D_2$), $D^z = -125$. From these data we have computed, for SO_3 (g), $Qf = 99$ and 92, respectively. The data of Hess[7] on sulfur trioxide are of historical interest only.

SO_3 (c, α), SO_3 (c, β). There are two crystalline forms of solid sulfur trioxide, the "ice-like" or α form which melts sharply at 16.8°, and the "wool-like" or β form which is stable above 16.8° but does not appear to be well defined. The vapor pressure data of Smits and Schoenmaker,[1, 2] yield −12.1 for the heat of sublimation of SO_3 (c, α), whence $Qf = 106\ 0$. Berthelot,[6, 9] and Grau and Roth[1] measured the heat of solution of SO_3 (c, β) in water. Their data yield $Qf = 105.8$ and $105\ 2$, respectively. Grau and Roth[1] showed that the heat of solution varied considerably with the sample, indicating that the "wool-like" or β form of sulfur trioxide may be a mixture of varying composition.

$H_2S_2O_7$ (c). Thomsen[15] measured the heat of solution.

$H_2S_2O_7$ (liq.). Auerbach[1] measured the heat of fusion of the solid.

$H_2S_2O_8$ (aq.). Berthelot[63, 107] measured the heats of reaction of $H_2S_2O_8$ (220) with ($FeSO_4 + H_2SO_4$) (440) and of H_2O_2 (aq.) with ($FeSO_4 + H_2SO_4$) (440). The difference in these heats of reaction gives that for $H_2S_2O_8$ (220) $+ 2H_2O$ (liq.) $= 2H_2SO_4$ (220) $+ H_2O_2$ (aq.). Berthelot's data on two preparations of aqueous persulfuric acid yield for this reaction $Q = 13.5$ and 13.4, respectively. Berthelot[63, 107] also obtained data on two other series of reactions, using instead of $H_2S_2O_8$ (220), the mixtures ($(NH_4)_2S_2O_8 + H_2SO_4$) (aq.) and ($K_2S_2O_8 + H_2SO_4$) (aq.), respectively. These data give for the foregoing reaction, $Q = 13.2$ and 13.0, respectively. Taking the value 13.4, we have computed, for $H_2S_2O_8$ (aq.), $Qf = 318.5$. Berthelot's[63, 107] data on the reaction of aqueous sulfurous acid with aqueous persulfuric acid yield a value for the heat of formation of the latter that is in accord with the foregoing.

S_2O_7 (c). Giran,[6] by an indirect method of which he does not give the details, computed the heat of solution of solid persulfuric acid anhydride to be 56 7.

$S_2O_3^{--}$ (aq.). This value is obtained from those for $Na_2S_2O_3$ (aq.) and Na^+ (aq.).

$S_2O_6^{--}$ (aq.). This value is obtained from those for $K_2S_2O_6$ (aq.) and K^+ (aq.).

$H_2S_2O_6$ (aq.). Thomsen[15] found $N_{1200} = 27.07$.

$S_3O_6^{--}$ (aq.). From the values for $Na_2S_3O_6$ (aq.) and $K_2S_3O_6$ (aq.), we have found, for $S_3O_6^{--}$ (aq.), $Qf = 279\ 6$ and $278\ 3$, respectively.

$S_4O_6^{--}$ (aq.). The value is obtained from those for $Na_2S_4O_6$ (aq.) and Na^+ (aq.).

$H_2S_4O_6$ (aq.). Assuming tetrathionic acid to be completely ionized, one finds Qf for $H_2S_4O_6$ (aq.) equal to that for $S_4O_6^{--}$ (aq.).

$S_5O_6^{--}$ (aq.). This value is obtained from those for $K_2S_5O_6$ (aq.) and K^+ (aq.).

$S_2O_4^{--}$ (aq.). Berthelot[40] measured the heat of reaction between oxy-

gen gas and a sodium sulfite solution freshly reduced by zinc. Presumably the active ion is $S_2O_4^{--}$; and, if so, the reaction is $S_2O_4^{--}$ (aq.) $+H_2O$ (liq.) $+\frac{1}{2}O_2$ (g) $=2HSO_3^-$ (aq.). Berthelot found $Q=67.8$, whence we have computed, for $S_2O_4^{--}$ (aq.), $Qf=161.8$.

S_2Cl_2 (liq.). For the heat of formation of liquid S_2Cl_2, Thomsen[15] found 14.26; Trautz,[6] 14.5; and Ogier,[6] 17.6.

S_2Cl_2 (g). For the heat of vaporization of liquid S_2Cl_2, Ogier[6] found -6.7 by direct measurement; Orndorff and Terrasse[1] reported -8.7 from data on boiling point elevation; Harvey and Schuette[1] -8.65 from vapor pressure data; and Trautz, Rick, and Acker[1] -8.5 from vapor pressure data. Gaseous S_2Cl_2 is partly dissociated.

S_2Cl_4 (liq.), SCl_4 (liq.). Trautz[9] and Ogier[6] measured the heat of solution of chlorine in liquid S_2Cl_2, and, for the more or less imaginary reaction, S_2Cl_2 (liq.) $+Cl_2$ (g) $=S_2Cl_4$ (liq.), reported $Q=9.8$ and 5.8, respectively. Absorption of 3 moles of Cl_2 per mole of S_2Cl_2 leads to values of $Q=12$ to 14 for the assumed reaction S_2Cl_2 (liq.) $+3Cl_2$ (g) $=2SCl_4$ (liq.). Thomsen[15] and Beckmann[5] noted that heat was evolved in the first reaction. Aten[1] quoted their results to prove the existence of S_2Cl_4, but the evidence in favor of the existence of S_2Cl_4 is not convincing, especially since the accepted freezing point diagram for the Cl_2-S system shows only two well defined solid compounds, S_2Cl_2 and SCl_4. But we find it convenient, nevertheless, to give a value for the heat of formation of the hypothetical S_2Cl_4 (liq.).

SO_2Cl_2 (liq.). Thomsen[15] discovered that solid iodine acted as a catalyst for the reaction, SO_2Cl_2 (liq.) $+2H_2O$ (liq.) $=(H_2SO_4+2HCl)$ (1000), and his calorimetric data yield for this reaction $Q=62.8$. Ogier[7] measured the heat of solution of liquid sulfuryl chloride in aqueous KOH to be 119.8. These data yield for SO_2Cl_2 (liq.) $Qf=92.9$ and 93.1, respectively.

SO_2Cl_2 (g). The data on the heat of vaporization of liquid sulfuryl chloride are: Trautz,[6] -6.68, from direct calorimetric measurement; Trautz, Baisch, and von Dechend,[1] -6.68, from vapor pressure data; Ogier,[7] -7.1, from the difference in the heats of solution of the gas and the liquid. These data yield, for SO_2Cl_2 (g), $Qf=86.2$, 86.2, and 85.8, respectively. Trautz and von Dechend[1] computed, from equilibrium data for the reaction, SO_2 (g) $+Cl_2$ (g) $=SO_2Cl_2$ (g), $Q=11.2$; whence, for SO_2Cl_2 (g), $Qf=82.1$. See also Heumann and Käcklin.[1]

$SOCl_2$ (liq.). Ogier[6, 7] measured the heat of solution of liquid thionyl chloride in water.

$SOCl_2$ (g). Ogier[6, 7] reported -6.5 for the heat of vaporization of the liquid; Arii,[3] from vapor pressure data, deduced the value -7.56.

$S_2O_5Cl_2$ (liq.). Ogier[7] found, for the heat of solution of liquid pyrosulfuryl chloride in 6 KOH (18), $Q=39.2$; whence, for $S_2O_5Cl_2$ (liq.), $Qf=166.5$.

$S_2O_5Cl_2$ (g.). Ogier[7] reported -13.2 for the heat of vaporization. See also Grignard and Muret.[1]

SO_3HCl (liq.). Ogier[6] measured the heat of formation of liquid sulfonic chloride from solid SO_3 (which we have assumed to be the wool-like form) and gaseous HCl; and the heat of solution of liquid SO_3HCl in water. For these reactions, he found $Q=14.3$ and 40.3, respectively; whence we have computed, for SO_3HCl (liq), $Qf=141.6$ and 143.0, respectively.

S_2Br_2 (liq.). Ogier[7] and Peterson[5] reported for the reaction, 2S (c, rhombic) $+Br_2$ (liq.) $=S_2Br_2$ (liq.), $Q=4.0$ and 3.6, respectively. It seems probable that both values are low.

S_xI_y (solid). According to Ogier[7] there is no heat effect on mixing sulfur and iodine.

$SOBr_2$ (liq.). Mayes and Partington[1] reported -10.40 for the heat of vaporization at 140°. There is some decomposition at the boiling point.

SF_6 (g). Yost and Claussen[1] reported $Qf=262.0$.

SF_6 (c). The data on the heat of sublimation are: Klemm and Henkel,[1] -5.57; Yost and Claussen,[1] $-5.64^{-63.8}$.

SF_6 (liq.). The data on the heat of fusion are: Klemm and Henkel,[1] -1.1; Yost and Claussen,[1] $-1\ 39^{-50\ 8}$.

Selenium

Se (solid). The stable form of selenium is the gray metallic hexagonal Se (c, I). There are also the red monoclinic form, Se (c, III), the intermediate black monoclinic form, Se (c, II), and the vitreous form, which latter is apparently identical with precipitated selenium. Briegleb[1] gave a summary of the thermal properties of the various forms of solid selenium. Mondain-Monval[1, 5] measured the heats of transition directly, finding: Se (vitreous) $=$Se (c, I), $Q^{125}=1.08$; Se (c, III) $=$Se (c, I), $Q^{150}=0.18$. Fabre,[2] from data on the difference in the heats of solution of the various forms of selenium in bromine, reported: Se (vitreous) $=$Se (c, I), $Q=2.79$; Se (vitreous) $=$Se (amorphous), $Q=0$. Peterson,[5] from data on the differences in the heats of their reaction with chlorine, gave: Se (c, III) $=$Se (c, I), $Q=0.70$; Se (vitreous) $=$Se (c, I), $Q=1.05$. There are no thermal data on Se (c, II).

Se (liq.). From data on the vapor pressures of Se (c, II) and Se (liq.) reported by Dodd,[1] Le Chatelier,[9] and Preuner and Brockmoller,[1] we have computed the heat of fusion to be -3.91, if the vapor is assumed to be Se_6, and -2.9, if the vapor is Se_8. From Mondain-Monval's[1, 5] values at 125°, we have computed $F_v=-1.6$ at the melting point, 220°. This value agrees best with the assumption that the vapor has the composition Se_8 at the melting point.

Se_2 (g), Se_6 (g), Se_8 (g). From the vapor pressure data of Dodd,[1] we have computed for Se_8 (g), $Qf=-34.8$, assuming that at the melting point of selenium its vapor is mostly Se_8. By analogy with sulfur we have computed, for Se_6 (g), $Qf=-36$. Preuner and Brockmoller[1] gave -56 for the heat of the reaction Se_6 (g) $=3\,Se_2$ (g), whence, for Se_2 (g),

$Qf = -30.7$. This was computed from equilibrium values calculated from their vapor density data. Similar data were given by Biltz[7] and Deville and Troost.[4] Preuner and Brockmuller[1] and Bodenstein[3] estimated, from equilibrium data on the reaction, $H_2Se\,(g) = H_2\,(g) + \frac{1}{2}\,Se_2\,(g)$, $Q = -22.5$, whence, anticipating the value for $H_2Se\,(g)$, we have computed, for $Se_2\,(g)$, $Qf = -29.5$.

Se (g). By analogy with O_2 and S_2, we have estimated the energy of dissociation of Se_2 to be -92, which value is in agreement with that estimated by von Wartenberg[3] from vapor density data.

The values of the energy states of gaseous monatomic selenium are taken from McLennan and Crawford.[1] Gibbs and Ruddy[1] reported a value for the ionization potential. The spectra of Se^+ (g) have not been analyzed, but the higher spectra are discussed by Rao[6] and Sawyer and Humphreys.[1] See also Bacher and Goudsmit.[1]

Se^{--} (aq.). The values for aqueous selenide ion are obtained from those for Li_2Se (aq.), Na_2Se (aq.), K_2Se (aq.). Li^+ (aq.), Na^+ (aq.), and K^+ (aq.)

SeO_2 (aq.). Thomsen[15] measured the heats of the following reactions: Se (vitreous) $+ \frac{1}{2}\,Cl_2\,(g) = \frac{1}{2}\,Se_2Cl_2$ (liq.), $\frac{1}{2}\,Se_2Cl_2$ (liq.) $+ \frac{3}{2}\,Cl_2\,(g) = SeCl_4$ (liq.), and $SeCl_4$ (liq.) $+ 2H_2O$ (liq.) $= (SeO_2 + 4HCl)$ (aq.). For these reactions, the data of Thomsen[15] yield $Q = 11.26$, 35.08, and 30.37, respectively. Addition of the three reactions yields for Se (vitreous) $+ 2Cl_2\,(g) + 2H_2O$ (liq.) $= (SeO_2 + 4HCl)$ (aq.), $Q = 76.71$; whence, for SeO_2 (aq.), $Qf = 55.43$. Thomsen[15] also measured the heat of the reaction SeO_2 (aq.) $+ 2HCl$ (aq.) $+ NaHS$ (aq.) $= NaCl$ (aq.) $+ 2\,H_2O$ (liq.) $+ S$ (solid, ppt.) $+ Se$ (solid, ppt.). His data yield, for this reaction, $Q = 73.40$; whence, for SeO_2 (aq.), $Qf = 55.64$.

SeO_2 (c). For the heat of solution of SeO_2 (c) in water, Thomsen[15] found $S = -0.92_{200}$ and Jannek and Meyer,[1] $S = -0.94_{100}$. These data yield, for SeO_2 (c), $Qf = 54.50$. Mixter[10] measured in a bomb calorimeter the heats of the reactions, $3\,Na_2O_2$ (c) $+ Se$ (c, III) $= Na_2\,SeO_4$ (c) $+ 2\,Na_2O$ (c) and SeO_2 (c) $+ Na_2O_2$ (c) $= Na_2SeO_4$ (c). He found, for these reactions, $Q = 95.90$ and 71.20, respectively, and the difference gives for, Se (c, III) $+ 2\,Na_2O_2$ (c) $= SeO_2$ (c) $+ 2\,Na_2O$ (c), $Q = 24.70$; whence, for SeO_2 (c), $Qf = 65.1$. This high value is due, as Mixter reported, to the fact that the second reaction did not go to completion.

H_2SeO_3 (c). Jannek and Meyer[1] measured the heat of solution in water. See also the vapor pressure data of Manchot.[1]

SeO_3^{--} (aq.). This value is computed from those for Na_2SeO_3 (aq.) and Na^+ (∞).

$HSeO_3^-$ (aq.). This value is computed from those for $NaHSeO_3$ (aq.) and Na^+ (∞).

H_2Se (g). Fabre[1] measured the heats of the reactions, H_2Se (g) $+ 2\,FeCl_3$ (aq.) $= Se$ (solid, ppt.) $+ (2\,FeCl_2 + 2\,HCl)$ (aq.) and $2\,H_2Se$ (g) $+ SeO_2$ (aq.) $= 3\,Se$ (solid, ppt.) $+ 2\,H_2O$ (liq.). His data yield $Q = 42.2$ and 120.1, respectively; whence we have computed, for H_2Se (g), Qf

$= -18.5$ and -19.8, respectively. Rolla's[1] data on the temperature coefficient of the equilibrium constant for the reaction, H_2Se (g) $+ I_2$ (c) $= 2$ HI (g) $+$ Se (solid), yield, for H_2Se (g), $Qf = -16.9$. Pelabon's[1] data on the equilibrium H_2Se (g) $= H_2$ (g) $+$ Se (liq.) yield, for H_2Se (g), $Qf = -19.0$.

H_2Se (aq.). From data on the temperature coefficient of the solubility of H_2Se in water, McAmis and Felsing[1] computed the heat of solution of gaseous hydrogen selenide to be 2.43. From the similar but less accurate data of de Forcrand and Fonzes-Diacon,[1, 2] we have computed $S = 3.2$. Fabre[1] measured the heats of reaction of aqueous H_2Se and gaseous H_2Se with aqueous NaOH and aqueous KOH, respectively. Proper differences of these reactions would give values for the heat of solution of H_2Se in water; but, unfortunately, the data when so treated yield $S = 9.36$ and 9.77, respectively,—values in sharp disagreement with the preceding ones. The discrepancy may be explained by assuming that Fabre erred in recording his data on the neutralizations with gaseous H_2Se. Fabre's value for the neutralization of aqueous H_2Se is in accord with similar data on the homologous H_2S (aq.). If we assume that to Fabre's[1] data on the reaction between gaseous H_2Se and aqueous NaOH and KOH respectively the factor $\frac{1}{2}$ should be applied, then one obtains, for H_2Se (g), $S = 1.00$ and 1.31, respectively.

HSe^- (aq.). This value is obtained from those for aqueous NaHSe and KHSe.

H_2SeO_4 (aq.). Thomsen[15] measured the heat of the reaction, SeO_2 (500) $+$ HClO (700) $+ H_2O$ (liq.) $= (H_2SeO_4 + HCl)$ (1200), and his data yield $Q = 29.78$; whence, neglecting the heat of mixing, we have computed, for H_2SeO_4 (1200), $Qf = 143.8$. Fabre's[1] data on the heat of the reaction, Se (c) $+ 3\,Br_2$ (liq.) $+ 4\,H_2O$ (liq.) $= (H_2SeO_4 + 6$ HBr) (aq.), yield $Q = 42.2$; whence, for H_2SeO_4 (aq.), $Qf = 144.5$. We have estimated the heat of dilution of aqueous selenic acid to be the same as that for sulfuric acid.

H_2SeO_4 (liq.). Metzner[1, 2] measured the heat of solution in water.

H_2SeO_4 (c). Metzner[1, 2] measured the heat of solution in water.

$H_2SeO_4 \cdot H_2O$ (liq.). Metzner[1, 2] measured the heat of solution in water.

$H_2SeO_4 \cdot H_2O$ (c). Metzner[1, 2] measured the heat of solution in water.

SeO_4^{--} (aq.). From the values for Na_2SeO_4 (∞), Na^+ (∞), K_2SeO_4 (∞), and K^+ (∞), we have computed that for SeO_4^{--} (∞).

$HSeO_4^-$ (aq.). We have computed this value from those for $NaHSeO_4$ (aq.), Na^+ (∞), $KHSeO_4$ (aq.), and K^+ (∞).

SeF_6 (g). Yost and Claussen[1] reported $Qf = 246.0$.

SeF_6 (c). Klemm and Henkel[1] reported -6.72^{-45} for the heat of sublimation; Yost and Claussen[1] reported $-6.60^{-46\,6}$.

SeF_6 (liq.). Klemm and Henkel[1] gave -1.1 for the heat of fusion of the solid; Yost and Claussen[1] reported $-2.0^{-34.6}$.

Se_2Cl_2 (liq.). Thomsen[15] and Peterson[5] measured the heat of formation of liquid Se_2Cl_2 from vitreous selenium and gaseous chlorine. Their data yield $Q=22.13$ and 21, respectively.

$SeCl_4$ (c). The data of Thomsen[15] on the reaction, Se_2Cl_2 (liq.) $+3\,Cl_2$ (g) $=2\,SeCl_4$ (c), yield $Q=70.10$; whence, for $SeCl_4$ (c), $Qf=46.12$.

$SeCl_2$ (g). From data on the dissociation pressure of solid $SeCl_4$, and on the vapor density of the dissociation products, Yost and Kircher[1] calculated, for $SeCl_4$ (c) $=SeCl_2$ (g) $+Cl_2$ (g), $Q^{160}=-35.38$; whence, for $SeCl_2$ (g), $Qf=10\,0$.

$SeO_2 \cdot SO_3$ (c). Metzner[1, 2] measured the heat of solution in water.

Tellurium

Te (c, II). Standard state.

Te (c, I). Umino[2] measured the heat of transition.

Te (solid, amorphous). Damiens[1] found the heat of solution, in strong bromine water, of the quenched melt of tellurium and the amorphous or chemically precipitated tellurium to be zero and 2.7, respectively, greater than that of Te (c, II).

Te (liq.). Umino[2] measured the heat of fusion of Te (c, I).

Te_2 (g). At temperatures above the boiling point, tellurium vapor is diatomic. The vapor pressure data of Doolan and Partington,[1] which were obtained at lower temperatures, do not extrapolate to the known boiling point, and indicate higher association of the vapor. See also Deville and Troost.[4] These data lead to the values $V^{\epsilon}=-28.0^{600}$ and -20.0^{1500}, whence, for Te_2 (g), $Qf=-24$. This value is not very certain.

Te (g). von Wartenberg[3] estimated, from vapor density measurements at 2200° and the Nernst equation, that the heat of dissociation of Te_2 (g) into 2 Te (g) is -87.0^{2200}. See also Biltz[7] and Deville and Troost.[1, 4]

McLennan and Crawford[1] gave data on the energy levels of monatomic gaseous tellurium. See also Bacher and Goudsmit.[1]

$TeCl_4$ (c). Thomsen's[15] data on the reaction, Te (c, II) $+2\,Cl_2$ (g) $=TeCl_4$ (c), yield, for the latter, $Qf=77.4$.

TeO_2 (aq. HCl). Thomsen[15] found the heat of solution of $TeCl_4$ (c) in water to be 20.37.

H_2TeO_3 (c).) Thomsen[15] found the heat of solution of this compound in water to be zero.

TeO_2 (c). Thomsen[15] measured the heat of the reaction, (TeO_2 $+4$ HCl) (aq.) $+2\,SnCl_2$ (aq) $=$ Te (amorp., ppt.) $+2\,SnCl_4$ (aq.) $+2\,H_2O$ (liq.), and his data yield, for TeO_2 (c), $Qf=77.6$. Schuhmann[2] measured the electromotive force at various temperatures of the cell in which the reaction was Te (c, II) $+2\,H_2O$ (liq.) $=TeO_2$ (c) $+2\,H_2$ (g), and his data yield, for TeO_2 (c, II), $Qf=77.58$. Mixter's[10] data on the reactions of sodium peroxide with Te and TeO_2, respectively, lead to a value of 88.7 for the heat of formation of TeO_2 (c).

H_2TeO_4 (aq.). Thomsen[15] measured the heat of oxidation of aqueous TeO_2 with potassium permanganate, and his data yield, for H_2TeO_4 (400), $Qf = 165.3$. Berthelot and Fabre[1] oxidized solid tellurium with liquid bromine in the presence of water, $Te\ (c) + 3\ Br_2\ (liq.) + 4\ H_2O\ (liq.) = (H_2TeO_4 + 6\ HBr)\ (aq.)$, and their data yield, for H_2TeO_4 (aq.), $Qf = 169.3$.

$H_2TeO_4 \cdot 2\ H_2O$ (c). Metzner[1] measured the heat of solution in water.

$SO_2 \cdot 2\ TeO_2$ (c). Metzner[1] measured the heat of solution of this compound in aqueous KOH.

H_2Te (g). The data of Berthelot and Fabre[1] on the reaction, $H_2Te\ (g) + 2\ FeCl_3\ (aq.) = Te\ (ppt.) + (2\ FeCl_2 + 2\ HCl)\ (aq.)$ yield, for H_2Te (g), $Qf = -34.2$.

$TeBr_4$ (c). Beck[1] found for the reaction of the solid tetrabromide with aqueous sodium acetate, $Q = 7.05$; whence, for $TeBr_4$ (c), $Qf = 49.3$.

TeF_6 (g). Yost and Claussen[1] reported $Qf = 315.0$.

TeF_6 (c). Klemm and Henkel[1] gave for the heat of sublimation, -5.13^{-28}; Yost and Claussen[1] reported $-6.74^{-38.9}$.

TeF_6 (liq.). Klemm and Henkel[1] gave for the heat of fusion, -1.6; Yost and Claussen[1] estimated -1.9.

Polonium

Po (c). Standard state.

Nitrogen

N_2 (g). The standard state is taken as the equilibrium gas at 18°. The values for the energy states of gaseous diatomic nitrogen are from Sponer,[1, 3] Birge and Hopfield,[1, 4] and Mulliken.[3, 6] See also Jevons.[1] Data on the energy of ionization of N_2 (g) were reported by Sponer,[3] Smyth,[3] Turner and Samson,[1] and Tate, Smith, and Vaughan,[1] the value of the last named being $15\ 65 \pm 0.02$ volt-electrons.

N (g). The value for the energy of dissociation of normal gaseous N_2 into normal gaseous N atoms is taken from Herzberg and Sponer,[1] Kaplan,[5] and Lozier.[3] Herzberg and Sponer[1] reported the value 7.34 ± 0.02 volt-electrons. See also van der Ziel,[1] Birge,[1, 3, 8, 10] Birge and Hopfield,[1, 4] Turner and Samson,[1] Lozier,[1] Hogness and Lunn,[1] Brandt,[1] Duncan,[1] Kneser,[1] Mohler and Foote,[1] and Grimm and Eucken.[1]

The energies of ionization of monatomic nitrogen to various stages are taken from the following works: Hopfield[4] and Compton and Boyce,[1] first step; Bowen[2] and Fowler and Freeman,[1] second step; Bowen,[2] Millikan and Bowen,[3, 4] and Freeman,[1] third step; Edlen,[1] fourth step; Edlen and Ericson,[5] fifth step. The values for the sixth and seventh steps are taken from the calculations of Laporte and Young.[1]

N_2 (liq.). From a review of the data of Alt,[1] Dana,[1] Eucken,[2, 3] Keesom and Houlhoff,[1] Millar and Sullivan,[1] Burnett,[1] Shearer,[1] Rodebush, Andrews, and Taylor,[1] and Mathias, Crommelin, and Onnes,[4] Wiebe and Brevoort[1] deduced $V = -1.335$ at the boiling point, −195.7°. Vapor

pressure data were reported by Crommelin,[4] Cath,[1] Mathias, Onnes, and Crommelin,[1] Onnes, Dorsman, and Holst,[1] Wroblewsky,[4] Baly,[1] Fischer and Alt,[1] Holst and Hamburger,[1, 2] Henning and Heuse,[1] Olschewsky,[1, 3, 5, 10, 11] Porter and Perry,[1] and von Siemans.[1]

N_2 (c). Eucken[2, 3] measured the heat of fusion of N_2 (c, I) and the heat of transition of N_2 (c, II) to N_2 (c, I). See also Estreicher.[1]

NH (g). Bates[1] determined, from spectroscopic data, the energy of dissociation of NH into normal atoms, and the energy of the first electronic state.

NH_3 (g). Thomsen[15] and Berthelot[21] measured the heat of combustion of gaseous ammonia, and their data yield, for NH_3 (g), $Qf = 11.7$ and 11.2, respectively. Haber,[4] Haber, Tamaru, and Ocholm,[1] Haber and Tamaru,[1] and Tamaru[1] measured the heat of the dissociation, NH_3 (g) $= \frac{1}{2} N_2$ (g) $+ \frac{3}{2} H_2$ (g), at various temperatures. Lewis and Randall[5] reviewed these data, and their equation yields, for NH_3 (g), $Qf = 10.97$. Equilibrium data on the synthesis of gaseous ammonia from nitrogen and hydrogen were obtained by Haber,[3, 4, 5] Haber, Tamaru, and Ponnay,[1] Haber and Maschke,[1] Haber and Greenwood,[1] Haber, Tamaru, and Ocholm,[1] Haber and Moser,[1] Haber and Le Rossignol,[1, 2, 3, 4] Claude,[1] Lebeau and Jost,[1, 2] Nernst,[4] Larson,[1] and Larson and Dodge.[1] See also Haber and van Oordt.[1, 2, 3] Gillespie[1, 4] and Gillespie and Beattie[1, 2, 3] critically reviewed the recent accurate data of Larson[1] and Larson and Dodge,[1] and, after making corrections for the deviations from the ideal gas laws, deduced, for NH_3 (g), $Qf = 10.74$.

NH_3 (liq.). The most accurate value for the heat of vaporization of liquid ammonia is that of Osborne and Van Dusen,[1] who found $V = -5.56$ at the normal boiling point. From this value, we have computed $V = -5.07$ at 18°. Other data on the heat of vaporization of ammonia are given by Estreicher and Schneer,[1] Holst,[1, 3] de Forcrand and Massol,[1] Henning,[1] Regnault,[3] Strombeck,[1] Franklin and Kraus,[1] Brill,[1] Eucken and Karwat,[1] and Donath.[1]

NH_3 (c). By direct calorimetric measurement, Eucken and Karwat[1] and Eucken and Donath[1] found $F = -1.43$ and -1.420, respectively, at the freezing point, $-77.6°$. From the difference in the heats of solution of the solid and the liquid, Massol[2] (see de Forcrand and Massol[1]) found the heat of fusion of solid ammonia to be -1.84 at $-75°$. The values of Eucken and co-workers are in accord with those calculated from the differences in the variation, with temperature, of the logarithm of the vapor pressures of the solid and liquid, respectively, data on which are given for the solid, by Cragoe, Meyers, and Taylor,[1] Karwat,[1] McKelvy and Taylor,[1] Smits and Postma,[1] Briner,[1] Burrell and Robertson,[1, 3] and Mundel,[1] and, for the liquid, by Cragoe, Meyers, and Taylor,[1] Henning and Stock,[1] and others. See also the calculations by Karwat[1] and Rideal.[1]

NH_3 (aq.). The data on the heat of solution of gaseous ammonia in water yield the following values: Thomsen,[3, 15] 8.47_{200}; Berthelot,[21] 8.82^{10}, 8.2^{100}; Favre and Silbermann,[3] 8.75^{15}; Baud and Gay,[1] $8.55_{200}{}^{13}$;

Wrevski and Savaritski,[1] 8.35_{200}. The data of Ramstetter and Hantke[1] show an incorrect trend. The data on the heat of dilution of aqueous ammonia given by Thomsen,[15] Baud and Gay,[1] and Wrevski and Savaritski[1] were reviewed by Bichowsky.[2]

NH_4F (aq.). Guntz[1] found $N=15.2$.

NH_4F (c). Guntz[1] quoted a value for the heat of solution obtained by Favre, whose report we have been unable to find. Simon, Simson, and Ruhemann[1] found no transitions in solid ammonium fluoride.

NH_4Cl (aq.). The data on the heat of neutralization of aqueous ammonia with aqueous hydrochloric acid yield the following values for N_{200}: Hess,[6] ——; Berthelot,[4] ——; Favre and Silbermann,[3] 13.5; Andrews,[1, 2, 11] 12.96; Thomsen,[15] 12.30; Biltz and Messerknecht,[2] 12.30. Data on the heat of dilution of aqueous ammonium chloride were reported by Pratt,[1] Thomsen,[15] Magie,[1] Stackelberg,[1] Winkelmann,[1] and Lehtonen.[1] We have extrapolated these data to infinite dilution.

NH_4^+ (aq.). From the values for NH_4Cl (∞) and Cl^- (∞), and NH_4NO_3 (∞) and NO_3^- (∞), we have computed, for NH_4^+ (∞), $Qf=31.455$ and 31.47, respectively.

NH_4Cl (c, II). The existing data yield the following values for the heat of solution of ammonium chloride: Anderson and Noyes,[1] -3.86_{200}; Berthelot,[7] -4.0; Favre and Silbermann,[3] -3.4; Mondain-Monval,[3] -3.84^{19}; Winkelmann,[1] -3.92_{200}; Colson,[5] $-3\,95_{200}$; Stackelberg,[1] -3.93_{150}; Van Deventer and van der Stadt,[1] -3.88_{200}; Thomsen,[15] -3.92_{200}. Lehtonen[1] measured the heat of solution at 0°. Raabe[1] measured the heat of the reaction, NH_3 (g) $+HCl$ (g) $=NH_4Cl$ (c), finding $Q=44.46$; whence, for NH_4Cl (c), $Qf=77.4$. Some error must exist in his data. Bronsted[8] measured the heat of the reaction $\frac{1}{2}H_2$ (g) $+NH_3$ (in sat'd. aq. NH_4Cl) $+HgCl$ (c) $=Hg$ (liq.) $+NH_4Cl$ (c, II), finding $Q=70.60$; but we can not use these data to obtain a value for the heat of formation of solid ammonium chloride without a value for the heat of solution of gaseous ammonia in saturated aqueous ammonium chloride.

NH_4Cl (c, I). For the transitior at 184°, Scheffer[3, 4] found -1.03; Bridgman,[7] -0.88, Klinkhardt,[1] -0.97.

NH_4Cl (c, III). Simon[3] found $T=-0.356_{\rightarrow II}$[31]. See also Ewald.[1]

NH_4Cl (g). Gutmann,[1] Johnston,[4] Neuberg,[1] Pullinger and Gardner,[1] Ramsay and Young,[1, 4] Deville and Troost,[1] Smith and Lombard,[1, 2] and Rodebush and Michalek[1] obtained data on the dissociation of gaseous ammonium chloride. These data yield for the reaction NH_3 (g) $+HCl$ (g) $=NH_4Cl$ (g), $Q=9.4$; whence, for NH_4Cl (g), $Qf=42.4$. See also Wegsheider[1] and Smith and Lombard.[1] Because they took special care to reach equilibrium, we have selected the values of Smith and Calvert[1, 2] and Smith and Lombard[1, 2] for the heat of sublimation of solid ammonium chloride, in preference to the values of Braune and Knoke,[1] Rassow,[1] Scheffer,[1] Johnson,[5] Horstman,[1] Ramsay and Young,[1, 4] Smith and Menzies,[1] and Wegscheider.[1, 2] See also Smits[1] and Smits and DeLange.[1]

NH_4Br_3 (c). The data of Hüttig and Schliessmann[1] on the dissociation pressure of solid NH_4Br_3 at various temperatures, yield $D=-12.8$, which value seems high. See also Ephraim.[3]

NH_4I (aq.). The value of Qf for this substance is obtained from those for aqueous ammonium and iodide ions.

NH_4I (c, I). The existing data yield the following values for the heat of solution: Thomsen,[15] -3.56_{200}; Varet,[2] -3.5.

NH_4^+ (g). Grimm[2] showed that the heat of formation of this substance can be calculated by the method of lattice energies. Using the values given by Sherman[1] for the lattice energies of NH_4F, NH_4Cl, NH_4Br, and NH_4I, and our values for the other thermal quantities needed, we have computed, for NH_4^+ (g), $Qf=0.0$, -17.3, -21.2 and -42.2, respectively. We have selected -20 as the mean of these very discordant results.

NH_4Br (aq.). The heat of formation of aqueous ammonium bromide is computed from the values for NH_4^+ (aq.) and Br^- (aq.).

NH_4Br (c, II). The data on the heat of solution yield the following values: Thomsen,[15] -4.45_{200}; Andre,[1] -4.87^{5}.

NH_4Br (c, I). Bridgman[7] determined the heat of transition.

NH_4I (c, II). Bridgman reported $T=-0.701_{\rightarrow I}$[-18]. See also Simon, Simson, and Ruhemann.[1]

NH_4I_3 (c). Foote and Bradley[1] studied the equilibrium, NH_4I_3 (c) $=NH_4I$ (c) $+I_2$ (g).

NH_4ClO_4 (aq.). Berthelot[79] measured the heat of neutralization.

NH_4ClO_4 (c). Berthelot[79] measured the heat of solution.

$(NH_4)_2S$ (aq.). Thomsen[15] measured the heat of solution of gaseous H_2S in aqueous ammonia to form aqueous $(NH_4)_2S$ to be 11.10; and Berthelot[14] measured the heat of neutralization of aqueous H_2S with aqueous ammonia to form aqueous $(NH_4)_2S$ to be 6.2[15]. These data yield for $(NH_4)_2S$ (aq), $Qf=55.0$ and 54.7, respectively.

NH_4HS (aq.). Thomsen[15] found $Q=0.15$ for the heat of mixing aqueous NH_3 with aqueous NH_4HS.

NH_4HS (c). Berthelot[14] measured the heat of solution. Vapor pressure data for solid ammonium bisulfide were given by Salet,[1] Isambert,[1, 7, 9] Briner,[1] Magnusson,[1] and Walker and Lumsden.[1] Randall and White[2] reviewed these data and gave for the reaction, NH_4HS (c) $=NH_3$ (g) $+H_2S$ (g), $Q=-22.24$, whence, for NH_4HS (c), $Qf=38\,5$.

NS (c). Berthelot and Vielle[3] determined the heat of decomposition to be -31.9.

NSe (c). Berthelot and Vielle[3] determined the heat of decomposition to be -42.3.

$(NH_4)_2S_n$ (aq.). Sabatier[1] measured the heats of reaction with aqueous iodine of $(NH_4)_2S_4$ (aq.), $(NH_4)_2S_5$ (aq), and $(NH_4)_2S_8$ (aq.), respectively.

$(NH_4)_2S_n$ (c). Sabatier[1] measured the heats of solution of $(NH_4)_2S_4$ (c), $(NH_4)_2S_5$ (c), and $(NH_4)_2S_8$ (c).

$(NH_4)_2SO_3$ (aq.). de Forcrand[5, 15] measured the heat of neutralization of SO_2 (aq.) with $2\,NH_3$ (aq.), and the heat of mixing NH_3 (aq.) with NH_4HSO_3 (aq.). His data yield, for $(NH_4)_2SO_3$ (aq.), $Qf = 210.8$ and 210.4, respectively.

$(NH_4)_2SO_3$ (c). de Forcrand[5, 15] measured the heat of solution.

$(NH_4)_2SO_3 \cdot H_2O$ (c). For the heat of solution, de Forcrand[5, 15] found -5.4[8] and Hartog[1] -4.3. de Forcrand's sample was not pure.

NH_4HSO_3 (aq.). de Forcrand[5, 15] measured the heat of mixing SO_2 (aq.) with NH_3 (aq.), finding $N = 14.78$[9], whence, for NH_4HSO_3 (aq.), $Qf = 180.85$.

NH_4HSO_3 (c). de Forcrand[5, 15] measured the heat of solution.

$(NH_4)_2S_2O_5$ (aq.). The value for this substance is taken equal to that for $2\,NH_4HSO_3$ (aq.) minus that for H_2O (liq.).

$(NH_4)_2SO_4$ (aq.). The existing data yield the following values for the heat of neutralization of aqueous ammonia with aqueous sulfuric acid: Thomsen,[15] 28.96_{400}; Berthelot,[4] $29.0_{400}{}^{20}$; Favre,[8] 29.8; Bouzat,[1] $29.05_{400}{}^{42}$; Hess,[1, 2, 3, 4]——; Andrews,[1, 2, 10] 29.4; Favre and Silbermann,[3] 29.4. See also Roth.[5] The heat of dilution of aqueous ammonium sulfate was measured by Thomsen.[15] See also Roth.[5]

$(NH_4)_2SO_4$ (c). The existing data on the heat of solution yield the following values: Thomsen,[15] -2.38_{400}; Favre,[8] -2.0; Berthelot,[4] -2.6; Van Deventer and van der Stadt,[1] -2.32_{200}; Roth,[5] -2.03_{200}. See also Favre and Silbermann.[3]

NH_4HSO_4 (aq.). Thomsen[15] and Berthelot[4] obtained the same value, -1.41, for the heat of the reaction, H_2SO_4 (200) + $(NH_4)_2SO_4$ (200) $= 2\,NH_4HSO_4$ (200).

NH_4HSO_4 (c). Thomsen[15] measured the heat of solution.

$(NH_4)_2S_2O_8$ (aq.). The value for this substance is obtained from those for the ions.

$(NH_4)_2S_2O_8$ (c). Berthelot[107] measured the heat of solution.

NH_4HSe (aq.). Fabre[1] found, for NH_3 (aq.) + H_2Se (aq.), $N = 6.2$.

$(NH_4)_2Se$ (aq.). The value for this substance is obtained from those for the ions.

NO (g). Berthelot[20, 58] measured the heats of the reactions, $\frac{1}{2}\,C_2N_2$ (g) + O_2 (g) = CO_2 (g) + $\frac{1}{2}\,N_2$ (g) and $\frac{1}{2}\,C_2N_2$ (g) + 2 NO (g) = CO_2 (g) + $\frac{3}{2}\,N_2$ (g). The difference gives the heat of the reaction, O_2 (g) + N_2 (g) = 2 NO (g), and Berthelot's data yield, for NO (g), $Qf = -21.85$. Berthelot's data on similar experiments with ethylene instead of cyanogen yield, for NO (g), $Qf = -21.6$. See also Favre and Silbermann[2] and Dulong.[2] The high temperature equilibrium data on the reaction between N_2 and O_2 to form NO, obtained by Nernst,[2, 3] Finckh,[1] Jellinek,[1] Grau and Russ,[1] Haber and Koenig,[1, 2] and Nuranen,[1] were reviewed by Lewis and Randall[5] and Randall and White,[1] and shown to be consistent with the heat of formation value deduced from Berthelot's data.

NO (liq.). By direct calorimetric measurement, Johnston and Giauque[1] found $V = -3.293^{-151.7}$. Similar data were obtained earlier by

Eucken and Karwat.[1] The vapor pressure data of Goldschmidt,[2] Henglein and Kruger,[1] and Johnston and Giauque[1] are in accord with the latter's direct calorimetric value.

NO (c). Johnston and Giauque[1] found $F = -0.550^{-163.6}$, which value is in accord with the values of the heat of sublimation obtained from the vapor pressure data of Johnston and Giauque,[1] Mundel,[1] Henglein and Kruger,[1] and Goldschmidt.[2]

The values of the energy states of the NO molecule are from Mulliken.[6] See also Jevons.[1]

N_2O (g). The heat of combustion of N_2O with H_2, or with CO, was measured by Favre,[1a] Berthelot,[5b] Thomsen,[15] Sutton,[1] Awbery and Griffiths,[2] and Fenning and Cotton.[1] Sutton[1] measured in a bomb calorimeter the heat of reaction of N_2O with H_2, and his data yield, for N_2O (g), $Qf = 20.4 \pm 0.3$. Awbery and Griffiths,[2] with a constant pressure flame calorimeter, and Fenning and Cotton,[1] with a bomb calorimeter, measured the heats of the reactions, $CO\ (g) + \frac{1}{2} O_2\ (g) = CO_2\ (g)$ and $N_2O\ (g) + CO\ (g) = CO_2\ (g) + N_2\ (g)$, the difference of which gives the heat of formation of nitrous oxide. Their data yield, for N_2O (g), $Qf = -19.52 \pm 0.22$ and -19.74 ± 0.07, respectively.

N_2O (liq.), N_2O(c). The heats of vaporization and fusion are evaluated from the data of Eucken and Donath,[1] Cailletet and Mathias,[1] Young,[2] Burrell and Robertson,[3] Bergstrom,[2, 3] Regnault,[7] Cardoso and Arni,[1] Grunmach,[1] Villard,[1, 3, 9] Kuenen,[1] Ramsay and Shield,[1] Pictet,[1] Hunter,[1] Dewar,[2] Faraday,[1, 3] Britton,[1] Cailletet and Colardeau,[1] Marshall and Ramsay,[1] Mathias,[1, 2] and Mills.[1]

N_2O (aq.). Villard[1, 2, 3, 4, 9, 10] measured the heat of solution of the gas in water at 0°.

$N_2O \cdot 6\ H_2O$ (c). The equilibrium data of Tamman and Krige[1] and Villard[1, 2, 3, 4, 9, 10] yield for the heat of decomposition of this hydrate (concerning whose composition there is some question) −15.0 per mole of gas. Villard's data yield 8.4 for the heat of formation of $N_2O \cdot 6\ H_2O$ (c) from aqueous N_2O and liquid H_2O.

NO_2 (g). Randall and White[1] reviewed the equilibrium data of Bodenstein,[5] Colson,[3] Schreber,[1] Russ,[1] Scheffer and Treub,[1] and Bodenstein and Katayama[1] on the reaction, $NO\ (g) + \frac{1}{2} O_2\ (g) = NO_2\ (g)$, and concluded that $Q = 13.57$; whence, for NO_2 (g), $Qf = -8.03$.

N_2O_4 (g). Randall and White[1] reviewed the equilibrium data (obtained from vapor densities) of Mittasch, Kuss, and Schlueter,[1] Scheffer and Treub,[2] Wourtzel,[1] Schreber,[1] Bodenstein,[5] Richardson,[2] and Deville and Troost[3] on the reaction, $2\ NO_2\ (g) = N_2O_4\ (g)$, and concluded that $Q = 13.00$. Bodenstein[5] gave 13.88; Wourtzell,[1] 13.43. Using the value 13.00 we have computed, for N_2O_4 (g), $Qf = -3.06$. The data of Thomsen[15] and Berthelot,[28] who each measured the heat of the reaction, $2\ NO\ (g) + O_2\ (g) = N_2O_4\ (g)$, yield, for N_2O_4 (g), $Qf = -4.06$ and -4.40, respectively.

N_2O_4 (liq.). Berthelot and Ogier[5] measured the heat of condensation

of gaseous N_2O_4 to be 8.6 at 25°. The vapor pressure data of Mittasch, Kuss, and Schlueter,[1] Scheffer and Treub,[2] Guye and Drouginine,[1] and Russ[1] yield −9.2 for the heat of vaporization of liquid N_2O_4 at 18°.

N_2O_4 (c). By direct measurement, Ramsay[2] found $F=-2.96^{-10}$, while data on the freezing point lowering yield −3.10. These values are in accord with the heat of sublimation calculated by Russ.[1] See also Egerton.[1]

N_2O_3 (g). This unstable gas exists in equilibrium mixtures with NO and N_2O_4. The equilibrium data of Abel and Proisl[1] on the reactions, $2\,NO\,(g)+N_2O_4\,(g)=2\,N_2O_3\,(g)$ and $NO\,(g)+NO_2\,(g)=N_2O_3\,(g)$, yield $Q=5.6$ and 9.6, respectively; whence, for N_2O_3 (g), $Qf=-20.3$ and −20.0.

N_2O_3 (liq.). The vapor pressure data of Guye and Drouginine[1] yield $V=-9.40^{20}$, which indicates partial dissociation of the vapor.

HNO_2 (aq.). Thomsen[13, 15] measured the heat of solution in water of gaseous N_2O_4 and the heat of reaction of aqueous N_2O_4 with gaseous Cl_2. If aqueous N_2O_4 is equivalent to an aqueous mixture of nitrous and nitric acids, then one may write $N_2O_4\,(g)+H_2O\,(liq.)=(HNO_2+HNO_3)\,(aq.)$, and $(HNO_2+HNO_3)\,(aq.)+H_2O\,(liq.)+Cl_2\,(g)=(2\,HNO_3+2\,HCl)\,(aq.)$. Neglecting the heats of mixing, and subtracting the second equation from the first, one obtains $N_2O_4\,(g)+2\,HCl\,(aq.)=2\,HNO_2\,(aq.)+Cl_2\,(g)$. Thomsen's data on these two reactions yield, for $HNO_2(aq.)$, $Qf=31\,4$. Klemenc and Hayek[1, 2] obtained data on the equilibrium $3\,HNO_2\,(aq.)=HNO_3\,(aq.)+2\,NO\,(g)+H_2O\,(liq.)$, and computed $Q=-10.72$. Combination of this value with Thomsen's data on the reaction of gaseous Cl_2 with aqueous N_2O_4 (see above) yields, for HNO_2 (aq.) $Qf=28\,45$.

Berthelot[28] measured the heat of the reaction between gaseous nitric oxide, oxygen, and aqueous barium hydroxide, and assumed that only nitrite was formed: $2\,NO\,(g)+\frac{1}{2}\,O_2\,(g)+Ba\,(OH)_2\,(aq.)=Ba(NO_2)_2\,(aq.)+H_2O\,(liq.)$. Berthelot[28] also measured the heat of the reaction $Ba(NO_2)_2\,(aq.)+H_2SO_4\,(aq.)=2\,HNO_2\,(aq.)+BaSO_4\,(c)$. Combination of these equations with our value for the heat of neutralization of aqueous $Ba\,(OH)_2$ with aqueous sulfuric acid gives $2\,NO\,(g)+\frac{1}{2}\,O_2\,(g)+H_2O\,(liq.)=2\,HNO_2\,(aq.)$. And from these data, we have computed, for HNO_2 (aq.), $Qf=30.0$. Berthelot's[28] data on the reaction between gaseous chlorine and aqueous barium nitrite yield, for HNO_2 (aq.), $Qf=28.3$. Berthelot[28] measured the heat of mixing solid BaO_2 with aqueous hydrochloric acid, and the heat of mixing the resultant solution with aqueous barium nitrite. These data yield, for HNO_2 (aq.) $Qf=27.8$. Berthelot's data on the reaction between aqueous potassium permanganate and an aqueous nitrite solution yield, for HNO_2 (aq.), $Qf=28.4$. These three foregoing values for aqueous nitrous acid depend upon the accuracy of Thomsen's value for the reaction between gaseous chlorine and aqueous N_2O_4 (see above).

Both Berthelot[23] and Thomsen[13, 15] measured the heat of the reaction

of decomposing ammonium nitrite, but because the former employed only a small amount of ammonium nitrite and used less refined apparatus, we have used only Thomsen's data. Thomsen apparently measured the heat of the reaction ($NH_4NO_2 + 2.8\,H_2O$) (liq.) $= N_2$ (g) $+ 2.8\,H_2O$ (liq.). We have carefully reviewed his data on this reaction, and utilizing Thomsen's value for the heat of solution of solid ammonium nitrite in $2.8\,H_2O$, we have computed $Q = 72\,04$ for the reaction NH_4NO_2 (c) $= N_2$ (g) $+ 2\,H_2O$ (liq.). With this we have combined the heat of solution of ammonium nitrite in $200\,H_2O$ and the heat of ionization of HNO_2, and have obtained, for HNO_2 (aq.), $Qf = 31.6$, which is in marked disagreement with the values obtained above.

Swietoslawski[6] measured the heats of the reactions, $((NH_2)_2CO + 2\,HCl)$ (aq.) $+ 2\,NaNO_2$ (aq.) $= CO_2$ (g) $+ N_2$ (g) $+ 3\,H_2O$ (liq.) $+ 2$ NaCl (aq) and $(NH_2)_2CO$ (aq.) $+ 2$ HCl (aq.) $= ((NH_2)_2CO + 2\,HCl)$ (aq.), finding, respectively, $Q = 172.6$ and 0.37. Combining with these data, the heat of combustion and of solution of urea and the heat of mixing aqueous sodium nitrite with aqueous hydrochloric acid, we have computed, for HNO_2 (aq), $Qf = 28\,9$. Swietoslawski[6] also measured the heat of the reaction $(CH_3)_2NC_6H_5$ (liq.) $+ HNO_2$ (aq.) $= H_2O$ (liq.) $+ NOC_6H_4N(CH_3)_2$ (liq.). Utilizing Swietoslawski's own values for the heats of combustion of these two organic liquids, we have computed, for HNO_2 (aq), $Qf = 28.4$. This value can not be given great weight as it is a small difference between large numbers, but nevertheless it is in gratifying agreement with the previous values.

As the best value for the heat of formation of aqueous nitrous acid we have selected the value 28 5, which is consistent with the above available data and with the value for aqueous nitric acid.

NO_2^- (aq.). The data of Klemenc and Hayek[1] on the conductivity of aqueous HNO_2 yield, for H^+ (aq.) $+ NO_2^-$ (aq.) $= HNO_2$ (aq.), $Q^6 = 4.48$, or $Q = 4.0$ at 18°; whence for NO_2^- (aq.), $Qf = 24.5$. Swietoslawski[6] found, for $NaNO_2$ (aq.) $+$ HCl (aq.) $= (HNO_2 + NaCl)$ (aq.), $Q = 3.45$; whence for NO_2^- (aq.), $Qf = 25.0$. From the value for NH_4NO_2 (aq.), we have deduced, for NO_2^- (aq.), $Qf = 25.4$.

HNO_3 (aq.). Thomsen[15] measured the heats of the reactions N_2O_4 (g) $= N_2O_4$ (aq.) and $5\,N_2O_4$ (aq.) $+ 2\,KMnO_4$ (aq.) $+ 2\,H_2O$ (liq.) $= (2\,Mn(NO_3)_2 + 2\,KNO_3 + 4\,HNO_3)$ (aq.). Neglecting the heats of mixing, his data yield, for HNO_3 (aq.), $Qf = 48.9$. Thomsen[15] also measured the heat of reaction between aqueous N_2O_4 and gaseous chlorine, and his data yield, for HNO_3 (200), $Qf = 49.41$. Berthelot[28] measured the heat of reaction between liquid N_2O_4, gaseous chlorine, and water, and his data yield, for HNO_3 (aq.), $Qf = 47.9$. Latimer and Ahlberg[1] calculated the entropy of aqueous $(M^+ + NO_3^-)$, in a hypothetical 1 molal solution, from data on the entropy of the solid MNO_3 (calculated from data on the heat capacity down to about −261°) and its heat and free energy of solution. Combination of the value of the entropy of aqueous $(M^+ + NO_3^-)$ with similar values for aqueous $(M^+ + Cl^-)$ and aqueous $(H^+ + Cl^-)$ gave the

entropy of aqueous ($H^+ + NO_3^-$). They combined this value with the entropies of hydrogen, nitrogen, and oxygen in their standard states, and computed the entropy of formation of aqueous ($H^+ + NO_3^-$). Combination of this last value with the value for the free energy of formation given by Lewis and Randall[5] yields, for HNO_3 (aq.), $Qf = 48.7$. As the best value for the heat of formation of HNO_3 (200), we have selected the value 49.1, which seems to be most consistent with the above data and with the reactions involving nitrous acid.

Data on the heat of dilution of aqueous nitric acid were obtained by Thomsen,[15] Berthelot,[17] Richards and Rowe,[2] Naudè,[2] Wrewskii and Faerman,[1] Berthelot,[9] and Petersen.[6] Bose[2] reviewed these data. Recently Rossini[3] utilized the accurate measurements of Richards and Rowe[2] to obtain values from 25 to ∞ H_2O. We have utilized Thomsen's[15] values in the range 0 to 25 H_2O.

HNO_3 (liq.). For the heat of solution of liquid HNO_3 in water Thomsen[15] found 7.44_{300} and Berthelot[17] 7.14.

HNO_3 (c). Berthelot[17] found the heat of fusion to be -0.60 at $-47°$.

HNO_3 (g). Berthelot[17] gave -7.2 for the heat of vaporization of the liquid, obtained from data on the heats of solution of the gas and the liquid in water.

HNO_3 ($C_2H_5OC_2H_5$). Hantzsch[1] measured the heat of solution in ether.

NH_4NO_2 (aq.). For the heat of neutralization of aqueous ammonia with aqueous nitrous acid, Berthelot[28] gave the value 9.1 at 12.5°, which he deduced from the heat of the reaction between aqueous ammonium sulfate and aqueous barium nitrite, for which no value was given. The foregoing value yields, for NH_4NO_2 (aq.), $Qf = 56.9$.

NH_4NO_2 (c). Berthelot[28] measured the heat of solution to be $-4.75_{430}^{12.5}$, from which we have estimated -4.66_{200} at 18°.

$H_2N_2O_2$ (aq.). Berthelot[105] measured the heat of solution of $CaN_2O_2 \cdot 4\,H_2O$ (c) in bromine water and hydrochloric acid, respectively, and the difference of these two reactions leads to the reaction $H_2N_2O_2$ (aq.) $+ 4\,H_2O$ (liq.) $+ 4\,Br_2$ (liq.) $= (2\,HNO_3 + 8\,HBr)$ (aq.), with $Q = 45.6$. Similar experiments with the strontium salt gave $Q = 46.4$. From the average of these values, we have computed, for $H_2N_2O_2$ (aq.), $Qf = 8.4$.

$N_2O_2^{--}$ (aq.). Berthelot[105] reported the heat of neutralization of the weak hyponitrous acid to be 15.6; whence we have computed, for $N_2O_2^{--}$ (aq.), $Qf = -3.5$.

N_2O_5 (c). Berthelot[9] found $S = 16.7$.

N_2O_5 (liq.). Berthelot[9] reported $S = 25.0$, but his sample must have contained water as liquid nitrogen pentoxide is not stable under his conditions. Berl and Saenger[1] measured the heat of solution of fuming nitric acid.

N_2O_5 (g). Berthelot[9] reported the heat of sublimation of solid nitrogen pentoxide to be -13.2. The vapor pressure data of Daniels and Bright[1] yield -13.8.

NO_3 (g). Schumacker and Sprenger[1] deduced, for NO_3 (g), $Qf = -13$, from activation energies of the monomolecular dissociation of gaseous N_2O_5, which is supposed to give gaseous NO_3.

NH_4NO_3 (aq.). The heat of neutralization of aqueous ammonia with aqueous nitric acid was measured by Hess,[6] Andrews,[1, 2, 11] Favre and Silbermann,[3] Favre,[3] Bouzat,[1] Berthelot,[3, 4] and Thomsen.[15]. Thomsen's data are the most reliable, and yield $N = 12.40_{200}$. Data on the heat of dilution of aqueous ammonium nitrate were obtained by Pratt,[1] Jirsa and Diamant,[1] Thomsen,[15] Tollinger,[1] Dunnington and Hoggard,[1] Mondain-Monval,[2,3] Lerner-Steinberg,[1] Rümelin,[1] Winkelmann,[1] and Fricke and Havestadt.[1] We have extrapolated the data to infinite dilution.

NH_4NO_3 (c, IV). The existing data on the heat of solution of ammonium nitrate in water are: Thomsen,[15] -6.32_{200}; van Deventer and van der Stadt,[1] -6.3; Favre and Silbermann,[3] -5.3; Berthelot,[131] -4.75_{400}[12]. See also Graham[3] and Mondain-Monval.[3] Cohen and Heldermann[4] reported values for concentrated solutions at 32.5°.

NH_4NO_3 (c, V). Bridgman[6a] reported $T = -0.13_{\rightarrow IV}$[-18].

NH_4NO_3 (c, III). For the heat of transition of this crystalline form to NH_4NO_3 (c, IV), at 32.2°, Bridgman[6a] gave 0.372; Cohen and Heldermann, 0.399; Bellati and Romanese,[4] 0.403; Mondain-Monval,[2] 0.40.

NH_4NO_3 (c, II). For the heat of transition of NH_4NO_3 (c, II) to NH_4NO_3 (c, III), Bridgman[6a] gave 0.32^{83}; Steiner and Johnston,[1] 0.31^{84}.

NH_4NO_3 (c, I). For the transition of this form to NH_4NO_3 (c, II), Bridgman[6a] gave 1.02^{125}; Steiner and Johnston,[1] 0.98^{129}. See also Atlas Powder Co.[1]

NOCl (g). Briner and Pylkoff[1] (see also Briner[2]) measured the heat of the reaction, NOCl (g) + 2 KOH (aq.) = (KCl + KNO_2) (aq.) + H_2O (liq.), finding $Q = 32.0$. The later and apparently more accurate measurements of Trautz and Wackenheim[1] on the similar reaction with aqueous sodium hydroxide yield $Q = 37.1$. These data yield respectively, for NOCl (g), $Qf = -7.7$ and -13.0. Lewis and Randall[5] reviewed the data of Sudborough and Miller,[1] Trautz,[3] Vago,[1] Trautz and Hinck,[1, 2] and Trautz and Wackenheim[1] on the equilibrium, NO (g) + ½ Cl_2 (g) = NOCl (g), and deduced for this reaction $Q = 9.1$; whence, for NOCl (g), $Qf = -12.5$. The recent equilibrium data of Dixon[1] on the same reaction yield $Q = 9.3$, whence, for NOCl (g), $Qf = -12.3$. Trautz and Wackenheim[1] estimated for this reaction $Q = 8.7$, whence, for NOCl (g), $Qf = -12.9$. See also Trautz and Schleiter.[1]

NOCl (liq.). The vapor pressure data of Trautz and Gerwig[1] and Briner and Pylkoff[1] yield for the heat of vaporization -6.1 at about $-15°$.

NOBr (liq.). The data of Trautz and Dalal[1] on the heat of solution of liquid NOBr in aqueous KOH yield, for NOBr (liq.), $Qf = -11.6$.

NOBr (g). We have estimated the heat of vaporization of the liquid to be -6.1, whence, for NOBr (g), $Qf = -17.7$. The data of Trautz and Dalal[1] on the equilibrium, NOBr (g) = NO (g) + ½ Br_2 (g), are not very

consistent, but from them we have estimated for this reaction $Q=8$ to 9; whence, for NOBr (g), $Qf=-16.4$ to -17.4.

$NOBr_3$ (liq.). The data of Trautz and Dalal[1] on the heat of solution of liquid $NOBr_3$ in aqueous KOH yield, for $NOBr_3$ (liq.), $Qf=1.7$.

$NOBr_3$ (g). We have estimated the heat of vaporization of the liquid.

$NH_2OH \cdot HNO_3$ (c). Berthelot and Andre[2] measured the heat of combustion of this substance in a bomb calorimeter, using naphthalene as an auxiliary combustible material. Correcting the heat of combustion of naphthalene to the modern value, we have computed for $NH_2OH \cdot HNO_3$ (c), $Qf=85.8$. Berthelot and Andre[2] measured the heat of solution of solid $NH_2OH \cdot HNO_3$ in water to be -5.93_{500}. Using the value 81 (see following) for $NH_2OH \cdot HNO_3$ (aq.), this gives for the solid, $Qf=86.9$.

$NH_2OH \cdot HNO_3$ (aq.). Thomsen[15] measured the heat of the reaction, $(NH_2OH \cdot HNO_3 + 6\,AgNO_3)$ (aq.) $+ 10\,NH_3$ (aq) $= N_2$ (g) $+ N_2O$ (g) $+3\,H_2O$ (liq.) $+6$ Ag (c) $+10\,NH_4NO_3$ (aq.). Correcting Thomsen's data for the dissolved N_2 and N_2O, one finds $Q=330.43$, whence, for $NH_2OH \cdot HNO_3$ (aq.), $Qf=82.2$.

$NH_2OH \cdot HCl$ (c). Swietoslawski[4] measured the heat of reaction, $NH_2OH \cdot HCl$ (c) $+NaNO_2$ (aq.) $=2H_2O$ (liq.) $+N_2O$ (g) $+NaCl$ (aq.), to be 65 8, whence, for $NH_2OH \cdot HCl$ (c), $Qf=74.2$.

$NH_2OH \cdot HCl$ (aq.). Berthelot and Matignon[4] measured the heat of solution of the solid to be $-3.31_{450}{}^{24}$. Thomsen[15] found -3.65_{200}. Combination with the preceding value gives, for $NH_2OH \cdot HCl$ (aq), $Qf=70.9$ and 70.5, respectively.

$NH_2OH \cdot H^+$ (aq.). From the values for aqueous $NH_2OH \cdot HNO_3$ and $NH_2OH \cdot HCl$, one finds, for $NH_2OH \cdot H^+$ (aq.), $Qf=32.3$ and 31.2.

NH_2OH (aq.). Berthelot's[41] data on the reaction between NH_2OH and KOH for which he gives few details, yield, for NH_2OH (aq.), $Qf=17.7$. For the heat of neutralization of NH_2OH (aq) with HCl (aq.), Thomsen[15] gave 9.26_{200}; Ellingson,[1] 9.48_{100}, $9\,29_{400}$; Berthelot,[41] $9\,2^{24}$. Using Thomsen's values, we have computed, for NH_2OH (aq.), $Qf=21.7$.

NH_2OH (c). Berthelot and Matignon[4] found $S=-3.8$.

$(NH_2OH)_2 \cdot H_2SO_4$ (aq.). Berthelot[41] measured the heat of mixing $2NH_2OH$ (aq.) with H_2SO_4 (aq.) to be 21.6 at 13°. Thomsen[15] found for the reaction, $Ba(OH)_2(400) + (NH_2OH)_2 \cdot H_2SO_4(600) = BaSO_4$ (c) $+2H_2O$ (liq.) $+2NH_2OH$ (500), $Q=15.32$. From these data we have computed, for $(NH_2OH)_2 \cdot H_2SO_4$ (aq.), $Qf=276.5$ and 276.7, respectively.

$NH_2OH \cdot H_2SO_4$ (aq.). Ellingson[1] found for the reaction, NH_2OH (aq.) $+H_2SO_4$ (aq.) $=NH_2OH \cdot H_2SO_4$ (aq.), $Q=11.45_{100}$ and 11.07_{400}. From these data we have computed, for $NH_2OH \cdot H_2SO_4$ (aq.), $Qf=244.3$.

$(NH_2OH)_2 \cdot H_2SO_4$ (c). Berthelot[41] found $S=-5.80_{900}{}^{18}$.

$NH_2OH \cdot H_2SO_4$ (c). Thomsen[15] found $S=-0.96$.

$N_2H_4 \cdot H_2SO_4$ (c). Berthelot and Matignon[3] measured the heat of combustion of hydrazine sulfate with camphor as the auxiliary combustible

substance. Correcting, as does Berthelot,[108] for the new values for the heat of combustion of camphor, we have computed, for $N_2H_4 \cdot H_2SO_4$ (c), $Qf = 228.4$.

$N_2H_4 \cdot H_2SO_4$ (aq.). Berthelot[108] found for the heat of solution of the solid in water, -8.7_{2000}[11]; Bach[1] found -8.52_{1200}[19].

N_2H_4 (aq.). For the heat of mixing N_2H_4 (aq.) with H_2SO_4 (aq.), Bach[1] found 11.29. For the reaction between $Ba(OH)_2$ (aq.) and $N_2H_4 \cdot H_2SO_4$ (aq.), Berthelot[108] found $Q = 25.7$. For the similar reaction with $BaCl_2$ (aq.), Bach found $Q = 7.48$. These data yield, for N_2H_4 (aq.), $Qf = -3.25$. Jirsa[1] measured the heat of oxidation of hydrazine with silver oxide, N_2H_4 (aq) $+2Ag_2O$ (c) $= 4Ag$ (c) $+N_2$ (g) $+2H_2O$ (liq.), finding $Q = 118.5$. Hence, for N_2H_4 (aq), $Qf = -4.5$. Bach[1] measured the heat of the reaction, $3N_2H_4 \cdot HCl$ (aq.) $+2K_2Cr_2O_7$ (aq.) $+ 13HCl$ (aq.) $= 3N_2$ (g) $+ 14H_2O$ (liq.) $+ (4KCl + 4CrCl_3)$ (aq.), to be 465.2. Combining with this reaction Bach's[1] value for the reaction, N_2H_4 (aq.) $+HCl$ (aq.) $= N_2H_4 \cdot HCl$ (aq.), $Q = 9.60$, yields, for N_2H_4 (aq), $Qf = -5.8$. Bach[1] also claimed to have measured the heat of the extraordinary reaction, $6N_2H_4 \cdot HNO_3$ (aq) $+ 6HNO_3$ (aq) $+ 21AgNO_3$ (aq) $+32NH_3$(aq.) $= 21Ag$ (c) $+\frac{5}{2} N_2$(g) $+33NH_4NO_3$(aq), to be 922.2. See also Thomsen.[17]

$N_2H_4 \cdot HCl$ (aq.). Bach[1] measured the heat of mixing aqueous hydrazine with aqueous hydrochloric acid.

$N_2H_4 \cdot HCl$ (c). Bach[1] measured the heat of solution.

$N_2H_4 \cdot 2HCl$ (aq.). Bach[1] measured the heat of mixing N_2H_4 (aq.) with 2HCl (aq).

$N_2H_4 \cdot 2HCl$ (c). Bach[1] measured the heat of solution.

$N_2H_4 \cdot H_2O$ (c). Bach[1] measured the heat of solution.

$N_2H_4 \cdot HNO_3$ (aq.). Bach[1] measured the heat of mixing N_2H_4 (aq.) with HNO_3 (aq.).

$N_2H_4 \cdot 2HNO_3$ (aq.). Bach[1] measured the heat of mixing N_2H_4 (aq.) with $2HNO_3$ (aq.)

NH_3HN_3 (c). Berthelot and Matignon[3] measured the heat of combustion of ammonium azide, NH_3HN_3 (c) $+O_2$ (g) $= N_2$ (g) $+2H_2O$ (liq.). Berthelot[107] corrected the original data on this reaction, obtaining $Q = 157.0$; whence, for NH_3HN_3 (c), $Qf = -20.2$.

NH_3HN_3 (aq.). For the heat of solution of solid ammonium azide, Berthelot and Matignon[3] found -7.08_{700}[12] and Bach[1] -6.73_{600}[17].

HN_3 (aq.). Bach[1] found for the reaction, NH_3HN_3 (aq.) $+HCl$ (aq.) $= (NH_4Cl + HN_3)$ (aq.), $Q = 3.97$; whence, for HN_3 (aq.), $Qf = -54.6$.

$NH_4X \cdot nNH_3$ (c). The values for the heats of dissociation of the ammonium halides are computed from the dissociation pressure data of Troost[1] and Roozeboom.[7]

$NH_4NO_3 \cdot 5NH_3$ (liq.). The heat of dissociation of this substance is computed from the dissociation pressure data of Troost.[2]

NCl_3 (CCl_4). Deville and Hautefeuille[1] measured the heats of two

reactions involving nitrogen trichloride: NH_4Cl (c) $+3Cl_2$ (aq.) $=4HCl$ (aq.) $+NCl_3$ (liq.) and NH_4Cl (c) $+3HClO$ (aq.) $=HCl$ (aq.) $+3H_2O$ (liq.) $+NCl_3$ (liq.). The observed heat values were 10.85 and 40.9, respectively, but there is considerable doubt about the second reaction. As written above, these data yield for NCl_3 (liq.), $Qf=-56.1$ and -43.3. Thomsen[5] corrected an error in the original calculations of Deville and Hautefeuille, but made another error at the same time. The recent accurate data of Noyes and Tuley[1] on the reaction, $NCl_3(CCl_4)+4HCl$ (g) $=NH_4Cl$ (c) $+3Cl_2$ (g), give $Q=41.8$; whence, for $NCl_3(CCl_4)$, $Qf=-55.0$.

$N_2O_3(SO_3)_2$ (c). Vaughan[1] measured the heat of solution of this substance in aqueous KOH.

$HNO_3 \cdot nH_2SO_4 \cdot n'H_2O$ (liq.). McDavid[1] measured the heat of mixing aqueous nitric and sulfuric acids in various proportions.

Phosphorus

P (c, I, yellow). Standard state.

P (c, II, yellow). Bridgman[2] reported the heat of transition.

P (c, red). The exact thermodynamic status of the solid forms of phosphorus other than yellow has not yet been determined. The vapor pressure of red phosphorus was measured by Chapman[1] and Troost and Hautefeuille[1]; and the latter calculated, from the difference in the temperature coefficients of the vapor pressures of the yellow and red forms, the heat of transition from yellow to red to be 4.2 at 700°. From the difference in the heats of combustion of the yellow and red forms of phosphorus, Giran[1] found $T=3.7$. A more direct measurement of the heat of transition is that from the data of Giran[1] on the heats of reaction of the two forms with bromine in carbon disulfide, $Q=38.79$ and 43.01 for the red and yellow forms, respectively. These data yield $T=4.22$. Giran[1] found that the so-called violet or black phosphorus had a heat of reaction of 38.56 with bromine in carbon disulfide. Apparently this form is thermochemically identical with the red form.

P (liq., yellow). The existing data on the heat of fusion of P (c, I, yellow) are: Pérson,[1] $-0.156^{44.2}$; Desaine,[2] -0.16^{44}; Peterson,[4] -0.147^{44}; Tammann,[3] $-0.152^{44\,1}$.

P_4 (g). Phosphorus molecules at saturation pressure below the boiling point are practically all tetratomic, according to the vapor density measurements of Deville and Troost,[1, 2] Meyer and Biltz,[1] Chapman,[1] Preuner and Brockmoller,[1] Stock, Gibson, and Stamm,[1] Hittorf,[1] Truthe,[1] and Mitscherlich.[1] The vapor pressure data of Centnerszwer,[1] MacRae and Voorhis,[1] and Smits and Bokhorst[2] on solid phosphorus yield -15.1 for the heat of sublimation. Vapor pressure data on liquid phosphorus were reported by Jolibois,[1] Schrötter,[1] MacRae and Van Voorhis,[1] Marckwald and Helmholtz,[1] Preuner and Brockmoller,[1] and Smits and Bokhorst.[1] For the heat of vaporization of liquid phosphorus to give gaseous P_4 at 300°, Preuner and Brockmoller[1] gave -12.5, Smits and Bok-

horst[2] gave −12.5, de Forcrand[37] calculated −12.2, and we have computed −12.6.

P_2 (g). From vapor density measurements, Preuner and Brockmoller[1] deduced, for the reaction, P_4 (g) $=2P_2$ (g), $Q^{800}=-31.5$. Assuming $\Delta C_p=3$, we have computed $Q=-30.0$ at 18°.

P (g). From vapor density data, Preuner and Brockmoller[1] deduced for the reaction, P_2 (g) $=2P$ (g), $Q^{1400}=-45.5$. Taking $\Delta C_p=3$, we have computed $Q=-42.2$ at 18°.

The ionization potentials of P (gas) are evaluated from the following: first step, Saltmarsh,[1] McLennan and McLay,[1] Kiess[2]; second step, Bowen[3]; third step, Bowen and Millikan,[1] Millikan and Bowen[1]; fourth step, Bowen and Millikan[1]; fifth step, Bowen and Millikan.[2]

P_2 (CS_2). Giran[1] measured the heat of solution of yellow phosphorus in carbon disulfide.

P_2O_5 (c). Data on the heat of combustion of phosphorus were reported by Favre and Silbermann,[12] Abria,[1] Andrews,[14, 16] Troost and Hautefeuille,[7] Berthelot,[50] and Giran.[1] The best of these data are undoubtedly those of Giran,[1] who measured the heats of combustion in a bomb calorimeter, the energy equivalent of which was determined by burning naphthalene. The result given by Giran[1] is not labeled either for constant volume or for constant pressure, but he uses the value in the latter sense, so we have assumed that he made the correction to constant pressure. Correction of his data to new atomic weights and for the new value for the heat of combustion of naphthalene yields, for the P_2O_5 formed in his bomb, $Q=366.4$. Giran[1] found the difference in the heats of solution of the above form and the crystalline form of P_2O_5 to be −6.42, so that, for P_2O_5 (c), we have computed $Qf=360.0$.

P_2O_5 (amorp.). Giran[1] found the heat of solution of the amorphous form of P_2O_5 to be 33.81, as compared with 40.79 for the crystalline form under the same conditions. This gives for the reaction, P_2O_5 (c) $=P_2O_5$ (amorphous), $Q=6.98$.

P_2O_5 (gls.). Giran[1] found the heat of solution of the vitreous form of P_2O_5 to be 29 09, as compared with 40.79 for the crystalline form under the same conditions. This gives, for P_2O_5 (c) $=P_2O_5$ (gls.), $Q=11.70$.

P_2O_5 (g). The vapor pressure data of Hoeflake and Scheffer[1] (see also Hautefeuille and Perry[1] and Smits and Rutgers[1]) yield, for the heat of sublimation, the following values for the various forms of solid P_2O_5: metastable crystals, −22.8; vitreous form, −20.4; stable crystalline form, −36.9. These data are in disagreement with our values for the various solid forms, and may be explained by assuming that equilibrium was not attained. The vapor density of phosphorus pentoxide is not known with any accuracy. The old data of Tilden and Barnett[1] and West[1] indicate association in the vapor.

HPO_3 (aq.). Giran[1] found that the solution of crystalline P_2O_5 in water, with $Q=40.79$, resulted in the formation of aqueous metaphosphoric acid; whence, for HPO_3 (aq.), $Qf=234.6$.

HPO_3 (c). Giran[1] found the heat of solution in water to form aque-metaphosphoric acid to be 9.76.

H_3PO_4 (aq.). In the presence of strong acids, sulfuric acid in particular, aqueous metaphosphoric acid is transformed into aqueous orthophosphoric acid. Giran[1] measured the heat of solution of solid HPO_3 in aqueous sulfuric acid to be 12.91. Hence, for the reaction, HPO_3 (aq.) $+H_2O$ (liq.) $=H_3PO_4$ (aq.), $Q=3.15$, and for H_3PO_4 (aq.), $Qf=306.1$. Thomsen[15] measured the heat of the reaction of phosphorus with aqueous HIO_3 to form a mixture of aqueous H_3PO_3 and H_3PO_4, and the heat of the reaction of bromine water with aqueous H_3PO_3: HIO_3 (aq.) $+1.6$ P (c, yellow) $+2.4\ H_2O$ (liq.) $=H_3PO_3$ (aq.) $+0.6\ H_3PO_4$ (aq.) $+HI$ (aq.), H_3PO_3 (aq.) $+Br_2$ (aq.) $+H_2O$ (liq.) $=H_3PO_4$ (aq.) $+2HBr$ (aq.). We have computed Thomsen's data on these reactions, obtaining $Q=205.2$ and 64.9, respectively. The sum gives for the reaction, HIO_3 (aq.) $+1.6$ P (c, yellow) $+3.4\ H_2O$ (liq.) $+Br_2$ (aq.) $=1.6\ H_3PO_4$ (aq.) $+2HBr$ (aq.) $+HI$ (aq.), $Q=270.1$, whence, for H_3PO_4 (aq.), $Qf=306.2$. Data on the heat of dilution of aqueous H_3PO_4 were reported by Thomsen.

H_3PO_4 (liq.), H_3PO_4 (c). Thomsen[15] measured the heats of solution. Rideal[1] calculated the heat of fusion to be -2.87.

$H_3PO_4 \cdot \frac{1}{2}\ H_2O$ (c). Thomsen[15] measured the heat of solution.

$H_3PO_4 \cdot \frac{1}{2}\ H_2O$ (liq.). Thomsen[15] measured the heat of solution.

H_3PO_3 (aq.). Thomsen's[15] data on the reaction between aqueous bromine and aqueous phosphorous acid, $Q=64.9$, yield, for H_3PO_3 (aq.), $Qf=229.0$ Thomsen[15] measured the heats of the following reactions: PCl_3 (liq.) $+Cl_2$ (g) $=PCl_5$ (c), PCl_5 (c) $+4H_2O$ (liq.) $=(H_3PO_4+5HCl)$ (aq.), and PCl_3 (liq.) $+3H_2O$ (liq.) $=(H_3PO_3+3HCl)$ (aq.). Combining these equations and neglecting the heats of mixing gives H_3PO_3 (aq.) $+Cl_2$ (g) $+H_2O$ (liq.) $=H_3PO_4$ (aq.) $+2HCl$ (aq.). These data yield, for H_3PO_3 (aq.), $Qf=228.8$.

H_3PO_3 (liq.), H_3PO_3 (c). Thomsen[15] measured the heat of solution of the solid and liquid in water.

P_2O_3 (g). The vapor pressure data of Schenck, Mihr, and Balthien,[1] when plotted as the logarithm of the pressure against the reciprocal of the absolute temperature, yield two straight lines of widely different slopes.

H_3PO_2 (aq.). Thomsen[15] measured the heat of the reaction, $BaH_4P_2O_4 \cdot H_2O$ (c) $+4Br_2$ (aq.) $+3H_2O$ (liq.) $=(2H_3PO_4+6HBr+BaBr_2)$ (aq.), to be 277.4. Taking the heat of solution of the salt, and assuming the heats of neutralization of $Ba(OH)_2$ (aq.) with HBr (aq.) and H_3PO_2 (aq.) to be 27.78 and 30.93, respectively, we have computed, for H_3PO_2 (aq.), $Qf=141.2$.

H_3PO_2 (c), H_3PO_2 (liq.). Thomsen[15] measured the heats of solution of the solid and the liquid.

$H_4P_2O_5$ (aq.). Amat[1] found the heat of hydration of pyrophosphorous acid, $H_4P_2O_5$ (aq.) $+H_2O$ (liq.) $=2H_3PO_2$ (aq.), to be 4.9; whence, for $H_4P_2O_5$ (aq.), $Qf=384.3$.

$H_4P_2O_6$ (aq.). There are no data with which to compute the heat of formation of aqueous hypophosphoric acid.

$H_4P_2O_6$ (c). Joly[2] measured the heat of solution of the solid.

$H_4P_2O_6 \cdot 2H_2O$ (c). Joly[2] measured the heat of solution of the solid.

$H_4P_2O_6 \cdot 2H_2O$ (liq.). Joly[2] measured the heat of solution of the liquid.

$H_4P_2O_7$ (liq.). Giran[1] measured the heat of solution of the liquid.

$H_4P_2O_7$ (c). Giran[1] measured the heat of solution of the solid.

$H_4P_2O_7$ (aq.). In a manner similar to that used for converting metaphosphoric into orthophosphoric acid, Giran[1] found for the reactions, $H_4P_2O_7$ (liq.) $+H_2O$ (liq) $=2H_3PO_4$ (aq.) and $H_4P_2O_7$ (c) $+H_2O$ (liq.) $=2H_3PO_4$ (aq.), $Q=14.47$ and 12.35, respectively.

$H_4P_2O_7 \cdot 1\frac{1}{2} H_2O$ (c). Giran[1] measured the heat of solution.

$H_4P_2O_7 \cdot 1\frac{1}{2} H_2O$ (liq.). Giran[1] measured the heat of solution of the liquid.

PCl_3 (liq.). Thomsen[15] and Berthelot and Louguinine[2] measured the heat of solution of liquid PCl_3 in water to be 65.1.

PCl_3 (g). Antoine[2, 3] and Andrews[14] found the heat of vaporization of liquid PCl_3 to be -6.9 and -7.1, respectively. Vapor pressure data were reported by Regnault.[4, 7].

PCl_5 (c). Thomsen[15] and Berthelot and Louguinine[2] measured the heat of solution of this substance in water. Their data give $Q=123.4$ for the reaction, PCl_5 (c) $+4H_2O$ (liq.) $=(H_3PO_4+5HCl)$ (aq.), from which we have computed, for PCl_5 (c), $Qf=106.5$. Thomsen's[15] data for the reaction, PCl_3 (liq.) $+Cl_2$ (g) $=PCl_5$ (c), $Q=29.69$, yield, for PCl_5 (c) $Qf=106.6$. See also Andrews.[16]

PCl_5 (g). Smith and Lombard[2] reported the value -15.5 for the heat of sublimation of solid PCl_5, corrected for dissociation. The data of Smith and Calvert[1] show that gaseous PCl_5 is partly dissociated. The equilibrium data of Mitscherlich,[1] Cahours,[1] Deville,[1, 2, 3], Naumann,[1, 3] Horstmann,[2] Gibbs,[2] Wichelhaus,[1] Troost and Hautefeuille,[9, 10, 11] Debray,[1] Wurtz,[1] Brill,[3] Smith and Lombard,[2] and Holland[1] yield for the reaction, PCl_3 (g) $+Cl_2$ (g) $=PCl_5$ (g), $Q=21\pm2$.

PBr_3 (CS_2). Giran[1] measured the heat of the reaction of liquid bromine with yellow phosphorus, each dissolved in carbon disulfide, to be 43.5.

PBr_3 (liq.). Berthelot and Louguinine[2] measured the heats of solution of liquid PBr_3 in water and in aqueous KOH to be 64.0 and 130.5, respectively, from which we have computed, for PBr_3 (liq.), $Qf=45.7$ and 48.8, respectively.

$POCl_3$ (liq.). For the heat of solution in water, Thomsen[15] found $72.19_{1000}{}^{20}$; Berthelot and Louguinine,[2] 74 6.

$POCl_3$ (c). Oddo[1] computed the heat of fusion to be $-3.2^{1.7}$, from data on the freezing point lowering.

$POCl_3$ (g). Arii[1] calculated the heat of vaporization of the liquid to

be -8.70^{25}, from vapor pressure data. Calculation by way of Trouton's rule yields $-8.1^{100.7}$.

PBr_5 (c). Ogier[4] reported the heat of solution to be 14.7.

$POBr_3$ (c). Ogier[4] reported the heat of solution to be 79.7.

PI_2 (c). The data of Ogier[4] and Berthelot and Louguinine[2] yield, for this substance, $Qf = 10.9$.

PI_3 (CS_2). Ogier[4] measured the heat of solution in carbon disulfide.

PH_3 (g). The data of Ogier,[1] who measured the heat of reaction between gaseous phosphine and saturated bromine water, yield, for PH_3 (g), $Qf = -3.6$. Lemoult[10] measured the heat of combustion of phosphine in oxygen to form H_3PO_4, and his data yield, $Q = 309.8$, whence, for PH_3 (g), $Qf = -6.3$. The equilibrium data of Ipatev and Frost[1] on the reaction, $4PH_3\ (g) = P_4\ (g) + 6H_2\ (g)$, yield $Q = -22.66$, whence, for PH_3 (g), $Qf = 2.34$. We have been unable to interpret similar data obtained by Drummond.[1]

PH_3 (liq.). The data of McIntosh and Steel[1] and Henning and Stock[1] yield $V = -3.9^{-80}$.

P_2H (c). Ogier[1] found for the heat of reaction of solid P_2H with saturated bromine water $Q = 367.2$; whence, for P_2H (c), $Qf = 11\ 9$.

PH_4I (c). Ogier[1] measured the heat of solution to be -4.77, whence, for PH_4I (c), $Qf = 20.4$. The dissociation pressure data of Smith and Calvert[1] yield $Q = 12.2$, and, assuming that the vapor is completely dissociated into PH_3 (g) and HI (g), we have computed, for PH_4I (c), $Qf = 20.9$.

PH_4Br (c). Ogier[1] measured the heat of solution to be -3.03, whence, for PH_4Br (c), $Qf = 33\ 8$. The dissociation pressure data of Johnson[2] yield $Q = 24.0$, whence, assuming complete dissociation into PH_3 (g) and HBr (g), $Qf = 34.9$. Vapor density measurements indicate that the vapor is not completely dissociated.

PH_4Cl (g). From vapor density data, Briner[1, 3, 4] computed, for $HCl\ (g) + PH_3\ (g) = PH_4Cl\ (g)$, $Q = 16.4$. See also Tammann[1, 3] and Scheffer.[5]

PH_4Cl (c). Briner[1, 3, 4] computed the heat of sublimation to be -27.0.

$PH_3 \cdot 6\,H_2O$ (c). The dissociation pressure data of Cailletet and Bordet[1] and de Forcrand and Taboury[1] yield $Q = -13.5$ for the reaction, $PH_3 \cdot 6\,H_2O\ (c) = PH_3\ (g) + 6\,H_2O$ (liq.), at 0°.

P_3N_5 (c). Stock and Wrede[1] measured the heat of combustion to be 1099.4.

$(NH_4)_nH_{3-n}PO_4$ (aq.). Berthelot and Louguinine[3] measured the heats of mixing aqueous H_3PO_4 with 1, 2, and 3 moles of aqueous NH_3, respectively.

$(NH_4)_nH_{3-n}PO_4$ (c). There are no data on the heats of solution of any of the ammonium phosphates. Warren,[1] from dissociation pressure data, computed for $(NH_4)_3PO_4\ (c) = NH_3\ (g) + (NH_4)_2HPO_4$, $Q = -9.40$, and for $(NH_4)_2HPO_4\ (c) = NH_3\ (g) + NH_4H_2PO_4\ (c)$, $Q = -19.05$.

Arsenic

As (solid). There are at least three forms of solid arsenic: As (c, α), metallic, trigonal, of high density, stable; As (c, γ), yellow, cubic, of low density, analogous to yellow phosphorous; As (amorphous β), grey or mirrorlike. Another form, the brown, may be identical with the β form. As (c, α) is taken as the standard state. Peterson[5] measured the heats of reaction of the various forms of arsenic with chlorine and with bromine, and concluded that for the γ to α transition, $T=3.53$, and for the γ to β transition, $T=4.12$. Berthelot and Engel[1] gave $T=1.0$ for the α to β transition. Laschtschenko[7] reported, for the transition from α to γ, $T=-0.55^{740}$, or about -1.5 at 18°.

As_4 (g). The vapor pressure data of Preuner and Brockmoller,[1] Gibson,[1] Ruff and Mugdan,[1] Ruff and Bergdahl,[1] Horiba,[2] Goubau,[1] Heike,[1] Jonker[1] Jolibois,[3] Krafft and Knocke,[1] and Rassow[1] yield -11.3^{400} for the heat of vaporization of liquid arsenic and -31.8^{400} for the heat of sublimation of the solid, both values computed for As_4 (g). According to the vapor density data (see following) arsenic vapor at or below the boiling point is practically all As_4.

As (liq.). From the above data on the heat of vaporization and sublimation is obtained the heat of fusion.

As_2 (g). The vapor density data of Mitscherlich,[1] Bineau,[1] Deville and Troost,[2] Mensching and Meyer,[1] Biltz and Meyer,[1] and Preuner and Brockmoller[1] yield for the reaction, As_4 (g) $=2\,As_2$ (g), $Q^{1000}=-25.0$, or about -21 at 18°.

As (g). The foregoing data yield for the reaction, As_2 (g) $=2$ As (g), $Q^{1000}=-38.0$, or about -35 at 18°. The values for the energy states of gaseous monatomic arsenic are from Meggers and de Bruin,[1] Rao, Gartlein, Pathabhiramiah, and Rao,[1] Rao,[2] Rao and Badami,[1] and Sawyer and Humphreys.[1]

AsF_5 (c), AsF_5 (liq.). Ruff, Menzel, and Plant[1] reported values for the heats of fusion and vaporization.

$AsCl_3$ (liq.). Andrews[16] and Thomsen[15] measured the heat of reaction between gaseous chlorine and metallic arsenic. The latter's data yield $Qf=71.54$. Peterson[5] reported 72.5.

$AsCl_3$ (g). The vapor pressure data of Baxter, Bezzenberger, and Wilson[1] and Maier[1] yield -7.50 for the heat of vaporization. The data of Beckmann[1] and Kolossowsky[2] on the elevation of the boiling point yield -8.08. See also Regnault.[6, 10]

H_3AsO_4 (aq.). Thomsen[15] measured the heat of the reaction, As(c, α) $+\frac{5}{2}\,Br_2$ (liq.) $+\,4\,H_2O$ (liq.) $=$ ($5\,HBr + H_3AsO_4$) (aq.), to be 83.7; whence, for H_3AsO_4 (aq.), $Qf=214.5$. The data of Berthelot and Engel[1] on the same reaction yield about the same value.

As_2O_5 (aq.). This is taken as equivalent to $2\,H_3AsO_4$ (aq.) $-3\,H_2O$ (liq.).

As_2O_5 (c). Thomsen[15] measured the heat of solution in 12 NaOH (200).

As_2O_3 (aq.). The data of Thomsen[15] yield, for the heat of oxidation of aqueous arsenious acid with aqueous iodic acid, $Q=148.5$, which gives, for As_2O_3 (aq.), $Qf=146.9$. Berthelot[151] reported $Q=52.6$ for the heat of the reaction between aqueous arsenious acid and liquid bromine; whence, for As_2O_3 (aq.), $Qf=148.4$. Thomsen[15] measured the heat of solution of $AsCl_3$ (liq.) in water to be 17.58, whence, for As_2O_3 (aq.), $Qf=147.0$.

As_2O_3 (c, octahedral). Schuhmann[1] measured the electromotive force at various temperatures for the cell in which the reaction was $2\,As\,(c,\alpha)+3\,H_2O\,(liq.)=As_2O_3\,(c,\text{octahedral})+3H_2\,(g)$, and computed $Q=51.0$, from which, for As_2O_3 (c, octahedral), $Qf=154.1$. Thomsen[15] measured the heat of solution of octahedral arsenic trioxide in four normal sodium hydroxide to be 7.52, from which, for As_2O_3 (c, octahedral), $Qf=154.1$.

As_2O_3 (g), As_4O_6 (g). According to Mitscherlich[1] and Biltz[7] the vapor of arsenic trioxide is mostly As_4O_6 at low temperatures and mostly As_2O_3 at high temperatures. Vapor pressure data were reported for both the solid and liquid forms by Rushton and Daniels,[1] Smellie,[1] Stelzner,[1] Niederschulte,[1] Welch and Duschak,[1] and Biltz.[7] From the data of Biltz, we have computed for the reaction, $As_4O_6\,(g)=2\,As_2O_3\,(g)$, $Q=-17$.

As_2O_3 (c, monoclinic). We have estimated the heat of transformation into the octahedral form from the above vapor pressure data.

As_2O_3 (liq.). The above vapor pressure data yield a surprisingly large value for the heat of fusion of solid arsenic trioxide.

$AsBr_3$ (c). Berthelot[50] measured the heat of solution in aqueous KOH to be 59.8 at 9°.

$AsBr_3$ (liq.). Tolloczko and Meyer[1] reported a value for the heat of fusion of the solid.

$AsBr_3$ (g). The meager vapor pressure data of Walden[2] and Jager[1] yield −11.0 for the heat of vaporization. Trouton's rule gives −10.0.

AsI_3 (c). Berthelot[50] measured the heat of solution in aqueous KOH to be 46.2 at 9°.

AsI_3 (liq.). We have estimated the heat of fusion.

AsI_3 (g). The vapor pressure data of Horiba and Inouye[1] yield −19.2 for the heat of vaporization of the liquid.

AsH_3 (g). Ogier[2] measured the heat of reaction of arsine with liquid bromine and water to be 212.9.

$AsH_3 \cdot 6\,H_2O$ (c). de Forcrand[49] determined the heat of dissociation of the hexahydrate.

Antimony

Sb (c). The metallic trigonal form is taken as the standard state. There is apparently a transition between 100° and 150°, but no thermal data on it are recorded. Another form of antimony is the so-called

"explosive" form prepared by electrolysis, and its heat of transformation into the metallic trigonal form is given by several investigators: Pebal,[1] 2.52; Cohen and Strengers,[1] 2.32 by direct measurement, and 2.56 from the difference in the heats of reaction with bromine.

Sb (liq.). The data on the heat of fusion of solid antimony at its melting point, 630°, are: Wust, Meuthen, and Durrer,[1] −4.67; Umino,[4] −4.9; Laschtschenko,[5] −4.85; Awbery and Griffiths,[1] −2.9. See also Herz.[2]

Sb_2 (g). The vapor pressure data of Greenwood,[2, 5] van Liempt,[2] Ruff and Bergdahl,[1] and Ruff and Mugdan[1] were reviewed by Johnston, Fenwick, and Leopold,[1] and yield -45.2^{1200} for the heat of vaporization of the liquid. According to Meyer and Biltz,[1] the vapor near the boiling point, 1440°, contains some Sb_4 molecules but is mostly Sb_2. We have estimated, for Sb_2 (g), $Qf = -52$.

Sb (g). For the reaction Sb_2 (g) = 2 Sb (g), we have estimated $Q = -27$. The values for the ionization potentials are from the following: first step, Green and Loring,[2] see also Ruark, Mohler, Foote, and Chenault[1]; second and third steps, Dhavale,[2] Lang,[2, 4, 5] Rao,[1] Nayaran and Rao,[1] and Gibbs and Vieweg[1]; fourth step, Gibbs and Vieweg,[1] Badami,[1] and Lang[1, 3]; fifth step, Badami,[1] and Lang.[6] See also Bacher and Goudsmit.[1]

$SbCl_3$ (c). Andrews[16] and Thomsen[15] measured the heat of reaction of solid antimony with gaseous chlorine. The data of the latter yield, for $SbCl_3$ (c), $Qf = 91.39$.

$SbCl_3$ (liq.). Tolloczko,[1, 2] from cryoscopic and calorimetric measurements, deduced the heat of fusion of the solid to be -3.01^{73}. Rideal[1] calculated −3.40.

$SbCl_3$ (g). The vapor pressure data of Braune and Tiedje,[1] Maier,[1] and Rotinyanz and Suchodskii[1] yield $V = -10.95^{125}$.

$SbCl_5$ (liq.). Thomsen[15] found $Q = 13.48$ for the reaction $SbCl_3$ (c) + Cl_2 (g) = $SbCl_5$ (liq.).

$SbCl_5$ (c). The cryoscopic data of Moles[1] and Beckmann[2] yield $F = -2.45^{-6.0}$.

$SbCl_5$ (g). The vapor pressure data of Braune and Tiedje[1] yield $V = -11.05^{67}$, giving, for $SbCl_5$ (g), $Qf = 93.82$. The equilibrium data of Braune and Tiedje[1] yield $Q = -16.30$ for the reaction, $SbCl_5$ (g) = $SbCl_3$ (g) + Cl_2 (g); whence, for $SbCl_5$ (g), $Qf = 93.7$.

Sb_2O_3 (aq.). Thomsen[15] measured the heats of the reactions, 4 $SbCl_3$ (c) + 5 H_2O (liq.) = $Sb_4O_5Cl_2$ (c) + 10 HCl (aq.) and $Sb_4O_5Cl_2$ (c) + 2 NaOH (aq.) = H_2O (liq.) + (2 NaCl + 2 Sb_2O_3) (aq.), to be 8.91 and 22.75, respectively; whence, for 4 $SbCl_3$ (c) + 4 H_2O (liq.) + 2 NaOH (aq.) = 10 HCl (aq.) + (2NaCl + 2 Sb_2O_3) (aq.), $Q = 31.66$, and for Sb_2O_3 (aq.), $Qf = 166.3$.

Sb_2O_3 (c, orthorhombic). Guntz[1, 7] measured the heats of solution of $SbCl_3$ (c) and of Sb_2O_3 (c, orthorhombic) in concentrated aqueous HCl, and his data yield, for Sb_2O_3 (c, orthorhombic), $Qf = 165.3$. Guntz[1, 6, 7]

also measured the heats of solution of the same substances in aqueous HF and aqueous HCl+HF, respectively, and his data yield, for Sb_2O_3 (c, orthorhombic), $Qf=164.5$. Mixter[9] measured, in a bomb calorimeter, the heat of the reactions of antimony and antimony trioxide with sodium peroxide, and his data yield, for Sb_2O_3 (c, orthorhombic), $Qf=167\,0$. The dissociation pressure data of Baubigny[1] and Biltz[1] yield, for Sb_2O_3 (c, rhombic) $= 2\,Sb$ (liq.) $+\frac{3}{2}\,O_2$ (g), $Q=-167.4$, whence, for Sb_2O_3 (c, orthorhombic), $Qf=153$, a value which is much too low.

Sb_2O_3 (c, octahedral). From the difference in the heats of solution of Sb_2O_3 (c, orthorhombic) and Sb_2O_3 (c, octahedral) in aqueous HF, Guntz[7] found the heat of transformation of the former into the latter to be 1.2.

Sb_2O_5 (aq.). Thomsen[15] found the heat of solution of $SbCl_5$ (liq.) in water to be 35.27, whence, for Sb_2O_5 (aq.), $Qf=228.0$.

Sb_2O_5 (c). Mixter[9] measured the heat of the reactions of antimony and antimony pentoxide with sodium peroxide, and his data yield, for Sb_2O_5 (c), $Qf=235.7$.

Sb_4O_6 (g). Hincke,[1] from data on the vapor pressure of solid Sb_2O_3, computed the following: $2\,Sb_2O_3$ (c, orthorhombic) $=Sb_4O_6$ (g), $Q=-44.08$; $2\,Sb_2O_3$ (c, cubic) $=Sb_4O_6$ (g), $Q=-47.32$; and $2\,Sb_2O_3$ (liq.) $=Sb_4O_6$ (g), $Q=-17.83$.

Sb_4O_6 (liq.). The vapor pressure data of Hincke[1] yield -13.6 for the heat of fusion of Sb_2O_3 (c, orthorhombic).

SbO (g). Mukherji[1] reported $D^z=-81$.

Sb_2O_4 (c). The data of Simon and Thaler[1] give $2\,Sb_2O_4$ (c) $=2\,Sb_2O_3$ (c) $+O_2$ (g), $Q^{1080}=-55.8$; whence, for Sb_2O_4 (c), $Qf=193.3$. Mixter[9] measured the heat of the reaction of antimony and antimony tetroxide with sodium peroxide, and his data yield, for Sb_2O_4 (c), $Qf=213.0$.

Sb_6O_{13} (c). The data of Simon and Thaler[1] give $3\,Sb_2O_5$ (c) $=Sb_6O_{13}$ (c) $+O_2$ (g), $Q^{400}=-25.5$, and $2\,Sb_6O_{13}$ (c) $=6\,Sb_2O_4$ (c) $+O_2$ (g), $Q^{780}=-39.3$. These values yield, for Sb_6O_{13} (c), $Qf=664.5$ and 658.7, respectively.

H_3SbF_6 (aq.). Guntz'[1, 6, 7] data on the heat of solution of Sb_2O_3 (c, orthorhombic) in aqueous HF yield, for H_3SbF_6 (aq.), $Qf=443.5$.

SbF_3 (c). Guntz[1, 6, 7] measured the heat of solution of SbF_3 (c) in 3 HF (aq.) to be 0.3.

SbF_3 (aq.). Guntz[1, 6, 7] measured the heat of solution of SbF_3 (c) in water to be -1.6_{200}[9].

$Sb_4O_5Cl_2$ (c). Thomsen's[15] data on the heat of solution of $SbCl_3$ (c) in water to form $Sb_4O_5Cl_2$ (c) and 10 HCl (aq.) yield, for $Sb_4O_5Cl_2$ (c), $Qf=348.40$. Guntz[1, 7] measured the heat of solution of $Sb_4O_5Cl_2$ (c) in aqueous HF but reported no experimental data. He computed for the reaction, $2\,Sb_2O_3$ (c, orthorhombic) $+2$ HCl (g) $=Sb_4O_5Cl_2$ (c) $+H_2O$ (c), $Q=41.2$; whence, for $Sb_4O_5Cl_2$ (c), $Qf=346.1$.

SbOCl (c). Guntz[1, 7] measured the heat of solution of SbOCl (c) in aqueous HF, but reported no experimental data. He computed for the

reaction, Sb_2O_3 (c, orthorhombic) $+2$ HCl (g) $=2$ SbOCl (c) $+H_2O$ (c), $Q=38.8$; whence, for SbOCl (c), $Qf=89.2$.

$SbF_3 \cdot n\,NH_3$ (c). Biltz and Rahlfs[2] measured the dissociation pressures at various temperatures of the ammines with 1, 2, 3, 4, and 6 moles of NH_3.

$SbBr_3$ (c). Guntz[1, 7] measured the heat of solution of $SbBr_3$ in HF, but did not report the result of this experiment. Instead he gave $Q=76.9$ for the reaction, Sb (c) $+\frac{3}{2}Br_2$ (g) $=SbBr_3$ (c). Making some assumptions as to the auxiliary data Guntz used in arriving at this value, we have computed, for $SbBr_3$ (c), $Qf=64.1$. Berthelot and Petit[1] dissolved $SbBr_3$ (c) in concentrated aqueous HCl $+Br_2$, finding $Q=27.5$. Assuming that H_3SbO_4 (aq.) was formed, we have deduced, for $SbBr_3$ (c), $Qf=55.5$, which value is evidently too small. Combining the data of Cohen and Strengers[1] on the reactions, $SbBr_3$ (c) $=SbBr_3$ (CS_2), $Q=-3.6$, and Sb (c, trigonal) $+\frac{3}{2}Br_2$ (CS_2) $=SbBr_3$ (CS_2), $Q=58.5$, we have obtained, for $SbBr_3$ (c), $Qf=60.0$.

$SbBr_3$ (liq.). Tolloczko and Meyer[1] and Tolloczko[1] gave -3.52^{100} for the heat of fusion of the solid. Rideal[1] calculated -3.60.

$SbBr_3$ (CS_2). Cohen and Strengers[1] measured the heat of formation of $SbBr_3$ in carbon disulfide from antimony and bromine, Sb (c, trigonal) $+\frac{3}{2}Br_2$ (CS_2) $=SbBr_3$ (CS_2), to be 58.5; whence, for $SbBr_3$ (CS_2), $Qf=56.4$.

SbI_3 (c). Guntz[8] gave 45.4 for the heat of the reaction, Sb (c, trigonal) $+\frac{3}{2}I_2$ (g) $=SbI_3$ (c), which he deduced from measurement of the heat of solution of SbI_3 (c) in aqueous HF. Making assumptions as to the subsidiary values used by Guntz,[8] we have obtained, for SbI_3 (c), $Qf=22.8$.

SbI_3 (aq.). Mosnier[1] measured the heat of solution of SbI_3 (c) in water to be -0.88.

SbH_3 (g). The data of Berthelot and Petit,[1] who measured the heat of solution of SbH_3 (g) in bromine water, yield for SbH_3 (g), $Qf=-79.5$. Stock and Wrede[1] measured directly the heat of the explosive decomposition of gaseous SbH_3 into solid Sb and gaseous H_2, and their data yield $Qf=-34.0$.

Sb_2S_3 (c, yellow). Berthelot[99] found the heat of reaction of dilute aqueous $SbCl_3$ with H_2S to be variable, and he ascribed this behavior to the formation of compounds similar to SbSCl. Berthelot[99] measured the heat of the reaction of $SbCl_3$ (c) with $6\,C_4H_6O_6$ (aq.) and of the resulting solution with aqueous H_2S, finding $Q=13.74$ and 32.26, respectively; whence, for Sb_2S_3 (c, yellow), $Qf=35.8$. Berthelot[99] also found the heat of reaction of $SbCl_3$ (c) with 12 HCl (20) to be 4.17, and that of the resulting mixture with aqueous H_2S to be 9.39; whence, for Sb_2S_3 (c, yellow), $Qf=35.2$.

$Sb_2(SO_4)_3$ (c). Beck[1] measured the heat of solution of this substance in aqueous NaOH to be 118.7.

Bismuth

Bi (c). Standard state.

Bi (liq.). The data on the heat of fusion of solid bismuth at the melting point, 271°, are: Person,[9] −2.59; Person,[2, 8] −2.64; Wust, Meuthen, and Durrer,[1] −2.14; Itaka,[1] −2.55; Awbery and Griffiths,[1] −2.72. From the cooling curve, Mazzotto[3] deduced −2 59; and, from data on the change in melting point with pressure, Bridgman[4] calculated −2.68. See also Tammann[4] and Johnston and Adams.[1]

Bi_2 (g). The vapor density data of Biltz and Meyer[1, 3] indicated that bismuth vapor at the boiling point is about $\frac{1}{2}$ Bi_2 + $\frac{1}{2}$ Bi. The vapor pressure data, for liquid bismuth, of Greenwood,[3] Ruff and Bergdahl,[1] Ruff and Mugdan,[1] and Barus[1, 2] yield −4.48 for the heat of vaporization at the boiling point. We have corrected this value for the amount of dissociation.

Bi (g). From spectroscopic data, Barratt and Bonar[1] obtained, for Bi_2 (g) = 2 Bi (g), $D^z = -18.5$. The values for the energy states of gaseous monatomic bismuth are taken from the following: first spectra, Thomsen[3] and Toshniwal[1]; second and third spectra, McLennan, McLay, and Crawford.[2] See also Bacher and Goudsmit.[1]

$BiCl_3$ (c). Thomsen[15] measured the heat of reaction of solid bismuth and gaseous chlorine, and his data give, for $BiCl_3$ (c), $Qf = 90.61$.

$BiCl_3$ (aq. HCl). Tanatar[8] measured the heat of solution of Bi_2O_3 (c) in excess HCl (25) to be 35.6. Assuming the reaction to be Bi_2O_3 (c) + 6 HCl (25) = 2 $BiCl_3$ (aq. HCl) + 3 H_2O (liq.), we have computed, for $BiCl_3$ (aq. HCl), $Qf = 84.5$.

BiOCl (c). Thomsen's[15] value for the heat of the reaction, $BiCl_3$ (c) + H_2O (liq.) = BiOCl (c) + 2 HCl (aq.), $Q = 7.83$, yields, for BiOCl (c), $Qf = 87.8$. Noyes and Chow[1] measured the electromotive force at various temperatures of the cell in which the reaction was Bi (c) + HCl (aq) + H_2O (liq.) = BiOCl (c) + $\frac{3}{2}$ H_2 (g), and calculated $Q = 18.50$; whence, for BiOCl (c), $Qf = 89.4$.

Bi_2O_3 (c, hydrated). Thomsen[15] measured the heat of reaction of $Bi_2O_3 \cdot n\,H_2O$ (c) with just enough aqueous HCl to form solid BiOCl to be 14.2, whence we have computed, for the hydrated oxide, $Qf = 136.8$.

H_3BiO_3 (c). Assuming the above hydrated oxide to be $Bi_2O_3 \cdot 3\,H_2O$ (c), we have computed, for H_3BiO_3 (c), $Qf = 171.1$.

Bi_2O_3 (c). Mixter[9] measured, in a bomb calorimeter, the following: 2 Bi (c) + 5 Na_2O_2 (c) = 2 Na_3BiO_4 (c) + 2 Na_2O (c), $Q = 170.6$; Bi_2O_3 (c) + 2 Na_2O_2 (c) + Na_2O (c) = 2 Na_3BiO_4 (c), $Q = 92.8$. The difference gives 2 Bi (c) + 3 Na_2O_2 (c) = Bi_2O_3 (c) + 3 Na_2O (c), $Q = 77.8$; from which, for Bi_2O_3 (c), $Qf = 137.1$.

BiO (c). Tanatar[8] measured the heat of solution of BiO (c) in excess aqueous HCl to be 24.6.

Bi_2S_3 (c). From equilibrium data on the reaction, Bi_2S_3 (c) + 3 H_2 (g) = 2 Bi (liq.) + 3 H_2S (g), Jellinek and Zakowski[1] computed $Q = -18.1$; whence, for Bi_2S_3 (c), $Qf = 29$.

$Bi_2(SO_4)_3$ (c). Beck[1] measured the heat of solution of this substance in aqueous NaOH to be 54.6.

BiI_3 (c). Mosnier[1] measured the heat of solution.

BiI_3 (aq.). We have estimated this value.

Carbon

C (c, diamond). We have selected diamond as the standard state for carbon because, with respect to heat content, it is the only truly reproducible form of solid carbon.

C (c, graphite). Roth[10] found that the heat of combustion of graphite varies considerably with its source or manner of preparation. The results obtained by Roth,[9, 10] Roth and Wallasch,[1] and Roth and Naeser[1] for the heats of combustion of graphite grouped themselves about two values; and Roth labeled those samples having the lower heat of combustion α graphite, and those having the higher heat of combustion β graphite. The differences in the values found by Roth and his coworkers for the heats of combustion of diamond, α graphite, and β graphite, when properly converted to true moles (see Rossini[15]) and to a pressure of 1 atmosphere (see Washburn[2]) yield 0.22 and 0.49 for the heats of transition at 18° of diamond to β graphite and to α graphite, respectively. The data of Roth,[9, 10] Roth and Wallasch,[1] and Roth and Naeser[1] yield 94.45, 94.23, and 93.96 for the heats of the reaction, $C(c) + O_2(g) = CO_2(g)$, for diamond, β graphite, and α graphite, respectively, at 18° and a constant pressure of 1 atmosphere. The uncertainty in these values is apparently about ± 0.10. Though some investigators used graphite degassed in air, Plummer[1] reported that such samples of graphite were partially oxidized. The older data on the heat of combustion of graphite are those of Favre and Silbermann,[1] Andrews,[16] Grassi,[1] Berthelot and Petit,[2] and Mixter.[3]

C (c, carbonado). Roth and Naeser[1] measured the heat of combustion of carbonado (bort or black diamond), and their data yield for the reaction, C (c, carbonado) $+ O_2(g) = CO_2(g)$, $Q = 94.55$.

C ("amorphous," charcoal). Thiele[1] studied the heat of combustion of charcoal prepared from sugar as a function of the temperature of preparation, and found that the heat of combustion was constant only for samples prepared above 1400°. The data of Thiele,[1] Mixter,[3] and Favre and Silbermann,[1, 5, 11] yield, respectively, 96.4, 96.6, and 96.4 for the heat of the reaction, C ("amorphous," charcoal) $+ O_2(g) = CO_2(g)$. Data on the heat of combustion of this form of carbon were also reported by Peterson,[1a] Despretz,[1] Berthelot and Petit,[2] Dulong,[2] Andrews,[14, 16] Berthelot and Vielle,[7, 12] Ruff and Gersten,[2] Thomsen,[7, 16] Pfaundler,[3] Nikiten,[1] and Lavoisier and Laplace[1] (see Mellor[1]).

C ("amorphous," "acetylene" carbon). Mixter's data yield 94.7 for the heat of the reaction, C ("amorphous," "acetylene" carbon) $+ O_2(g) = CO_2(g)$.

C ("amorphous," "Glanzkohlenstoff"). Roth and Doepke[1] measured the heats of combustion of samples of "Glanzkohlenstoff" of different

densities, and their data yield the following values for the heats of formation, from diamond as the standard state, of samples having the densities 2.07, 2.0, and 1.86 grams per cm³, respectively: −2.1, −2.3, and −3.2. See also Roth, Naeser, and Doepke.[1]

C ("amorphous," "gas" carbon). Roth[9] and Favre and Silbermann[1] measured the heat of combustion of this form of carbon, and their data yield for the reaction, C ("amorphous," "gas" carbon) $+O_2$ (g) $=CO_2$ (g), $Q=95.93$ and 96.5, respectively.

C_2 (g). The values for the energy of dissociation of C_2 (g) into 2C (g), with each substance in the normal or ground state, are, in volt-electrons, the following: Mulliken,[3] 5.5; Birge,[1] 7.0; Johnson and Asundi,[2] 7.02; Vaughan and Kistiakowsky,[1] 7.43, 8.28, 6.78, and 6 97. The value for the energy of excitation of C_2 (g) is from Mulliken.[3] See also Hori[2] and Lennard-Jones.[4]

C (liq.). Ryschkewitsch[1, 2] and Ryschkewitsch and Merck[1] obtained values for the vapor pressures of solid and liquid carbon at various temperatures by assuming that the partial pressure of gaseous carbon in the crater is equal to the external pressure. Their data on the difference in the slopes of the curves giving the logarithm of the pressure against the reciprocal of the absolute temperature for both solid and liquid carbon yield −11 for the heat of fusion of carbon at the melting point. Fajans[6] estimated the value to be −10. There is now general agreement (see Ryschkewitsch,[1, 2] Hagenback and Luthy,[1] Sauerwold,[1] Despretz,[3, 4] Braun,[1] La Rosa,[1] Lummer,[1] Ruff,[1] and Munch[1]) that the melting point of carbon is about 3580°.

C (g). The heat of formation of gaseous monatomic carbon can be computed from values of the heat of sublimation of carbon or of the energy of dissociation of gaseous CO into gaseous carbon and oxygen atoms.

Values for the heat of sublimation of carbon have been determined in three ways: (1), by estimation of the heat of vaporization from the boiling point and Trouton's constant, and combination with the heat of fusion; (2), by experimental determination of the vapor pressure at various temperatures, assuming that the partial pressure of gaseous carbon in the carbon arc is equal to the external pressure of the inert gas; (3), by experimental determination of the vapor pressure at various temperatures by measuring the rate of loss of carbon from a carbon filament heated to known temperatures, assuming an accommodation coefficient of 1. In each of these three methods there is required a knowledge of the relative concentrations of C_2 (g) and C (g) in the gaseous carbon, and of the energy of dissociation of C_2 (g) into 2C (g), in order that the heat of the reaction C (c) $=$ C (g) may be calculated. Vaughan and Kistiakowsky[1] calculated that, if the energy of dissociation of C_2 (g) into 2C (g) is −160, the concentration of C (g) in gaseous carbon is 9.7 mole per cent at 3880° and 12.7 mole per cent at 4430°.

Calculation of the heat of sublimation of carbon at 18° from values

for the boiling point and Trouton's constant yields values ranging from −150 to −200. The various published values for the boiling point of carbon range from 3900 to 5680°. Johnston, Fenwick, and Leopold[1] estimated the value 3930 ± 100°, from a review of the then-published vapor pressure data. Other estimates are the following: Ryschkewitsch,[2] 3900°; Kohn and Guckel,[1, 2] 3930°; Fajans,[1, 2, 7] 4050°; Herbst,[1] not less than 5700°; van Laar,[5] 5030°. See also Crookes,[1] Violle,[5] Moissan,[3] Mott,[1] and van Laar.[1, 3, 6, 7]

Data on the change in vapor pressure of carbon with temperature, obtained by assuming the partial pressure of gaseous carbon in the carbon are equal to the external pressure of the inert gas, were reported by Fajans,[1, 7] Kohn,[1] Kohn and Guckel,[1, 2] Thiele and Ritter,[1] Ryschkewisch,[2] and Podszus.[1] These data yield values ranging from −140 to −190 for the heat of sublimation of carbon at 18°.

Data on the change in vapor pressure of carbon with temperature, obtained by measuring the rate of loss of carbon from a carbon filament heated to known temperatures, were reported by Wertenstein and Jedrzejewski,[1] Brody and Millner,[1, 2] and Marshall and Norton.[1] These data yield values ranging from −160 to −210 for the heat of sublimation of carbon at 18°. Marshall and Norton[1] computed from their data the value −178 ± 1 for the heat of the reaction, C (c, graphite) = C (g), at −273°.

Estimates of the heat of sublimation of carbon were made by Violle,[2, 3, 4] Wilson,[4] Wilson and Fitzgerald,[1] Wanner,[1] Watts and Mendenhall,[1] Lummer,[1] Fajans,[7] Smithells,[1] Weinberg,[1] Gruneisen,[1] Padoa,[1] and Lande.[2] Most of the foregoing data were reviewed by Johnston, Fenwick, and Leopold,[1] who gave −129 for the heat of vaporization of liquid carbon in the range 3900 to 4400°.

Vaughan and Kistiakowsky[1] calculated by the statistical method, on the assumption that the published experimentally determined vapor pressures (but not the corresponding temperatures) of carbon were correct, that the heat of sublimation of carbon into gaseous atoms at −273° is −161 or −195, depending upon whether the value 5 5 or 7.0 volt-electrons is taken as the energy of dissociation of C_2 (g) into 2C (g).

Birge and Sponer[1] extrapolated the vibrational levels of CO (from band spectra) and their data yield 10.2 volt-electrons for the energy of dissociation of CO. For this same quantity, Mulliken[6] estimated 10.0 and Wiezel[1] 10.3 volt-electrons. Coster and Brons[1] obtained predissociation data in the 0−1 Angstrom band of CO, and, assuming the products of dissociation of CO in the B state to be carbon and oxygen atoms each in the ^1D state, deduced the energy of dissociation of CO to be 9.82 volt-electrons. The assumption that the products of dissociation are C(^1D) and O(^3P) yields the value of 11.06 volt-electrons. These predissociation data were confirmed by Read,[1] who set an upper limit of 11.05 volts for the energy of dissociation of CO. From electron bombardment experiments, Tate and Lozier[1] deduced 9.3 ± 0.5 volt-electrons for the

energy of dissociation of CO. The similar, but later and more accurate, data of Lozier[2] were subjected to two interpretations, one yielding the value 9.6 ± 0.1 and the other 11.6 ± 0.1 volt-electrons.

Because of the existing uncertainties in the data leading to the heat of formation of gaseous monatomic carbon, we have arbitrarily selected for the energy of dissociation of normal CO (g) into normal C (g) and O (g), the value $D^z = 11.06 - a'$ volt-electrons, or $-255.0 + a$ kilocalories per mole, where a is an unknown whose value at this writing may be as much as +60 kilocalories, so that, for C (g), $-110 > Qf > -170$.

The energy states of gaseous monatomic carbon are evaluated from the data of Fowler and Selwyn,[1, 2] Bowen,[2] Edlen,[2] Edlen and Stenman,[1] Edlen and Ericson,[5] Eckart,[1] and Paschen and Kruger.[1]

CO (g). The heat of combustion of carbon monoxide was measured by Andrews,[14] Grassi,[2] Lagerlof,[1] Dulong,[2] Favre and Silbermann,[1] Berthelot,[45, 58] Berthelot and Matignon,[11] Thomsen,[7, 10, 15, 16] Rossini,[2, 5] Roth and Banse,[2] Fenning and Cotton,[1] and Awbery and Griffiths.[2] The last four named investigations were completed in the years 1930 to 1933, and all the others prior to 1904. The data of the modern determinations yield the following values for the heat of the reaction, $CO\ (g) + \frac{1}{2} O_2\ (g) = CO_2\ (g)$, at 18° and a constant pressure of 1 atmosphere: Rossini,[2, 5] 67.61 ± 0.03; Roth and Banse,[2] 67.86 ± 0.20; Fenning and Cotton,[1] 67.65 ± 0.05; Awbery and Griffiths,[1] 67.58 ± 0.10.

The energy states of CO (g) are evaluated from the data of Hund,[1] Mulliken,[3] Johnson,[4] Dunkel,[1] Birge,[6, 7] Hopfield and Birge,[1] Duffendack and Fox,[2] Knauss,[1] Herzberg,[2] Johnson and Asundi,[1] Asundi,[1, 2] Eastey,[1] Hepburn,[1] Kallman and Rosen,[1] Hogness and Harkness,[1] Dunkel,[1] and Birge and Sponer.[17]

CO (liq.). Vapor pressure data on liquid carbon monoxide were reported by Olszewsky,[7, 8] Wroblewsky,[1, 5, 2] Baly and Donnan,[1] Clusius and Teske,[1] Hoppel,[1] Verschoyle,[1] Crommelin, Bijleveld, and Brown,[1] and Clayton and Giauque.[1] The calorimetric data on the heat of vaporization of liquid carbon monoxide are: Eucken,[2, 3] -1.414 at $-190°$; Clayton and Giauque,[1] -1.444 at $-191.5°$.

CO (c). Vapor pressure data on solid carbon dioxide were reported by Olszewsky,[7, 8] Wroblewsky,[1, 5, 2] Baly and Donnan,[1] Clusius and Teske,[1] Hoppel,[1] Verschoyle,[1] Crommelin, Bijleveld, and Brown,[1] and Clayton and Giauque.[1] The calorimetric data on the heat of fusion of CO (c, I) are: Eucken,[2, 3] -0.224 at $-205.8°$; Clusius,[2] -0.2015 at $-204.9°$; Clayton and Giauque,[1] -0.1997 at $-205.0°$. The calorimetric data on the heat of transition of CO (c, II) to CO (c, I) are Eucken,[2, 3] -0.144 at $-212.9°$; Clusius,[2] -0.1512 at $-211.6°$; Clayton and Giauque,[1] -0.1515 at $-211.6°$.

CO (aq.). Adolph and Henderson[1] calculated the heat of solution of gaseous carbon monoxide in water from the solubility-temperature data of Winkler[8] and Bunsen.[1]

CO_2 (g). The heat of combustion of diamond was measured by Ber-

thelot and Petit,[2, 6] Favre and Silbermann,[1, 4, 5, 11] Andrews,[2, 7, 16] Roth and Wallasch,[1] and Roth and Naeser.[1] The modern data, those of Roth and his coworkers, yield 94.45 for the heat of the reaction, C (c, diamond) $+O_2$ (g) $=CO_2$ (g).

CO_2^+ (g). Smyth and Steuckelberg[1] reported a value for the energy of the reaction, CO_2 (g) $=CO_2^+$ (g) $+\theta$.

CO_2 (liq.). Liquid carbon dioxide does not exist at a pressure of 1 atmosphere. The heat of vaporization of liquid carbon dioxide was measured by Chappuis[1, 2] and Mathias.[1] Vapor pressure data on liquid carbon dioxide were reported by Faraday,[3] Regnault,[6] Mollier,[1] Amagat,[1, 2, 3] Tate,[2] Balserna,[1] Cailletet,[3] DuBois and Wills,[1] Verschaffelt,[1] Villard and Jarry,[1] Zeleny and Smith,[1] Antoine,[2] Jarolimek,[1, 2, 3, 4] Andrews,[17] Keyes and Kenney,[1] Kuenen and Robson,[1] Meyers and Van Dusen,[1] Scheffer,[2] von Siemens,[1] Stock, Henning, and Kuss,[1] Villard,[1] and Jenkins and Pye.[1, 2]

CO_2 (c). Calorimetric data on the heat of sublimation of solid carbon dioxide were reported by Andrews,[8] Favre and Silbermann,[3] Behn,[1] and Eucken and Donath.[1] Vapor pressure data on solid carbon dioxide were reported by Faraday,[3] Dubois and Wills,[1] Henning,[3] Henning and Stock,[1] Kuenen and Robson,[1] Onnes and Weber,[2] von Siemens,[1] Stock, Henning, and Kuss,[1] Homfray,[1] Villard and Jarry,[1] and Zeleny and Smith.[1, 2]

CO_2 (aq.). The calorimetric data on the heat of solution of CO_2 (g) in water are: Thomsen,[15] $5\,88_{1,500}$; Berthelot,[7] 5.6; Adolph and Henderson,[1] 4.69. The data on the solubility of carbon dioxide in water at various temperatures yield 4.76.

$CO_2 \cdot 6H_2O$ (c). The data of Villard[2, 10] and Wroblewsky[3] yield -8.3 for the heat of the reaction, $CO_2 \cdot 6H_2O$ (c) $=CO_2$ (aq.) $+6H_2O$ (liq.), at 0°.

CO_3^{--} (∞). The value for aqueous carbonate ion at infinite dilution is obtained from those for aqueous lithium, sodium, and potassium carbonates at infinite dilution.

CO_3^{--} (g). The lattice energy calculations of Lennard-Jones and Dent[1, 2] on the carbonates of zinc, cadmium, calcium, and magnesium yield, for CO_3^{--} (g), $Qf = -75 \pm 10$.

$C_2O_4^{--}$ (aq.). The value for aqueous oxalate ion is obtained from those for aqueous sodium and potassium oxalates.

C_3O_2 (liq.). Vapor pressure data were reported by Stock and Stolzenberg.[1]

CH (g). The value for the energy of dissociation of CH (g) into gaseous carbon and hydrogen atoms is obtained from the data of Mulliken,[5] Kratzer,[2] Hori,[4] and Villars.[1] The values for the energy states of CH (g) are from Mulliken.[5]

CH_3^+ (g). The data of Hogness and Kvalnes[1] (see also Pietsch and Wilcke[1]) yield a value for the energy of the reaction, CH_4 (g) $=CH_3^+$ (g) $+H$ (g) $+\theta$.

CH_4 (g). The heat of combustion of methane was measured by Andrews,[14] Favre and Silbermann,[1] Thomsen,[15] Berthelot and Matignon,[7] Roth and Banse,[2] and Rossini.[2, 5] Mixter[1] made two experiments on the heat of decomposition of methane into carbon and hydrogen by exploding a mixture of acetylene, methane, and hydrogen in a bomb. The modern data yield the following values for the heat of the reaction, CH_4 (g) $+2\,O_2$ (g) $=CO_2$ (g) $+2H_2O$ (liq.), at 18° and a constant pressure of 1 atmosphere: Roth and Banse,[2] 213 27 ± 0.64; Rossini,[2, 5] 212.95 ± 0.07.

CH_4^+ (g). The value for the energy of ionization of CH_4 (g) is obtained from the data of Pietsch and Wilcke,[1] Glockler,[1] Morris,[1] Mayer,[1] Hughes and Klein,[1] and Pietsch.[1]

CH_4 (liq.). Vapor pressure data on liquid methane were reported by Keyes, Taylor, and Smith,[1] Crommelin,[6] Homfray,[1] and Stock, Henning, and Kuss.[1] See also Satterly and Patterson.[1]

CH_4 (c). Vapor pressure data on solid methane were reported by Karwat[1] and Freeth and Verschoyle.[1] The calorimetric data on the heat of fusion are: Eucken and Karwat,[1] −0.23 at −182°; Clusius,[2] −0.224 at −182.5° Clusius[2] measured the heat of transition at −252.7°.

$CH_4 \cdot 6H_2O$ (c). The dissociation pressure data of Villard[2, 10] yield −14.2 for the heat of the reaction, $CH_4 \cdot 6H_2O$ (c) $=CH_4$ (g) $+6H_2O$ (liq.).

C_2H_2 (g). The heat of combustion of acetylene was measured by Berthelot,[71] Berthelot and Matignon,[8] Thomsen,[15] and Mixter.[4] The data of the latter two investigations yield the following values for the heat of combustion of acetylene: Thomsen,[15] 309.8 ± 1.5; Mixter,[4] 312.5 ± 2.5. Hence, for C_2H_2 (g), $Qf = -52.5 \pm 1.5$ and -55.2 ± 2.5, respectively. Mixter[4] also measured the heat of decomposition of acetylene into "acetylene" carbon and hydrogen. His data yield for the reaction, C_2H_2(g) $=2C$ ("amorphous," "acetylene" carbon) $+H_2$(g), $Q = 53.3 \pm 0.1$; whence, for C_2H_2 (g), $Qf = -53.9 \pm 0.2$. See also Berthelot[32] and Berner.[3]

C_2H_2 (liq.). Acetylene does not exist as a liquid at a pressure of 1 atmosphere. Vapor pressure data on liquid acetylene were obtained by McIntosh,[1] Cardoso and Baum,[1] Kuenen,[2] Villard,[1] Ansdell,[2] Ladenburg and Krugel,[2] Hunter,[1] and Cailletet.[1] McIntosh[1] reported a value for the heat of vaporization at the triple point, −81.5°.

C_2H_2 (c). Solid acetylene has a vapor pressure of 1 atmosphere at −84.0°. Vapor pressure data on solid acetylene were reported by McIntosh,[1] Cardoso and Baum,[1] Kuenen,[2] Villard,[1] Ansdell,[2] Ladenburg and Krugel,[2] Hunter,[1] and Cailletet.[1] McIntosh[1] reported a value for the heat of sublimation and the heat of fusion.

C_2H_2 (aq.). Villard[7] reported the heat of solution of acetylene in water to be 5.3. The solubility-temperature data of Winkler[5] yield 4.0.

$C_2H_2 \cdot 6H_2O$ (c). Villard[6] determined the heats of the reactions $C_2H_2 \cdot 6H_2O$ (c) $=C_2H_2$ (aq.) $+6H_2O$ (liq.), and $C_2H_2 \cdot 6H_2O$ (c) $=C_2H_2$ (g) $+6H_2O$ (liq.), to be −10.1 and −15.4, respectively, at 0°; whence, for $C_2H_2 \cdot 6H_2O$ (c), $Qf = 370.6$ and 371.9.

$(C_2H_2)_3$ (g). Sameshima and Fukaya[1] reported $Q=-3.03$ for the heat of dissociation of the polymer of acetylene, $(C_2H_2)_3\ (g)=3C_2H_2\ (g)$.

C_2H_4 (g). The heat of combustion of ethylene was measured by Dulong,[2] Grassi,[1] Favre and Silbermann,[1] Andrews,[14] Berthelot,[71] Berthelot and Matignon,[8] Thomsen,[15] and Mixter.[1] The data of the last four named investigations yield the following values for the heat of the reaction, $C_2H_4\ (g)+3\ O_2\ (g)=2CO_2\ (g)+2H_2O$ (liq.): Berthelot,[71] 341.3 ± 2.2; Berthelot and Matignon,[8] 341.2 ± 1.3; Thomsen,[15] 333.1 ± 0.8; Mixter, 344.5 ± 2.3. These values yield, for C_2H_4 (g), $Qf=-15.7\pm 2.2$, -15.6 ± 1.3, -7.5 ± 0.8, and -18.9 ± 2.3, respectively. Mixter[1] also performed three experiments involving the explosion of a mixture acetylene and ethylene. His data yield for the reaction, $C_2H_4\ (g)=2C$ ("amorphous," "acetylene" carbon) $+2H_2\ (g)$, $Q=-15.1\pm 4.0$; whence, for C_2H_4 (g), $Qf=-15.7\pm 4.0$. von Wartenberg and Krause[1] measured the heat of hydrogenation of ethylene to form ethane. Their data yield $Q=30.6\pm 0.4$ for the reaction, $C_2H_4\ (g)+H_2\ (g)=C_2H_6\ (g)$; whence, for C_2H_4 (g), $Qf=-9.6\pm 0.4$.

C_2H_4 (liq.), C_2H_4 (c). Vapor pressure data were reported by Faraday,[3] Dewar,[2] Cailletet,[2] Olszewski,[6, 11] Witkowski,[1] Ladenburg and Krugel,[1] Hunter,[1] Villard,[1] Cardoso and Arni,[1] Burrell and Robertson,[2] Maass and Wright,[1] Henning and Stock,[1] and Britton.[1]

$C_2H_4\cdot 6H_2O$ (c). Villard[6] reported $Q=-15.4$ for the reaction, $C_2H_4\cdot 6H_2O\ (c)=C_2H_4\ (g)+6H_2O$ (liq.)

C_2H_6 (g). The heat of combustion of ethane was measured by Berthelot,[71] Berthelot and Matignon,[8] Thomsen,[15] and Rossini.[13] The last named investigator found for the reaction, $C_2H_6\ (g)+3\frac{1}{2}\ O_2\ (g)=2\ CO_2\ (g)+3H_2O$ (liq.), $Q=372.81\pm 0.11$, at 25° and a constant pressure of 1 atmosphere. This value is equivalent to 373.05 ± 0.11 at 18°, whence, for C_2H_6 (g), $Qf=20.96\pm 0.15$.

C_2H_6 (liq.). Wiebe, Hubbard, and Brevoort[1] measured the heat of vaporization of ethane. Vapor pressure data were reported by Porter,[1] Dana, Jenkins, Burdick, and Timms,[1] Loomis and Waters,[1] Prins,[1] Burrell and Robertson,[2] Maass and McIntosh,[1] Cardoso and Bell,[11] Cardoso,[1] Kuenen and Robson,[1] Kuenen,[1] Olszewski,[2, 11] Hara and Shinozaki,[1] Ladenburg and Krugel,[2] and Dewar.[2]

C_2H_6 (c). Wiebe, Hubbard, and Brevoort[1] measured the heat of fusion of ethane.

CHO_2^- (aq.). The value for aqueous formate ion is obtained from those for aqueous sodium and potassium formates.

HCO_3^- (aq.). The values for aqueous bicarbonate ion, obtained from aqueous $LiHCO_3$, $NaHCO_3$, $KHCO_3$, and $RbHCO_3$, are 164.8, 164.9, 164.7, and 164.9, respectively. The equilibrium data of Kendall[1] and of Klemenc and Herzog[1] yield $Q=2.89$ and 2.78, respectively, for the reaction, $H_2CO_3\ (aq.)=H^+\ (aq.)+HCO_3^-\ (aq.)$; whence, for HCO_3^- (aq.), $Qf=164.7$ and 164.8, respectively.

HCHO (g). The data of von Wartenberg, Muchlinski, and Riedler[1] (see Kharasch[1]) yield 134.1 for the heat of combustion of gaseous formaldehyde.

CH_3OH (g). The heat of combustion of gaseous methyl alcohol was measured by Thomsen[15] and Rossini,[9, 10] and of liquid methyl alcohol by Favre and Silbermann,[1] Stohmann, Kleber, and Langbein,[4] Richards and Davis,[1] Roth and Muller,[3] Roth and Banse,[1] and I. G. Farbenfabrik.[1] These data were reviewed by Rossini.[10] For the heat for the reaction, $CH_3OH\ (g) + \frac{3}{2}O_2\ (g) = CO_2\ (g) + 2H_2O\ (liq.)$, at 25° and a constant total pressure of 1 atmosphere (the methyl alcohol being at a pressure slightly below saturation), Rossini[16] gave the value 182.58 ± 0.05. At 18°, this value becomes $182\ 75 \pm 0\ 05$.

CH_3OH (liq.). Rossini[16] reviewed the published data on the heat of vaporization of methyl alcohol and concluded that the best data are those of Fiock, Ginnings, and Holton.[1] Earlier calorimetric determinations on the heat of vaporization of methyl alcohol were reported by Brown,[1, 2] Marshall,[1] Mathews,[2] Mills,[1], Tyrer,[1, 2] Wirtz,[1] Young,[2] Jahn,[4] and Schall.[1] Vapor pressure data on methyl alcohol were reported by Timmermans,[1] Young,[2] Richards and Shipley,[1] Mundel,[1] Richardson,[1] Tyrer,[4] Drucker, Jimmens, and Kangro,[1] Atkins and Wallace,[1] Young and Fortey,[1] and Regnault.[6]

CH_3OH (c). Data on the heat of fusion of methyl alcohol were reported by the following: Kelley,[1] −0.76 at −98°; Maass and Waldbauer,[1] −0.53 at −97°; Parks,[1] − 0 71 at − 98°. See also Mitzukuri.[1] Parks[1] measured the heat of transition at −112°.

CH_3OH (aq.). Data on the heat of solution of methyl alcohol in water were reported by Berthelot,[36] deForcrand,[6, 7] and Bose.[1a] The latter's data also yield values for the heat of dilution of aqueous methyl alcohol.

CH_3O^- (CH_3OH). Wolfenden, Jackson, and Hartley[1] reported the heat of ionization of liquid methyl alcohol, in liquid methyl alcohol, to be −11.2.

HCOOH (liq.). The heat of combustion of gaseous formic acid was measured by Favre and Silbermann[1] and Thomsen,[15] and of liquid formic acid by Berthelot and Matignon,[5, 10] and Jahn.[2] The data yield the following values for the heat of combustion of liquid formic acid: Thomsen,[15] 63.0; Berthelot and Matignon,[5, 10] 62 5; Jahn,[2] 63.0. Berthelot,[25, 150] measured the heat of decomposition of formic acid with aqueous sulfuric acid.

HCOOH (g), $(HCOOH)_2$ (g). Ramsperger and Porter[2] and Coolidge[1] studied the equilibrium, $(HCOOH)_2\ (g) = 2HCOOH\ (g)$, and their data yield −14.13 for the heat of this reaction. The equilibrium concentrations in mole fraction are, for $(HCOOH)_2$ (g) and HCOOH (g), respectively, about 0.80 and 0.20 at 18°, and about 0.52 and 0.48 at the boiling point, 100.8°. Data on the heat of vaporization of liquid formic acid to form the equilibrium mixture of $(HCOOH)_2$ (g) and HCOOH (g)

were reported by Ramsperger and Porter,[1, 2] Marshall,[1] Ogier,[5] and Favre and Silbermann.[10] We have calculated $Q = -8.57$ for the reaction $2HCOOH\ (liq.) = (HCOOH)_2\ (g)$, at 18°.

HCOOH (c). The data on the heat of fusion of formic acid at its melting point are: Coolidge,[1] −3.05; Zanninovich-Tessarin,[1] −2.63; Tammann,[3] −2.82; Petersen,[3, 4] −2.68; Berthelot,[25] −2.40; Rideal,[1] −2.62.

HCOOH (aq.). Data on the heat of solution and of dilution of formic acid in water were reported by Berthelot,[25] Faucon,[1] and Thomsen.[15] Thomsen[15] measured the heat of oxidation of aqueous formic acid with aqueous potassium permanganate, and his data yield, for HCOOH (aq.), $Qf = 101.4$. See also Wrewskii and Stagoleva,[1] who reported values for the heat of polymerization of formic acid in water (and also in benzene).

H_2CO_3 (aq.). This is taken as equivalent to $CO_2\ (aq.) + H_2O\ (liq.)$.

$HC_2O_4^-$ (aq.). The value for aqueous bioxalate ion is obtained from $NaHC_2O_4\ (aq)$.

$(COOH)_2$ (c). The heat of combustion of crystalline oxalic acid was measured by Stohmann, Kleber, and Langbein,[1] Jahn,[2] and Verkade, Hartman, and Coops.[2] The data of the last named investigation were reviewed by Washburn,[2] who showed that the correction to a pressure of 1 atmosphere (from the conditions of the bomb process) is −0.66 per cent. With the Washburn correction to 1 atmosphere, the data of Verkade, Hartman, and Coops[2] yield 59.7 for the heat of the reaction, $(COOH)_2\ (c) + \frac{1}{2}\ O_2\ (g) = 2CO_2\ (g) + H_2O\ (liq.)$ at 18° and a constant pressure of 1 atmosphere.

$(COOH)_2$ (g). Vapor pressure data on crystalline oxalic acid were reported by Noyes and Webbe.[1]

$(COOH)_2$ (aq.). Thomsen[15] and Berthelot[10, 25] measured the heat of solution of oxalic acid. With Thomsen's value $S = -2.26_{200}$, we have computed, for $(COOH)_2\ (aq.)$, $Qf = 195.3$. Thomsen's[15] data on the reaction of aqueous hypochlorous acid with aqueous oxalic acid yield, for $(COOH)_2$ (aq.), $Qf = 194.5$. Berthelot's[25] data on the reaction of gaseous chlorine with aqueous oxalic acid yield, for $(COOH)_2$ (aq.), $Qf = 194.8$. Berthelot's[25] data on the reaction of aqueous potassium permanganate with aqueous oxalic acid yield, for $(COOH)_2$ (aq.), $Qf = 195.5$.

$(COOH)_2 \cdot 2H_2O$ (c). The heat of solution of oxalic acid dihydrate was measured by Thomsen,[15] Favre and Silbermann,[3] Berthelot,[10] Graham,[3] Jorissen,[2] Jorissen and van der Stadt,[1] and Roth and Eymann.[1] Jorissen and van der Stadt[1] measured the heat of combustion. Timofejew[1] measured the heat of solution in methyl and ethyl alcohols.

$C_2H_3O_2^-$ (∞). The value for aqueous acetate ion at infinite dilution is obtained from that for aqueous sodium acetate at infinite dilution.

$C_2H_3O_3^-$ (aq.). The value for aqueous glycollate ion is obtained from those for the aqueous salts.

$(CHO)_2$ (c). Estimating the Washburn[2] correction to be −0.15 per cent, we have computed from the data of deForcrand[3] (see Kharasch[1]) the heat of combustion of glyoxal to be 172.0.

$(CHO)_2$ (aq.). deForcrand[3] measured the heat of solution of glyoxal.

$(CHO)_2$ (g). We have estimated the heat of sublimation of glyoxal.

$(HO)_2CHCOOH$ (c). Berthelot and Matignon[6] (see Kharasch[1]) measured the heat of combustion of glyoxylic acid. Estimating the Washburn[2] correction to be −0.25 per cent, we have calculated the heat of combustion to be 125.2.

$(HO)_2CHCOOH$ (aq.). deForcrand[17] measured the heat of solution of glyoxylic acid.

CH_3CHO (g). The heat of combustion of gaseous acetaldehyde was measured by Thomsen[15] and Berthelot and Ogier,[2] and of liquid acetaldehyde by Berthelot and Delepine[4] and Louguinine.[25] Thomsen's[15] data yield 281.6 for the heat of combustion of the gas.

CH_3CHO (liq.). Berthelot[33] measured the heat of vaporization of acetaldehyde to be −6.02 at 22°. The vapor pressure data of Gilmour[1] yield −6.6 at 22°.

CH_3CHO (c). Cooper[1] measured the heat of fusion of acetaldehyde.

C_2H_4O (g). Thomsen's[15] data yield 312.3 for the heat of combustion of ethylene oxide in the gaseous state; those of Berthelot[81] yield the value 308.4.

C_2H_4O (liq.). Berthelot[81] reported a value for the heat of vaporization of ethylene oxide. Vapor pressure data were reported by Eversheim.[1]

CH_3COOH (liq.). The heat of combustion of liquid acetic acid was measured by Berthelot and Matignon[3] and Roth,[2] and of gaseous acetic acid by Thomsen.[13] Applying a Washburn correction of −0.10 per cent, we have computed Roth's[2] value to be 206.7 for the heat of combustion of the liquid, and that of Berthelot and Matignon[3] to be 209.2. Thomsen's[15] data yield 227.4 for the heat of reaction of gaseous acetic acid at 111° with oxygen at 18° to form gaseous carbon dioxide and liquid water at 18°.

CH_3COOH (c). Louguinine and Dupont,[1] Parks and Kelley,[1] Berthelot,[3] Petterson,[1, 4] Bridgman,[7] Raoult,[1] Garner, Madden, and Rushbroke,[1] and Pickering[10] determined the heat of fusion of acetic acid.

CH_3COOH (aq.). The heat of solution of solid acetic acid in water was measured by Berthelot,[3, 9] and Petterson,[1] and of liquid acetic acid in water by Berthelot,[3, 9] and Berthelot and Louguinine.[1] Data on the heat of dilution of aqueous acetic acid were reported by Thomsen,[15] Berthelot and Louguinine,[1] Berthelot,[3, 9] Faucon,[1] Payn and Perman,[1] Bose,[1] and Richards and Gucker.[1] We have extrapolated the data of Richards and Gucker[1] to infinite dilution to obtain a value for aqueous undissociated CH_3COOH at infinite dilution in water.

$HCOOCH_3$ (g). Thomsen[15] and Berthelot and Ogier[3] measured the heat of combustion of gaseous methyl formate, and Berthelot and Dele-

pine[4] that of liquid methyl formate. Their data yield for the heat of combustion of the gas, 241.0, 240.2, and 240.9, respectively.

$HCOOCH_3$ (liq.). The heat of vaporization of methyl formate was measured by Mathews[2] and Berthelot and Ogier,[3] who reported the values 6.75 and 6.9, respectively, at 31°. Vapor pressure data were reported by Olszewski[2] and Pierre.[1]

$HCOOCH_3$ (c). Rideal[1] computed the heat of fusion of methyl formate.

C_2H_5OH (g). The heat of combustion of ethyl alcohol was measured by Andrews,[5, 14] Favre and Silbermann,[1] Berthelot and Matignon,[5] Atwater and Rosa,[1] Atwater and Snell,[1] Emory and Benedict,[1] Roth and Muller,[3] Richards and Davis,[1] and Rossini.[10]. These data were reviewed by Rossini[10] whose own experiments on the heat of combustion of gaseous ethyl alcohol at 32.50° yield (see Rossini[16]) for the heat of the reaction, $C_2H_5OH\ (g) + 3\ O_2\ (g) = 2CO_2\ (g) + 3H_2O\ (liq.)$, $Q = 336\ 78 \pm 0.10$ at 25° and a constant total pressure of 1 atmosphere. This value becomes 337.06 ± 0.10 at 18°.

C_2H_5OH (liq.). The heat of vaporization of ethyl alcohol was measured by Brown,[1, 2] Marshall and Ramsay,[1] Louguinine,[11] Mathews,[2] Mills,[1] Tyrer,[1] Wirtz,[1] Young,[2] Jahn,[4] Regnault,[6, 9] Schall,[1] Andrews,[6] Parks and Nelson,[1] Svensson,[1] and Fiock, Ginnings and Holton.[1] See Rossini.[16]

C_2H_5OH (c). The heat of fusion of ethyl alcohol was measured by Gibson, Parks, and Latimer[1] and Parks.[1] See also Mitsukuri[1] and Mitsukuri and Hara.[2]

C_2H_5OH (aq.). The heat of mixing alcohol with water was measured by Berthelot,[36] Bose,[1] Dupre and Page,[1] MacInnis and Braham,[1] Pratt,[1] de Forcrand,[22] Winkelmann,[4] and Kolosovskii.[1]

$C_2H_5O^-$ (aq.). van Deventer and Cohen[1] measured the heat of neutralization of $NaOC_2H_5$ in ethyl alcohol with HCl in ethyl alcohol.

$CH_2OHCOOH$ (c). Stohmann, Kleber, Langbein, and Offenhauer,[1, 2] (see Kharasch[1]) measured the heat of combustion of solid glycollic acid.

$CH_2OHCOOH$ (aq.). de Forcrand[3] measured the heat of solution of solid glycollic acid in water.

$(CH_3)_2O$ (g). The heat of combustion of gaseous dimethyl ether was measured by Thomsen[15] and Berthelot.[71] See also Berner.[4] Thomsen's[15] data yield 349 0 for the heat of combustion of the gas.

$(CH_3)_2O$ (liq.). Vapor pressure data were reported by Cardoso and Bruni[1] and Regnault.[7]

$(CH_2OH)_2$ (liq.). Stohman and Langbein[3] and Louguinine[2] measured the heat of combustion of ethylene glycol (see Kharasch[1]).

$(CH_2OH)_2$ (g). Vapor pressure data on ethylene glycol were reported by de Forcrand.[33] Louguinine[2] measured the heat of condensation. These data yield $V = -14.3$ and -11.8, respectively.

CF_4 (g). von Wartenberg and Schütte[1] measured the heat of the reaction, $C\ (charcoal) + 2\ F_2\ (g) = CF_4\ (g)$, to be 165.0 ± 2.0.

CH_2FCH_2OH (liq.). Swarts[4, 5] (see Kharasch[1]) measured the heat of combustion of monofluoroethanol.

CHF_2CH_2OH (liq.). Swarts[4, 5] (see Kharasch[1]) measured the heat of combustion of difluoroethanol.

CH_2FCOOH (c). Swarts[4] (see Kharasch[1]) measured the heat of combustion of monofluoroacetic acid.

CHF_2COOH (liq.). Swarts[4] (see Kharasch[1]) measured the heat of combustion of difluoroacetic acid.

CCl_4 (g). Bodenstein, Gunther, and Hoffmeister[1] measured the heat of the reaction, CCl_4 (g) $+2\ H_2$ (g) $=$ C ("acetylene" carbon) $+4$ HCl (g), to be 62.0; whence, for CCl_4 (g), $Qf = 25.9$. Berthelot[108] and Thomsen[15] measured the heat of combustion of carbon tetrachloride.

CCl_4 (liq.). Data on the heat of vaporization of carbon tetrachloride were reported by Marshall,[1] Mathews,[2] Mills,[1] Tyrer,[3] and Regnault.[8, 9] Vapor pressure data were reported by Young,[2] Burrell and Robertson,[2] Cardoso and Braume,[2] Guye and Drouginine,[1] Keyes, Taylor, and Smith,[1] Olszewski,[2, 4] and Pierre.[1]

CCl_4 (c). The data on the heat of fusion of CCl_4 (c, I) are: Latimer,[1] -0.69 at $-24°$; Bridgman,[2] -0.55 at $-23°$. Latimer[1] measured the heat of transition.

C_2Cl_6 (c). Berthelot[108] measured the heat of combustion of solid hexachloroethane, but his value of 110 0 (see Kharasch[1]) is much too low. The vapor pressure data of Nelson[1] yield -17.0 for the heat of sublimation.

C_2Cl_6 (g). We have estimated this value.

C_2Cl_4 (g). Thomsen[15] measured the heat of combustion of gaseous tetrachloroethylene, and his data yield $Qf = -6\ 0$.

C_2Cl_4 (liq.). Berthelot[108] reported a value for the heat of combustion of liquid tetrachloroethylene, but his value must be too low. Mathews[2] reported the heat of vaporization to be $-8\ 27$ at 120°; the vapor pressure data of Herz and Rathmann[1] yield -8.4.

$COCl_2$ (g). Thomsen's[15] data on the heat of combustion of gaseous phosgene yield $Qf = 52.7$. Thomsen[15] and Berthelot[51] measured the heat of reaction of gaseous phosgene with aqueous potassium hydroxide, and their data yield, for $COCl_2$ (g), $Qf = 54.4$ and 60.6, respectively. The equilibrium data of Bodenstein and Plant,[1] Bodenstein and Danant,[1] Atkinson, Heycock, and Pope,[1] Christiansen,[1] and Weigert[1] on the reaction, CO (g) $+ Cl_2$ (g) $= COCl_2$ (g), yield, for $COCl_2$ (g), $Qf = 53.5$.

$COCl_2$ (liq.). Vapor pressure data were reported by Atkinson, Heycock, and Pope,[1] Nikiten,[2] Paterno and Mazzuchelli,[1] Perry and Porter,[1] and Germann and Taylor.[1]

CH_3Cl (g). Thomsen[15] and Berthelot[70] measured the heat of combustion of methyl chloride. Thomsen's[15] data yield $Qf = 20.1$.

CH_3Cl (liq.). The heat of vaporization was measured by Chappuis,[3] Shorthose,[1] Yates,[1] and Regnault.[9] Vapor pressure data were reported by Holts,[2] Shorthose,[1] and Regnault.[6, 7]

$C_2H_2Cl_2$ (liq.). Berthelot and Ogier[1] measured the heat of combustion.

$C_2H_2Cl_2$ (g). Mathews[2] found the heat of vaporization to be −6.69 at 40°. Vapor pressure data were reported by Korber,[1] Nilson and Petterson,[1] and Perry.[1]

$CHCl_3$ (g). The heat of combustion of chloroform was measured by Thomsen,[15] Berthelot,[108] and Berthelot and Matignon.[5a] Thomsen's[15] data yield, for $CHCl_3$ (g), $Qf=21.7$. We have estimated 23.6.

$CHCl_3$ (liq.). Data on the heat of vaporization of chloroform were reported by Regnault,[8, 9] Marshall,[1] Mathews,[2] Mills,[1] Tyrer,[3] and Wirtz.[1]

$CHCl_3$ (c). Mitsukuri and Aoki[1] reported a value for the heat of fusion.

$CHCl_3$ (aq.). Berthelot[43] measured the heat of solution of chloroform in water.

C_2H_3Cl (g). Thomsen's[15] data on the heat of combustion yield, for monochlorethylene, or vinyl chloride, $Qf=-6.5$. We have estimated $Qf=-9$.

C_2H_3Cl (liq.). Vapor pressure data were reported by Dana, Burdick, and Jenkins.[1]

C_2H_5Cl (g). Thomsen[15] and Berthelot[108] measured the heat of combustion of ethyl chloride. The data of the former yield $Qf=25\,7$.

C_2H_5Cl (liq.). Yates[1] and Regnault[6] measured the heat of vaporization. Vapor pressure data were reported by Berthoud,[1] Jenkins and Shorthose,[1] Regnault,[6] and Antoine.[3]

CH_2ClCH_2Cl (g). Thomsen[15] measured the heat of combustion of ethylene chloride.

CH_2ClCH_2Cl (liq.). The heat of vaporization of ethylene chloride was measured by Jahn[4] and Mathews.[2] Vapor pressure data were reported by Pearce and Peters,[1] Rex,[1] Stadel,[1] and Timmermans.[1]

CH_3CHCl_2 (g). Data on the heat of combustion of ethylidene chloride were reported by Thomsen[15] and Berthelot and Ogier.[3]

CH_3CHCl_2 (liq.). Vapor pressure data were reported by Reilly and Hickinbottom[1] and Stadel.[1]

$CHCl_2CHCl_2$ (g). We have estimated the heat of formation of symmetrical tetrachloroethane.

$CHCl_2CHCl_2$ (liq.). Vapor pressure data were obtained by Nelson.[1]

$CHCl_2CCl_3$ (g). We have estimated the value for pentachloroethane.

$CHCl_2CCl_3$ (liq.). Vapor pressure data were obtained by Nelson.[1]

CH_2ClCHO (liq.). Rivals[1, 2] measured the heat of combustion of monochloroacetaldehyde.

CH_3COCl (liq.). Berthelot and Louguinine[1] measured the heat of reaction of liquid acetyl chloride with water to be 23.3. See also Rivals.[1, 5]

CH_3COCl (g). Berthelot and Ogier[8] measured the heat of vaporization of acetyl chloride.

$CH_2ClCOCl$ (liq.). Rivals[1, 2] measured the heat of reaction of liquid monochloroacetyl chloride with aqueous potassium hydroxide.

Cl_3CCHO (aq.). Berthelot[43, 60] measured the heat of the reaction, Cl_3CCHO (aq.) + KOH (aq.) = ($KCHO_2$ + $CHCl_3$) (aq.), to be 13.15; whence, for aqueous chloral, $Qf = 65.4$.

Cl_3CCHO (liq.). Berthelot[43, 60] measured the heat of solution of liquid chloral in water.

Cl_3CCHO (g). Berthelot[43, 60] determined the heat of vaporization of liquid chloral.

$Cl_3CCH(OH)_2$ (g). Berthelot[43, 60] measured the heat of solution of gaseous chloral hydrate.

$Cl_3CCH(OH)_2$ (c, II). Berthelot[43, 60] measured the heat of solution of this solid form of chloral hydrate.

$Cl_3CCH(OH)_2$ (liq.). Berthelot reported the heat of fusion of chloral hydrate (c, II).

$Cl_3CCH(OH)_2$ (c, I). Berthelot[43, 60] measured the heat of fusion.

$CH_2ClCOOH$ (c, α). Berthelot and Matignon[7] measured the heat of combustion of monochloroacetic acid (c, α).

$CH_2ClCOOH$ (liq.). The data on the heat of fusion of monochloroacetic acid (c, α) at 61° are: Pickering,[10] −3 90; Steiner and Johnston,[1] −4.63. See also Tanatar[4] and Louguinine.[1]

$CH_2ClCOOH$ (c, β). The data on the heat of fusion of monochloroacetic acid (c, β) at 56° are: Pickering,[10] −3.33; Steiner and Johnston,[1] −4.45. See also Tanatar[4] and Louguinine.[1]

$CH_2ClCOOH$ (c, γ). Steiner and Johnston[1] measured the heat of fusion of monochloroacetic acid (c, γ). See also Tanatar[4] and Louguinine.[1]

$CH_2ClCOOH$ (aq.). For the heat of solution of monochloroacetic acid (c, α) in water, Pickering[10] found −3.35 and Louguinine −2.33.

$CH_2ClCOOH$ (g). Vapor pressure data were reported by Patterson.[1]

CH_2ClCOO^- (aq.). The value for aqueous monochloroacetate ion is obtained from that for the aqueous sodium salt.

CCl_3COOH (c). Berthelot and Matignon[7] measured the heat of combustion of trichloroacetic acid.

CCl_3COOH (liq.). Pickering[10] measured the heat of fusion.

CCl_3COOH (aq.). Pickering[10] and Louguinine[1] found the heat of solution of solid trichloroacetic acid in water to be 2.70_{400}^{15} and 2.89_{100}, respectively.

$CHCl_2COOH$ (aq.). We have estimated the value for the heat of formation of aqueous dichloroacetic acid.

$CHCl_2COOH$ (liq.). Louguinine[1] and Pickering[10] measured the heat of solution of liquid dichloroacetic acid.

$CHCl_2COOH$ (c). Pickering[10] measured the heat of fusion of dichloroacetic acid.

$CHCl_2COOH$ (g). Louguinine[1] measured the heat of vaporization.

CH_2ClCH_2OH (liq.). Berthelot[82] reported $Q = 36.0$ for the reaction

of gaseous ethylene oxide with gaseous hydrogen chloride to form liquid monochloroethanol.

$COBr_2$ (g). Trautz[8] studied the equilibrium, CO (g) + Br_2 (g) = $COBr_2$ (g), and computed $Q=3.14$; whence, for $COBr_2$ (g), $Qf=22.3$.

CH_3Br (g). Thomsen[15] and Berthelot[70, 116] measured the heat of combustion. Thomsen's[15] data yield $Qf=8.5$.

C_2H_5Br (g). Thomsen[15] measured the heat of combustion of gaseous ethyl bromide.

C_2H_5Br (liq.). The heat of vaporization was measured by Tyrer,[2] Marshall,[1] and Berthelot.[53, 87] Vapor pressure data were reported by Regnault,[6, 7] Rex,[1] Richards and Mathews,[1] Timmermans,[1] and Tyrer.[1]

CH_2BrCH_2Br (liq.). Berthelot[84] found $Q=29.3$ for the reaction, C_2H_4 (g) + Br_2 (liq.) = CH_2BrCH_2Br (liq.); whence, for liquid symmetrical dibromoethane, $Qf=19.7$.

CH_2BrCH_2Br (g). Vapor pressure data were reported by Regnault[6] and Timmermans.[2] Berthelot[53] reported $V=-8.2$. Antoine[3] calculated $V=-9.1$.

$CH_3OH \cdot HBr$ (c). McIntosh[2] reported values for the heat of fusion and the heat of dissociation, at −83°.

$CHBr_3$ (g). We have estimated the value for gaseous bromoform.

CH_2Br_2 (g). We have estimated the value for gaseous dibromomethane.

CBr_4 (g). We have estimated the value for gaseous carbon tetrabromide.

CH_3COBr (liq.). Berthelot and Louguinine[1] measured the heat of reaction of liquid acetyl bromide with water.

$Br_3CCH(OH)_2$ (c, I). Bruner[2] measured the heat of solution of bromal hydrate (c, I) (old crystallized material) in aqueous KOH.

$Br_3CCH(OH)_2$ (c, II). Bruner[2] measured the heat of solution of bromal hydrate (c, II) (freshly crystallized material) in aqueous KOH.

$Br_3CCH(OH)_2$ (aq.). Bruner[2] measured the heat of solution of bromal hydrate in water.

$CH_2BrCOOH$ (c). Pickering[10] measured the heat of solution of monobromoacetic acid.

$CHBr_2COOH$ (c). Pickering[10] measured the heat of solution of dibromoacetic acid.

CBr_3COOH (c). Pickering[10] measured the heat of solution of tribromoacetic acid.

C_2I_4 (c). Berthelot[121] measured the heat of combustion of tetraiodoethylene.

CH_3I (g). Thomsen[15] and Berthelot[121] measured the heat of combustion of gaseous methyl iodide.

CH_3I (liq.). Marshall[1] measured the heat of vaporization. Vapor pressure data were reported by Brown and Acree,[1] Rex,[1] and Robertson and Acree.[1]

CH_2I_2 (liq.). Berthelot[121] measured the heat of combustion.

CH_2I_2 (g). We have estimated the value for diiodomethane.

CHI_3 (c). Berthelot[121] measured the heat of combustion.

CHI_3 (g). We have estimated the value for gaseous iodoform.

C_2H_5I (g). Thomsen[15] measured the heat of combustion of ethyl iodide.

C_2H_5I (liq.). Data on the heat of vaporization were reported by Mathews,[2] Marshall,[1] Regnault[6] and Andrews.[10] Vapor pressure data were reported by Regnault,[7] Rex,[1] Robertson and Acree,[1] Thorpe and Rodger,[1] and Tyrer.[4]

CH_2ICH_2I (c). Berthelot[121] measured the heat of combustion of ethylene iodide.

CH_2ICH_2I (g). We have estimated this value.

CH_3COI (liq.). Berthelot and Louguinine[1] measured the heat of reaction of acetyl iodide with water.

CH_2ICH_2Br (c). Berthelot[74] measured the heat of the reaction, CH_2ICH_2I (c) $+Br_2$ (liq) $=CH_2ICH_2Br$ (c) $+IBr$ (liq), to be 13.9.

$(CS)_x$ (c). Dewar[2] measured the heat of combustion of solid polymerized carbon monosulfide.

CS (g). We have estimated this value

CS_2 (g). Thomsen[15] measured the heat of combustion of gaseous carbon disulfide, and Berthelot[73, 108] that of the liquid. For CS_2 (g), Thomsen's[15] data yield $Qf=-28.6$, and those of Berthelot -17.0 and -24.4, respectively. The equilibrium data of Koref[2] yield -16.7.

CS_2 (liq.). Data on the heat of vaporization were reported by Mathews,[2] Mills,[1] Wirtz,[1] Winkelmann,[2, 3] Koref,[1] Andrews,[5] and Person.[7] Vapor pressure data were reported by Battelli,[1] Henning and Stock,[1] Mund,[1] Regnault,[6, 7] von Siemens,[1] Rex,[1] Stock and Seelig,[1] Galitzine,[1] Hannay,[1] and Muller and Grotrian.[1]

CS_2 (c). Mitsukuri and Aoki[1] reported a value for the heat of fusion.

COS (g). Thomsen's[15] data on the heat of combustion of gaseous carbonylsulfide yield, for COS (g), $Qf=34.5$. This value is in accord with the estimate of Lewis and Lacey[1] and with the equilibrium data of Stock, Sieke, and Pohland.[1] Berthelot's[51] data on the heat of combustion are in disagreement with the foregoing data. From spectroscopic data, Lockte, Holtgreven, and Bawn[1] computed the energy of dissociation of COS (g) into CO (g) and S (g), and their data yield, for COS (g), $Qf=35$.

COS (liq.). Vapor pressure data were reported by Stock and Kuss.[1]

CH_3SH (g). Thomsen[15] reported the heat of combustion of gaseous methyl mercaptan.

CH_3SH (liq.). Vapor pressure data were reported by Berthoud and Brun.[1]

$(CH_3)_2S$ (g). Thomsen[15] measured the heat of combustion of gaseous dimethyl sulfide.

$(CH_3)_2S$ (liq.). Vapor pressure data were reported by Berthoud and Brun.[1]

C_2H_5SH (g). The heat of combustion data of Thomsen[15] and Berthelot[124, 125] yield, for gaseous ethyl mercaptan, $Qf = 9.7$ and 19, respectively.

C_2H_5SH (liq.). Vapor pressure data were reported by Berthoud and Brun.[1]

$C_2H_5HSO_4$ (aq.). Berthelot[36] reported the heat of reaction of aqueous ethanol with aqueous sulfuric acid. His data yield, for aqueous ethylsulfuric acid, $Qf = 208.2$, which value seems too low.

C_2N_2 (g). For the heat of the reaction, $C_2N_2(g) + 2\,O_2(g) = 2\,CO_2(g) + N_2(g)$, the various data are: Thomsen,[15] 259.4; Berner,[4] 262.1; Berthelot,[54] 264; Dulong,[2] 275; von Wartenberg and Schutza,[1] 261.3; McMorris and Badger,[1] 251.4.

C_2N_2 (liq.). Vapor pressure data were reported by Faraday,[3] Terwen,[1] Perry and Bardwell,[1] Chappuis and Riviere,[1] Cardoso and Braume,[1] Dewar,[2] and Bunsen.[2]

C_2N_2 (aq.). Cyanogen is slowly hydrolyzed in contact with water. The data of Berthelot[129] and Hammerl[2] on the heat of solution of gaseous cyanogen in water yield, when extrapolated to zero time, $S = 8.8$ and 6.8, respectively.

NCN_3 (c). Darzen[1] measured the heat of decomposition of carbon perazuride.

HCN (g). The data on the heat of combustion are: Thomsen,[15] 158.5; Berthelot,[76] 159.3.

HCN (liq.). Berthelot's[27] data on the reaction, $HCN\ (liq.) + 2\,H_2O\ (liq.) + HCl\ (aq.) = (NH_4Cl + HCHO_2)\ (aq.)$, yield, for HCN (liq.), $Qf = -16.2$. Berthelot[27] measured the heat of vaporization of liquid HCN to be -5.7 at the boiling point. The following values, computed from vapor pressure data, were reported for the heat of vaporization at 25°: Bredig and Teichmann,[1] -6.74; Hara and Sinozaki,[1] -6.6; Sinozaki, Hara, and Mitsukuri,[1] -6.67; Perry and Porter,[1] -6.65; Bussy and Brugnet,[1] -6.7.

HCN (c). The data on the heat of fusion at $-14°$ are: Sinozaki, Hara, and Mitsukuri,[1] -1.72; Perry and Porter,[1] -1.73; Piloty and Steinbock,[1] -1.68.

HCN (aq.). Data on the heat of solution of HCN (liq.) were reported by Berthelot[27] and Bussy and Brugnet.[1]

CN^- (aq.). The values for aqueous lithium, sodium, and potassium cyanides yield, for CN^- (aq.), $Qf = -35.0$, -34.9, and -34.8, respectively. von Steinwehr's[1] conductivity data yield $Q = -11.0$ for the reaction, $HCN\ (aq.) = H^+\ (aq.) + CN^-\ (aq.)$; whence, for CN^- (aq.), $Qf = -34.9$.

CN (g). The energy of dissociation into gaseous atoms was reported by Birge and Sponer.[1] The values for the energy states of gaseous CN are from Mulliken,[6] Jenkins,[1] Kratjer,[1] Ryde and Asundi,[1] Herzberg,[2] Heitler and Herzberg,[1] Turner and Samson,[1] and Weizel.[1]

CN^- (g). Lederle[2] calculated the energy of the reaction, $CN\ (g) + \theta = CN^-\ (g)$, to be 92, from spectroscopic data on cyanonitrite. From the

lattice energies of KCN and NaCN, Sherman[1] computed the values 110.5 and 112.5 for the electron affinity of CN (g).

CNO^- (aq.). This value is obtained from those for the aqueous salts.

CH_3NH_2 (g). For the heat of combustion of gaseous methylamine, Thomsen[15] found 258.1 and Muller[4] 261.4. See also Lemoult.[2]

CH_3NH_2 (liq.). Gautier (see Berthelot[151]) measured the heat of vaporization to be −6.57. The vapor pressure data of Berthoud,[1] Felsing and Thomas,[1] and Plank and Vahl[1] yield −6.40 at −7°.

CH_3NH_2 (aq.). Data on the heat of solution of gaseous methylamine in water were obtained by Bonnifoi[3] and Felsing and Wohlford.[1]

$CH_3NH_2 \cdot HCl$ (aq.). Muller[1, 6] measured the heat of reaction of aqueous methylamine with aqueous HCl to be 13.0.

$CH_3NH_3^+$ (aq.). The value for aqueous methylaminium ion is obtained from aqueous methylamine hydrochloride.

CH_3CN (g). Thomsen[15] and Lemoult,[1] respectively, measured the heats of combustion of gaseous and of liquid acetonitrile, methylcyanide. Their data yield, for CH_3CN (g), $Qf = -20.3$ and -17.9, respectively.

CH_3CN (liq.). Kahlenberg[1] reported a value for the heat of vaporization.

NH_2CN (c). Lemoult[1, 6] measured the heat of combustion of solid cyanamide.

NH_2CN (aq.). Lemoult[1, 6] measured the heat of solution of solid cyanamide in water.

NH_2CN (liq.). Pratolongo[1] measured the heat of fusion.

NH_4CN (aq.). Berthelot[27] measured the heat of reaction of NH_4OH (aq.) with HCN (aq.) to be 1.3.

NH_4CN (c). Berthelot[27] measured the heat of solution of ammonium cyanide.

CH_3NC (liq.). The data on the heat of combustion (see Kharasch[1]) of liquid methylisocyanide are: Lemoult,[9] 317.4; Guillemard,[1] 320.1.

$C_2H_5NH_2$ (g). Thomsen's[15] data on the heat of combustion of the gas yield, for gaseous ethylamine, $Qf = 13.0$; those of Lemoult[2] on the heat of combustion of the liquid yield $Qf = 13.3$. See also Berthelot.[75]

$C_2H_5NH_2$ (liq.). Gautier (see Berthelot[102]) measured the heat of vaporization to be −6.5 at 15°. The vapor pressure data of Berthoud[1] and Pohland and Mehl[1] yield −6.75 and −6.53 at 15°

$C_2H_5NH_2$ (aq.). Data on the heat of solution of liquid ethylamine were reported by Baud, Ducelliez, and Gay,[1] Berthelot,[75] and Colson.[1]

$C_2H_5NH_2 \cdot HCl$ (aq.). Thomsen[15] measured the heat of reaction of aqueous ethylamine with aqueous HCl to be 13.44_{400}.

$C_2H_5NH_2 \cdot HCl$ (c). Gautier[2] (see Berthelot[151]) measured the heat of solution of crystalline ethylamine hydrochloride.

$C_2H_5NH_2 \cdot H^+$ (aq.). The value for aqueous ethylaminium ion is obtained from aqueous ethylamine hydrochloride.

$(CH_3)_2NH$ (g). Thomsen[15] and Muller[4] measured the heat of com-

bustion of gaseous dimethylamine: Lemoult[2] that of the liquid. Their data yield, for $(CH_3)_2NH$ (g), $Qf = 8.2$, 2.0, and 5.0, respectively.

$(CH_3)_2NH$ (liq.). Vapor pressure data were reported by Berthoud.[1]

$(CH_3)_2NH$ (aq.). We have estimated the heat of solution of dimethylamine.

$(CH_3)_2NH \cdot HCl$ (aq.). Thomsen measured the heat of reaction of $(CH_3)_2NH$ (aq.) with HCl (aq.) to be 11.81_{400}.

$(CH_3)_2NH \cdot H^+$ (aq.). The value for aqueous dimethylaminium ion is obtained from that for aqueous dimethylamine hydrochloride.

$H_2NC(:NH)NHCN$ (c). Lemoult[1] measured the heat of combustion of dicyandiamide.

$H_2NC(:NH)NHCN$ (aq.). Lemoult[1] measured the heat of solution of dicyandiamide.

NH_4CNO (c). The equilibrium data of Walker and Wood[1] yield 4.9 for the heat of the reaction, NH_4CNO (c) = $(NH_2)_2CO$ (c); whence, for NH_4CNO (c), $Qf = 73.6$.

NH_4CNO (aq.). Walker and Wood[1] measured the heat of solution of solid ammonium cyanate in water to be -6.23.

HCNO (aq.). Berthelot[27] measured the heat of reaction of aqueous potassium cyanate with aqueous hydrochloric acid, and Lemoult[1] that of aqueous barium cyanate with aqueous nitric acid and with aqueous sulfuric acid.

$(NH_2)_2CO$ (c). The heat of combustion of urea was measured by Berthelot and Petit,[1] Emery and Benedict,[1] Krummacher,[1] and Stohmann and Langbein.[2]

$(NH_2)_2CO$ (aq.). The heat of solution of urea was measured by Thomsen,[15] Berthelot and Petit,[5] Matignon,[1] and Walker and Wood.[1] Data on the heat of dilution of aqueous urea were reported by Naudè,[2] Perman and Lovett,[1] and Fricke and Havestadt.[1]

$(NH_2)_2CO \cdot HNO_3$ (aq.). Thomsen[15] measured the heat of mixing aqueous urea with aqueous nitric acid.

$(NH_2)_2CO \cdot HNO_3$ (c). Matignon measured the heat of solution of urea nitrate.

$HCONH_2$ (liq.). The data of Stohmann and Schmidt[4] (see Karasch[1]) on the heat of combustion of liquid formamide yield $Qf = 62.1$.

$HCONH_2$ (aq.). Calvet[1, 2] found $Q = 6.73$ for the reaction, $HCONH_2$ (200) + NaOH (200) = HCOONa (200) + NH_3 (200); whence, for aqueous formamide, $Qf = 57.8$. Berthelot found $Q = 1.0$ for the reaction of $HCONH_2$ (aq.) with H_2O (liq.); whence, for aqueous formamide, $Qf = 61.9$.

CH_3CONH_2 (aq.). Calvet[1, 2] reported $Q = 6.55$ for the reaction, CH_3CONH_2 (200) + NaOH (200) = CH_3COONa (200) + NH_3 (200); whence, for CH_3CONH_2 (200), $Qf = 75.93$.

CH_3CONH_2 (c). The data of Stohmann and Schmidt[4] and Berthelot and Fogh[1] on the heat of combustion of crystalline acetamide yield $Qf = 77.2$ and 71.7, respectively. Speyers[1] measured the heat of solution

of crystalline acetamide in water to be −1.98 at 23°, while Berthelot and Fogh[1] and Calvet[1, 2] found −1.85 and -2.05_{200}[17], respectively. The last value yields, for CH_3CONH_2 (c), $Qf = 77.98$.

CH_3CONH_2 (liq.). Bridgman[7] reported a value for the heat of fusion.

CH_3NO_2 (liq.). Thomsen[15] measured the heat of combustion of gaseous nitromethane and Berthelot and Matignon[7] and Swietoslawski[6] that of liquid nitromethane. Their data yield, respectively, for CH_3NO_2 (liq.), $Qf = 25.3$, 27.6, and 27.2.

CH_3NO_2 (g). For the heat of vaporization of nitromethane, the data are: Berthelot and Matignon,[7] −6.98 at 22°; Mathews,[2] −8.25 at 99°. The vapor pressure data of Williams[1] are in accord with the latter value.

CH_3NO_2 (aq.). Berthelot and Matignon[7] measured the heat of solution of liquid nitromethane in water.

$CH_2NO_2^-$ (aq.). Berthelot and Matignon[7] measured the heat of solution of liquid nitromethane in aqueous KOH to be 7.0.

$HCOONH_4$ (aq.). Berthelot[11] measured the heat of neutralization of aqueous formic acid with aqueous ammonia to be 11.9_{200}[10].

$HCOONH_4$ (c). Berthelot[11] measured the heat of solution of ammonium formate.

NH_4HCO_3 (aq.). Berthelot[4] and Berthelot and Andre[1] reported values for the heat of neutralization of NH_4OH (aq.) with H_2CO_3 (aq.). Data on the heat of dilution of ammonium bicarbonate were reported by Thomsen[15].

NH_4HCO_3 (c). Berthelot and Andre[1] measured the heat of solution. Bonnier[1] measured the dissociation pressure.

$(NH_2)_2C(:NH)\cdot HNO_3$ (c). Matignon[1] measured the heat of combustion of guanidine nitrate.

$(NH_2)_2C(:NH)\cdot HNO_3$ (aq.). Matignon[1] measured the heat of solution of guanidine nitrate.

$(NH_2)_2CNH$ (aq.). Matignon[1] measured the heat of neutralization of aqueous guanidine nitrate to be 14.1, whence, for aqueous guanidine, $Qf = 32.3$.

$(NH_2)_2CNH$ (c). Matignon[1] measured the heat of solution of a sample of crystalline guanidine that contained nearly one-half mole of water to be 1 23.

$(NH_4)_2CO_3$ (aq.). Thomsen[15] and Berthelot[4] measured the heat of neutralization of aqueous ammonia with aqueous carbon dioxide.

NH_2COONH_4 (aq.). Aqueous ammonium carbamate is taken equivalent to $(NH_4)_2CO_3$ (aq.) $-H_2O$ (liq.).

NH_2COONH_4 (c). The data on the heat of solution are: Matignon,[9] −3.80 at 15°; Raabe,[1] −3.45. Raabe[1] and Clark and Hetherington[1] reported for the heat of the reaction, $2\,NH_3\,(g) + CO_2\,(g) = NH_2COONH_4$ (c), $Q = 39.3$ and 38.06, respectively, whence, for solid ammonium carbamate, $Qf = 160.7$ and 159.45. Equilibrium data on this last reaction were reported by Briggs and Migrdichian,[1] Briner,[1] Matignon and Frejacques,[1] and Isambert.[8] See also Lecker[1] and Hori.[1]

$HOCH_2CN$ (liq.). Berthelot and Andre[4] measured the heat of combustion of liquid glycollic nitrile.

CH_3NCO (liq.). Lemoult[9] measured the heat of combustion of liquid methyl isocyanate.

$NH_2OCCOOH$ (c). Matignon[1] and Stohmann and Haussmann[1, 2] found 128.6 and 132.6, respectively, for the heat of combustion of solid oxamic acid.

$NH_2OCCOOH$ (aq.). Matignon[1] measured the heat of solution of solid oxamic acid.

NH_2OCCOO^- (aq.). Matignon[1] measured the heat of reaction of aqueous oxamic acid with aqueous potassium hydroxide.

$(CONH_2)_2$ (c). Stohmann and Haussmann[1, 2] measured the heat of combustion of solid oxamide.

$NH_2OCNHCHO$ (liq.). Matignon[1] measured the heat of combustion of liquid formylurea.

CH_3CHNOH (c). Landrieu[1] (see Kharasch[1]) measured the heat of combustion of solid acetaldoxime.

$CH_2OHCOONH_4$ (aq.). de Forcrand[3] measured the heat of neutralization of aqueous glycollic acid with aqueous ammonia.

$CH_2OHCOONH_4$ (c). de Forcrand[1] measured the heat of solution of ammonium glycollate.

NH_2CH_2COOH (c). The heat of combustion of aminoacetic acid, glycine, was measured by Stohmann and Langbein[2] and Wrede[2] to be 234.5 and 233.4, respectively.

NH_2CH_2COOH (aq.). Louguinine[1] measured the heat of solution of solid aminoacetic acid, glycine

$NH_2CH_2COO^-$ (aq.). Louguinine[1] found $Q = 2.97$ for the reaction of aqueous aminoacetic acid with aqueous OH^- to form aqueous glycinate, or aminoacetate, ion. Branch and Miyamoto,[1] from conductivity measurements, calculated the heat of ionization of aqueous aminoacetic acid into aqueous H^+ and aqueous glycinate ion to be $-10\ 70$.

$NH_2CH_2COOH \cdot H^+$ (aq.). Branch and Miyamoto[1] calculated, from conductivity, data $Q = -14\ 60$ for the reaction, H_2O (liq.) $+ NH_2CH_2COOH$ (aq.) $= OH^-$ (aq.) $+ NH_2CH_2COOH \cdot H^+$ (aq.).

$C_2H_5NO_2$ (g). Thomsen[15] measured the heat of combustion of gaseous nitroethane, and Berthelot and Matignon[6] that of the liquid. Their data yield, for gaseous nitroethane, $Qf = 22.2$ and 27.7, respectively.

$C_2H_5NO_2$ (liq.). Berthelot and Matignon[6] measured the heat of vaporization of nitroethane.

$C_2H_5NO_2$ (aq.). We have estimated the heat of solution of liquid nitroethane.

$C_2H_4NO_2^-$ (aq.). Berthelot and Matignon[6] measured the heat of reaction of aqueous nitroethane with aqueous OH^- to be 10.1.

C_2H_5ONO (g). Thomsen[15] measured the heat of combustion of gaseous ethyl nitrite to be 333.9; whence $Qf = 25.9$.

$C_2H_5ONO_2$ (g). Thomsen[15] measured the heat of combustion of gaseous ethyl nitrate to be 326.4; whence $Qf=33.4$.

$C_2H_5ONO_2$ (liq.). We have estimated the heat of vaporization of ethyl nitrate.

$NH_4HC_2O_4$ (aq.). Berthelot[131] measured the heat of reaction of NH_3 (aq.) with $H_2C_2O_4$ (aq.) to form aqueous ammonium acid oxalate. See also Andrews.[11]

$(NH_4)_2C_2O_4$ (aq.). Berthelot[131] measured the heat of neutralization of aqueous ammonia with aqueous oxalic acid.

$(NH_4)_2C_2O_4$ (c). Berthelot[131] measured the heat of solution of ammonium oxalate.

$(NH_4)_2C_2O_4 \cdot H_2O$ (c). Berthelot[131] measured the heat of solution of ammonium oxalate monohydrate.

$C_2H_5NHNO_2$ (liq.). Swarts[4, 5] (see Kharasch[1]) measured the heat of combustion of ethylnitroamine.

$(CH_3)_2NNO_2$ (liq.). Swietoslawski[6] measured the heat of combustion of liquid dimethylnitrosoamine.

$CH_3NH_2 \cdot H_2CO_3$ (aq.). Muller[6] measured the heat of reaction of 1 mole of aqueous methylamine with 1 mole of aqueous carbon dioxide.

CH_3COONH_4 (aq.). The heat of neutralization of aqueous acetic acid with aqueous ammonia was measured by Thomsen,[15] Berthelot,[9, 31] and Andrews.[11] Data on the heat of dilution of aqueous ammonium acetate were reported by Thomsen[15] and Dunnington and Hoggard.[1]

CH_3COONH_4 (c). Berthelot[131] measured the heat of solution of ammonium acetate.

$(CH_2NH_2)_2 \cdot H_2O$ (c). Berthelot[118] measured the heat of combustion of solid ethylene diamine monohydrate.

$(CH_2NH_2)_2$ (aq.). Berthelot[118] measured the heat of solution of ethylene diamine monohydrate in water to be 5.08_{1000}^{25}

$(CH_2NH_2)_2 \cdot 2\,HCl$ (aq.). Berthelot[118] measured the heat of reaction of aqueous ethylene diamine with 2 HCl (aq.) to be 23.2; Colson and Darzen[1] found 23.5.

$(CH_2NH_2)_2 \cdot 2\,HCl$ (c). Berthelot[118] and Colson and Darzen[1] measured the heat of solution of ethylene diamine dihydrochloride to be -6.65^{25} and -7.6, respectively.

$(CH_2NH_2)_2 \cdot 2\,HNO_3$ (aq.). Berthelot[118] measured the heat of reaction of aqueous ethylene diamine with 2 HNO_3 (aq.) to be 23.2.

$(CH_2NH_2 \cdot H)_2^{++}$ (aq.). The value for aqueous ethylene diaminium ion is obtained from aqueous ethylene diamine dihydrochloride.

CH_2FONH_2 (c). Swarts[5] (see Kharasch[1]) measured the heat of combustion of monofluoroacetamide.

CNCl (liq.). Berthelot[27] found $Q=61.7$ for the reaction, CNCl (liq.) $+2\,H_2O$ (liq.) $=(NH_4Cl+CO_2)$ (aq.).

CNCl (g). Berthelot[27] measured the heat of vaporization. Vapor pressure data were reported by Regnault.[6]

$CH_2ClCOONH_4$ (aq.). Rivals[1] measured the heat of neutralization of aqueous monochloroacetic acid with aqueous ammonia.

CCl_3COONH_4 (aq.). Rivals[1] measured the heat of neutralization of aqueous trichloroacetic acid with aqueous ammonia.

$CH_2ClCONH_2$ (c). Rivals[1] measured the heat of combustion of monochloroacetamide.

$CH_2ClCONH_2$ (aq.). Calvet[2] measured the heat of reaction of aqueous monochloroacetamide with aqueous KOH to be 9.01.

$CHCl_2CONH_2$ (aq.). Calvet[2] measured the heat of reaction of aqueous dichloroacetamide with aqueous NaOH to be 10.12.

CCl_3CONH_2 (c). Rivals[3, 4] measured the heat of combustion of trichloroacetamide.

CCl_3CONH_2 (aq.). Calvet[2] measured the heat of reaction of aqueous trichloroacetamide with aqueous NaOH to be 19.71.

$CHF_2CH_2NH_2$ (liq.). Swarts[4, 5] measured the heat of combustion of liquid difluoroethylamine.

$CHF_2CH_2NHNO_2$ (c). Swarts[4, 5] measured the heat of combustion of solid difluoroethylnitroamine.

CNI (aq.). Berthelot[27] found $Q=6.4$ for the reaction, KCN (aq.) $+I_2$ (c) = (CNI+KI) (aq.).

CNI (c). Berthelot[27] measured the heat of solution.

CNS^- (∞). This value is obtained from those for NaCNS (∞) and KCNS (∞).

NH_4CNS (aq.). This value is obtained from those for the aqueous ions.

NH_4CNS (c). Berthelot[9] measured the heat of solution of ammonium thiocyanate. Matignon[1] measured the heat of combustion.

$(NH_2)_2CS$ (c). Matignon[1] measured the heat of combustion of thiourea.

$(NH_2)_2CS$ (aq.). Matignon[1] measured the heat of solution of solid thiourea.

$(NH_2)_2CS \cdot HNO_3$ (aq.). Matignon[1] measured the heat of mixing aqueous thiourea with aqueous nitric acid to be 0.07.

$(NH_2)_2CS \cdot HNO_3$ (c). Matignon[1] measured the heat of solution of thiourea nitrate.

$(C_2H_5)_3PO_4$ (liq.). Cavalier[1] measured the heat of reaction of $POCl_3$ (liq.) with 3 NaC_2H_5O (benzene) to be 109.8.

CH_3CNS (g). The data of Thomsen[15] on the heat of combustion of gaseous methyl thiocyanate yield, for CH_3CNS (g), $Qf=-36.2$.

CH_3CNS (liq.). The data of Berthelot[120] on the heat of combustion of liquid methyl thiocyanate yield, for CH_3CNS (liq.), $Qf=-18.5$.

CH_3NCS (g). The data of Thomsen[15] on the heat of combustion of gaseous methyl isothiocyanate yield, for CH_3NCS (g), $Qf=-29.3$.

CH_3NCS (c). The data of Berthelot[120] on the heat of combustion of solid methyl isothiocyanate yield, for CH_3NCS (c), $Qf=-8.3$.

Silicon

Si (c). Standard state.

Si (amorphous). The data of von Wartenberg,[2] who measured the heats of combustion of both the crystalline and amorphous forms of silicon, yield for the latter $Qf = -1.0$.

Si (g). von Wartenberg[2] considered the vapor to be polyatomic and gave −44 as the heat of sublimation. Recently Ruff and Konschak[1] measured what they believed to be the vapor pressure of silicon, and deduced the heat of sublimation to be −85 at 18°. The heat of sublimation of silicon can also be computed by utilizing the lattice energy of SiO_2, which is 3247 according to Hylleraas,[2] but the value obtained is a small difference of very large numbers and the uncertainty may be as much as 200.

The energy states of gaseous monatomic silicon are taken from the following works: first spectra, Fowler[2, 4]; second, Fowler[5] and Bowen[4]; third, Fowler[5] and Sawyer and Paschen[1]; fourth, Fowler[5]; fifth, Edlen and Ericson.[1]

SiO_2 (solid). The heat of combustion of silicon to form silicon dioxide was measured by Potter,[1] von Wartenberg,[2] and Roth,[4] who found, respectively, $Q = 215$, 195, and 204 0. Mixter[3] measured the heats of the reactions, $Si\ (c) + 2\ Na_2O_2\ (c) = Na_2SiO_3\ (c) + Na_2O\ (c)$ and $SiO_2\ (gls.) + Na_2O\ (c) = Na_2SiO_3$ (solid, fused), to be 234.6 and 73 27, respectively; whence, for $Si\ (c) + 2\ Na_2O_2\ (c) = SiO_2\ (gls.) + 2\ Na_2O\ (c)$, $Q = 161.0$, and for SiO_2 (gls.), $Qf = 200.8$. The various solid forms of SiO_2 are silica glass, α and β quartz, α and β cristobalite, and tridymite. The thermal properties of the various forms are determined from data on their heats of solution in concentrated aqueous HF which have been obtained by Mulert,[1] Ray,[1] Wietzel,[1] and from data on heat capacities which have been obtained by Wietzel,[1] Cohn,[1] Neumann,[1] Perrier and Roux,[1] and White.[1] The values we have selected for the heats of solution in 35% aqueous HF are: SiO_2 (gls.), 36.98; SiO_2 (quartz), 33.65; SiO_2 (colloid), 38.9.

SiO_2 (liq.). From melting point curves, Kraeck[1] calculated the heat of fusion of cristobalite to be −1.84 at 1530°.

SiO_2 (g). Ruff and Schmidt[1] measured the vapor pressure of silica. Their data, which are not very concordant, yield a value of about −79 for the heat of vaporization at 1900°.

H_2SiF_6 (aq.). The heat of solution of silica glass in aqueous HF varies considerably with the concentration of the acid, as shown by the following data: Ray,[1] 37 24 in 35% HF; Mulert,[1] 32.14 in 20% HF; Wietzel,[1] 35.97 in 35% HF, and 38.8 in fuming HF. Mulert[1] measured the heat of solution of silica containing various amounts of water in the same acid used for the solution of silica glass, and found that beyond $SiO_2 \cdot 50\ H_2O$, the heat of solution was constant and equal to 33.6 in 20% HF. Mulert[1] also measured the heat of solution of the same hydrated material in exactly 6 moles of dilute acid, obtaining 32.3.

From these data we have computed $Q = 30.7$ for the reaction, SiO_2 (gls.) $+6HF\ (6) = H_2SiF_6$ (aq.), whence, for H_2SiF_6 (aq.), $Qf = 547.8$.

SiF_4 (g). The data of von Wartenberg and Schutte,[1] who measured directly the heat of formation of this substance, give for SiF_4 (g), $Qf = 359.7$ Truchot[1, 2, 3] measured the heat of solution of SiF_4 (g) in 2 moles of aqueous HF to be 34.0; Guntz[1] found 33.50. Selecting the value 33.8, we have computed, for SiF_4 (g), $Qf = 363\ 0$.

Johnson and Jenkins[1] reported a critical potential of 5.03 volt-electrons for the SiF_4 molecule, but the excited state is not known.

SiF_4 (liq.), SiF_4 (c). The vapor pressure data of Patnode and Papish,[1] Ruff and Ascher,[1] and LeBoucher, Fischer, and Biltz[1] yield -4.46^{-90} for the heat of vaporization and -6.16^{-95} for the heat of sublimation.

$SiO_2 \cdot nH_2O$ (c). Silicic acids of almost every possible composition have been described, but there seems to be no evidence that these substances are definite compounds. Mulert[1] measured the heats of solution of the hydrates ranging in composition from $SiO_2 \cdot H_2O$ to $SiO_2 \cdot 86.6\ H_2O$, and found no break in the curve representing the relation between the heat of solution and the number of moles of water in the so-called hydrates. On the other hand, Thiessen and Koerner[1] obtained some vapor pressure evidence indicating the existence of the hydrates containing $\frac{1}{2}$, 1, $1\frac{1}{2}$, and 2 moles of water. Their data yield 12.7, 10.9, 10 1, and 8.7 for the respective heats of dissociation per mole of water vapor.

SiH_4 (g). Ogier[1] measured the heat of combustion to be 324.3, whence, for SiH_4 (g), $Qf = 13.7$ The equilibrium data of von Wartenberg[2] yield $Qf = 8.7$.

SiH_4 (liq.). Wintgen[1] reported -3.03 for the heat of vaporization of the liquid at the boiling point, $-112°$

Si_nH_{2n+2} (g). Wintgen[1] reported the heats of vaporization for Si_2H_6, Si_3H_8, and Si_4H_{10}.

$SiCl_4$ (liq.). Troost and Hautefeuille[4, 5] measured the heat of the direct combination of amorphous silicon and gaseous chlorine to form liquid silicon tetrachloride, reporting $Q = 157.6$. Berthelot[50] reviewed their data and deduced $Q = 150.1$, by making some calorimetric corrections to their data. For the heat of the reaction, $SiCl_4$ (liq.) $+2H_2O$ (liq.) $= SiO_2$ (aq., colloid) $+4HCl$ (aq.), the following values were reported: Troost and Hautefeuille,[3, 5] 70 0; Roth and Schwartz,[1] 70.1; Berthelot,[50] 69.7; Thomsen,[15] 69 3. From these data, we have computed, for $SiCl_4$ (liq.), $Qf = 150.1$.

$SiCl_4$ (g). The calorimetric data on the heat of vaporization of the liquid at 57° are: Ogier,[1] -6.3; Stock, Somiesky, and Wintgen,[1] -7.19; Wintgen,[1] -7.19. These values are in accord with the vapor pressure data of Regnault[6] and Becker and Meyer.[1] Kahlenberg and Koenig[1] deduced -6.2 by an uncertain method.

$SiCl_4$ (c). Latimer[1] found $F = -1.85$ at $-70°$.

$SiBr_4$ (liq.). Berthelot[50] found the heat of reaction of this substance with water to be 83.0, whence, for $SiBr_4$ (liq.), $Qf=93.6$.

SiI_4 (c). Berthelot[50] found the heat of reaction of this substance with water to be 85.7, which gives, for SiI_4 (c), $Qf=29.8$.

SiH_2Cl_2 (g). Stock and Somieski[3] reported $V=-6.1^{12}$.

SiH_3Cl (g). Stock and Somieski[3] reported $V=-5.1^{10}$.

SiH_2Br_2 (g). Stock and Somieski[2] reported $V=-7.4^{66}$.

SiH_3Br (g). Stock and Somieski[1] reported $V=-5.85^{2}$.

$(SiCl_3)_2O$ (g). Stock, Somieski, and Wintgen[1] reported $V=-9.4^{137}$

Si_2Cl_6 (g). Guinchant[4, 5] reported $V=-11.0^{139}$.

Si_3Cl_8 (g). Guinchant[4, 5] reported $V=-12.1^{213}$.

SiS_2 (c). Sabatier[1] measured the heat of the reaction SiS_2 (c) $+2H_2O$ (liq.) $=SiO_2$ (colloid, aq.) $+2H_2S$ (g), finding $Q^{9.5}=38.8$ and 54.0, respectively, for white and yellow SiS_2.

Si_3N_4 (c). Hincke and Brantley,[1] from their equilibrium data on the reaction, Si_3N_4 (c) $=3Si$ (c) $+2N_2$ (g), computed $Q^{1600}=-176.3$, which gives $Qf=157$. Matignon[10, 13] measured the equilibrium $3SiO_2$ (c) $+6C$ (amorphous) $+2N_2$ (g) $=Si_3N_4$ (c) $+6CO$ (g), and computed, with the aid of the Nernst equation, $Q=-203$, whence, for Si_3N_4 (c), $Qf=230$.

$(NH_4)_2SiF_6$ (aq.). Truchot[3] found $Q=31.2^{20}$ for the reaction SiF_4 (g) $+2NH_4F$ (aq.) $=(NH_4)_2SiF_6$ (aq.).

$(NH_4)_2SiF_6$ (c). Truchot[3] measured the heat of solution.

$(C_2H_5O)_4Si$ (liq.) Ogier[1] measured the heat of hydrolysis of this substance to be 21.6.

$(CH_3O)_4Si$ (g). Kahlenberg and Koenig[1] reported $V=-7.08^{121}$.

SiC (c). von Wartenberg and Schutte[1] measured the heat of the reaction of gaseous fluorine with silicon carbide to be 491.3, from which we find $Qf=30$. The data of Mixter[5] yield for the reactions, SiC (c) $+4Na_2O_2$ (c) $=Na_2SiO_3$ (gls.) $+Na_2CO_3$ (c) $+2Na_2O$ (c) and Si (c) $+2Na_2O_2$ (c) $=Na_2SiO_3$ (gls) $+Na_2O$ (c), $Q=365\,9$ and 234.6, respectively. The difference gives for SiC (c) $+2Na_2O_2$ (c) $=Si$ (c) $+Na_2CO_3$ (c) $+Na_2O$ (c), $Q=131.3$, from which, for SiC (c), $Qf=0.2$. The vapor pressure data of Ruff and Konschak[1] yield the approximate value, $Qf=25$. The equilibrium data of Baure and Brunner[1] yield the estimated value 36. Ruff and Grieger[1] measured the heats of the reactions studied by Mixter[5] (see above) and found $Q=375.1$ and 259.3, respectively. The differences give, for SiC (c) $+2Na_2O_2$ (c) $=Si$ (c) $+Na_2CO_3$ (c) $+Na_2O$ (c), $Q=115.8$, from which, for SiC (c), $Qf=15.7$.

GERMANIUM

Ge (c). Standard state.

Ge (g). We have estimated the heat of sublimation to be -85. The energy states of monatomic gaseous germanium are evaluated from the data of Rao,[4] Gartlein,[1] Lang,[1] and Rao and Narayan.[2]

GeO_2 (colloid, aq.). We have estimated $Qf=230$.

$GeCl_4$ (liq.). Roth and Schwartz[1] measured the heat of solution of this substance in water to be 25, whence, for $GeCl_4$ (liq.), $Qf = 226.1$.

$GeCl_4$ (g). The vapor pressure data of Nilson and Petterson[1] yield -9.2^{86} for the heat of vaporization of the liquid.

Ge_2H_6 (g). Dennis, Corey, and Moore[1] reported $V = -6.3^{29}$.

Ge_3H_8 (g). Dennis, Corey, and Moore[1] reported $V = -7.6^{111}$.

TIN

Sn (c). The three solid forms of tin are: I, rhombic, white; II, tetragonal, white; III, cubic, gray. The transition temperatures are respectively 161° and 18°. We have selected Sn (c, II, tetragonal) as the standard state. For the heat of transition of III to II, the data are: Brönsted,[6] −0.53; Cohen,[3] −0.73; Meyer,[1] −1.13. For the heat of transition from II to I, Werner[2] reported −0.002.

Sn (liq.). The data on the heat of fusion of tin at the melting point, 232°, are: Awbery and Griffiths,[1] −1.73; Iitaka,[1] −1.59; Umino,[3] −1.69; Person,[2] −1.69; Rudberg,[1] −1.58; Mazzotto,[3] −1.61; Spring,[1] −1.74; Guinchant,[5] −1.70; Pionchon,[1] −1.73; Robertson,[1] −1.66.

Sn (g). Vapor pressure data on liquid tin were obtained by Ruff and Bergdahl,[1] Greenwood,[2, 3, 5, 6] van Liempt,[2] von Wartenberg,[9] and Harteck.[1] The data are discordant. We have taken −75 as the best value for the heat of vaporization of the liquid and have assumed the vapor to be monatomic.

Values for the energy states of monatomic gaseous Sn are taken from the following: Bach,[3] Green and Loring,[1] Narayan and Rao,[1] Randall and Wright,[1] Carroll,[1] Rao,[1] Gibbs and White,[2] Gibbs and Vieweg,[1] Lang,[2] and Rao, Narayan, and Rao.[1]

SnH_4 (liq.). From vapor pressure data, Paneth, Haken, and Rabinowitsch[1] computed $V = -4.55^{-150}$.

SnO_2 (c, III). For the heat of combustion of tin to form SnO_2, the data are: Dulong,[2] 145; Andrews,[14] 136; Mixter,[7] 137.8; Moose and Parr,[1] 138.8. From data on the entropies of SnO_2, Sn, and O_2, and the free energy of formation of SnO_2, Millar[5] computed, for SnO_2 (c, III), $Qf = 137.8$.

SnO_2 (c, I), SnO_2 (c, II). Laschtschenko[1] found the heats of transition of III to II and II to I to be -0.45^{430} and -0.30^{540}, respectively.

SnO (c). For the heat of oxidation of SnO to form SnO_2, the data are: Mixter,[7] 70.4; Andrews,[14] 69.6; Dulong,[2] 71. Using Mixter's value of 70.4, we have computed, for SnO, $Qf = 67.7$. Equilibrium measurements involving SnO were made by Maeda,[1] Fraenkel and Snipischski,[1] Rosenhain,[1] and Eastman and Robinson.[1]

$SnCl_2$ (aq. HCl). Thomsen[15] measured the heat of the reaction, $SnCl_2$ (aq. HCl) + Zn (c) = $ZnCl_2$ (aq. HCl) + Sn (c), finding $Q = 33.0$, 33.5, 33.0, 33.2, 30.2, 30.5, 28.9, and 30.9. Disregarding the four low values, we have computed, for $SnCl_2$ (aq. HCl), $Qf = 81.5$.

$SnCl_2$ (c). The data on the heat of solution are: Thomsen,[15] 0.35; Biltz and Fischer,[2] 0.8; Berthelot,[50] 0.40.

$SnCl_2 \cdot 2H_2O$ (c). The data on the heat of solution are: Thomsen,[15] -5.29_{200}; Berthelot,[131] -5.26.

$SnCl_2$ (g). For the heat of vaporization of stannous chloride, Maier[6] reported -21.1 at 623°.

$SnCl_4$ (aq. HCl). Thomsen's[15] data on the reaction, $SnCl_2$ (aq. HCl) $+HCl$ (aq.) $+HClO$ (aq) $=SnCl_4$ (aq HCl) $+H_2O$ (liq.), yield $Q=74.97$; whence, for $SnCl_4$ (aq. HCl), $Qf=157.34$. Thomsen[15] also measured the heat of oxidation of $SnCl_2$ (aq. HCl) with aqueous HIO_3 and with aqueous H_2O_2. His data yield, $Q=155.50$ and 88.74, respectively; whence, for $SnCl_4$ (aq. HCl), $Qf=157.66$ and 158.1. The last value is not given great weight because the reaction involving H_2O_2 may not be clear cut. Berthelot[26] measured the heat of the reaction $SnCl_2$ (aq. HCl) $+Cl_2$ (g) $=SnCl_4$ (aq. HCl). His data yield $Q=76.0$; whence, for $SnCl_4$ (aq. HCl), $Qf=157.5$.

$SnCl_4$ (liq.). Thomsen[15] found the heat of solution of liquid stannic chloride to be 29.92[20]; Berthelot[50] found 28.5.

$SnCl_4$ (c). Latimer[1] measured the heat of fusion to be -2.20[33].

$SnCl_4$ (g). The heat of vaporization of liquid stannic chloride was measured by Kahlenberg and Koenig,[1] Hammick,[1] and Andrews.[10] Vapor pressure data were obtained by Regnault,[6] Mundel,[1] and Young.[2] For the heat of vaporization, Andrews[10] found -8.0 and Hammick[1] -8.5; Young[2] calculated -9.0.

$Sn(OH)_2$ (c). Thomsen[15] reported $Q=24.72$ for the reaction, $SnCl_2$ (aq) $+2NaOH$ (aq.) $=2NaCl$ (aq) $+Sn(OH)_2$ (c). This gives, for the freshly precipitated stannous hydroxide, $Qf=136.1$.

$Sn(OH)_4$ (c). Thomsen[15] reported $Q=51\,87$ for the reaction, $SnCl_4$ (aq.) $+4NaOH$ (aq.) $=4NaCl$ (aq.) $+Sn(OH)_4$ (c). This gives, for the freshly precipitated stannic hydroxide, $Qf=268\,9$.

$SnBr_2$ (c). By means of "double decomposition" or "reciprocal pair" experiments Berthelot[50] found, for $SnCl_2$ (c) $+2KBr$ (aq.) $=SnBr_2$ (c) $+2KCl$ (aq.), $Q=2.20$; whence, for $SnBr_2$ (c), $Qf=61.4$.

$SnBr_2$ (aq.). The data on the heat of solution of $SnBr_2$ (c) are: Berthelot,[50] 1 6; Biltz and Fischer,[2] 1.6.

SnI_2 (c). In a manner similar to that for stannous bromide, Berthelot[50] found, for $SnCl_2$ (c) $+2KI$ (aq.) $=SnI_2$ (c) $+2KCl$ (aq.), $Q=4.0$; whence, for SnI_2 (c), $Qf=38.9$.

SnI_2 (aq.). Mosnier[1] found the heat of solution of SnI_2 (c) to be 0.61.

H_2SnF_6 (aq.). For the reaction, $SnCl_4$ (aq. HCl) $+6HF$ (aq.) $=(H_2SnF_6+4HCl)$ (aq.), Thomsen[15] found $Q=17.6$. This gives, for H_2SnF_6 (aq.) $Qf=470.4$.

SnF_6^{--} (aq.). Assuming the heat of neutralization of aqueous H_2SnF_6 to be the same as that for H_2SiF_6, 26.6, we have computed, for SnF_6^{--}(aq.), $Qf=469.8$.

$SnBr_4$ (c). Berthelot[50] measured the heat of mixing $SnCl_4$ (liq.) with

4KBr (aq.), and of $SnBr_4$ (c) with 4KCl (aq.), to be 28.1 and 16.8, respectively. The difference gives, for $SnCl_4$ (liq.) + 4KBr (aq.) = $SnBr_4$ (c) + 4KCl (aq.), $Q = 11.3$, from which we have computed, for $SnBr_4$ (c), $Qf = 94.8$.

$SnBr_4$ (aq.). For the heat of solution of solid stannic bromide the data are: Berthelot,[50] 17.6_{800}[10]; Pickering,[12] 15.54_{1000}[15]. Using the value 15.5, one finds, for $SnBr_4$ (aq.), $Qf = 110.3$. Herschkowitsch[2] measured the heat of solution of tin in a saturated aqueous solution of $KBr + Br_2$, to form $SnBr_4$ (aq.), to be 110.2.

$SnBr_4$ (liq.). The data on the heat of fusion of solid stannic bromide are: Tolloczko,[1] −2.74; Garelli,[1] −2.84; Raoult,[1] −3.14; Berthelot,[50] −3.10; Pickering,[12] −2 97.

$SnBr_4 \cdot 8H_2O$ (c). Pickering[12] measured the heat of solution.

$SnBr_4 \cdot 8H_2O$ (liq.). Pickering[12] measured the heat of fusion of the solid octahydrate.

SnS (c). There are no calorimetric data on this substance. The equilibrium data of Jellinek and Zakowsky[1] yield, for SnS (c) + H_2 (g) = Sn (liq.) + H_2S (g), $Q = -20.0$; whence, for SnS (c), $Qf = 22.7$.

$Sn(SO_4)_2$ (c). Beck[1] found $Q = 91.1$ for the heat of reaction between this substance and 8KOH (aq.). Assuming the reaction, $Sn(SO_4)_2$ (c) + 4KOH (aq.) = $2K_2SO_4$ (aq.) + $Sn(OH)_4$ (c), we have computed, for $Sn(SO_4)_2$ (c), $Qf = 391.1$.

$SnCl_4 \cdot 1\frac{1}{2} PH_3$ (c). Holtje[1] reported $Q = 17.6$ for the heat of the reaction, $SnCl_4$ (liq.) + $1\frac{1}{2}$ PH_3 (g) = $SnCl_4 \cdot 1\frac{1}{2}$ PH_3 (c).

Sn_nBi_m (c). From data on the heats of solution in mercury, Magnus and Mannheimer[1] determined the heats of formation of the solid alloys, SnBi, $SnBi_2$, Sn_2Bi, Sn_5Bi, and $SnBi_5$.

$SnX_2 \cdot nNH_3$ (c). Biltz and Fischer[2] measured the dissociation pressures at various temperatures for some stannous halide ammines, and also determined the heats of solution of some of them in aqueous HCl. Their data are as follows: $SnCl_2 \cdot 2\frac{1}{2} NH_3$ (c), $S = 14.0$; $SnCl_2 \cdot 4NH_3$ (c), $D = -9\,3$; $SnCl_2 \cdot 9NH_3$ (c), $D = -7.6$; $SnBr_2 \cdot NH_3$ (c), $S = 7.3$; $SnBr_2 \cdot 3NH_3$ (c), $D = -12.5$, $S = 14.8$; $SnBr_2 \cdot 5NH_3$ (c), $D = -9.8$; $SnBr_2 \cdot 9NH_3$ (c), $D = -7\,55$; $SnI_2 \cdot NH_3$ (c), $D = -16.0$; $SnI_2 \cdot 2NH_3$ (c), $D = -13.3$, $S = 6.5$; $SnI_2 \cdot 3NH_3$ (c), $D = -11.9$, $S = 14.8$; $SnI_2 \cdot 5NH_3$ (c), $D = -10.2$; $SnI_2 \cdot 9NH_3$ (c), $D = -7.9$.

LEAD

Pb (c, non-radioactive). Standard state.

Pb (solid, "stick" form). From data on the electromotive force of cells involving lead in both the crystalline and the "stick" form, Gerke[1] found for the transition from the former to the latter $Q = -0.07$.

Pb (liq.). The data on the heat of fusion of lead are: Umino,[3] −1.14; Iitaka,[1] −1.14; Robertson,[2] −1.34; Magnus and Oppenheimer,[1] −1.224; Awbery and Griffiths,[1] −1.295; Person,[10] −1.13; Mazzotto,[3] −....; Glaser,[2] −1.01; Spring,[1] −1.10; Klinkhardt,[1] −1.21.

Pb (g). von Wartenberg[9] showed that lead vapor is monatomic above 1870°. The vapor pressure data of Harteck,[1] von Wartenberg,[7, 9] Greenwood,[2, 3, 5, 6] Ruff and Bergdahl,[1] Rodebush and Dixon,[1, 2] Egerton,[3, 4] and Rodebush[1] yield −45 for the heat of vaporization. See also Hildebrand,[2] Johnson,[5] and van Leimpt.[2] From direct but rough measurements, Tate[1] found $V=-37$.

The energy states of gaseous monatomic lead are evaluated from the following: Bacher and Goudsmit,[1] Back,[2] Gieseler and Grotrian,[1, 2] McLennan, Young, and McLay,[1] Sponer,[2] Sur,[2, 3] Thorsen,[1, 2] Geiseler,[1] Rão and Narayan,[4] Smith,[9] Rao, Narayan, and Rao,[1] and Carroll.[1]

$PbCl_2$ (c). The electromotive force data of Gerke[1] on the cells in which the reactions are: $Pb\ (c)+2AgCl\ (c)=PbCl_2\ (c)+2Ag\ (c)$ and $Pb\ (c)+2HgCl\ (c)=PbCl_2\ (c)+2Hg\ (liq.)$, when combined with his own data on the formation of AgCl (c) and HgCl (c), yield, for $PbCl_2$ (c), $Qf=85.71$ and 85.95, respectively. The data of Krahmer,[1] Brönsted,[1] Gunther,[1] Wolff,[2] and Getman[2] are in accord with the lower of these values.

$PbCl_2$ (aq.). The data on the heat of solution of lead chloride in water are: Thomsen,[15] −3.44; Berthelot,[9] −4.0; Bronsted,[4] −3.28.

$PbCl_2$ (liq.). The data on the heat of fusion of lead chloride are: Ehrhardt,[1] −5.8; Weber,[1] −5.61; Rudberg,[1] −5.81; Goodwin and Kalmus,[1] −5.15.

$PbCl_2$ (g). The vapor pressure data of von Wartenberg and Bosse,[1] Jellinek and Rudat,[2] Jellinek and Golubowski,[1] Eastman and Duschak,[1] and Maier[6] yield −28.5 for the heat of vaporization of the liquid at 860°.

PbO (c, red). For the heat of the reaction, $PbO\ (c, red)+H_2\ (g)=Pb\ (c)+H_2O\ (liq.)$, the data of Smith and Wood[1] give 15.91, and those of Fried[1] give 16.6. These values yield, for PbO (c), $Qf=52.46$ and 51.8 respectively. From electromotive force measurements Treadwell[1] computed the heat of formation to be 50.4 at high temperatures. Combination of Thomsen's[15] data on the two reactions, $PbO\ (c)+2HNO_3(200)=Pb(NO_3)_2(400)+H_2O\ (liq.)$ and $Pb(NO_3)_2(400)+2KCl(200)=2KNO_3(400)+PbCl_2\ (c)$, yield for the reaction, $PbO\ (c)+2HNO_3(200)+2KCl(200)=2KNO_3(400)+H_2O\ (liq.)+PbCl_2\ (c)$, $Q=22.22$. From this we have computed, for PbO (c), $Qf=52.91$. Marshall and Bruzs[1] measured the heat of solution of PbO in 10 per cent aqueous nitric acid to be 19.8.

$Pb(NO_3)_2$ (aq.). Thomsen[15] measured the heat of the reaction, $PbO\,(c)+2\,HNO_3(200)=Pb(NO_3)_2(400)+H_2O(liq.)$, and his data yield $Q=17.76$, whence, for $Pb(NO_3)_2(400)$, $Qf=100.05$. It is probable that Thomsen used the yellow form of PbO, in which case the value for aqueous lead nitrate would be a little less than that given above. For the reaction, $Pb(NO_3)_2(400)+2\,KCl(200)=PbCl_2\ (c)+2\,KNO_3(400)$, Thomsen[15] reported $Q=4.46$, from which we have computed, for $Pb(NO_3)_2(400)$, $Qf=100.50$. For the similar reaction with aqueous KI, Thomsen[15]

reported $Q=13.79$. This yields, for $Pb(NO_3)_2(400)$, $Qf=99.80$. Thomsen[15] measured the heat of dilution of aqueous lead nitrate.

$Pb(NO_3)_2$ (c). The data on the heat of solution of lead nitrate are: Thomsen,[15] -7.61_{400}; Favre and Silbermann,[3] -7.93; Tammann and Krings,[1] -8.49. See also Berthelot.[10]

$PbSO_4$ (c, II). Thomsen[15] measured the heats of the reactions, $Pb(NO_3)_2(400)+H_2SO_4(400)=PbSO_4\ (c)+2\ HNO_3(400)$, $Pb(C_2H_3O_2)_2(400)+H_2SO_4(400)=PbSO_4\ (c)+2HC_2H_3O_2(400)$, and $Pb(NO_3)_2(400)+Na_2SO_4(400)=PbSO_4\ (c)+2\ NaNO_3(400)$. His data yield $Q=5.40$, 7 58, and 1.70, respectively; whence, for $PbSO_4$ (c), we have computed $Qf=218\ 30$, 218.80, and 218.36. From electromotive force measurements, Klein[1] computed $Q=-2.48$ for the reaction, $PbCl_2\ (c)+K_2SO_4(100)=PbSO_4\ (c)+2\ KCl(50)$, whence, for $PbSO_4$ (c), $Qf=219.99$. Combination of the electromotive force data of Henderson and Stegeman[1] with those of Gerke[1] yield, for $Pb\ (c)+Hg_2SO_4\ (c)=PbSO_4\ (c)+Hg$ (liq.), $Q=42.17$; whence, for $PbSO_4$ (c), $Qf=217\ 8$. See also Ishikawa.[4]

$PbSO_4$ (c, I). Hare[1] measured the heat of transition.

PbO_2 (c). Tscheltzow[1] measured the heats of the reactions, $PbO_2\ (c)+SO_2\ (g)=PbSO_4\ (c)$ and $PbO_2\ (c)+(2\ HgNO_3+4\ HNO_3)\ (aq)=Pb(NO_3)_2+Hg(NO_3)_2(aq)+2\ H_2O$ (liq.), and his data yield $Q=82.62$ and 31.85, respectively; whence, for PbO_2 (c), $Qf=64.9$ and 63.2. Vosburgh and Craig[1] measured the electromotive force at various temperatures of the cell in which the reaction is $PbO_2\ (c)+2\ Hg\ (liq)+2\ H_2SO_4(50)=Hg_2SO_4\ (c)+PbSO_4\ (c)+2\ H_2O$ (liq), and computed $Q=44.73$ at 25°. This gives, for PbO_2 (c), $Qf=64\ 18$. Millar[5] computed the entropy of PbO_2 (c) from his data on heat capacities at low temperatures, and utilizing the equilibrium data of Glasstone and Westcott[1] on the reactions, $PbO_2\ (c)+H_2\ (g)=PbO\ (c)+H_2O$ (liq.) and $PbCl_2\ (c)+Cl_2\ (g)+2\ H_2O$ (liq.) $=PbO_2\ (c)+4\ HCl\ (g)$, computed, for PbO_2 (c), $Qf=65\ 96$. Mixter[8] measured the heats of the reactions, $Pb\ (c)+2\ Na_2O_2\ (c)=Na_2PbO_3\ (c)+Na_2O\ (c)$ and $PbO_2\ (c)+Na_2O\ (c)=Na_2PbO_3\ (c)$, finding $Q=63.6$ and 38.44, respectively. The difference gives, for $Pb\ (c)+2\ Na_2O_2\ (c)=PbO_2\ (c)+2\ Na_2O\ (c)$, $Q=25\ 16$; whence, for PbO_2 (c), $Qf=64\ 7$. There is an old value for the heat of formation of lead peroxide obtained by Hess.[7]

Pb_3O_4 (c). The equilibrium, $2\ Pb_3O_4\ (c)=6\ PbO\ (c)+O_2\ (g)$, was studied by LeChatelier[2] and by Reinders and Hamburger.[1] From the data of the former, Biltz[8] deduced $Q=-32\ 2$, while the latter gave $Q=-33.5$. These values yield, for Pb_3O_4 (c), $Qf=173\ 5$ and 174.1, respectively. For the heat of the reaction, $3\ PbO_2\ (c)=Pb_3O_4\ (c)+O_2\ (g)$, Debray[2] gave $-23\ 8$, which yields, for Pb_3O_4 (c), $Qf=171.2$. See also Henglein.[1] From his own data on the heat capacity down to low temperatures, and from the electromotive force data of Glasstone,[1] Millar[5] computed, for Pb_3O_4 (c), $Qf=172.4$.

Pb_2O (c). For the heats of solution of Pb_2O (c) and PbO (c) in aqueous acetic acid, Herschkowitsch[1] found 16.71 and 15.50, while

Aufenast and Terry[1] found 15.26 and 15.6, respectively. These data yield, for Pb_2O (c), $Qf = 51.3$ and 52.8, respectively.

$Pb(OH)_2$ (c). The heat of neutralization of $Pb(OH)_2$ (c) with aqueous nitric acid was measured by Berthelot,[5] Sveda,[1] Herschkowitsch,[1] Tanatar,[6] and Aufenast and Terry.[1] Their data yield, for $Pb(OH)_2$ (c), $Qf = 122.7$.

PbF_2 (c). Guntz[1] found 2 2 for the heat of reaction of aqueous lead nitrate with aqueous hydrofluoric acid. This gives for PbF_2 (c), $Qf = 159.5$. From equilibrium data, Jellinek and Rudat[1] calculated $Qf = 156$.

PbF_2 (g). The vapor pressure data of von Wartenberg and Bosse[1] yield -39.4 for the heat of sublimation at 1200°.

$PbCl_2 \cdot n PbO$ (c). Andre[1] measured the heats of solution in aqueous HCl of $PbCl_2 \cdot PbO$ (c), $PbCl_2 \cdot 2\,PbO$ (c), and $PbCl_2 \cdot 3\,PbO$ (c). The last named substance may probably be just a mixture, not a true compound.

$PbBr_2$ (c). Thomsen[15] found $Q = 8.02$ for the reaction, $Pb(NO_3)_2(200) + 2\,KBr(100) = 2\,KNO_3(200) + PbBr_2$ (c), whence, for $PbBr_2$ (c), $Qf = 66.58$. Krahmer[1] gave $Q = -17.96$ for the reaction, Pb (c) $+ 2\,AgBr$ (c) $= 2\,Ag$ (c) $+ PbBr_2$ (c); whence, for $PbBr_2$ (c), $Qf = 64.58$. Klein[1] reported $Q = 3.56$ for the reaction, $PbCl_2$ (c) $+ 2\,KBr$ (aq.) $= PbBr_2$ (c) $+ 2\,KCl$ (aq.); whence, for $PbBr_2$ (c), $Qf = 67.6$. Equilibrium data involving lead bromide were reported by Jellinek and Rudat[1] and Lorenz and Schultz.[1]

$PbBr_2$ (aq.). Thomsen[15] measured the heat of solution of lead bromide.

$PbBr_2$ (liq.). The data on the heat of fusion are: Weber,[1] -5.01; Goodwin and Kalmus,[1] -4.52. See also Erhardt[1] and Czepinsky.[1]

$PbBr_2$ (g). The vapor pressure data of von Wartenberg and Bosse[1] yield -28 for the heat of vaporization at 916°.

$PbBr_2 \cdot n PbO$ (c). Andre[1] measured the heats of solution in aqueous HBr of $PbBr_2 \cdot PbO$ (c), $PbBr_2 \cdot 2\,PbO$ (c), and $PbBr_2 \cdot 3\,PbO$ (c).

PbI_2 (c). The data of Gerke[1] on the cell reaction, Pb (c) $+ I_2$ (c) $= PbI_2$ (c), yield, for PbI_2 (c), $Qf = 41.77$. See also Braune and Koref,[1] who reported $Qf = 41.6$.

PbI_2 (liq.). For the heat of fusion of lead iodide, Ehrhardt[1] found -5.28 at 375° and Czepinski[2] -5.28.

PbI_2 (g). The vapor pressure data of Jellinek and Rudat[1] yield -27.7 for the heat of vaporization at 800°.

$PbI_2 \cdot HI \cdot 5\,H_2O$ (c). Berthelot[69] measured the heat of solution of this substance.

PbS (c). Berthelot[14] found the heats of reaction of aqueous hydrogen sulfide to be 13.34 and 11.34 with aqueous lead nitrate and aqueous lead acetate, respectively; whence, for PbS (c), $Qf = 24.8$ and 20.6, respectively. Thomsen[15] found $Q = 30.98$ for the reaction between aqueous lead nitrate and aqueous sodium sulfide; whence, for PbS (c), $Qf = 22.5$. From equilibrium data, Jellinek and Zakowski[1] deduced $Qf = 20.0$; Watanabe[2] obtained 22.85; Jellinek and Deubel,[1] 26.2.

$PbSO_4 \cdot nPbO$ (c). There has been a long polemic concerning the nature of the successive reactions occurring in the roasting of lead sulfate with lead sulfide, between Reinders[1, 2, 3, 4] on the one hand and Schenck and coworkers (Schenck and Rassback,[1, 2] Schenck and Borkenstein,[1] Schenck and Albers[1]) on the other. See also Hofmann and Wanjukow.[1] According to Schenck and coworkers, the reactants for the various equilibrium curves are: $PbSO_4 + PbS$; $PbSO_4 \cdot PbO + PbS$; $PbSO_4 \cdot 2\,PbO + PbS$; $PbSO_4 \cdot 3\,PbO + PbS$; $PbO + PbS$. This interpretation leads to the following values for the heats of formation: $PbSO_4 \cdot PbO$ (c), 280; $PbSO_4 \cdot 2\,PbO$ (c), 340; $PbSO_4 \cdot 3\,PbO$ (c), 398; PbO (c), 57. According to Reinders the reactants are: $PbSO_4 + PbS$; $PbSO_4 \cdot PbO + Pb$; $PbSO_4 \cdot 2\,PbO + Pb$; $PbSO_4 \cdot 3\,PbO + Pb$; $PbO + PbS$. This interpretation yields the following values for Qf: $PbSO_4 \cdot PbO$ (c), 280; $PbSO_4 \cdot 2\,PbO$ (c), 338; $PbSO_4 \cdot 3\,PbO$ (c), 369; PbO (c), 51. In spite of the high value for PbO, we have accepted Schenck's as the more logical explanation of the equilibrium data obtained.

$PbSO_4 \cdot 2\,HCl$ (c). Ephraim[7] studied the dissociation pressure of this substance.

PbS_2O_3 (c). Fogh[1] found $Q = 5.80$ for the reaction between aqueous lead acetate and aqueous sodium thiosulfate to form an insoluble white product which was presumably lead thiosulfate. Hence, for PbS_2O_3 (c), $Qf = 151.1$.

PbS_3O_6 (c). Fogh[1] measured the heat of solution.

$PbS_2O_6 \cdot 4\,H_2O$ (c). Thomsen[15] measured the heat of solution.

PbSe (c). Fabre[1] found $Q = 40.1$ for the reaction of aqueous lead acetate with gaseous hydrogen selenide; whence, for PbSe (c), $Qf = 21.2$, For the heat of solution of crystalline lead selenide in saturated bromine water to form lead selenate Fabre[1] found 92.1; whence, for PbSe (c), $Qf = 10$.

$PbSeO_4$ (c). Metzner[2] found $Q = 0.62$ for the reaction of aqueous lead nitrate with aqueous sodium selenate; whence, for $PbSeO_4$ (c), $Qf = 148.6$.

PbTe (c). Fabre[3] found 104.5 for the heat of solution of solid lead telluride in saturated bromine water. These data yield, for PbTe (c), $Qf = 19.1$ or 6.0, depending upon whether tellurate or tellurite was formed. Fabre[3] said that the product was tellurite, but in another experiment he found that tellurium dissolved under the same conditions to form tellurate.

PbN_6 (c). Wohler and Martin[1] measured the heat of decomposition by explosion into solid lead and gaseous nitrogen to be 103.0.

$Pb(NO_3)_2 \cdot PbO$ (c). Thomsen's[15] data on the reaction between aqueous lead nitrate and aqueous sodium hydroxide yield, for $Pb(NO_3)_2 \cdot PbO$ (c), $Qf = 167.6$.

$PbX_2 \cdot nNH_3$ (c). Biltz and Fischer[1] measured at various temperatures the dissociation pressures of the ammines of $PbCl_2$ with 1, 1½, 2, 3½, and 8 moles of NH_3, of $PbBr_2$ with 1, 2, 3, 5½, and 8 moles of NH_3, and of PbI_2 with ½, 1, 2, 5, and 8 moles of NH_3. See also Ephraim.[10]

$2\,PbCl_2 \cdot NH_4Cl$ (c). Brönsted[8] determined, from electromotive force measurements, the heat of formation of this substance from solid lead chloride and solid ammonium chloride to be 0.35.

$3\,PbI_2 \cdot 4\,NH_4I \cdot nH_2O$ (c). Mosnier[1] measured the heat of solution of the anhydrous salt and the hexadecahydrate.

$PbSO_4 \cdot (NH_4)_2SO_4$ (c). Barre[1] found $Q = 1.93$ for the heat of formation of this substance from solid lead sulfate and solid ammonium sulfate.

$PbHPO_3$ (c). Amat[1] found $Q = 0\,65$ for the heat of mixing Na_2HPO_3 (aq.) with $Pb(NO_3)_2$ (aq.).

$SnI_2 \cdot PbI_2 \cdot nH_2O$ (c). Mosnier[1] measured the heats of solution of the anhydrous salt and the octahydrate.

$3\,PbI_2 \cdot SbI_3 \cdot nH_2O$ (c). Mosnier[1] measured the heats of solution of the anhydrous salt and the dodecahydrate.

$3\,PbI_2 \cdot PI_3 \cdot nH_2O$ (c). Mosnier[1] measured the heats of solution of the anhydrous salt and the dodecahydrate.

$3\,PbI_2 \cdot AsI_3 \cdot nH_2O$ (c). Mosnier[1] measured the heats of solution of the anhydrous salt and the dodecahydrate.

$3\,PbI_2 \cdot BiI_3 \cdot nH_2O$ (c). Mosnier[1] measured the heats of solution of the anhydrous salt and the dodecahydrate.

$PbCO_3$ (c). Thomsen[15] found 6.11 for the heat of the reaction, $Pb(NO_3)_2(200) + Na_2CO_3(200) = PbCO_3$ (c) $+ 2\,NaNO_3(200)$; whence, for $PbCO_3$ (c), $Qf = 169\,8$. Berthelot[12] found 5 04 and 5 72 for the above reaction with sodium and potassium carbonates respectively. Berthelot[12] believed the reaction took place in two steps: the formation of amorphous lead carbonate and then its crystallization. He deduced 4.2 for the heat of crystallization. Marshall and Bruzs[1] measured the heat of solution of $PbCO_3$ (c) in 10 per cent aqueous nitric acid to be 1.69, whence for $PbCO_3$ (c), $Qf = 168.0$.

$PbCO_3 \cdot nPbO$ (c). Marshall and Bruzs[1] measured the heat of solution in 10 per cent aqueous nitric acid of $PbCO_3 \cdot PbO$ (c) to be 8.69. From equilibrium data, Centnerswer, Falk, and Awerbuch[1] calculated: for $3\,PbO$ (c) $+ CO_2$ (g) $= PbCO_3 \cdot 2\,PbO$ (c), $Q = 25$; for $PbCO_3 \cdot PbO$ (c) $+ CO_2$ (g) $= 2\,PbCO_3$ (c), $Q = -19.8$; and for $2\,(PbCO_3 \cdot 2\,PbO)$ (c) $+ CO_2$ (g) $= 3\,(PbCO_3 \cdot PbO)$ (c), $Q = 23$.

PbC_2O_4 (c). Berthelot[12] measured the heat of reaction between aqueous lead nitrate and aqueous potassium oxalate to be 9.3.

$Pb(C_2H_3O_2)_2$ (aq.). The data of Thomsen[15] yield for the reactions, Zn (c) $+ Pb(C_2H_3O_2)_2(400) = Zn(C_2H_3O_2)_2(400) + Pb$ (c), and PbO (c) $+ 2\,HC_2H_3O_2(200) = Pb(C_2H_3O_2)_2(400) + H_2O$ (liq.), $Q = 34.90$ and 15.46, respectively. From the known values for the other substances we have obtained, for $Pb(C_2H_3O_2)_2(400)$, $Qf = 236.0$ and 235.6, respectively. The data of Herschkowtisch[1] and Aufenast and Terry[1] yield for the second reaction above $Q = 15\,50$ and 15.6, respectively; whence, for $Pb(C_2H_3O_2)_2$ (aq.), $Qf = 235.7$ and 235.8.

$Pb(C_2H_3O_2)_2$ (c). Berthelot[9] measured the heat of solution.

$Pb(C_2H_3O_2)_2 \cdot 3\,H_2O$ (c). The data on the heat of solution are: Berthelot,[9] -5.5_{220}[11]; Favre and Silbermann,[3] -4.9; Thomsen,[15] -6.14_{200}.

$Pb(C_2H_3O_2)_2 \cdot PbO$ (c). Thomsen's[15] data yield, for this substance, $Qf = 292.9$.

$Pb(CHO_2)_2$ (aq.). Berthelot[9] found 13.2 for the heat of neutralization of solid lead hydroxide with aqueous formic acid.

$Pb(CHO_2)_2$ (c). Berthelot[9] measured the heat of solution of lead formate.

$Pb(C_2H_3O_3)_2$ (aq.). de Forcrand[3] measured the heat of reaction of aqueous lead glycollate with aqueous hydrogen sulfide to be 11 5.

$Pb(C_2H_3O_3)_2$ (c). deForcrand[3] measured the heat of solution of lead glycollate.

$Pb(CN)_2 \cdot 2\,PbO \cdot H_2O$ (c). Joannis[1] measured the heat of solution of this substance in aqueous nitric acid to be 36.8.[19].

$Pb(CNS)_2$ (c). Joannis[1] measured the heat of mixing aqueous lead acetate with aqueous potassium sulfocyanide to be 7.4.

PbSn (c). Magnus and Mannheimer[1] found the heat of formation of PbSn (c) to be 0.03 by measuring the heats of solution in mercury.

$PbSn_n$ (liq.). Magnus and Mannheimer[1] measured the heat of mixing the two liquid metals.

$PbSb_n$ (liq.). Guthrie and Libmans[1] discussed the data of Wust and Durrer[1] on the heat of mixing the liquid metals. See also Dobereiner[1] and Taylor.[3]

Gallium

Ga (c). Standard state.

Ga (g). We have estimated the heat of sublimation to be -52. The somewhat uncertain vapor pressure data of Harteck[2] yield $-50.^{900}$ The values for the various energy states of gaseous monatomic gallium are from the following: first spectra, Uhler and Tanch,[1] Paschen and Meissner[1]; second spectra, Sawyer and Lang,[1] Lang,[1] and Rao, Narayan, and Rao[1]; third spectra. Lang[1]; fourth spectra, Mack, LaPorte and Lang.[1]

$GaCl_3$ (aq.). Schwarz von Bergkampf[1] measured the heat of solution of Ga (c) in HCl (9) to be 32. We have estimated the value for the dilute solution.

Ga_2O_3 (c). Roth and Becker[3] determined the heat of formation of this oxide by combustion of gallium in oxygen to be 255 8.

Ga^{+++} (aq.). This value is obtained from that for aqueous gallium chloride.

Indium

In (c). Standard state.

In (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic indium are from the following: first spectra, Paschen and Meissner,[1] Uhler and Tanch[1]; second spectra, Lang and Sawyer[1]; third spectra, Rao, Narayan, and Nao.[1] See also Bacher and Goudsmit.[1]

In_2O_3 (c). Ditte[6] measured the heat of combustion of indium.

$InCl_3$ (aq.). Klemm and Brautigam[1] measured the heat of reaction of In (c) with Cl_2 (aq.).

In^{+++} (aq.). The value for this substance is obtained from those for $InCl_3$ (aq.) and Cl^- (aq.).

$InBr_3$ (aq.), InI_3 (aq.). The values for these substances are obtained from those for the ions.

InCl (c), $InCl_2$ (c). Klemm and Brautigam[1] measured the heats of reaction of these substances, respectively, with aqueous chlorine to form aqueous $InCl_3$.

$InCl_3$ (c), $InBr_3$ (c), InI_3 (c). Klemm[1] measured the heats of solution of these substances in HCl (21).

$InX_3 \cdot nNH_3$ (c). Klemm[1] measured the heats of solution in HCl (22) of the following: NH_3 (g), 12.3; $InCl_3 \cdot NH_3$ (c), 15.4; $InCl_3 \cdot 2\,NH_3$ (c), 15.8; $InCl_3 \cdot 3\,NH_3$ (c), 16 8; $InCl_3 \cdot 5\,NH_3$ (c), 34.4; $InBr_3 \cdot 3\,NH_3$ (c), 17.3; $InBr_3 \cdot 5\,NH_3$ (c), 30.8; $InBr_3 \cdot 7\,NH_3$ (c), 54.6; $InI_3 \cdot 2\,NH_3$ (c), 14 0; $InI_3 \cdot 5\,NH_3$ (c), 27.7; $InI_3 \cdot 7\,NH_3$ (c), 46.4. Klemm[1] also determined from dissociation pressure data the heats of dissociation of the following: $InCl_3$ with 1, 2, 3, 5, 7, and 15 moles of NH_3; $InBr_3$ with 5, 6, and 15 moles of NH_3; InI_3 with 1, 9, and 15 moles of NH_3.

Thallium

Tl (c, II). Standard state.

Tl (c, I). The heat of transition at 226° was determined by Bridgman,[7, 8] Werner,[2] and Umino.[1]

Tl (liq.). The data on the heat of fusion of thallium yield the following values: Heycock and Nevilles,[1] −1.05; Robertson,[1] −1.47; Richards and Smyth,[1] −1.52; Lewis and Randall,[4] −1.45; Roos,[1] −1.52. See also Umino.[1]

Tl (g). We have assumed that gaseous thallium is monatomic. Vapor pressure data were reported by Gibson,[1] Krafte and Knocke,[1] von Wartenberg,[9] and Fischer and Geiger[1] (see Sherman[1]). These data yield values for the heat of sublimation ranging from −28 to −45. Butkow[1] and Butkow and Terenin[1] reported −81 for the heat of reaction TlI (g) = Tl (g) + I* (g); whence, for Tl (g), $Qf = -35\,9$. Similar data on TlCl (g) and TlBr (g) yield, for Tl (g), $Qf = -41.9$ and −37.5, respectively. The values of Mayer[2] for the lattice energies of TlCl, TlBr, and TlI yield, for Tl (g), $Qf = -38.6$, −43.4, and $-40\,2$.

The values for the energy states of gaseous monatomic thallium are from Fowler,[3] McLennan, McLay, and Crawford,[1] Carroll,[1] and Smith.[5]

Tl_2SO_4 (aq.). Thomsen[15] measured the heats of solution of Tl (c, II) and of Tl_2SO_4 (c) in $H_2SO_4(50)$, and of Tl_2SO_4 (c) in water. His data yield for $Tl_2SO_4(1600)$, $Qf = 213.7$. Data on the heat of dilution of aqueous thallous sulfate were reported by Thomsen[15] and deForcrand.[71]

Tl_2SO_4 (c). The data on the heat of solution in water are: Cohen and Kooy,[1] $-7.94_{3200}{}^{20}$; Thomsen,[15] -8.28_{1600}. See also Ishikawa.[1, 2]

TlOH (aq.). Thomsen[15] measured the heat of neutralization of 2 TlOH(200) with H_2SO_4(400) to be 31.12_{800}. See also deForcrand.[71]

Tl_2O_3 (c). From equilibrium studies, Duncan[2] computed $Q^{1000} = -77$ for the reaction Tl_2O_3 (liq.) = Tl_2O (liq.) + O_2 (g). From these data we have estimated, for Tl_2O_3 (c), $Qf = 120$. See also Roth and Becker.[3]

TlOH (c). Thomsen[15] found $S = -3.15$. See also Aufenast and Terrey.[1]

Tl_2O (c). Thomsen[15] found $S = -3.08$, whence, for Tl_2O (c), $Qf = 42.3$. From equilibrium data, Bahr[1] computed $Q = -14.1$ for the reaction, 2 TlOH (c) = Tl_2O (c) + H_2O (g); whence, for Tl_2O (c), $Qf = 42.0$.

TlCl (c). The accurate electromotive force data of Gerke[1] yield for, TlCl (c), $Qf = 48.62$. Combination of the data of Thomsen[15] on the heat of neutralization of TlOH (aq.) with HCl (aq.) and the heat of solution of TlCl (c), yields, for the latter, $Qf = 48\ 95$. See also Blaszkewska.[1]

TlCl (aq.). The data on the heat of solution of TlCl (c) are: Thomsen,[15] −10.0; Butler and Hiscock,[1] −10.56.

TlCl (liq.). Roos[1] reported -3.95^{430} for the heat of fusion.

TlCl (g). The vapor pressure data of von Wartenberg and Bosse[1] yield $-25\ 2^{806}$ for the heat of vaporization; whence, for TlCl (g), $Qf = 16.4$.

TlF (aq.). de Forcrand[69] measured the heats of solution of Tl_2O (c) and TlOH (c) in HF(600) to be 28.33^{13} and 25.21^{13}, respectively. Petersen[1] measured the heat of neutralization of TlOH(400) with HF(400) to be 16.44. These data yield, for TlF(800), $Qf = 76.8$ and 77.5, respectively. If excess HF (aq.) was present in de Forcrand's experiments, the value from his data should be increased by 0.58.

TlF (c). There are no data on the heat of solution of thallous fluoride.

TlF (g). The vapor pressure data of von Wartenberg and Bosse[1] yield -25.1^{298} for the heat of vaporization.

TlBr (c). Thomsen[15] measured the heat of reaction of Tl_2SO_4 (aq.) with KBr (aq.), his data yielding, for TlBr (c), $Qf = 41.48$.

TlBr (liq.). Roos[1] reported $F = -3.6^{450}$. See also Mellor.[1]

TlBr (g). The vapor pressure data of von Wartenberg[1] yield -25.2^{817} for the heat of vaporization, whence, for TlBr (g), $Qf = 9.5$.

TlI (c). Thomsen's[15] data on the reaction of Tl_2SO_4 (aq.) with HI (aq.) yield, for TlI (c), $Qf = 31.16$. The electromotive force data of Jones and Schumb[1] yield $Qf = 29.2$, but there may be some doubt concerning the reaction.

TlI (g). The vapor pressure data of von Wartenberg and Bosse[1] yield $V = -25.3^{818}$, whence, for TlI (g), $Qf = -0.6$. See also Terenin.[1]

$TlNO_3$ (aq.). For the heat of neutralization of TlOH (aq.) with HNO_3 (aq.), Thomsen[15] found $Q = 13.70$, whence, for $TlNO_3$ (aq.), $Qf = 48.2$.

$TlNO_3$ (c, III). Thomsen[15] found $S = -10.0$.

$TlNO_3$ (c, II). Bridgman[6a] reported, for the transition III to II, $T = -0.24^{75}$.

$TlNO_3$ (c, I). Bridgman[6a] reported, for the transition II to I, $T = -0.76^{145}$.

TlN_3 (c). Wohler and Martin[1] found the heat of decomposition of thallium azide to be 54.7.

Tl_2S (c). Thomsen[15] and Sabatier[1] reported the same value, 33.7, for the heat of the reaction, $2\,TlNO_3(200) + Na_2S(200) = Tl_2S\ (c) + 2\,NaNO_3(300)$.

$TlC_2H_3O_2$ (aq.). de Forcrand[69] found 13.99 for the heat of neutralization of TlOH (aq.) with aqueous acetic acid; whence, for aqueous thallous acetate, $Q = 117.4$. From the ions, we have obtained $Qf = 117.0$.

Tl_2Se (c). Fabre[6] measured the heat of reaction between aqueous thallous acetate and gaseous H_2Se to be 41.2, and the heat of solution of Tl_2Se (c) in bromine water to be 143.5. These data yield, for Tl_2Se (c), $Qf = 20.6$ and 11.0, respectively.

Tl_2Te (c). Fabre[6] measured the heat of solution of Tl_2Te (c) in bromine water to be 159.5; whence, for Tl_2Te (c), $Qf = 7.2$.

TlONC (c). Wohler and Martin[1] found the heat of decomposition of thallium fulminate to be 52 5, the products being CO (g), $\frac{1}{2}\,N_2$ (g), and Tl (c).

$TlX \cdot nNH_3$ (c). Biltz and Stollenwerk[1] determined the heats of dissociation of the triammines of TlCl, TlBr, and TlI.

$Tl_2SO_4 \cdot 10NH_3$ (c). Ephraim and Millman[1] reported $D = -13.3$, but the products are not known.

TlC_2H_5O (C_2H_5OH). de Forcrand[71, 71a] computed $Q = -10.4$ for the reaction, $Tl\ (c) + C_2H_5OH\ (liq.) = TlC_2H_5O\ (C_2H_5OH) + \frac{1}{2}\,H_2\ (g)$, but the experimental data were not reported.

$TlBr_3$ (aq.). Thomsen[15] reported $Q = 36.50$ for the reaction, $TlBr_3$ (aq.) + $SO_2(200)$ = TlBr (c) + 2 HBr(200) + $H_2SO_4(300)$; whence, for $TlBr_3$ (aq.), $Qf = 58.1$.

Tl^{+++} (aq.). The value for this substance is obtained from those for $TlBr_3$ (aq.) and Br^- (aq.).

$TlX_3 \cdot nH_2O$ (c). Thomas[1] measured the following heats of solution: $TlCl_3$, 8.43_{300}; $TlCl_3 \cdot 4\,H_2O$ (c), -2.12_{300}; $TlBr_3 \cdot 4\,H_2O$ (c), -2.25_{500}; $TlBr_2Cl \cdot 4\,H_2O$ (c), -2.90_{300}.

Zinc

Zn (c). Standard state. Laschtschenko[9] reported a transition in solid zinc at 320° with $T = -0.19$, but modern evidence points to but one form of crystalline zinc.

Zn (liq.). The data on the heat of fusion of zinc at its melting point, 419°, are: Mazzotto,[1] −1.83; Glaser,[1] −1.73; Iitaka,[1] −1.50; Wust,[1] −1.85; Person,[2] −1.79; Awbery and Griffiths,[1] −1.74; Umino,[3] −1.54; Heycock and Neville,[2] −1.85. See also Richards[1] and Laschtschenko.[8]

Zn (g). According to the vapor density data of Biltz[7] and von Wartenberg,[3] gaseous zinc is practically monatomic. The vapor pressure

data of Barnes,[1, 2] Richards,[2] Ruff and Bergdahl,[1] Braunes,[1] Deckert,[1] Greenwood,[3, 6] Rodebush and Dixon,[1] Egerton,[1] and Jenkins[3] yield −27.4 for the heat of sublimation, and −25.9 for the heat of vaporization, at 18°. Millar[1] computed −27.2 for the heat of sublimation. The direct calorimetric measurements of Whnelt and Muscelleanii,[1] Muscelleanii,[1] and Tate[1] yield −26.3 for the heat of vaporization.

The energy states of gaseous monatomic zinc are from Saunders,[1] Sawyer and Beese,[1] Wolff,[1] Fowler,[3] Sahs.[1] Fues,[1] Kayser and Runge,[2] and Paschen.[1, 2, 3, 5]

Zn_2 (g). The spectroscopic data of Winans[2] yield $D^z = -5.67$. See also Mrozowski.[1]

$ZnCl_2$ (aq.). The following are the data on the heat of the reaction, Zn (c) + 2 HCl (n) = $ZnCl_2$ ($2n$) + H_2 (g): Richards and Thorvaldson,[1] HCl(200), $Q = 36.25$; Richards, Rowe, and Burgess,[7] HCl(200), $Q = 36.6$; Thomsen,[15] HCl(100), $Q = 34\ 20$; Hess,[10] $Q = 34.9$; Favre and Silbermann,[3] $Q = 33$; Richards and Thorvaldson,[1] HCl(20), $Q = 32.79^{20}$; Maier,[5] HCl(20), $Q = 32.19$; Sieverts and Gotta,[2] HCl(20), $Q = 31.1^{19}$; Hablutzel,[1] HCl(20), $Q = 31.5$; Biltz and Wagner,[1] HCl(20), $Q = 30.06$; Sieverts and Gotta,[3] HCl(20), $Q = 30.28$; Biltz and Hohorst,[1] HCl(20), $Q = 30.15$; Sommermeier,[1] HCl(20), $Q = 30.43$; Biltz and Hohorst,[1] HCl(8), $Q = 33.55$. The heat of dilution of aqueous zinc chloride was measured by Thomsen,[15] and computed from vapor pressure-temperature data by Fricke and Havestadt.[1]

$ZnSO_4$ (aq.). Thomsen[15] measured the heats of the reactions, $ZnSO_4$ (400) + $BaCl_2$ (400) = $BaSO_4$ (c) + $ZnCl_2$ (800) and H_2SO_4 (400) + $BaCl_2$ (400) = $BaSO_4$ (c) + 2 HCl (400), to be 5.50 and 9.15, respectively. The difference gives $Q = -3\ 65$ for the reaction, $ZnSO_4$ (400) + 2 HCl (400) = H_2SO_4 (400) + $ZnCl_2$ (800); whence, for $ZnSO_4$ (400), $Qf = 251.95$. de Forcrand[8] measured the heat of solution of zinc in aqueous sulfuric acid and his data yield, for $ZnSO_4$ (200), $Qf = 247$. See also Ditte[5] and Hess.[10] The heat of dilution of aqueous zinc sulfate was measured by Thomsen,[15] Berthelot,[5] and de Forcrand.[8]

$ZnSO_4$ (c). The data on the heat of solution of zinc sulfate in water are: Thomsen,[15] 18.54_{400}; Mees,[1] $18\ 27_{400}$.

$ZnSO_4 \cdot nH_2O$ (c). Thomsen[15] found the heat of solution of the monohydrate to be −10 0. (He also gave values for the tri- and tetrahydrates but the heat of solution-composition curve shows no breaks at these points to indicate definite hydrates.) For the hexahydrate, Thomsen[15] found $S = -0.84$. For the heptahydrate, the heat of solution data are: Thomsen,[15] -4.28_{400}; Mees,[1] -4.26_{400}; Favre and Silbermann,[3] −3.76. The dissociation pressure data of Frowein,[1] Muller and Erzback,[4] and Rolla and Accame[1] yield the following results: $ZnSO_4 \cdot 7\ H_2O$ (c) = $ZnSO_4 \cdot 6\ H_2O$ (c) + H_2O (g), $Q = -13.26$; $ZnSO_4 \cdot 6\ H_2O$ (c) = $ZnSO_4$ H_2O (c) + 5 H_2O (g), $Q = 5\ (-13.36)$; $ZnSO_4 \cdot H_2O$ (c) = $ZnSO_4$ (c) + H_2O (g), $Q = -15.2$. See also Foote and Scholes,[1] Lescoeur,[1] Wiedemann,[1] and Ishikawa and Murooka.[1] From electromotive force measure-

ments, Cohen and Inouye[1] found $Q = 3.605^{39}$ for the reaction $ZnSO_4 \cdot 7\,H_2O$ (c) $= ZnSO_4 \cdot 6\,H_2O$ (c) $+ H_2O$ (aq. satd. soln.).

Zn^{++} (aq.). We have obtained the value for this substance from those for $ZnCl_2$ (aq.) and $ZnSO_4$ (aq.). See also Getman and Gibbons[1] and Latimer.[2]

ZnO (c). The heat of solution of unfused zinc oxide in aqueous hydrochloric acid was measured by Favre and Silbermann,[3] Hess,[10] Maier,[5] Parks, Hablutzel, and Webster,[1] and Maier, Parks, and Anderson.[1] Apparently, the heat of solution of unfused zinc oxide is independent of the manner of its preparation. These data yield, for ZnO (c, unfused), $Qf = 83.5$. Ditte,[5] de Forcrand[8,9,40,41,42] and Marignac[1] measured the heat of solution of zinc oxide in aqueous sulfuric acid. Their data yield, for ZnO (c, unfused), $Qf = 83.7$, and for ZnO (c, fused), $Qf = 85.5$. See also Woods,[1] Berthelot,[141, 142] and Theis.[1] Parr and Moose[1] measured the heat of combustion of zinc to form fused zinc oxide to be 85.2. See also the old values of Dulong,[1] Andrews,[14, 15] and Despretz.[2]

ZnH (g). The energy of dissociation of gaseous zinc hydride, in the normal state, into gaseous zinc and hydrogen atoms, each in the normal state, was reported by Fukuda[1] and Bengtsson and Hulthen[1] from their spectroscopic data. The values for the higher energy states of gaseous ZnH are taken from the foregoing authors and from Grundstrom.[1]

$Zn(OH)_2$ (c, ppt.). Thomsen[15] measured the heat of reaction of aqueous zinc sulfate with aqueous barium hydroxide and aqueous potassium hydroxide, and his data yield for $Zn(OH)_2$ (c, ppt.), $Qf = 155.3$. de Forcrand[8] measured the heat of solution of $Zn(OH)_2$ (c, ppt.) in $H_2SO_4(200)$ to be 18.9, which gives $Qf = 155.3$. See also Mixter.[11]

$Zn(OH)_2$ (c, not ppt.). The electromotive force data of Maier, Parks, and Anderson[1] yield for this substance $Qf = 155.84$, but the cell reaction may be somewhat uncertain.

$Zn(OH)_2 \cdot H_2O$ (c, ppt.). de Forcrand[8] measured the heat of solution of this substance in $H_2SO_4(200)$.

$ZnO_2 \cdot 2\,H_2O$ (c). de Forcrand[8] measured the heat of solution in $H_2SO_4(200)$.

$Zn_3O_5 \cdot nH_2O$ (c). de Forcrand[8] measured the heats of solution of the di- and trihydrates in $H_2SO_4(200)$.

ZnF_2 (aq.). Petersen[1] measured the heat of the reaction of aqueous zinc chloride with solid silver fluoride to be 31.84. Mulert[1] measured the heat of solution of ZnO in aqueous (20%) HF to be 21.82. See also Jellinek and Rudat.[1]

$ZnCl_2$ (c). The data on the heat of solution of solid zinc chloride in water are: Thomsen,[15] 15.72_{400}; Pickering,[8] $15\,22_{400}$; Baud,[1] 15.89_{400}[15]; Ishikawa and Murooka,[1] 16.71_{400}. See also Andrews[16] and Favre and Silbermann.[3] The use of Thomsen's value yields, for $ZnCl_2$ (c), $Qf = 99.6$. The data of Klemm and Brautigam,[1] who measured in an ice calorimeter the heats of solution of Zn (c), Cl_2 (g), and $ZnCl_2$ (c), in aqueous (33%) KBr containing excess liquid Br_2, yield, for $ZnCl_2$ (c), $Qf = 99.8$. The

electromotive force data of Foxton and Shutt,[1] on the cell in which the reaction was Zn (c) + Cl_2 (g) = $ZnCl_2$(11.11), give $Q^{70} = 105.4$.

$ZnCl_2(C_2H_5OH)$. Pickering[8] measured the heat of solution of zinc chloride in ethyl alcohol.

$ZnCl_2 \cdot nZnO \cdot n'H_2O$ (c). Andre[1] measured the heats of solution of $ZnCl_2 \cdot 3\,ZnO \cdot 5\,H_2O$ (c), $ZnCl_2 \cdot 4\,ZnO \cdot 11\,H_2O$ (c), $ZnCl_2 \cdot 5\,ZnO\ 8\,H_2O$ (c), and $ZnCl_2 \cdot 8\,ZnO \cdot 10\,H_2O$ (c).

$ZnBr_2$ (aq.). The value for this substance is obtained from those for the ions, and by analogy with $ZnCl_2$ (aq.).

$ZnBr_2$ (c). The data on the heat of solution of zinc bromide are: Thomsen,[15] 15.02_{400}; Andre,[1] 13.8[5]. The use of Thomsen's value gives, for $ZnBr_2$ (c), $Qf = 78\,3$. From electromotive force data, Ishikawa and Yoshida[1] computed, for $ZnBr_2$ (c), $Qf = 78.47$. See also Czepinski[2] and Andrews.[3]

$ZnBr_2 \cdot 4\,ZnO \cdot 13\,H_2O$ (c). Andre[1] measured the heat of solution.

ZnI_2 (aq.). The value for this substance is obtained from those for the ions, and by analogy with $ZnCl_2$ (aq.), to be 62 3 for ZnI_2(600). Webb[1,2] measured the heat of solution of zinc in iodine water to form ZnI_2(650), and computed, for the latter, $Qf = 61.4$.

ZnI_2 (c). Webb[1, 2] measured the heat of solution of zinc iodide in water to be 11.6_{650}, whence, for ZnI (c), $Qf = 49.8$. See also Andrews.[2] Mosnier[1] found $S = 11.4$. Webb's[1, 2] data on the cell in which ZnI_2 (c) was formed from its elements gave $Qf = 49.90$. Similar data by Ishikawa and Shibata[1] yield $Qf = 51.2$.

$ZnI_2 \cdot 5\,ZnO \cdot 11H_2O$ (c). Tassilly[1] measured the heat of solution in aqueous HI to be 115.6.

ZnI (g). Sponer[4] estimated $D^z = -46$, from spectroscopic data, for the dissociation into gaseous normal zinc and iodine atoms. Wieland[1] reported a value for the energy of the excited state of gaseous ZnI.

$Zn(C_2H_3O_2)_2$ (aq.). Thomsen[15] measured the heat of the reaction of aqueous barium acetate and zinc sulfate, $Ba(C_2H_3O_2)_2$(200) + $ZnSO_4$ (200) = $BaSO_4$ (c) + $Zn(C_2H_3O_2)_2$(400), to be 4.61; whence, for $Zn(C_2H_3O_2)_2$(400), $Qf = 270.9$. Berthelot[5] measured the heat of reaction of aqueous zinc acetate with aqueous sodium hydroxide to be 10.8. See also Favre and Silbermann.[3] The heat of dilution of aqueous zinc acetate was measured by Thomsen.[15] See also Berthelot.[5]

ZnS (c). Thomsen[15] measured the heat of reaction of aqueous zinc sulfate with aqueous sodium sulfide, his data yielding, for ZnS (c, ppt.), $Qf = 44.3$. The data of Mixter,[15] who measured in a bomb calorimeter the reaction of ZnS with Na_2O_2, yield, for ZnS (c, zinc blende), $Qf = 41.3$. See also Berthelot[14] and Jellinek and Zakowsky.[1]

ZnS_2O_4 (aq.). Berthelot measured the heat of oxidation with oxygen of an aqueous solution containing zinc, sodium, and, presumably, hydrosulfite ions, to be 67.8.

$ZnS_2O_6 \cdot 6\,H_2O$ (c). Thomsen[15] measured the heat of solution.

ZnSe (c). Fabre[3] measured the heat of reaction of aqueous zinc ace-

tate with gaseous H_2Se and aqueous Na_2Se to be 23.3 and 32.7, respectively, whence, for ZnSe (c), $Qf=39.6$ and 34.6. Fabre[3] also measured the heat of the reaction of zinc selenide with water and bromine to be 100.0; whence, for ZnSe (c), $Qf=33.4$.

ZnTe (c). Fabre[3] measured the heat of the reaction of zinc telluride with water and bromine, and his data yield, for ZnTe (c), $Qf=33$.

ZnN_6 (c). Wohler and Martin[1] measured the heat of decomposition of zinc azide into Zn (c) and $3\,N_2$ (g) to be 50.8.

$Zn(NO_3)_2$ (aq.). Thomsen[15] measured the heat of reaction of $Zn(OH)_2$ (c, ppt.) with aqueous nitric acid to form $Zn(NO_3)_2(400)$, to be 19.83. The heat of dilution of aqueous zinc nitrate was measured by Thomsen.[15] We have extrapolated the values to $3\,H_2O$.

$Zn(NO_3)_2 \cdot nH_2O$ (c). Thomsen[15] measured the heat of solution of hexahydrate. Morgan and Owens[1] determined the heat of fusion of the trihydrate.

$ZnF_2 \cdot 2\,H_2O \cdot nNH_3$ (c). Biltz and Ralphs[2] reported $Q=2\frac{1}{2}$ (11.2) for the dissociation, $ZnF_2 \cdot 2\,H_2O \cdot 3\,NH_3\,(c) = ZnF_2 \cdot 2\,H_2O \cdot \frac{1}{2}\,NH_3\,(c) + 2\frac{1}{2}\,NH_3\,(g)$.

$ZnX_2 \cdot nNH_3$ (c). Biltz and Messerknecht[1] obtained dissociation pressure-temperature data on the ammines of $ZnCl_2$ with 1, 2, 4, 6, and $10\,NH_3$, on those of $ZnBr_2$ with 1, 2, 4, and $6\,NH_3$, and on those of ZnI_2 with 1, 2, 4, and $6\,NH_3$. Ephraim[9] obtained similar data on the hexammines of $ZnCl_2$ and $ZnBr_2$. Isambert[5] measured the heat of solution of the decammine of $ZnCl_2$ in aqueous HCl; Biltz and Messerknecht[1] those of the di-, tetra- and hexammines of $ZnCl_2$; Tassilly[1] those of the tetrammines of $ZnBr_2$ and ZnI_2 and the diammine of ZnI_2.

$Zn(XO_3)_2 \cdot nNH_3$ (c.). Ephraim and Jahnsen[1] obtained dissociation pressure data on $Zn(ClO_3)_2 \cdot 4\,NH_3$ (c), $Zn(ClO_3)_2 \cdot 6\,NH_3$ (c), and $Zn(IO_3)_2 \cdot 4\,NH_3$ (c). Ephraim and Bolle[1] obtained similar data on the tetra- and hexammines of zinc chlorate.

$Zn(ClO_4)_2 \cdot 6\,NH_3$ (c.). Ephraim and Bolle[1] measured the dissociation pressures.

$Zn(NO_3)_2 \cdot nNH_3$ (c.). Ephraim and Bolle[1] measured the dissociation pressure at various temperatures of the tetra- and hexammines of zinc nitrate.

$Zn(C_2H_3O_2)_2 \cdot 2\,NH_3$ (c.). Ephraim and Bolle[1] measured the dissociation pressures.

$Zn(NO_2)_2 \cdot NH_3$ (c.). Ephraim and Bolle[1] measured the dissociation pressures.

$ZnSO_3 \cdot 3\,NH_3$ (c.). Ephraim and Bolle[1] measured the dissociation pressures.

$ZnS_2O_6 \cdot 4\,NH_3 \cdot H_2O$ (c.). Ephraim and Bolle[1] obtained dissociation pressure data.

$Zn(CNS)_2 \cdot nNH_3$ (c.). Ephraim and Bolle[1] obtained dissociation pressure data on the tetra- and hexammines of Zn $(CNS)_2$.

$ZnS_2O_6 \cdot 5\,NH_3$ (c.). Ephraim and Bolle[1] obtained dissociation pressure data.

$ZnS_4O_6 \cdot 5\,NH_3$ (c.). Ephraim and Bolle[1] measured the dissociation pressures.

$ZnS_2O_3 \cdot 5\,NH_3$ (c.). Ephraim and Bolle[1] measured the dissociation pressures.

$Zn(CHO_2)_2 \cdot 5\,NH_3$ (c.). Ephraim and Bolle[1] measured the dissociation pressures.

$ZnC_2O_4 \cdot 5\,NH_3$ (c.). Ephraim and Bolle[1] measured the dissociation pressures.

$ZnCl_2 \cdot 5\,NH_3 \cdot H_2O$ (c.). Andre[1] measured the heat of solution in HCl(100).

$ZnCl_2 \cdot 2\,NH_3 \cdot \frac{1}{4}\,H_2O$ (c.). Andre[1] measured the heat of solution in HCl(100).

$ZnCl_2 \cdot 8\,NH_4Cl \cdot ZnO$ (c.). Andre[1] measured the heat of solution in HCl(100).

$3\,ZnCl_2 \cdot 6\,NH_4Cl \cdot H_2O$ (c.). Andre[1] measured the heat of solution in HCl(100).

$3\,ZnCl_2 \cdot ZnO \cdot 10\,NH_4Cl$ (c.). Andre[1] measured the heat of solution.

$6\,ZnCl_2 \cdot ZnO \cdot 12\,NH_3$ (c.). Andre[1] measured the heat of solution.

$ZnSO_4 \cdot n NH_3$ (c.). The values for the ammines of zinc sulfate with $\frac{1}{2}$, 1, 2, 3, 4, and $5\,NH_3$ are taken from the work of Ephraim[8, 10] and Ephraim and Bolle.[1]

$Zn(NH_4)_2(SO_4)_2 \cdot n H_2O$ (c.). Graham[2] measured the heat of solution of the hexahydrate. Caven and Ferguson[2] measured the dissociation pressures of the system containing the hexahydrate, dihydrate, and water vapor.

$Zn(NH_4)_2(SeO_4)_2 \cdot 6\,H_2O$ (c.). Caven and Ferguson[2] measured the dissociation pressure to the dihydrate.

$Zn(C_2H_5)_2$ (liq.). Guntz[9] measured the heat of solution of liquid zinc ethyl in aqueous sulfuric and hydrochloric acids to be 79.8 and 78.0, respectively. Correcting for the heat of mixing gives, for $Zn(C_2H_5)_2$ (liq.), $Qf = 10.0$.

$ZnC_2O_4 \cdot 2\,H_2O$ (c). Berthelot[10] reported the heat of the reaction, $Zn(OH)_2(c) + H_2C_2O_4\,(aq.) = ZnC_2O_4 \cdot 2\,H_2O$ (c), to be $Q = 25.0$. This was derived from his unpublished figures on the reaction between zinc sulfate and potassium oxalate.

$ZnCO_3$ (c). Berthelot's[12] data on the heats of reaction of aqueous zinc sulfate with aqueous sodium carbonate and aqueous potassium carbonate yield, for $ZnCO_3$ (c), $Qf = 192.4$ and 194.2.

$Zn(CHO_2)_2$ (aq.). Berthelot[9, 131] reported a value for the heat of neutralization of formic acid with zinc hydroxide.

$Zn(CHO_2)_2$ (c). Berthelot[9, 131] measured the heat of solution of zinc formate.

$Zn(CHO_2)_2 \cdot 2\,H_2O$ (c). Berthelot[9, 131] measured the heat of solution of the dihydrate.

$Zn(C_2H_3O_2)_2$ (c). Berthelot[9, 131] measured the heat of solution of zinc acetate.

$Zn(C_2H_3O_2)_2 \cdot nH_2O$ (c). Berthelot[9, 131] measured the heats of solution of the mono- and dihydrates.

$Zn(C_2H_3O_3)_2$ (aq.). de Forcrand[3] measured the heat of reaction of zinc sulfate with barium glycollate.

$Zn(C_2H_3O_3)_2 \cdot nH_2O$ (c). de Forcrand[3] measured the heats of solution of the anhydrous zinc glycollate and of the dihydrate.

$Zn(CN)_2$ (c). Joannis[1] and Berthelot[114] measured the heat of precipitation of zinc cyanide. We have used the data of Joannis.

$Zn(CN)_4^{--}$ (aq.). Berthelot measured the heat of solution of $Zn(CN)_2$ (c) in aqueous KCN to be 8.6.

$ZnSiO_3$ (c). Mulert[1] measured the heat of solution in aqueous 20% HF.

Zn_2SiO_4 (gls.). Mulert[1] measured the heat of solution in aqueous 20% HF.

Zn_2SiO_4 (c). Mulert[1] measured the heat of solution in aqueous 20% HF.

$ZnSn_n$ (c). Herschowitsch[2] computed the heats of formation of the solid alloys, $ZnSn_2$, $ZnSn_{0.6}$, $ZnSn_{0.21}$, and $ZnSn_{0.1}$, from his data on heats of solution in bromine water. See also Magnus and Mannheimer.[1]

$2ZnI_2 \cdot PbI_2$ (c). Mosnier[1] measured the heat of solution.

Cadmium

Cd (c). The hexagonal form is taken as the standard state. Getman[1] found $T = -0.055$ for the transition from II to I at 37.5°. Cohen and Heldermann,[1, 3] reported a transition from III to II at 18° with $T = -0.74$, but the X-ray and other data of Getman[1] can not be reconciled to the existence of a third form of cadmium.

Cd (liq.). The data on the heat of fusion of cadmium at its melting point, 321°, are: Umino,[3] −1.45; Wust, Meuthen and Durrer,[1] −1.23; Person,[1] −1.54; Richards,[1] −1.48; Johnston and Adams,[2] −1.54; Roos,[2] −1.49.

Cd (g). Vapor pressure data for cadmium were reported by Maier,[3] Egerton,[1] Jenkins,[3] Barus,[1, 2] Ruff and Bergdahl,[1] Braune,[1] Fogler and Rodebush,[1] Bennewitz,[1] and Weber.[1] By direct measurement, Wehnelt and Muscelleanii[1] obtained the value −20.4 for the heat of vaporization of liquid cadmium. Calculations of the heat of vaporization were made by Johnston,[6] van Liempt,[2] Hildebrand,[2] Millar,[1] and Maier.[3] Maier's[3] equation yields, for Cd (g), $Qf = -26.8$. The vapor density data of Biltz[7] and Deville and Troost[1] indicate that gaseous cadmium is practically monatomic, as do the entropy calculations of Tolman,[1] Fogler and Rodebush,[1] and Lange and Simon.[1]

The energy states of gaseous monatomic cadmium are evaluated from the work of Fowler,[3] Fues,[1] and Salis.[1]

Cd_2 (g). The spectroscopic data of Winans[1, 2] gave $D^z = -5$, while

the later work of Kuhn and Arrhenius[1] gave $D^{\circ} = -46$. See also Mrozowski.[2]

$CdCl_2$ (aq.). The data on the heat of solution of Cd (c) in 2HCl(200) are: Thomsen,[15] 17.61; Richards, Rowe, and Burgess,[1] 17.12; Richards and Tamaru,[1] 17.15. Data on the heat of dilution of aqueous cadmium chloride were obtained by Thomsen.[15] The value, $Q = -0.062$, reported by Cohen and Bruins[3] for the dilution from 9.192 to 400 H_2O seems unreasonable.

$CdCl_2$ (c). The data on the heat of solution of cadmium chloride are: Cohen and Bruins,[3] 3.09_{400}; Thomsen,[15] 3.01_{400}; Pickering,[6] 3.39_{400}; Berthelot,[69] 3.0; Agostini,[2] 2.07_{500}'. See also Lorenz and Hering,[2] Lorenz and Fox,[1] and Weber.[1]

$CdCl_2$ (liq.). Weber[1] found $F = -10.5^{566}$.

$CdCl_2 \cdot H_2O$ (c). Pickering[6] found $S = 0.62$. Thomsen[15] reported $S = 0.76$ for a dihydrate, but undoubtedly his sample was the monohydrate.

$CdCl_2 \cdot 2\frac{1}{2}\ H_2O$ (c). Cohen and Bruins[3] found $S = -2.94_{400}$; Pickering[6] reported $S = -2.29$ for a dihydrate, but his sample must have been largely the hydrate with $2\frac{1}{2}\ H_2O$. The former value yields, for $CdCl_2 \cdot 2\frac{1}{2}\ H_2O$ (c), $Qf = 269.93$. Electromotive force data on the cell reaction, Cd (c) + $PbCl_2$ (c) + $2\frac{1}{2}\ H_2O$ (satd. soln.) = $CdCl_2 \cdot 2\frac{1}{2}\ H_2O$ (c) + Pb (c), were obtained by Vosburg[1] and Taylor and Perrott.[1] The latter investigators also obtained data on the analagous cells with AgCl (c) and HgCl (c). These data yield, respectively, for $CdCl_2 \cdot 2\frac{1}{2}\ H_2O$ (c), $Qf = 270.02$, 269.90, 269.42, and 269.58. The values from the cell with lead chloride are probably the best. See also Getman.[3]

$CdCl_2 \cdot 4H_2O$ (c). Worobiew[1] reported $Q = -0.76$ for the heat of congruent melting of the tetrahydrate.

$CdCl_2 \cdot 2HCl \cdot 7H_2O$ (c). Berthelot[69] measured the heat of solution.

$CdCl_2 \cdot CdO \cdot H_2O$ (c). Tassilly[1] measured the heat of solution.

$CdSO_4$ (aq.). Thomsen[15] found $Q = 5.74$ for the heat of the reaction of $CdSO_4$(200) with $BaCl_2$(200); whence, for $CdSO_4$(200), $Qf = 232.70$. Holsboer[1] measured the heat of dilution of aqueous cadmium sulfate. See also von Steinwehr,[1] Ishikawa,[2] and Ishikawa and Murooka.[1]

$CdSO_4$ (c). For the heat of solution, Thomsen[15] found 10.74_{400}; Cohen, Helderman, and Moesveld,[1] 10.69_{400}.

$CdSO_4 \cdot H_2O$ (c). Thomsen[15] measured the heat of solution.

$CdSO_4 \cdot 2\frac{2}{3}\ H_2O$ (c). The data on the heat of solution are: Thomsen,[15] 2.66_{400}; Cohen, Helderman, and Moesveld,[1] 2.54_{400}; Holsboer,[1] 2.67. See also Kohnstamm and Cohen[1] and Carpenter and Jette.[1]

$CdSO_4 \cdot 2\frac{1}{2}\ H_2O$ (c). Matignon[18] measured the heat of solution.

CdS_2O_6 (aq.). Thomsen[15] measured the heat of the reaction of BaS_2O_6(400) with $CdSO_4$(400) to be 5.60.

Cd^{++} (aq.). Extrapolation to infinite dilution of the values for $CdCl_2$ (aq.) and for $CdSO_4$ (aq.) yield for, $Cd^{++}(\infty)$, $Qf = 17.1$ and 17.6,

respectively. The latter value is probably the more accurate on account of the less uncertain extrapolation. See also Latimer.[2]

CdO (c). For the heat of combustion of cadmium to form CdO (c), Moose and Parr[1] found the value 65.2, Mixter[15] found 64.2. Mixter's[15] data on the reaction of Cd (c) with Na_2O_2 (c) yield, for CdO (c), $Qf=60$, but this value is not as accurate as the directly measured ones.

Cd_4O (c). Tanatar[7] claimed to have formed this substance, and measured its heat of solution to be 16.9 and 13 9 in aqueous H_2SO_4 and aqueous HCl, respectively.

CdH (g). The values for the energies of dissociation and excitation of gaseous CdH are from the works of Bengtsson and Hulthen,[1] Svensson,[2] and Bengtsson and Rydberg.[1]

$Cd(OH)_2$ (c). Thomsen[15] measured the heats of the reactions, $CdSO_4(400)+Ba(OH)_2(400)=Cd(OH)_2(c)+BaSO_4(c)$ and $CdSO_4(400)+2KOH(200)=Cd(OH)_2(c)+K_2SO_4(800)$, to be 13.07 and 7.07, respectively. From these data we have obtained, for $Cd(OH)_2$ (c), $Qf=133.6$. For the reaction of $CdCl_2$ (aq.) with 2KOH (aq.), Agostini[2] found $Q=5\ 66$. From electromotive force data on the cell in which the reaction was presumably Cd (c) + HgO (c) + H_2O (liq.) = Hg (liq.) + $Cd(OH)_2$(c), Maier[4] found $Q=36.4$.

CdF_2 (aq.). Petersen[3] measured the heat of the reaction of $CdCl_2$ (aq.) with 2AgF (c) to be 31.9. Mulert[1] measured the heat of solution of CdO (c) in aqueous (20%) HF to be 23.45.

$CdBr_2$ (aq.). Thomsen[15] measured the heats of reaction of $BaBr_2(200)$ with $CdSO_4(200)$ and with $H_2SO_4(200)$ to be 6.88 and 9.54, respectively; whence, for $CdBr_2(400)$, $Qf=76.17$. From direct measurement, Nernst[6] obtained, for $CdBr_2$ (aq.), $Qf=76.3$. Getman[3] obtained electromotive force data on the cell in which the reaction was $CdBr_2$ (aq., satd.) + Hg (liq.) = Cd (c) + Hg_2Br_2 (c). He found $Q=25.66$; whence, for $CdBr_2$ (aq., satd), $Qf=74.9$. See also Herschkowitsch.[2]

$CdBr_2$ (c). The data on the heat of solution are: Thomsen,[15] 0.44_{400}; Varet,[2] 0.4^{15}.

$CdBr_2$ (liq.). Weber[1] found $F=-5.0^{580}$. See also Lorenz and Fox.[1]

$CdBr_2 \cdot 4H_2O$ (c). Thomsen[15] measured the heat of solution.

$CdBr_2 \cdot CdO \cdot H_2O$ (c). Tassilly[1] measured the heat of solution in aqueous HBr.

CdBr (g). Sponer[4] estimated $D^z=-60$. Wieland[1] reported the energy of excitation.

CdI_2 (aq.). Thomsen[15] measured the heats of reaction of $BaI_2(200)$ with $CdSO_4(200)$ and with $H_2SO_4(200)$ to be 9.61 and 9.55, respectively; whence, for $CdI_2(400)$, $Qf=47.6$.

CdI_2 (c). Thomsen[15] found $S=-0.96_{400}$. Taylor and Perrott[1] measured the heats of the reaction of 2KI (aq.) with Cd (c) + I_2 (c) and with CdI_2 (c), to be 52.37 and 3.93, respectively; whence, for CdI_2 (c), $Qf=48.44$. The electromotive force data of Taylor and Perrott[1] yield, for CdI_2 (c), $Qf=48.18$ and 48.97. Similar data by Vosburg[1] yield 48.37.

See also Yoshida,[1] Cohen, Hetterschij, and Moesveld,[1] Cohen and Bruins,[1, 2, 4] and Wasastjerna.[1]

CdI_2 (liq.). We have estimated the heat of fusion.

CdI_2 (g). Schmidt and Walter[1] calculated $V = -28.7^{700}$.

CdI_2 (CH_3OH). Timofejew[2] measured the heat of solution of cadmium iodide in methyl alcohol.

CdI_2 (C_2H_5OH). Timofejew[2] measured the heat of solution in ethyl alcohol.

CdI (g). Sponer[4] estimated $D^e = -32$. Wieland[1] gave a value for the energy of excitation.

$CdI_2 \cdot CdO \cdot H_2O$ (c). Tassilly[1] measured the heat of solution in aqueous HI.

CdS (c). Thomsen[15] measured the heat of reaction of aqueous $CdSO_4$ with aqueous Na_2S, obtaining $Q = 27\,12$; whence, for CdS (c), $Qf = 34.6$. Mixter's[15] data on the reaction of CdS (c) with Na_2O_2 (c) yield $Qf = 35$. See also the equilibrium data of Jellinek and Podjaski[1] and Jellinek and Zucker.[1]

CdSe (c). Fabre[1, 2] measured the heats of the reactions, CdSe (c) + 4 Br_2 (liq.) + 4 H_2O (liq.) = ($CdBr_2$ + 6 HBr + H_2SeO_4) (aq), $CdSO_4$ (500) + Na_2Se(500) = Na_2SO_4(1000) + CdSe (c), and CdI_2(500) + H_2Se (500) = CdSe (c) + 2 HI(500), to be 100 0, 41 2, and 27.1, respectively; whence, for CdSe (c), $Qf = 17\,0$, 27 1, and 34, respectively. We have taken 25 as a very rough average.

CdTe (c). Fabre's[3] data on the reaction of CdTe (c) with bromine water yield $Qf = 16$, but this value is probably not very accurate (see CdSe (c)).

CdN_6 (c). Wohler and Martin[1] measured the heat of decomposition into Cd (c) and 3 N_2 (g) to be 106.2.

$Cd(NO_3)_2$ (aq.). Thomsen[15] measured the heat of the reaction of $Ba(NO_3)_2$(200) with $CdSO_4$(200) to be 5.13; whence, for $Cd(NO_3)_2$(400), $Qf = 115.67$.

$Cd(NO_3)_2$ (c). Malquori,[1] from equilibrium data, computed $Q = 55.9^{260}$ for the reaction, 2 $Cd(NO_3)_2$ (c) = CdO (c) + 4 NO_2 (g) + 2 O_2 (g); whence, for $Cd(NO_3)_2$ (c), $Qf = 77.1$. But the result seems very much too low, as it would require the heat of solution to be 40.

$Cd(NO_3)_2$ (liq.). Reisenfeld and Milchsack[1] reported the heat of fusion.

$Cd(NO_3)_2 \cdot nH_2O$ (c). Thomsen[15] measured the heats of solution of the mono- and tetrahydrates.

$CdCl_2 \cdot nNH_3$ (c). Biltz, Klatte, and Rahlfs[1] and Biltz and Mau[1] obtained dissociation pressure data on the ammines with 1, 2, 4, 6, and 10 NH_3; Ephraim[1, 9] on the hexammine. Tassilly[1] found the heat of solution of the diammine in aqueous HCl to be 8.56.[16]

$CdBr_2 \cdot nNH_3$ (c). Biltz and Mau[1] obtained dissociation pressure data on the ammines with 1, 2, 6, and 12 NH_3; Ephraim[1, 9] on the hexam-

mine. Tassilly[1] measured the heat of solution of the diammine in aqueous HBr to be 7.77.[15]

$CdI_2 \cdot nNH_3$ (c). Biltz and Mau[1] obtained dissociation pressure data on the ammines with 2 and 6 NH_3; Ephraim[1, 9] on the hexammine. Tassilly[1] found the heat of solution of the diammine in aqueous HI to be 11.9.[15]

$CdCl_2 \cdot 4\,NH_4Cl$ (c). Tassilly[1] measured the heat of solution.

$CdCl_2 \cdot NH_4Cl \cdot \frac{1}{2}\,H_2O$ (c). Tassilly[1] measured the heat of solution.

$CdBr_2 \cdot NH_4Br \cdot \frac{1}{2}\,H_2O$ (c). Tassilly[1] measured the heat of solution.

$CdI_2 \cdot NH_4I \cdot \frac{1}{2}\,H_2O$ (c). Tassilly[1] measured the heat of solution.

$CdSO_4 \cdot nNH_3$ (c). Ephraim[8] obtained dissociation pressure data on the ammines with 1, 2, 5, and 6 NH_3. See also Isambert[3] and Ephraim.[10]

$Cd(ClO_3)_2 \cdot nNH_3$ (c). Ephraim and Jahnsen[1] obtained dissociation pressure data on the ammines with 4 and 6 NH_3.

Cd_mSb_n (c). Biltz and Haase[1] computed the heats of formation of CdSb and Cd_3Sb_2 from the heats of solution in ($KBr+Br_2$) (aq.) of Cd, Sb, and the solid alloys.

$CdCO_3$ (c). Thomsen[15] measured the heat of reaction of $CdSO_4$(400) with Na_2CO_3(400) to be 0.36; whence, for $CdCO_3$ (c), $Qf = 178.56$. The equilibrium data of Andrussow[1] and Jander[1] give -21.8 and -22.0 for the reaction, $CdCO_3$ (c) $= CdO$ (c) $+ CO_2$ (g), whence $Qf = 181.4$.

$Cd(CN)_2$ (c). Joannis[1] measured the heat of solution of $Cd(CN)_2$ (c) in aqueous HCl to be 5 8,[21] and in aqueous H_2SO_4 to be 8.3.[20]

$Cd(ONC)_2$ (c). Wohler and Martin[1] measured the heat of decomposition of cadmium fulminate into Cd (c) $+ 2$ CO (g) $+ N_2$ (g) to be 89.0.

$Cd(CN)_2 \cdot CdO \cdot 5\,H_2O$ (c). Joannis[1] measured the heat of solution in aqueous sulfuric acid.

$2\,CdI_2 \cdot PbI_2$ (c). Mosnier[1] measured the heat of solution.

$CdZn_n$ (c). Herschkowitsch[2] computed the heats of formation of the solid alloys, $CdZn_{0.36}$, $CdZn_{1.28}$, and $CdZn_{4.61}$, from data on the heats of solution in ($KBr+Br_2$) (aq.).

$CdPb_n$ (c). See Magnus and Mannheimer.[1]

$CdSn_n$ (c). See Magnus and Mannheimer.[1]

MERCURY

Hg (liq.). Standard state.

Hg (g). The vapor pressure of mercury, whose vapor is practically monatomic, was studied by Stock and Zimmerman,[1] Hertz,[1] Thorpe,[1] Hagen,[1] Ruff and Bergdahl,[1] Regnault,[5] Laby,[1] Morley,[1] Jewett,[1] Gebhardt,[1] Villiers,[1] van der Platts,[1] Menzies,[2, 3a] Bernhart,[1] Haber and Kerschbaum,[1] Cailletet, Colardeau, and Riviere,[1] Poindexter,[1] Egerton[1, 2, 3] Smith and Menzies,[1] Kahlbaum,[1] Heycock and Lamplough,[1] Hill,[1] Jenkins,[3] Rodebush and Dixon,[2] Ramsay and Young,[3] Callendar and Griffiths,[1] Pfaundler,[1] Scott,[1] Volmer and Eastman,[1] Volmer and Kirchoff,[1] and Young.[1] The vapor pressure data have been reviewed by Randall,[2] whose equation gives $V = -14.60$. The following are the directly measured values of the heat of vaporization of mercury at 623°:

Person,[3, 4] −12.4; Kurbatoff,[1, 1a] −13.6; Muscelleanii,[1] −12.77; Konowalow,[2] −15.5; Marignac,[2] −15.5. See also Beckmann and Liesche.[1]

The energy states of gaseous monatomic mercury are evaluated from the data of Fowler[3] and Paschen.[9] See also Carroll[1] and Valasek.[1]

Hg (c). The data on the heat of fusion of mercury are: Person,[3, 4] −0.60; Koref,[1] −0.57; Bridgman,[5] −0.54. See also Pollitzer,[1] Langlois,[1] Henning,[3] and Wilhelm.[1, 1a]

Hg_2 (g). Winans[2] reported $D^z = -1.4$.

HgI_2 (c, red). Varet[1] measured, at 12°, the heats of the reactions of Hg (liq.), HgI_2 (c), Hg_2I_2 (c), Hg_2Cl_2 (c), HgBr (c), Hg_2SO_4 (c) $Hg_2(C_2H_3O_2)_2$ (c), and $Hg_2(NO_3)_2$ (aq.), respectively, with KI (aq.) or KI_3 (aq.). His various data yield the following values for HgI_2 (c, red): $Qf = 25.2, 25\ 3, 25\ 3, 25\ 3, 25.1, 25.4$, and 25.2.

HgI_2 (c, yellow). For the heat of transition of mercuric iodide from the red to the yellow form, Bridgman[6] reported -0.547^{126}; Schwartz,[1] -0.522^{127}; Steiner and Johnston,[1] −0.64; Guinchaut,[4] -0.68^{130}; Brockhorst,[1] −0.42 to −0.56. From the difference in the heats of solution, Berthelot[84] found $T = -3.0$.

HgI_2 (liq.). The data on the heat of fusion of HgI_2 (c, red) are: Guinchaut,[4] -4.45^{250}; Beckmann,[2] −5.5; Rinse,[1] −4 9.

HgI_2 (g). Vapor pressure data on mercuric iodide were reported by Rinse,[1] Stelzner and Niederschulte,[1] Arctowski,[1] Johnson,[1] Ditte,[11] Prideaux,[1] and Schmidt and Walter.[1] These data were reviewed by Egerton and Edmondson,[1] and their values give −19.6 for the heat of sublimation at 256° and −15.0 for the heat of vaporization.

Hg_2I_2 (c, yellow). Varet's data (see paragraph under HgI_2 (c, red)) yield, for this substance, $Qf = 28.87$. The electromotive force data of Vosburgh[2] yield $Qf = 28.42$ and 28.93.

HgI (g). Vapor pressure data on Hg_2I_2 were reported by Stelzner and Niederschulte,[1] whose data yield −6.4 to −5.8 for the heat of sublimation of 328 grams of mercurous iodide. According to the vapor density data, gaseous mercurous iodide is either HgI or $Hg + HgI_2$. The heat of sublimation data indicate that the vapor is HgI. Sponer[4] estimated the energy of dissociation of HgI (g) to be about −19.

HgI_4 (aq.). Thomsen[15] measured the heat of solution of HgI_2 (c) in 2 KI(200) to be 3.48.

$HgBr_2$ (c). By direct measurement, Nernst[6] and Varet[1] obtained $Qf = 40.5$ and 40.70, respectively. Varet's[1] data on the reaction with aqueous KI yield $Qf = 40.70$.

$HgBr_2$ (liq.). Beckmann[1] reported $F = -4.5$.[236]

$HgBr_2$ (g). Vapor pressure data were reported by Stelzner and Niederschulte,[1] Johnson,[1] Prideaux,[1] Arctowski,[1] and Jung and Ziegler.[1] Their data (see Egerton and Edmondson[1]) yield −19.1 for the heat of sublimation and −14.6 for the heat of vaporization.

HgBr (g). From spectroscopic data Jung and Ziegler[1] obtained values for the reaction, $HgBr_2$ (g) = Br (g) + HgBr (g), and for the energy

of excitation of HgBr (g). The vapor pressure data of Jung and Ziegler[1] yield −19.6 for the heat of sublimation of 281 grams of mercurous bromide. These authors believed the vapor to be $Hg+HgBr_2$, but it is more likely HgBr. Sponer[4] found from spectroscopic data a value for the energy of dissociation of HgBr (g) which yields, for this substance, $Qf=-16$. Wieland[1] gave a value for the energy of excitation of HgBr (g).

$HgBr_4^{--}$ (aq.). Thomsen[15] measured the heat of solution of $HgBr_2$ (c) in 2 KBr(200) to be 1.64; Berthelot[54] found 3.0[11] in 2 HBr (aq.).

$HgBr_2$ (aq.). By working with dilute solutions, Berthelot[54] determined the true heat of solution of $HgBr_2$ (c) to be −2.4.

Hg_2Cl_2 (c). Gerke's[1] data on the cell in which the reaction was 2 Hg (liq) $+Cl_2$ (g) $=Hg_2Cl_2$ (c) yield $Qf=63.33$. See also the data of Lewis and Randall[1] on the cell in which the reaction was H_2 (g) $+\frac{1}{2}Hg_2Cl_2$ (c) $=HCl(555)+Hg$ (liq), Ellis[1] and Harned and Brumbaugh's[1] data on the same reaction, and Rossini.[10] Varet's[1] data on the reactions of mercurous chloride with KI (aq), with KI_3 (aq.), and with KNO_3 (aq.), yield, for Hg_2Cl_2 (c), $Qf=62.65$, 62 65, and 62.60. Brodsky's[1] electromotive force data on the cell reaction, Hg_2Cl_2 (c) $+2\,Br^-$ (aq) $=Hg_2Br_2$ (c) $+2\,Cl^-$ (aq.), yield $Qf=62.78$.

HgCl (g). The vapor pressure data of Maier,[1] Smith and Calvert,[2] von Richter,[1] and Stelzner and Niederschulte[1] yield −19.2 for the heat of sublimation, but the value is not accurate. In order to be in accord with the spectroscopic data, the vapor of mercurous chloride must be HgCl and not $2\,Hg+Cl_2$. Sponer[4] found $D^z=-32$ for HgCl (g) from spectroscopic data; whence, for the latter, $Qf=-12$. Wieland[1] gave a value for the energy of excitation of HgCl (g).

$HgCl_2$ (c). Thomsen[15] measured the heats of the reactions of 4 KCl (aq.) with Hg_2Cl_2(c) $+Cl_2$(g), and with $HgCl_2$(c). His data yield, for the latter, $Qf=53.4$. See also Andrews.[16]

$HgCl_2$ (g). The vapor pressure data of Richter,[1] Prideaux,[1] Johnson,[1] Stelzner and Niederschulte,[1] and Schmidt and Walker,[1] which show an abnormal trend, yield −14 6 for the heat of vaporization, and −18.7 for the heat of sublimation at the melting point. According to Wyneken[1] and Mitscherlich,[1] the vapor is little dissociated.

$HgCl_2$ (liq.). From the foregoing, we have calculated $F=-4.1$.[277]

$HgCl_2$ (aq.). Thomsen's[15] data on the reaction between $HgCl_2$ (aq.) and 2 KI (aq.) yield, for the former, $Qf=50.8$. Varet's[1] data leads to the same value

The data on the heat of solution of $HgCl_2$ (c) in water are: Thomsen,[15] -3.32_{300}; Berthelot,[7] −3.1; Berthelot,[10] −3.04; Pickering,[8] -2.12_{300}. The value of Thomsen[15] yields, for $HgCl_2$ (aq.), $Qf=50.1$.

HgO (c, yellow ppt.). Thomsen[15] measured the heats of reaction of 2 KOH(200) with $HgCl_2$(400), K_2HgCl_4(400), and K_2HgBr_4(400), respectively, to be 8.10, 6.81, and −5.26; whence, for HgO (c, yellow ppt.), $Qf=20.00$, 20.70, and 20.84. Berthelot[55] measured the heat of solution of

the yellow oxide in aqueous HCN to be 31.6, and in aqueous HCl to be 18.6; whence, for HgO (c, yellow), $Qf = 21\ 0$.

HgO (c, red). Berthelot's[55] data yield $Q = 30.8$ for the heat of solution of HgO (c, red) in aqueous HBr to form the solid $HgBr_2$; whence, for HgO (c, red), $Qf = 21.3$. Varet[1] found the same value for the heat of solution of red HgO as did Berthelot for the yellow form, and concluded that the heat of transformation was small; but such a method of comparison is inaccurate because it involves the assumption that the systematic errors in the work of the two experimenters were the same in value. The dissociation pressure data of Taylor and Hulett[1] yield, for HgO (c, red), $Qf = 21.6$ The electromotive force data of Ishikawa and Kimura,[1] Fried,[1] and Brönsted[5] on the cell reaction, HgO (c, red) $+ H_2$ (g) $= H_2O$ (liq.) $+$ Hg (liq), yield $Q = 46\ 77$, 46.88, and 46.65; whence, for HgO (c, red), $Qf = 21.60$, 21.49 and 21.72, respectively. In differentiating between the red and yellow forms of mercuric oxide we imply not a difference in the crystalline species, but merely a difference in the heat contents, which may be due to the difference in the size of the crystals of the two forms.

$Hg_2(NO_3)_2$ (aq.). Thomsen[15] measured the heats of the reactions of aqueous mercurous nitrate with KCl (aq.), KBr (aq.), and KI (aq.); and his data yield, for $Hg_2(NO_3)_2$ (aq.), $Qf = 57.8$, 58.3, and 57.9. See also Berthelot[85] and Nernst.[6]

$Hg_2(NO_3)_2 \cdot 2\,H_2O$ (c). Varet[1] measured the heat of solution of this substance in 2 HI (aq.) and in $(3\,HI + I_2)$ (aq.) to be 32.8 and 63.9, respectively; whence, for the solid dihydrate, $Qf = 206.6$ and 206.4. Varet's[1] similar data on the solution of the dihydrate in aqueous KI, KBr, and KCl yield, for $Hg_2(NO_3)_2 \cdot 2\,H_2O$ (c), the mean value of $Qf = 207.9$

$HgF_2 \cdot n NH_3$ (c). Biltz and Rahlfs[2] measured the dissociation pressures of the ammines with 2, 4, and 5 NH_3.

$HgX_2 \cdot n HgO$ (c). Andre[1, 4] measured the heats of solution of $HgCl_2 \cdot HgO$ (c), $HgCl_2 \cdot 2\,HgO$ (c), $HgCl_2 \cdot 3\,HgO$ (c), $HgCl_2 \cdot 4\,HgO$ (c), $HgBr_2 \cdot HgO$ (c), $HgBr_2 \cdot 2\,HgO$ (c), $HgBr_2 \cdot 3\,HgO$ (c), and $HgBr_2\ 4HgO$ (c).

HgS (c). Thomsen[15] found $Q = 46.10$ for the reaction between Na_2S (200) and $HgCl_2$ (200); whence, for HgS (c, black), $Qf = 7.20$. Berthelot[14] found $Q = 29.6$ for the reaction of $HgCl_2$ (aq.) with H_2S (aq.); whence, for HgS (c, black), $Qf = 10.7$. Varet's[1] data on the reaction between HgO (c) and H_2S (aq.) yield, for HgS (c, black), $Qf = 10.9$. Varet[1] measured the heat of transformation, HgS (c, black) $=$ HgS (c, red), to be 0.30. See also the equilibrium data of Pelabon,[1] Rinse,[1] and Jellinek and Zakowski.[1]

$Hg_2(NO_3)_2 \cdot HNO_3$ (aq.). Varet[1] measured the heat of solution of $Hg_2(NO_3)_2 \cdot 2\,H_2O$ (c) in HNO_3 (aq.) to be -12.4.

Hg_2O (c). Thomsen[15] measured the heat of the reaction of $(Hg_2(NO_3)_2 + 1.079\,HNO_3)$ (aq.) with 3.079 NaOH (aq.), and his data yield, for Hg_2O (c), $Qf = 21.67$. Varet's[1] data on the reaction of mercurous

chloride with aqueous KOH yield, for Hg_2O (c), $Qf=21.7$. Varet's[1] data on the heat of reaction of solid mercurous acetate with aqueous KOH yield, for Hg_2O (c), $Qf=21.4$.

$Hg_2(C_2H_3O_2)_2$ (c). Varet[1] measured the heats of reaction of this substance with aqueous KI and aqueous KI_3, his data yielding, for solid mercurous acetate, $Qf=203.2$ and 203.3.

HgH (g). The values for the energy of dissociation and of excitation of gaseous HgH are taken from Bengtsson and Hulthen[1] and Hori.[3]

Hg_2SO_4 (c). Varet's[1] data on the reaction with KI (aq.), KI_3 (aq.), and KOH (aq.) yield, for Hg_2SO_4 (c), $Qf=176.37$, 176.47, and 176.85. The data of Henderson and Stegeman[1] on the cell reaction, $Pb(c)+Hg_2SO_4(c)=PbSO_4(c)+2\,Hg$ (liq.), yield $Q=42.14$; whence, for Hg_2SO_4 (c), $Qf=176.36$. See also Ishikawa.[4]

$HgSO_4$ (c). Varet[1] measured the heat of solution of this substance in 2 HCl (aq.), and his data yield, for $HgSO_4$ (c), $Qf=165.7$. Varet's[1] data on the reaction of mercuric sulfate with aqueous HCN yield, for $HgSO_4$(c), $Qf=166.7$. Berthelot's[83] data on the heats of mixing $HgSO_4$ with HCl (aq.), with NaCl (aq.), and with H_2SO_4 (aq.) yield, for $HgSO_4$ (c), $Qf=166.6$.

$HgSO_4\cdot 4\,H_2SO_4$ (aq.). Varet[1] measured the heat of solution of $HgSO_4$ (c) in $4\,H_2SO_4$(100) to be 4.4.

$(HgO)_3SO_3$ (c). Varet[1] measured the heat of solution of this substance in 6 HCl (aq.) and 25 H_2SO_4 (aq.) to be 43.4 and 9.1, respectively.

HgSe (c). Fabre[2] found the heat of solution of mercuric selenide in bromine water to be 76.1, and the heat of mixing $HgCl_2$(500) with Na_2Se (500) to be 70.4; whence, for HgSe (c), $Qf=3.5$ and 8.0, respectively.

Hg_2N_6 (c). Berthelot and Vieille[10] found the heat of decomposition of mercury azide to be 143.5; Wohler and Martin[1] found 100.0.

$Hg(NO_3)_2$ (aq.). Thomsen's[15] data on the reaction of HgO (c) with HNO_3 (aq.) yield, for $Hg(NO_3)_2$ (aq.), $Qf=57.0$. Varet's[1] data on the heat of solution of the hemihydrate in aqueous HCl and in aqueous HNO_3 yield, for $Hg(NO_3)_2$ (aq.), $Qf=56.2$.

$Hg(NO_3)_2\cdot\frac{1}{2}\,H_2O$ (c). Varet[1] measured the heat of solution of the hemihydrate in HCl (aq.), in KCN (aq.), and in HNO_3 (aq.) to be 4.62, 24.0, and -1.4, respectively.

$Hg(NO_3)_2\cdot 2\,HgO\cdot H_2O$ (c). Varet[1] measured the heat of solution of this substance in HNO_3 (aq.) and in KCN (aq.) to be 3.8 and 77.6, respectively.

$(Hg_2N)_2O$ (c). We have here formally considered all the mercury nitrogen compounds derived from Millon's base, $Hg_2NH_5O_3$, to be derivatives of the oxide $(Hg_2N)_2O$, where the group Hg_2N has an ordinary valence of plus one. The thermochemistry of these compounds has been studied by Gaudechon,[1] who measured the heats of solution of the derivatives and of HgO in aqueous KCN. For the oxide $(Hg_2N)_2O$ (c), Gaudechon[1] measured the heat of solution in KCN (aq.) to be 151.0, and

for HgO (c) in KCN (aq.) to be 154.6; whence, for $(Hg_2N)_2O$ (c), $Qf = -77.0$.

$(Hg_2N)_2O$ (aq.). Gaudechon[1] measured the heat of solution of the solid.

$Hg_2NOH \cdot nH_2O$ (c). Gaudechon[1, 2] measured the heats of solution, in aqueous KCN, of Hg_2NOH (c) and of the hydrates with $1\frac{1}{2}$, 2, and 4 H_2O.

$Hg_2NCl \cdot nH_2O$ (c). Gaudechon[1, 2] measured the heats of solution, in aqueous KCN, of the hemi- and monohydrates.

$Hg_2NCl \cdot nNH_4Cl$ (c). Gaudechon[1, 2] measured the heat of solution, in aqueous KCN, of $Hg_2NCl \cdot NH_4Cl$ (c) and of $Hg_2NCl \cdot 3NH_4Cl$ (c).

$Hg_2NCl \cdot nNH_3$ (c). Gaudechon[1, 2] measured the heats of solution of the ammines with $\frac{1}{2}$ and 1 NH_3.

$Hg_2NCl \cdot \frac{1}{2}HgCl_2$ (c). Gaudechon[1] measured the heat of solution in aqueous KCN.

Hg_2NBr (c). Gaudechon[1] measured the heat of solution in aqueous KCN.

$Hg_2NBr \cdot nHgBr_2$ (c). Gaudechon[1] measured the heats of solution, in aqueous KCN, of these compounds with $n = \frac{1}{4}$, $\frac{1}{2}$, 1, and 3.

$HgCl_2 \cdot nNH_3$ (c). Biltz, Klatte, and Rahlfs[1] measured the heat of solution of mercuric chloride and of the diammine in aqueous HCl to be -1.5 and 34.5, respectively. Biltz and Mau[1] measured the heat of solution of the diammine in water to be 10.2. Biltz and Mau[1] obtained dissociation pressure data on the ammines with 8 and $8\frac{1}{2}$ NH_3.

$HgBr_2 \cdot nNH_3$ (c). Biltz, Klatte, and Rahlfs[1] obtained dissociation pressure data on the octammine, and measured the heat of solution of the diammine in aqueous (20 per cent) KCN.

$HgI_2 \cdot nNH_3$ (c). Biltz, Klatte, and Rahlfs[1] measured the dissociation pressures of the di- and octammines, and measured the heat of solution of the diammine in aqueous (20 per cent) KCN. For the dissociation, $HgI_2 \cdot 2\,NH_3$ (c) = $HgI \cdot \frac{3}{4}\,NH_3$ (c) + $1\frac{1}{4}\,NH_3$ (g), the data of these authors give $Q = 1\frac{1}{4}(-13.1)$.

$HgF_2 \cdot nNH_3$ (c). Biltz and Rahlfs[2] measured the dissociation pressures of the di-, tetra-, and pentammines.

$HgBr_2 \cdot 2\,NH_4Br$ (aq.). Varet's[6] data on the heat of mixing yield $Qf = 160.8$. We have computed, from the ions, $Qf = 162.3$.

$Hg_2Cl_2 \cdot 2\,NH_3$ (c). Bonnefoi[1] calculated the heat of dissociation from the data of Isambert.[1]

$Hg_2SO_4 \cdot nNH_3$ (c). Ephraim[8] measured the dissociation pressures of these ammines, but the data can not be used because of uncertainty as to the products of dissociation.

HgC_2O_4 (c). Berthelot[90] measured the heat of solution of mercuric oxalate in 4 HCl(100).

$Hg_2(C_2H_3O_2)_2$ (c) Varet[1] found the heat of solution of mercurous acetate in KI (aq.) and in KI_3 (aq.) to be 36.6 and 67.5; whence, for $Hg_2(C_2H_3O_2)_2$ (c), $Qf = 203.16$ and 203.36, respectively.

$Hg(C_2H_3O_2)_2$ (aq.). Berthelot[90] measured the heat of reaction of aqueous mercuric acetate with HCl (aq.), with aqueous acetic acid, and with KOH (aq.), respectively.

$Hg(C_2H_3O_2)_2$ (c). Berthelot[90] measured the heat of solution.

$HgCl_2 \cdot CH_3OH$ (c). Lloyd, Brown, Bunnell, and Jones[1] measured the dissociation pressures.

$Hg(CN)_2$ (aq.). Thomsen[15] found the heats of the reaction of $HgCl_2$ (400) with 4 KCN(100), and of $K_2Hg(CN)_4$ (aq.) with $HgCl_2$(400), to be 45.6 and 22.0, respectively; whence, for $Hg(CN)_2$ (aq.), $Qf = -64.8$. Varet[1] measured the heat of solution of $HgSO_4$ (c) in 2 HCN(250) to be 28.33, and of HgO (c, red) in 2 HCN (aq.) to be 31.6. Berthelot[87] measured the heat of the latter reaction to be 31.0[15].

$Hg(CN)_2$ (c). Thomsen's[15] data yield -2.97 for the heat of solution; Berthelot[7] found -3.0.

$Hg(CN)_4^{--}$ (aq.). Berthelot[87] measured the heats of mixing $Hg(CN)_2$ (aq.) with 2 KCN (aq.), and of $K_2Hg(CN)_4$ (aq.) with 2 HCl (aq.).

$Hg(CN)_2 \cdot n HgO$ (c). Joannis[1] measured the heats of solution, in aqueous HCl, of these compounds with $n = \frac{1}{2}$ and 1.

$Hg(CN)_2 \cdot n NH_4CN$ (aq.). Varet[1] measured the heat of mixing $Hg(CN)_2$ (aq.) with 1 and 2 moles of NH_4CN (aq.), respectively.

$Hg(CN)_2 \cdot NH_4X$ (aq.). Varet[2] measured the heat of mixing $Hg(CN)_2$ (aq.) with NH_4Cl (aq.), NH_4Br (aq.), and NH_4I (aq), respectively.

$Hg(CN)_2 \cdot NH_4X \cdot n H_2O$ (c). Varet[2] measured the heats of solution of $Hg(CN)_2 \cdot NH_4Cl \cdot \frac{3}{4} H_2O$ (c), of $Hg(CN)_2 \cdot NH_4Br \cdot H_2O$ (c), and of $Hg(CN)_2 \cdot NH_4I \cdot \frac{1}{4} H_2O$ (c).

$Hg(ONC)_2$ (c). Kast and Selle[1] measured the heat of decomposition of mercuric fulminate to be 117.7. See also Berthelot and Vieille.[1]

$Hg(CNS)_2$ (c). Joannis[1] measured the heat of reaction of $HgCl_2$ (aq.) with 2 KCNS (aq.) to be 14.6.

$Hg_{100}Bi$ (liq.). Tammann and Ohler[1] determined the heat of formation of this amalgam.

Hg_nSn (liq.). The values for $Hg_{50}Sn$ (liq.) and $Hg_{100}Sn$ (liq.) are from van Heteren,[1] Richards and Wilson,[1] and Tammann and Ohler.[1]

Hg_nPb (liq.). The values for these amalgams, with $n = 100$, 260, and 1000, are from Richards and Garrod-Thomas[1] and Tammann and Ohler.[1]

$HgPb_2$ (c). The value for this amalgam is obtained from the data of Gerke,[1] Brönsted,[1, 4] and Henderson and Stegeman.[1]

Hg_5Tl_2 (c). The data of Biltz and Meyer[2] yield $Qf = 2.5$ for this amalgam.

Hg_nTl (liq.). The values for the liquid thallium amalgams are from Richards and Daniels[1] and Richards and Smith.[2]

Hg_mIn_n. See Richards and Wilson.[1]

Hg_mZn_n (liq.). The values for the liquid zinc amalgams are from Richards and Lewis,[1] Richards and Wilson,[1] Favre,[1, 2] Taylor,[3] and Pearce and Eversole.[1]

Hg_mCd_n (c), Hg_mCd (liq.). The values for the liquid and solid cadmium amalgams are from Richards and Garrod-Thomas,[1] Biji,[1] Richards and Forbes,[1] Cohen,[5] Carhart,[1] Richards and Lewis,[1, 2] Richards, Frevert, and Teeter,[1] Hulett,[1] Tammann and Ohler,[1] Richards and Wilson,[1] Getman,[1] and Hildebrand, Foster, and Beebe.[1]

$HgBr_2 \cdot nZnBr_2$ (aq.). Varet[2, 6] measured the heat of mixing $HgBr_2$ (aq.) with $\frac{1}{2}$, 1, and 2 moles of $ZnBr_2$ (aq.).

$Hg(CN)_2 \cdot ZnCl_2$ (aq.). Varet[2, 6] measured the heat of mixing.

$Hg(CN)_2 \cdot ZnCl_2 \cdot 7\,H_2O$ (c). Varet[2, 6] measured the heat of solution.

$Hg(CN)_2 \cdot ZnBr_2$ (aq.). Varet[2, 6] measured the heat of mixing.

$Hg(CN)_2 \cdot ZnBr_2 \cdot 8\,H_2O$ (c). Varet[2, 6] measured the heat of solution.

$HgBr_2 \cdot nCdBr_2$ (aq.). Varet[2, 6] measured the heat of mixing $HgBr_2$ (aq.) with $\frac{1}{2}$, 1, and 2 moles of $CdBr_2$ (aq.).

$Hg(CN)_2 \cdot nCdX_2$ (aq.). Varet measured the heat of mixing $Hg(CN)_2$ (aq.) with 1 mole of $CdCl_2$ (aq.), with $\frac{1}{2}$ and 1 mole of $CdBr_2$ (aq.), and with $\frac{1}{2}$ mole of CdI_2 (aq.).

$nHg(CN)_2 \cdot CdX_2 \cdot mH_2O$ (c). Varet[2, 6] measured the heats of solution of $Hg(CN)_2 \cdot CdCl_2 \cdot 2\,H_2O$ (c), $Hg(CN)_2 \cdot CdBr_2 \cdot 3\,H_2O$ (c), and $2\,Hg(CN)_2 \cdot CdI_2 \cdot 8\,H_2O$ (c).

COPPER

Cu (c). Standard state.

Cu (liq.). Data on the heat of fusion of copper at its melting point, 1083°, were reported by the following: Umino,[3] −3.21; Glaser,[1] −2.65; Richards,[1a] −2 70; Wust, Meuthen, and Durrer[1] (recalculated by Randall, Nielsen, and West[1]), −3 24. See also Honda and Ishigaki.[1] These data were reviewed by Randall, Nielsen, and West.[1]

Cu (g). Vapor pressure data were reported by Fery,[1] Greenwood,[3, 4, 5, 7] Harteck,[1] Jones, Langmuir, and Mackay,[1] Ruff and Bergdahl,[1] Ruff and Konschak,[1] and Ruff and Mugdan.[1] From these data Randall, Nielsen, and West[1] computed the heat of sublimation at 25° to be −90 4. This value is much higher than those calculated from the same data by van Laar,[1] van Liempt,[1] Sherman,[1] and us; and is not in agreement with the calculations of Langmuir and Mackay,[1] and the measurements of Rosenhain and Ewen.[1] The measurements of Jones, Langmuir, and Mackay[1] lead to the value −82.0. We have selected Sherman's[1] value of −81.2.

The energy states of gaseous monatomic copper have been evaluated from the following: Fowler,[3] Shenstone,[1a] Kichlu,[1] Bacher and Goudsmit,[1] Krueger,[2] Lang,[1a] and Wahlin.[2]

Cu_2O (c). Maier's[1a] equilibrium data on the reaction, Cu_2O (c) + H_2 (g) = 2 Cu (c) + H_2O (g), yield $Q = 16.45$; whence, for Cu_2O (c), $Qf = 41.35$. Maier's[4] electromotive force data on the cell reaction, Cu_2O (c) + H_2 (g) = 2 Cu (c) + H_2O (liq.), yield $Q = 27.45$; whence, for Cu_2O (c), $Qf = 40.92$. From the data on entropies and free energies of the substances in the foregoing reaction, Millar[5] computed, for Cu_2O (c), $Qf = 40.64$.

Thomsen[15] found $Q=15.16$ for the reaction, Cu_2O (c) $+H_2SO_4(100)=Cu$ (c) $+CuSO_4(100)+H_2O$ (liq.); whence, for Cu_2O (c), $Qf=42.5$. See also Wohler and Balz,[2] Allmand,[1, 1a] Ishikawa and Kimura,[1] Nielsen and Brown,[1] Andrews,[14] and Dulong.[2]

Cu_2O (liq.). Randall, Nielsen, and West[1] calculated the heat of fusion of cuprous oxide.

CuO (c). The data of von Wartenberg and Werth[1] yield for the reaction, CuO (c) $+H_2$ (g) $=Cu$ (c) $+H_2O$ (liq.), $Q=38.3$; whence, for CuO (c), $Qf=38.5$. The values reported by Andrews[14] and Dulong[2] nearly 100 years ago were 38.4 and 39.4, respectively. Randall, Nielsen, and West[1] reviewed the equilibrium data of Smyth and Roberts,[1] Roberts and Smyth,[1] Foote and Smith,[1] Wohler and Foss,[1] Wohler and Balz,[2] Moles and Paya,[1] and Ruer and Nakamota,[1] and concluded that, for CuO (c), $Qf=34.4$. Maier's[4] electromotive force data on the cell reaction, Cu_2O (c) $+ H_2O$ (liq.) $= 2\,CuO$ (c) $+ H_2$ (g), yield $Q=-30.0$; whence, for CuO (c), $Qf=38.4$. See also Biltz,[8] Smyth and Roberts,[1] Brody and Mullner,[1] Halla,[1] Treadwell,[1] and Bernoulli.[1]

CuO (liq.). From the foregoing data on equilibria involving both solid and liquid CuO, we have computed the heat of fusion to be -13.3^{1336}.

$CuSO_4$ (aq.). Thomsen's[15] data on the heat of solution of CuO in aqueous H_2SO_4 yield, for $CuSO_4(400)$, $Qf=200\,8$. For the heat of the reaction, $CuSO_4(400)+Fe$ (c) $=FeSO_4(400)+Cu$ (c), Thomsen[15] found $Q=37.24$; whence, for $CuSO_4(400)$, $Qf=198.7$. Data on the heat of dilution were reported by Thomsen,[15] Perreu,[2] and Arrhenius.[2]

$CuSO_4$ (c). The data on the heat of solution are: Thomsen,[15] 15.80_{800}; Donnan and Hope,[1] 15 7; Pickering,[7] 15.92_{400}; Schottky,[1] 15.93_{400}.

$CuSO_4 \cdot H_2O$ (c). The data on the heat of solution are: Thomsen,[15] 9.32_{400}; Donnan and Hope,[1] 10.1; Jorissen[2] (see Thomsen[15]), 9.33; Pickering,[7] 8.90_{400}; Schottky,[1] 9.33_{400}. See also Siggel.[1] Vapor pressure data on the system $CuSO_4 \cdot H_2O$ (c) $-CuSO_4$ (c) $-H_2O$ (g) were reported by Lescoeur,[4] Siggel,[1] Schottky,[1] and Foote and Scholes.[1]

$CuSO_4 \cdot 3\,H_2O$ (c). The data on the heat of solution are: Thomsen,[15] $2\,84_{400}$; Jorissen[2] (see Thomsen[15]), 3.08; Partington and Huntingford,[1] 3.46; Donnan and Hope,[1] 3.20. Vapor pressure data on the system $CuSO_4 \cdot 3\,H_2O$ (c) $-CuSO_4 \cdot H_2O$ (c) $-H_2O$ (g) were reported by Lescoeur,[4] Frowein,[1] and Carpenter and Jette.[1] These data were reviewed by Randall, Nielsen, and West.[1]

$CuSO_4 \cdot 5\,H_2O$ (c). The data on the heat of solution are: Donnan and Hope,[1] -3.3; Favre,[8] -3.17^{19}; Pickering, -2.80_{600}; Scholz, $-3.4_{400}{}^{0}$. See also Favre and Valson[1] and Perreu.[1] Vapor pressure data on the system $CuSO_4 \cdot 5\,H_2O$ (c) $-CuSO_4 \cdot 3\,H_2O$ (c) $-H_2O$ (g) were reported by Lescoeur,[4] Carpenter and Jette,[1] Frowein,[1] Hollman,[1] Wilson,[2] Noyes and Westbrook,[1] Foote and Scholes,[1] Linebarger,[1] Partington,[1] Partington and Huntingford,[1] and Schumb.[1] These data were reviewed by Randall, Nielsen, and West.[1] The electromotive force data of Oholm[1] and Obata[1]

on the cell reaction, Cu (c) + Hg_2SO_4 (c) + 5 H_2O (satd. soln. of $CuSO_4$) = $CuSO_4 \cdot 5\,H_2O$ (c) + Hg (liq.), yield $Q = 24.86$ and 24.71, respectively. The average yields, for $CuSO_4 \cdot 5\,H_2O$ (c), $Qf = 545.34$. See also Cohen, Chattaway, and Tombrock,[1] Nielsen and Brown,[1] Bedeau,[1] and Burian.[1]

CuCl (c). Thomsen[15] measured the heat of reaction of cuprous oxide with 2 HCl (aq.) to be 14.66; whence, for CuCl (c), $Qf = 33.8$. Noyes and Chow[1] found $Q = 9.81$ for the reaction, 3 CuCl (c) + $1\frac{1}{2}$ Sn (c) = $1\frac{1}{2}SnCl_2$ (aq.) + 3 Cu (c); whence, for CuCl (c), $Qf = 37.15$. The electromotive force data of Noyes and Chow[1] on the cell reaction, $1\frac{1}{2}$ H_2 (g) + 3 CuCl (c) = 3 Cu (c) + 3 HCl (aq.), yield $Q = 21.57$; whence, for CuCl (c), $Qf = 32.3$. From equilibrium data on the reaction between cuprous chloride and hydrogen, Watanabe[1a, 2] calculated, for CuCl (c), $Qf = 32.6$. Bodlander and Storbeck[1] estimated $Qf = 32.9$. See also Parravano and Malquorri.[3] Thomsen's[15] data on the reaction of cuprous chloride with $KMnO_4$ (aq.) yield, for CuCl (c), $Qf = 34.2$. Berthelot's[59] data on the reaction of cuprous chloride with hydrogen peroxide yield, for CuCl (c), $Qf = 37.1$. The data of Edgar and Cannon[1] on the equilibrium, CuCl (c) + AgCl (c) = $CuCl_2$ (aq.) + Ag (c), yield, for CuCl (c), $Qf = 32.0$. Sievert and Gotta's[1] data on the reaction, Cu (c) + $CuCl_2$ (aq.) = 2 CuCl (c), yield $Q = 3.80$; whence, for CuCl (c), $Qf = 33.9$.

CuCl (aq. HCl). Noyes and Chow[1] found the heat of solution of CuCl in HCl(500) to be −6.44; Berthelot[59] found values ranging from -0.8^{14} for HCl(5) to 9.5^{14} for HCl(60).

Cu_2Cl_2 (liq.). Watanabe[1a, 2] reported $F = -7.74^{430}$.

Cu_2Cl_2 (g). The vapor pressure data of von Wartenberg and Bosse[1] yield −19.2 for the heat of vaporization. The vapor of cuprous chloride is Cu_2Cl_2.

$CuCl_2$ (aq.). Thomsen's[15] data on the reactions, $CuCl_2(200) + H_2SO_4(200) = CuSO_4(200) + 2\,HCl(200)$ and $CuSO_4(400) + BaCl_2(400) = CuCl_2(800) + BaSo_4$ (c), yield, for $CuCl_2(200)$, $Qf = 64.0$. Data on the heat of dilution of aqueous cupric chloride were reported by Thomsen,[15] Reicher and van Deventer,[2] Berthelot,[5] and Partington and Soper.[1]

$CuCl_2$ (c). The data on the heat of solution are: Favre and Silbermann,[3] 9.9; Sabatier,[2] $11.2_{400}{}^{20}$; Partington and Soper,[1] $16.30_{200}{}^{25}$; Agostini,[1] 11.08_{600}; Thomsen,[15] 11.12_{600}.

$CuCl_2 \cdot 2\,H_2O$ (c). The data on the heat of solution are: van Deventer and van der Stadt,[1] 3.71_{200}; Thomsen,[15] 4.21_{400}; Biltz, Broham, and Wein,[1] 6.3, in HCl(20).

$CuCl_2 \cdot 3\,CuO \cdot nH_2O$ (c). Berthelot[77] measured the heats of solution in aqueous HCl of the anhydrous salt and the tetrahydrate.

$CuO \cdot CuCl_2$ (c). Korvezee,[1] from equilibrium data, reported $Q = 29.05$ for the reaction, 2 $CuCl_2$(c) + $\frac{1}{2}$ O_2(g) = Cl_2(g) + $CuO \cdot CuCl_2$(c).

$CuCl_2(C_2H_5OH)$. Partington and Soper[1] measured the heat of solution of cupric chloride in various amounts of ethyl alcohol.

CuH (g). The energy of dissociation and of excitation of gaseous CuH are taken from the work of Bengtsson and Hulthen.[1]

$Cu(OH)_2$ (c). Sabatier[9] and de Forcrand[63] measured the heats of solution of both the blue and the green forms of solid cupric hydroxide in aqueous nitric acid. Thomsen[15] measured the heat of reaction of KOH (aq.) with $CuSO_4$ (aq.), and of $Ba(OH)_2$ (aq.) with $CuSO_4$ (aq.). See also Bouzat.[1]

$3\,CuO \cdot H_2O$ (c). Sabatier[9] and de Forcrand[63] measured the heat of solution in aqueous nitric acid.

CuF_2 (aq.). Petersen[3] measured the heat of reaction of $CuCl_2(300)$ with 2 AgF to be 31.88.

$Cu(ClO_3)_2$ (aq.). Thomsen[15] measured the heat of reaction of $CuSO_4$ (200) with $Ba(ClO_3)_2(200)$ to be 4.37.

$Cu(ClO_4)_2$ (aq.). The value for this substance has been computed from those for the ions.

$CuClO_4$ (aq.). Heinerth[1] reported $Q = -18.80$ for the reaction, Cu (c) $+ Cu(ClO_4)_2$ (aq.) $= 2\,CuClO_4$ (aq.).

CuBr (c). Thomsen[15] measured the heat of reaction of Cu_2O (c) with 2 HBr (aq.) to be 20 76; whence, for CuBr (c), $Qf = 26.0$. Bodlander and Storbeck[1] estimated $Qf = 25\,0$. Klein's[1] electromotive force data on the cell reaction, CuBr (c) + KI (aq.) = CuI (c) + KBr (aq.), yield, for CuBr (c), $Qf = 26.6$.

Cu_2Br_2 (g). The vapor pressure data of von Wartenberg and Bosse[1] and of Jellinek and Rudat[2] yield $-18\,8$ for the heat of vaporization at 1000°.

$CuBr_2$ (aq.). Rolla[1] measured the heat of solution of copper in bromine water to be 38.3

$CuBr_2$ (c). The data on the heat of solution are: Thomsen,[15] $8.25_{400}{}^{20}$; Sabatier,[7] 7.9[12].

$CuBr_2 \cdot 4\,H_2O$ (c). Sabatier[7] measured the heat of solution.

$CuBr_2 \cdot 3\,Cu(OH)_2$ (c). Sabatier[9] measured the heat of solution in aqueous HBr.

CuI (c). Thomsen[15] measured the heat of reaction of Cu_2O (c) with 2 HI (aq.) to be 33.73; whence, for CuI (c), $Qf = 17\,2$. Bodlander and Storbeck[1] estimated $Qf = 16.3$. Thomsen's[15] data on the reaction, $2\,CuSO_4$ (aq.) $+ H_2O$ (liq.) $+ 2\,KI$ (aq.) $+ H_2SO_3$ (aq.) $= 2\,CuI$ (c) $+ (2\,KHSO_4 + H_2SO_4)$ (aq.), yield, for CuI (c), $Qf = 17.7$. Berthelot's[59] data on the reaction of aqueous cupric sulfate with aqueous KI yield, for CuI (c), $Qf = 18.1$. Joannis'[5] data on the reaction of cupric oxide with aqueous HI yield, for CuI (c), $Qf = 16.2$.

CuI (g). From spectroscopic data, Butkow and Terenin[1] reported $Q = -131$ for the reaction CuI (g) $= Cu^*$ (g) + I (g).

Cu_2I_2 (g). The vapor pressure data of von Wartenberg and Bosse[1] yield -18.9 for the heat of vaporization at 1300°. Gaseous cuprous iodide is practically all Cu_2I_2.

CuI_2 (aq.). The value for aqueous cupric iodide is obtained from the ions.

CuI_2 (c). We have estimated the heat of formation of this substance.

CuS (c). By direct measurement, von Wartenberg[10] found, for CuS (c), $Qf = 11.61$. Berthelot[14] found the heat of reaction of $CuSO_4$ (aq.) with H_2S (aq.) and with Na_2S (aq.) to be 13.2 and 37.4, respectively; whence, for CuS (c), $Qf = 11.86$ and 12.3. For the reaction, $CuSO_4(200) + Na_2S(200) = CuS\ (c) + Na_2SO_4(400)$, Thomsen[15] found $Q = 37.23$; whence, for CuS (c), $Qf = 12.17$. Equilibrium data were reported by Biltz and Juza,[1] Preuner and Brockmoller,[1] Allen and Lombard,[1] and Halferdahl.[1]

Cu_2S (c). By direct measurement, von Wartenberg[10] found, for Cu_2S (c, III), $Qf = 18.97$. Thomsen's data on the reaction of cuprous chloride with aqueous sodium sulfide yield, for Cu_2S (c, III), $Qf = 20.1$. Equilibrium data involving cuprous sulfide were reported by Jellinek and Zakowski,[1] Allen and Lombard,[1] Biltz and Juza,[1] Preuner and Brockmoller,[1] Tubandt and Reinhold,[1] Halferdahl,[1] Stubbs,[1] Wajuchnowa,[1] Reinders and Goudriaan,[1] and Schenck and Hempelmann.[1] Data on the heats of transition of cuprous sulfide were obtained by Bellati and Lussana[1] and Bornemann and Hengstenberg.[1] These data were reviewed by Randall, Nielsen, and West,[1] whose values we have selected.

$3\,CuO \cdot CuSO_4$ (c). From their equilibrium data, Reinders and Goudriaan[1] assumed the existence of this substance, and reported $Q = 39.1$ for the reaction, $2\,CuSO_4\ (c) + Cu_2O\ (c) = 3\,CuO \cdot CuSO_4\ (c) + SO_2\ (g)$; but these data are uncertain.

$3\,CuO \cdot CuSO_4 \cdot 4\,H_2O$ (c). Sabatier[9] measured the heat of solution of this substance in aqueous sulfuric acid.

Cu_2SO_4 (c). Recoura[4] found $Q = 21.0$ for the reaction, $Cu_2SO_4\ (c) = Cu\ (c) + CuSO_4\ (aq.)$.

Cu_2SO_4 (aq.). From equilibrium data, Heinerth[1] computed $Q = -9.4$ for the reaction, $CuSO_4\ (aq.) + Cu\ (c) = Cu_2SO_4\ (aq.)$.

CuS_2O_6 (aq.). The value for this substance is obtained from those for the ions.

$CuS_2O_6 \cdot 5\,H_2O$ (c). Thomsen[15] measured the heat of solution.

$CuSO_4 \cdot 2\,HCl$ (c). Ephraim[7] obtained dissociation pressure data on this substance.

CuSe (c). Favre's[2] data on the reaction of aqueous cupric acetate with gaseous hydrogen selenide yield, for CuSe (c), $Qf = 19$.

Cu_2Se (c). Favre's[2] data on the reaction of cuprous selenide with bromine water yield, for Cu_2Se (c, II), $Qf = 14.5$. The equilibrium data of Tubandt and Reinhold[1] on the reaction, $Ag_2S\ (c) + Cu_2Se\ (c) = Ag_2Se\ (c) + Cu_2S\ (c)$, yield, for Cu_2Se (c, I), $Qf = 10.6$. Bellati and Lussana[1] gave $T = -1.12^{110}$ for the transition from II to I.

$CuSeO_4$ (aq.). Metzner[1] found $Q = 13.07$ for the reaction, $CuSeO_4\ (aq.) + 2\,KOH\ (aq.) = K_2SeO_4\ (aq.) + Cu(OH)_2\ (c)$.

$CuSeO_4 \cdot 5\,H_2O$ (c). Metzner[1] measured the heat of solution of the pentahydrate.

CuN_3 (c). Wohler and Martin[1] measured the heat of decomposition of copper azide to be 56.8.

$Cu(NO_3)_2$ (aq.). Thomsen[15] measured the heat of the reaction, $2\,AgNO_3(400) + Cu\ (c) = 2\,Ag\ (c) + Cu(NO_3)_2(800)$, to be 35.63; whence, for $Cu(NO_3)_2(800)$, $Qf = 83.55$. Thomsen's[15] data on the reaction between aqueous barium nitrate and aqueous cupric sulfate yield, for $Cu(NO_3)_2(200)$, $Qf = 81.4$. Data on the heat of dilution of aqueous copper nitrate were reported by Thomsen[15] and Berthelot.[5]

$Cu(NO_3)_2$ (c). Guntz and Martin[1] measured the heat of solution.

$Cu(NO_3)_2 \cdot 3\,H_2O$ (c). Sabatier[9] measured the heat of solution.

$Cu(NO_3)_2 \cdot 6\,H_2O$ (c). The data on the heat of solution are: Sabatier,[9] -10.5^{15}; Thomsen,[15] -10.71_{400}. Reisenfeld and Milchsack[1] found the heat of fusion to be -8.68^{26}.

$Cu(NO_3)_2 \cdot nNH_3$ (c). Ephraim and Bolle[2] measured the dissociation pressures of the tetra- and hexammines.

$Cu(NO_3)_2 \cdot 3\,CuO \cdot 3\,H_2O$ (c). Sabatier[9] measured the heat of solution in aqueous nitric acid.

$CuCl_2 \cdot nNH_3$ (aq.). Bouzat[1] measured the heat of adding 4, 6, 8, and 12 NH_3 (aq.) to $CuCl_2$ (aq.).

$CuSO_4 \cdot nNH_3$ (aq.). Bouzat[1] measured the heats of adding 4, 6, 8, and 12 NH_3 (aq.) to $CuSO_4$ (aq.).

$Cu(C_2H_3O_2)_2 \cdot nNH_3$ (aq.). Bouzat[1] measured the heats of adding 4, 6, 8, and 12 NH_3 (aq.) to 1 mole of aqueous cupric acetate.

$Cu(NH_3)_n^{++}$ (aq.). The values given for the heats of formation of these ions, with $n = 4$, 6, 8, and 12, are purely formal, since the actual ion is probably $Cu(NH_3)_4^{++}$. The values are obtained from the values for the aqueous ammonia solutions of cupric acetate, cupric chloride, and cupric sulfate.

$CuCl_2 \cdot 2\,NH_3$ (c). Bouzat[1] measured the heat of solution of the diammine to be 3.3[7] in 6 NH_3 (aq.) and 7.95 in HCl (aq.); Biltz, Brohan, and Wein[1] found the heat of solution in HCl(20) to be 6.1. Biltz, Klatte, and Rahlfs[1] reported $D = -21$.

$CuCl_2 \cdot 2\,NH_3 \cdot \frac{1}{4}\,H_2O$ (c). Bouzat[1] measured the heat of solution in aqueous ammonia.

$CuCl_2 \cdot 3\frac{1}{2}NH_3$ (c). Biltz, Klatte, and Rahlfs[1] reported $D = -14.1$.

$CuCl_2 \cdot 4\,NH_3 \cdot 2\,H_2O$ (c). Bouzat[1] measured the heat of solution in aqueous ammonia.

$CuCl_2 \cdot nNH_3$ (c). Biltz, Klatte, and Rahlfs[1] reported dissociation pressure data on the ammines with 5, 6, and 10 NH_3. See also Biltz, Brohan, and Wein[1] and Ephraim.[1, 3, 5]

$CuCl_2 \cdot 5\,NH_3 \cdot nH_2O$ (c). Bouzat[1] measured the heats of solution of these hydrated pentammines with $\frac{1}{2}$ and $1\frac{1}{2}$ H_2O.

$CuCl_2 \cdot 2\,NH_4Cl \cdot nH_2O$ (c). Bouzat[1] and Bouzat and Chauvenet[1] measured the heats of solution of the anhydrous compound and of the dihydrate.

$CuCl \cdot nNH_3$ (c). Biltz and Stollenwerk[2] obtained dissociation pressure data on the ammines with 1, $1\frac{1}{2}$, and 3 NH_3. See also Lloyd.[1]

$CuBr_2 \cdot nNH_3$ (c). Biltz, Brohan, and Wein[1] measured the heat of

solution of the diammine in aqueous HCl, and obtained dissociation pressure data on the ammines with 2, $3\frac{1}{3}$, 5, 6, and 10 NH_3. See also Biltz, Klatte, and Rahlfs[1] and Ephraim.[1, 9]

$CuBr \cdot nNH_3$ (c). Biltz and Stollenwerk[1] obtained dissociation pressure data on the ammines with 1, $1\frac{1}{2}$, and 3 NH_3. See also Lloyd.[1]

$CuI_2 \cdot nNH_3$ (c). Biltz, Brohan, and Wein[1] reported dissociation pressure data on the ammines with 2, $3\frac{1}{3}$, 5, and 10 NH_3. See also Ephraim.[9]

$CuI \cdot nNH_3$ (c). Biltz and Stollenwerk[1] measured the dissociation pressures of the ammines with $\frac{1}{2}$, 1, 2, and 3 NH_3. See also Lloyd.[1]

$Cu(ClO_3)_2 \cdot nNH_3$ (c). Ephraim and Bolle[2] measured the dissociation pressures of the tetra- and hexammines.

$Cu(IO_3)_2 \cdot 5\,NH_3$ (c). Ephraim and Bolle[2] measured the dissociation pressure of the pentammine.

$Cu(ClO_4)_2 \cdot nNH_3$ (c). Ephraim and Bolle[2] measured the dissociation pressures of the tetra- and hexammines.

$CuSO_4 \cdot nNH_3$ (c). Bouzat[1] measured the heats of solution in aqueous ammonia of the mono-, di-, and tetrammines. Ephraim[8, 10] measured the dissociation pressures of the tetra- and pentammines. Bouzat[1] obtained data on the hexammine.

$CuSO_4 \cdot 4\,NH_3 \cdot 1\frac{1}{2}\,H_2O$ (c). Bouzat[1] measured the heat of solution in aqueous ammonia.

$CuSO_4 \cdot (NH_4)_2SO_4 \cdot nH_2O$ (c). Bouzat[1] measured the heat of solution of the hexahydrate; Favre[3] (See Bouzat[1]) measured that of the anhydrous salt. Caven and Ferguson[1] measured the dissociation pressures for the system, hexahydrate -dihydrate -water vapor, and found $D = -18.5$.

$CuS_2O_6 \cdot nNH_3$ (c). Ephraim and Bolle[2] measured the dissociation pressures of the tetra- and pentammines.

$CuS_4O_6 \cdot 4\,NH_3$ (c). Ephraim and Bolle[2] measured the dissociation pressures.

CuP_2 (c). Granger[1] obtained equilibrium data on the reaction, $2\,CuP_2\,(c) = 2\,Cu\,(c) + P_4\,(g)$.

Cu_3Sb (c). Biltz and Haase[1] measured the heats of solution in aqueous (30 per cent) KBr_3 of $3\,Cu\,(c) + Sb\,(c)$ and of Cu_3Sb (c).

$CuCO_3 \cdot Cu(OH)_2$ (c). Berthelot[12] found the reaction of aqueous copper sulfate with aqueous sodium carbonate to go in two stages, with $Q = -2.1$ and 1.7, respectively. The product is indefinite, but probably approximates $CuCO_3\ Cu(OH)_2$ (c).

$Cu(CHO_2)_2$ (aq.). Berthelot[9, 10] measured the heat of neutralization of aqueous formic acid with cupric hydroxide.

$Cu(CHO_2)_2$ (c). Berthelot[9, 10] measured the heat of solution of cupric formate.

$Cu(CHO_2)_2 \cdot 4\,H_2O$ (c). Berthelot[9, 10] measured the heat of solution of cupric formate tetrahydrate.

$Cu(C_2H_3O_2)_2$ (aq.). Berthelot[5, 9] measured the heat of neutralization

of aqueous acetic acid with cupric hydroxide. Thomsen[15] measured the heat of reaction of aqueous cupric acetate with aqueous barium hydroxide.

$Cu(C_2H_3O_2)_2$ (c). Berthelot[5, 9] measured the heat of solution of cupric acetate.

$Cu(C_2H_3O_2)_2 \cdot H_2O$ (c). For the heat of solution, Berthelot[5, 9] found -0.80_{220}[10]; Thomsen[15] found 0.17_{400}[18]

$Cu(C_2H_3O_3)_2$ (c). de Forcrand[3] measured the heat of reaction of solid copper glycollate with aqueous hydrogen sulfide.

$Cu(C_2H_3O_3)_2$ (aq.). de Forcrand[3] measured the heat of reaction of aqueous cupric sulfate with aqueous lead glycollate.

$Cu_2Cl_2 \cdot CO \cdot 2\,H_2O$ (aq.). Hammerl[1] reported the heat of formation of this substance.

$Cu_2Cl_2 \cdot CO \cdot 2\,H_2O$ (c). Hammerl[1] reported the heat of formation of this substance.

$CuCl_2 \cdot 2\,CH_3OH$ (c). Dissociation pressure data were reported by Lloyd, Brown, Bonnell, and Jones.[1]

$Cu(C_2H_5SO_4)_2$ (aq.). Thomsen[15] measured the heat of mixing aqueous barium ethyl sulfate with aqueous cupric sulfate.

CuONC (c). Wohler and Martin[1] measured the heat of decomposition to be 50.0.

CuCN (aq.). Varet[3] measured the heat of reaction of cuprous iodide with aqueous mercuric cyanide.

Cu_3Sn (c). Biltz[6] and Herschkowitsch[2] measured the heats of solution of various bronzes. Biltz[6] found, for Cu_3Sn (c), $Qf = 8.0$

Cu_2Zn_3 (c). Biltz,[6] Baker,[2] Galt,[1] and Herschkowitsch[2] investigated the heats of formation of the brasses. Biltz[6] found, for Cu_2Zn_3 (c), $Qf = 16.0$.

Cu_2Cd_3 (c). This alloy was studied by Biltz and Haase,[1] Roos,[2] and Schreiner and Seljesaeter.[1] Biltz and Haase[1] found, for Cu_2Cd_3 (c), $Qf = 3.0$.

$CuC_2O_4 \cdot 5\,NH_3$ (c). Ephraim and Bolle[2] measured the dissociation pressures of the pentammine of cupric oxalate.

$Cu(CHO_2)_2 \cdot 4\,NH_3$ (c). Ephraim and Bolle[2] measured the dissociation pressures of the tetrammine of cupric formate.

$Cu(C_2H_3O_2)_2 \cdot 4\,NH_3$ (c). Ephraim and Bolle[2] measured the dissociation pressures of the tetrammine of cupric acetate.

$Cu(CNS)_2 \cdot nNH_3$ (c). Ephraim and Bolle[2] measured the dissociation pressures of the tetra- and hexammines.

$CuSO_4 \cdot Tl_2SO_4 \cdot 6\,H_2O$ (c). Caven and Ferguson[1] measured the dissociation pressures for the system, hexahydrate -dihydrate -water vapor.

Silver

Ag (c). Standard state. Though both Berthelot[122] and Petersen[5] reported significant differences (1.2 and 3.2, respectively) between the heat contents of electrolytic and precipitated silver, modern evidence indicates that there is but one form of solid silver. Some of the observed

differences in heat content may be due to differences in the size of the crystals.

Ag (liq.). The data on the heat of fusion of silver are: Person,[1] −2.28; Umino,[3] −2.69; Wust, Meuthen, and Durrer,[1] −2.8.

Ag (g). Vapor pressure data were reported by Greenwood,[2, 3, 5, 6] Ruff and Bergdahl,[1] von Wartenberg,[3, 7] Harteck,[2] and Jones, Langmuir, and Mackay.[1] van Liempt[2] reviewed the data. See also Piersol[1] and Tiede and Birnbrauer.[1] We have assumed gaseous silver to be monatomic.

The energy states of gaseous monatomic silver have been evaluated from the data of Fowler,[3] Blair,[1] Kayser and Runge,[1] Randall,[1] Ritz,[1] Shenstone,[1, 3] Fujioka and Nakamura,[1] White,[1] Frings,[1] McLennan and McLay,[2] Majumdar,[1] and Gibbs and White.[1]

Ag^+ (aq.). The value for this substance is obtained from those for $AgNO_3$ (aq.) and NO_3^- (aq.).

Ag_2O (c). Equilibrium data on the decomposition of silver oxide were reported by Lewis,[4] Keyes and Hara,[1] and Benton and Drake.[1] Lewis and Randall[5] calculated from the data of the first two investigations, $Qf = 6.95$; while Benton and Drake[1] calculated $Qf = 7.02$. Mixter's[12] data yield $Qf = 6\,2$. See also Biltz,[8] Favre and Silbermann,[2] and Newton.[1]

Ag_2O_2 (c). Jirsa[2, 3, 4] measured the heats of solution of Ag_2O (c) and of Ag_2O_2 (c) in aqueous $HClO_4$ and aqueous HNO_3; and measured the heats of reduction of Ag_2O (c) and of Ag_2O_2 (c) with aqueous N_2H_2. His data yield, for Ag_2O_2 (c), $Qf = 5\,95$ and $6\,4$, respectively.

AgH (g). Farkas[1] studied the equilibrium, $2\,Ag\,(c) + H_2\,(g) = 2\,AgH\,(g)$, spectroscopically, and calculated $Q = 7.5$.

$AgNO_3$ (aq.). For the heat of solution of Ag_2O (c) in aqueous nitric acid, Jirsa[1] found 12.2 and Berthelot[12,8] 10.32; whence, for $AgNO_3$ (aq.), $Qf = 24.5$ and 23.6, respectively. Thomsen's[15] data on the reactions of $Ba(OH)_2(400)$ with $2\,AgNO_3(200)$ and with $2\,HNO_3(200)$, $Q = 17.38$ and 28.28, respectively, yield, for $AgNO_3(200)$, $Qf = 23.83$. Lange and Fuoss'[11] data on the reaction of $AgNO_3(600)$ with $KCl(660)$, $Q = 15.77^{25}$, yield, for $AgNO_3(600)$, $Qf = 23.92$. Thomsen's[15] data on the reaction of $AgNO_3(200)$ with $KCl(200)$ and with $HCl(200)$ yield $Q = 15.87$ and 15.75, respectively, whence, for $AgNO_3(200)$, $Qf = 23.99$ and 24.10. See also Berthelot[12] and Andre.[1] Berthelot,[12] Lange and Shibata,[1] and Thomsen[15] measured the heat of reaction of aqueous silver nitrate with aqueous potassium iodide. The data of the latter two investigations yield, respectively, $AgNO_3(1000)$, $Qf = 24.22$, and $AgNO_3$ (400), $Qf = 24.36$. Jahn[1] obtained electromotive force data on the cell reaction of Pb (c) with $2\,AgNO_3$ (aq.). Data on the heat of dilution of aqueous silver nitrate were reported by Fricke and Havestadt.[1]

$AgNO_3$ (c, II). The data on the heat of solution are Thomsen,[15] -5.46_{400}; Berthelot,[10] −5.7; Favre and Silbermann,[10] −5.3; Bruni and Levi,[2] −5.3. See also Petersen.[5]

$AgNO_3$ (c, I). Bridgman[6a] reported the heat of transition.

$AgNO_3$ (liq.). Magnus and Oppenheimer[1] reported the heat of fusion of silver nitrate.

AgCl (c). The electromotive force data of Gerke[1] and of Wolff[2] on the cell reaction, Ag (c) $+\frac{1}{2}$ Cl_2 (g) = AgCl (c), yield $Qf = 30.32$ and 30.16, respectively. The electromotive force data on the cell reaction, Ag (c) +HgCl (c) = AgCl (c) +Hg (liq.), yield the following values for Q: Brönsted,[1] −1.40; Gerke,[1] −1.276; Brönsted,[2a] −1.30; Halle,[2] −1.40. See also the electromotive force data of Gerke,[1] Brönsted,[4] Halle,[2] and Krahmer[1] on the cell reaction, 2 Ag (c) +$PbCl_2$ (c) = 2 AgCl (c) +Pb (c). See also Noyes and Ellis,[1] Harned and Brumbaugh,[1] Butler and Robertson,[1] Melcher,[1] and Rossini.[10] Berthelot[8c] and Lange and Fuoss[1] found the difference in energy content of the variously prepared forms of silver chloride to be small.

AgCl (liq.). The data on the heat of fusion are: Weber,[1] −4.4; Goodwin and Kalmus,[1] −3.06.

AgCl (g). Vapor pressure data were reported by von Wartenberg and Bosse[1] and Maier.[6] Brice[1] reported a value of −72.3 for the energy of dissociation of gaseous silver chloride at −273°, from spectroscopic data. The assumption that the dissociated atoms are in the normal state yields, for AgCl (g), $Qf = -24.7$.

AgI (c, II). Webb's[1, 2] data on the direct combination of silver with iodine yield $Qf = 14.94$. Webb's[1, 2] data on the heats of dissolving, in concentrated aqueous KI, AgI (c) and Ag (c) +I_2 (c) yield, for AgI (c), $Qf = 15.01$. In similar experiments with aqueous KCN as the solvent, Webb[1, 2] found, for AgI (c), $Qf = 15\,2$. From experiments similar to the latter Braune and Koref[1] found $Qf = 15.1$. The electromotive force data yield the following values: Taylor and Anderson,[1] 15.13; Jones and Kaplan,[1] 14.35; Gerke,[1] 14 81; Taylor,[2] 15.15. From the difference in the heats of solution of AgCl (c) and AgI (c) in aqueous KCN, the data of Fischer[1] and Wolff[1] yield, for AgI (c), $Qf = 15.1$ and 14 93. See Bodlander[2] and Bernoulli.[1]

AgI (c, I). The following are the data on the transition from II to I at 146°: Cohen and Joss,[1] −1.26; Mallard and LeChatelier,[1] −1.5.

AgI (g). Jellinek and Rudat[2] computed the heat of vaporization from vapor pressure data. From the spectroscopic absorption limit and the assumption that the products of dissociation are a normal silver atom and an excited iodine atom, Franck and Kuhn[1] computed a value for the energy of dissociation of gaseous silver iodide which leads to the value $Qf = -38$ for AgI (g).

AgF (aq.). Petersen[3] measured the heat of reaction of AgF (aq.) with HCl (aq) to be 13.31; Guntz[1] that of AgF (aq.) with KOH (aq.) to be 17.6.[10]

AgF (c). Guntz[1] measured the heat of solution.

AgF (amorphous, red). Guntz[1] measured the heat of solution.

$AgF \cdot nH_2O$ (c). Guntz[1] measured the heat of solution of the tetrahydrate; Guntz and Guntz[1, 2] those of the mono- and dihydrates.

$AgHF_2$ (aq.). Guntz[1] measured the heat of mixing AgF (aq.) + HF (aq.) to be 2.0.

Ag_2F (c). Guntz[10] measured the heat of solution.

Ag_2Cl (c). Without giving details, Guntz[11] reported for the reaction, Ag (c) + AgCl (c) = Ag_2Cl (c), $Q = 0.5$.

$AgClO_3$ (aq.). The value for this substance is obtained from those for the ions.

$AgClO_3$ (c). Foote and Saxon[1] measured the heat of solution. See also Bedeau.[1]

$AgClO_4$ (aq.). Jirsa[1] found the heats of reaction of $AgClO_4$ (aq.) with HCl (aq.), HBr (aq.), and HI (aq.), respectively, to be 15.75, 20.52, and 26.87. Jirsa[1] also measured the heat of reaction of Ag_2O (c) with concentrated $HClO_4$ (aq.).

$AgClO_4$ (c). Bruni and Levi[2] measured the heat of solution.

AgBr (c). Webb's[1, 2] electromotive force data on the reaction, Ag (c) + $\frac{1}{2}$ Br_2 (liq.) = AgBr (c), yield $Qf = 23.81$. Krahmer's[1] electromotive force data on the reaction, AgI (c) + $\frac{1}{2}$ $PbBr_2$ (c) = AgBr (c) + $\frac{1}{2}$ PbI_2 (c), yield, for AgBr (c), $Qf = 24.16$. See also Klein[1] and Bernoulli.[1] Berthelot[12] and Thomsen[15] measured the heat of reaction of aqueous silver nitrate with aqueous hydrobromic acid. The latter's data yield, for AgBr (c), $Qf = 23.68$.

AgBr (g). Jellinek and Rudat[2] computed the heat of vaporization from vapor pressure data.

AgBr (liq.). We have estimated the heat of fusion.

3 AgI · HI · 7 H_2O (c). Berthelot[69] measured the heat of solution.

AgI_3^{--} (aq.). Webb[1] measured the heat of solution of silver iodide in concentrated aqueous potassium iodide to be 1.8. See also Berthelot.[151]

Ag_2S (c, II). Thomsen's[15] data on the reaction of 2 $AgNO_3$(100) with Na_2S(200) yield, for Ag_2S (c, II), $Qf = 6\,86$. Berthelot's[14, 133] data on the similar reaction with H_2S (aq.) yield $Qf = 5.0$. Equilibrium data on the reaction, Ag_2S (c) + H_2 (g) = H_2S (g) + 2 Ag (c), were reported by Jellinek and Zakowski,[1] Pelabon,[3] Keyes and Felsing,[1] and Watanabe.[1] The latter calculated $Qf = 5.1$. See also Jellinek and Podjaski[1] and Noyes and Freed.[1]

Ag_2S (c, I). Bellati and Lussana[1] reported the heat of transition.

Ag_2SO_4 (aq.). Thomsen's[15] data on the reaction of Ag_2SO_4 (aq.) with 2 KOH (aq.) yield, for Ag_2SO_4 (aq.), $Qf = 165.27$. See also Berthelot.[128]

Ag_2SO_4 (c). From indirect measurements, Thomsen[15] reported the heat of solution to be −4.48. Thomsen's[15] data on the reaction of 2 $AgNO_3$ (100) with $(NH_4)_2SO_4$(100) yield −4.58 for the heat of solution of silver sulfate. See also Marchal.[3]

$Ag(S_2O_3)_2^{---}$ (aq.). Fogh[1] measured the heat of reaction of aqueous silver nitrate with excess aqueous sodium thiosulfate to be 20.0.

$Ag_2S_2O_6$ (aq.). The value for this substance is obtained from the ions.

$Ag_2S_2O_6 \cdot 2\,H_2O$ (c). Thomsen[15] measured the heat of solution.

Ag_2Se (c, II). Fabre[2] measured the heats of reaction of silver selenide with bromine water and of aqueous silver acetate with gaseous hydrogen selenide. See also Pelabon[1] and Tubandt and Reingold.[1]

Ag_2Se (c, I). Bellati and Lussana[1] reported the heat of transition.

Ag_2SeO_4 (c). Metzner[1, 2] measured the heat of reaction of aqueous silver nitrate with aqueous potassium selenate to be 8.48.

AgN_3 (c). Wohler and Martin[1] measured the heat of decomposition of silver azide to be 67.3.

$AgNO_2$ (aq.). Berthelot[9, 10, 28] reported a value for the heat of neutralization of nitrous acid with silver oxide.

$AgNO_2$ (c). Berthelot[9, 10, 28] measured the heat of solution.

$Ag_2N_2O_2$ (c). Berthelot and Ogier[7] reported a value for the heat of neutralization of hyponitrous acid with silver oxide.

$Ag_2O_2 \cdot HNO_3 \cdot 2\,H_2O$ (liq.). Jirsa[2] reported a value for the heat of formation of this substance.

$AgNO_3 \cdot n NH_3$ (aq.). Bruni and Levi[1] measured the heat of mixing $AgNO_3(100)$ with $2\,NH_3(1100)$ to be 12.79, and found no evolution of heat on the addition of more ammonia. For the same reaction, Berthelot and Delepine[2] found $Q = 13.39$. These investigators also measured the heat of reaction of $AgNO_3 \cdot 2\,NH_3$ (aq.) with aqueous nitric acid to be 11.64 and 12.25, respectively. Bruni and Levi[2] measured the heat of reaction of the aqueous triammine with aqueous nitric acid to be 24.01.

$AgNO_3 \cdot 2\,NH_3$ (c). The data on the heat of solution are: Bruni and Levi,[2] −9.05; Berthelot and Delepine,[2] −8.97; Jirsa and Diamant,[1] −9.23.

$AgNO_3 \cdot NH_3$ (c). Data on the dissociation pressure of the system, diammine-monoammine-NH_3 (g), were reported by Ephraim.[4] See also Joannis and Crozier[1] and Lemoult.[1]

$AgNO_3 \cdot 3\,NH_3$ (c). For the heat of solution Bruni and Levi[2] found −10.44 in water, Jirsa and Diamant[1] −9.23 in aqueous nitric acid. Data on the dissociation pressure of the triammine were reported by Ephraim.[4] See also Joannis and Crozier[1] and Lemoult.[1]

$AgClO_4 \cdot n NH_3$ (aq.). Bruni and Levi[2] measured the heat of mixing aqueous silver perchlorate with aqueous ammonia.

$AgClO_4 \cdot n NH_3$ (c). Bruni and Levi[2] measured the heats of solution of the di- and triammines.

$Ag(NH_3)_2^+$ (aq.). The value for this substance is obtained from those for $AgNO_3 \cdot 2\,NH_3$ (aq.) and NO_3^- (aq.).

$AgX \cdot n NH_3$ (c). Isambert[5] reported values for the heats for formation of $AgCl \cdot 3\,NH_3$ (c) and of $AgCl \cdot 1\frac{1}{2}\,NH_3$ (c), computed from unpublished values for the heats of solution. The dissociation pressure data of Biltz and Stollenwerk[1] yield values for the ammines of AgCl with 1, $1\frac{1}{2}$, and $3\,NH_3$, for those of AgBr with 1, $1\frac{1}{2}$, and $3\,NH_3$, and for those of AgI with $\frac{1}{2}$, 1, $1\frac{1}{2}$, 2, and $3\,NH_3$. See also Jarry,[1] Bonnefoi,[1] and Joannis and Crozier.[1]

$AgBrO_3 \cdot 3\,NH_3$ (c). Ephraim[4] obtained dissociation pressure data on this ammine.

$AgNO_2 \cdot 3\,NH_3$ (c). Ephraim[4] obtained dissociation pressure data on this ammine.

Ag_2C_2 (c). Berthelot and Delepine[1] measured the heat of reaction of acetylene with $2\,AgNO_3 \cdot 2\,NH_3$(c), and the heat of solution of Ag_2C_2(c) in aqueous silver nitrate.

$Ag_2C_2 \cdot n$AgCl (c). Berthelot and Delepine[1] measured the heats of solution of $Ag_2C_2 \cdot$ AgCl (c) and of $Ag_2C_2 \cdot \frac{1}{2}$ AgCl (c) in aqueous HCl.

$Ag_2C_2 \cdot n$AgI (c). Berthelot and Delepine[1] measured the heats of solution in aqueous HCl of $Ag_2C_2 \cdot$ AgI (c) and of $Ag_2C_2 \cdot 2$ AgI (c).

$Ag_2C_2 \cdot \frac{1}{2}\,Ag_2SO_4$ (c). Berthelot and Delepine[1] measured the heat of solution in aqueous HCl.

$Ag_2C_2 \cdot AgNO_3$ (c). Berthelot and Delepine[1] measured the heat of solution in aqueous HCl.

Ag_2CO_3 (c). Berthelot's[12] data on the reaction of aqueous silver nitrate with aqueous potassium carbonate yield $Qf = 117$ for the freshly precipitated silver carbonate, and $Qf = 121$ for the crystallized material. The equilibrium data of Centnerszwer and Krustinson[1] on the reaction, Ag_2CO_3 (c) $= Ag_2O$ (c) $+ CO_2$ (g), yield, for Ag_2CO_3 (c), $Qf = 119.9$.

$Ag_2C_2O_4$ (c). Berthelot[10] measured the heat of reaction of aqueous silver nitrate with aqueous potassium oxalate to be 14.6.

$AgC_2H_3O_2$ (aq.). Berthelot[9] reported a value for the heat of neutralization of silver oxide with aqueous acetic acid.

$AgC_2H_3O_2$ (c). The data on the heat of solution are: Berthelot,[9] −4.3; van Laar,[10] −4.41; Goldschmidt and van Maarsevenn,[1] −4.37. See also Rudolphi.[1]

$AgCN_2^-$ (aq.). The value for this substance is obtained from those for the aqueous salts.

AgCN (c). Thomsen[15] measured the heats of the reactions, $AgNO_3$ (200) $+ 2$ KCN (200) $=$ (KAg(CN)$_2$ $+$ KNO$_3$) (600) and KAg(CN)$_2$(600) $+$ AgNO$_3$(200) $=$ KNO$_3$(800) $+ 2$ AgCN (c), to be 33.21 and 20.22, respectively.

$Ag(CN)_3^{--}$ (aq.). Varet[5] measured the heat of solution of silver cyanide in various aqueous cyanides.

$AgCN \cdot NH_3$ (c). Joannis and Crozier[1] reported $D = -14.0$.

AgCNO (c). Lemoult[1] measured the heat of the reaction, KCNO (aq.) $+$ AgNO$_3$ (aq.) $=$ KNO$_3$ (aq.) $+$ AgCNO (c), to be 13.46.

Ag_2CN_2 (c). Lemoult[1] measured the heat of solution in aqueous HCl.

AgONC (c). Wohler and Martin[1] measured the heat of decomposition of silver fulminate into Ag (c) $+ \frac{1}{2}$ N$_2$ (g) $+$ CO (g) to be 69.6.

AgCNS (c). Joannis[1] measured the heat of the reaction, HCNS (aq.) $+$ AgNO$_3$ (aq.) $=$ HNO$_3$ (aq.) $+$ AgCNS (c), to be 22.44.

AgCNS (aq.). Kirschner's[1] data on the temperature coefficient of the solubility yield −21.3 for the heat of solution.

$AgX \cdot CH_3NH_2$ (c). Jarry[1] obtained dissociation pressure data on

the monomethylammines of silver chloride, silver bromide, and silver iodide.

AgI · PbI_2 (c). Bellati and Romanese[2] measured the heat of transition.

AgI · *n*CuI (c). Bellati and Romanese[2] measured the heat of transition of these compounds with $n=1$ and 2.

Ag_3Hg_4 (c). Data on the silver amalgams were reported by Berthelot[123] and Littleton.[1]

GOLD

Au (c). Standard state.

Au (liq.). For the heat of fusion at its melting point, 1063°, Wust, Meuthen, and Durrer[1] reported −3.13 and Umino[3] −3.11.

Au (g). The vapor pressure data of Ruff and Bergdahl,[1] Tiede and Birnbauer,[1] and von Wartenberg[3] yield −86 for the heat of vaporization at 2611°. The energy states of gaseous monatomic gold are evaluated from the data of McLennan and McLay.[1]

AuCl (c). Fischer and Biltz[1] measured the heats of solution of Cl_2 (g), Au (c), and AuCl (c) in aqueous ICl_3 to be 7.1, 18.5, and 17.2, respectively; whence, for AuCl (c), $Qf=8.4$. The dissociation pressure data of Fischer and Biltz[1] and of Ephraim[6] yield, for AuCl (c), $Qf=8.8$ and 8.25, respectively. See also Matignon[9] and Meyer.[1a]

$AuCl_3$ (c). Fischer and Biltz[1] measured the heats of solution in aqueous ICl_3 of Cl_2 (g), Au (c), and $AuCl_3$ (c), and their data yield, for the latter, $Qf=28.3$. The dissociation pressure data of Fischer and Biltz,[7] Petit,[2] and Pellaton[1] yield, for $AuCl_3$ (c), $Qf=28.1$, 26.6, and 29.5.

AuBr (c). Fischer and Biltz[1] measured the heats of solution of Au (c), Br_2 (liq.), and AuBr (c) in aqueous ICl_3, their data yielding, for AuBr (c), $Qf=3.4$. Thomsen[15] measured the heat of solution of AuBr (c) in HBr (aq.) to be 1.20 and in H_2SO_3 (aq.) to be 21.38; whence, for AuBr (c), $Qf=5.0$ and 5.8. Fischer and Biltz[1] studied the equilibrium, AuBr (c) $+Br_2$ (g) $=AuBr_3$ (c), and found $Q=17\pm2$. See also Ephraim,[6] Meyer,[1] and Petersen.[1, 2]

$AuBr_3$ (c). Fischer and Biltz[1] measured the heats of solution of Au (c), Br_2 (liq.), and $AuBr_3$ (c) in aqueous ICl_3, their data yielding, for $AuBr_3$ (c), $Qf=14.5$.

$AuBr_3$ (aq.). Thomsen[15] measured the heat of solution of $AuBr_3$ (c) to be -3.76_{200}.

$AuCl_3$ (aq.). Thomsen[15] measured the heat of reaction of $2\,AuCl_3$ (1500) with $3\,SO_2$(500) to be 83.60; whence, for $AuCl_3$ (aq.), $Qf=29.78$. Thomsen[15] measured the heat of solution of $AuCl_3$ in water to be 4.45_{900}. Combination with Fischer and Biltz's[1] value for $AuCl_3$ (c) yield, for $AuCl_3$ (aq.), $Qf=32.75$.

$AuCl_3 \cdot 2\,H_2O$ (c). Fischer and Biltz[1] measured the heat of solution.

$HAuCl_4$ (aq.). Thomsen[15] and Fischer and Biltz[1] measured the heat of solution of $AuCl_3$ (c) in aqueous HCl to be 8.98 and 10.1, respectively. Using 28.3 as the value for $AuCl_3$ (c), one obtains, for $HAuCl_4$ (aq.),

$Qf = 76.7$ and 77.8. Thomsen[15] and Fischer and Biltz[1] measured the heat of the reaction, 3 AuCl (c) + HCl (aq.) = $HAuCl_4$ (aq.) + 2 Au (c), to be 5.0 and 13.5, respectively; whence, for $HAuCl_4$ (aq.), $Qf = 69.4$ and 77.8. Thomsen[15] explained the difference in his two values by assuming that the gold formed in the latter reaction has an energy content of about 5 greater than that of ordinary gold; but there is no other evidence to support this view.

$HAuCl_4 \cdot nH_2O$ (c). Thomsen[15] measured the heats of solution of the tri- and tetrahydrates.

$AuCl_2$ (c). Fischer and Biltz[1] and Petersen[1, 2] measured the heat of solution of this supposed compound to be, respectively, 6.75 in HCl(100) and 5.15 in HCl(900). These data yield, for $AuCl_2$ (c), $Qf = 18.1$ and 19.7, respectively. One-half the sum of the values for AuCl (c) and $AuCl_3$ (c) is 18.3.

$HAuBr_4$ (aq.). Thomsen[15] measured the heat of mixing $AuBr_3$ (aq.) with HBr (aq.) to be 7.70; whence, for $HAuBr_4$ (aq.), $Qf = 47.1$.

$HAuBr_4 \cdot 5\,H_2O$ (c). Thomsen[15] measured the heat of solution.

AuI (c). Thomsen[15] measured the heat of the reaction, $AuCl_3$ (aq.) + 3 KI (aq.) = AuI (c) + 3 KCl (aq.) + I_2 (c), to be 45.66; whence, for AuI (c), $Qf = -0.3$. Thomsen[15] also measured the heat of the reaction of aurous iodide with aqueous sulfur dioxide. Fischer and Biltz[1] measured the heats of solution in aqueous ICl_3 of Au (c), I_2 (c), and AuI (c), and their data yield, for AuI (c), $Qf = -0.2$.

$Au(OH)_3$ (c). Thomsen[15] measured the heat of solution in 4 HBr (aq.) and in 4 HCl (aq.).

Au_2O_3 (c). Mixter's[12] data on the heats of the reactions of 3 Na_2O_2 (c) with 2 Au (c) and with Au_2O_3 (c), yield, for the latter, $Qf = -11$.

AuH (g). From band spectra, Bengtsson and Hulthen[1] calculated $D^z = -103.5$. See also Farkas.[1]

$Au(CN)_2^-$ (aq.). Biltz[6a, 6b] measured the heats of solution of AuI (c), AuBr (c), and AuCl (c) in aqueous cyanide solutions, and his data yield, for $Au(CN)_2^-$ (aq.), $Qf = -58.0$, -56.8, and -57.5.

$AuHg_{100}$ (liq.). Data on the heat of formation of gold amalgam were reported by Biltz and Meyer[2] and Tammann and Ohler,[1] who found, for $AuHg_{100}$ (liq.), $Qf = -1.3$ and -2.0, respectively.

$AuAgCl_2$ (c). We have estimated the heat of formation of this substance from AgCl (c) and AuCl (c) to be zero.

$AuAgCl_4$ (c). Parravano and Malquori[3] studied the equilibrium, $AuAgCl_4$ (c) = Cl_2 (g) + $AuAgCl_2$ (c), and calculated $Q = 18.6$.

$AuCl \cdot nNH_3$ (c). Biltz[6a, 6b] measured the heats of solution of the mono- and diammines in aqueous KCN, and obtained dissociation pressure data on the di- and hexammines. Ephraim[6] measured the dissociation pressures of the diammine.

$AuBr \cdot nNH_3$ (c). Biltz[6a, 6b] measured the heats of solution of the mono- and diammines in aqueous KCN, and obtained dissociation pressure data on the di-, tri-, tetra-, and hexammines.

AuI · nNH$_3$ (c). Biltz[6a, 6b] measured the heat of solution of the monoammine, and obtained dissociation pressure data on the di-, tri-, hexa-, and octammines.

PLATINUM

Pt (c). Standard state.

Pt (g). Jones, Langmuir, and Mackay[1] calculated the heat of sublimation of platinum to be −127, from the rate of loss of the metal from a hot platinum wire. See also Langmuir and Mackay[2] and van Liempt.[2] The energy states of gaseous monatomic platinum have been evaluated from the data of Livingood.[1]

Pt (liq.). Violle[1] measured the heat of fusion.

H_2PtCl_6 (aq.). Thomsen's[15] data on the heat of neutralization of H_2PtCl_6(600) with 2 NaOH(300) yield $Q=27.02$; whence, for H_2PtCl_6 (600), $Qf=166.2$. Pigeon's[1] data on the reaction of H_2PtCl_6 (aq.) with solid cobalt yield, for H_2PtCl_6 (aq.), $Qf=152.7$, which value is quite divergent. Pigeon[1] measured the heats of the following reactions: $PtCl_4$ (aq.) + 2 Co (c) = 2 $CoCl_2$ (aq.) + Pt (c), $Q = 110.1$; $PtCl_4$ (c) = $PtCl_4$ (aq.), $Q=19.56$; $PtCl_4$ (c) + 2 HCl (aq.) = H_2PtCl_6 (aq.), $Q=24.8$. Combination of these data yields, for H_2PtCl_6 (aq.), $Qf=165.6$. Combination of Thomsen's[15] data on the heat of the reaction, Na_2PtCl_6 (aq.) + 2 CuCl (c) = (Na_2PtCl_4 + 2 $CuCl_2$) (aq.), with his data on the heat of neutralization of H_2PtCl_6 (aq.) with 2 NaOH (aq.) yields, for H_2PtCl_6 (aq.), $Qf=166.1$.

$PtCl_6^{--}$ (aq.). The value for this substance is obtained from those for the aqueous sodium and potassium salts. Miller and Terrey[1] obtained electromotive force data on the cell reaction, 2 Hg (liq.) + $PtCl_6^{--}$ (aq.), = 2 HgCl (c) + $PtCl_4^{--}$ (aq.), which give $Q=21.71$; whence, for the reaction, $PtCl_4^{--}$ (aq.) + Cl_2 (g) = $PtCl_6^{--}$ (aq.), $Q=41.4$.

$HPtCl_5 \cdot 2\,H_2O$ (c). Pigeon[1] measured the heat of solution in aqueous HCl.

$H_2PtCl_6 \cdot 6\,H_2O$ (c). Pigeon[1] measured the heat of solution in aqueous HCl.

H_2PtCl_4 (aq.). The heat of neutralization of H_2PtCl_4 (aq.) with 2 NaOH (aq.) is assumed to be the same as that for H_2PtCl_6 (aq.).

$PtCl_4^{--}$ (aq.). This value is obtained from those for the aqueous sodium and potassium salts.

$PtCl_n$ (c). Pigeon[1] measured the heat of solution of $PtCl_4$ (c) in water to be 19.56, and in 2 HCl (aq.) to be 24.8. Wohler and Streicher[2] obtained dissociation pressure data on PtCl (c), $PtCl_2$ (c), $PtCl_3$ (c), and $PtCl_4$ (c).

$PtCl_4 \cdot 5\,H_2O$ (c). Pigeon[1] measured the heat of solution.

$Pt(OH)_2$ (c). Thomsen[15] measured the heat of reduction of this substance with aqueous formic acid to be 48.3; whence, for $Pt(OH)_2$ (c), $Qf=87.5$.

H_2PtBr_6 (aq.). Pigeon's[1] data on the reactions of $PtBr_4$ (aq.) with 2 Co (c), of $PtBr_4$ (c) with water, and of $PtBr_4$ (c) with 2 HBr (aq.),

yield, for H_2PtBr_6 (aq.), $Qf = 119.8$. Thomsen's[15] data on the platinous salts together with the heat of oxidation with liquid bromine yield $Qf = 115.3$. From the values for Na_2PtBr_6 (aq.) and K_2PtBr_6 (aq.) and the heat of neutralization of H_2PtBr_6 (aq.) with 2 NaOH (aq.) or 2 KOH (aq.) (assumed to be the same as that for H_2PtCl_6 (aq.)), one obtains, for H_2PtBr_6 (aq.), $Qf = 116.2$ and 115.5.

$PtBr_6^{--}$ (aq.). This value is obtained from those for the aqueous sodium and potassium salts.

$H_2PtBr_6 \cdot 9\,H_2O$ (c). Pigeon[1] measured the heat of solution.

$PtBr_4$ (aq.). Pigeon[1] measured the heat of reduction of this substance with 2 Co (c) to be 93.5.

$PtBr_4$ (c). Pigeon[1] measured the heat of solution of this substance in water to be 9.86, and in 2 HBr (aq.) to be 18 27.

$PtBr_4^{--}$ (aq.). The value for this substance is obtained from that for K_2PtBr_4 (aq.).

PtI_4 (c). Pigeon[1] measured the heat of reaction of this substance with 2 NaI (aq.) to be 7.3.

PtI_6^{--} (aq.). This value is obtained from that for Na_2PtI_6 (aq.).

PtS (c), PtS_2 (c). Biltz and Jirsa[1] obtained dissociation pressure data on these sulfides.

$Pt(NH_3)_4Cl_2 \cdot H_2O$ (c). We have estimated the heat of formation of this hydrate from that for $PtCl_2 \cdot 4\,NH_3$ (c).

$Pt(NH_3)_4Cl_2$ (aq.). Thomsen[15] measured the heat of solution of $Pt(NH_3)_4Cl_2 \cdot H_2O$ (c) in water.

$Pt(NH_3)_4(OH)_2$ (aq.). Thomsen[15] measured the heat of reaction of this substance with 2 HCl (aq.) to be 27.3.

$Pt(NH_3)_4SO_4$ (aq.). Thomsen[15] measured the heat of reaction of $Pt(NH_3)_4(OH)_2$ (aq.) with H_2SO_4 (aq.) to be 30.85.

$(NH_4)_2PtCl_4$ (aq.). The value for this substance is obtained from those for NH_4^+ (aq.) and $PtCl_4^{--}$ (aq.).

$(NH_4)_2PtCl_4$ (c). Thomsen[15] measured the heat of solution.

$PtCl_2 \cdot n NH_3$ (c). Isambert[1] reported a value for the heat of formation of the diammine. Ephraim and Millman[1] obtained dissociation pressure data on the tetra- and pentammines.

$PtI_2 \cdot n NH_3$ (c). Ephraim and Millman[1] obtained dissociation pressure data on the tetra- and hexammines.

Ag_2PtCl_6 (c). Pigeon[1] measured the heat of reaction of H_2PtCl_6 (aq.) with 2 $AgNO_3$ (aq.) to be 14.55.

Ag_2PtBr_6 (c). Pigeon[1] measured the heat of reaction of H_2PtBr_6 (aq.) with 2 $AgNO_3$ (aq.) to be 32.0.

$[Pt \cdot 6\,NH_3]^{++++}$ (aq.), $[Pt \cdot 5\,NH_3 \cdot NH_2]^{+++}$ (aq.), $[Pt \cdot 5\,NH_3 \cdot Cl]^{+++}$ (aq.), $[Pt \cdot 4\,NH_3 \cdot NH_2 \cdot Cl]^{++}$ (aq.). See Grunberg and Faermann.[1]

IRIDIUM

Ir (c). Standard state.

Ir (g). We have estimated the heat of sublimation to be −120. See Meggers and Laporte[1] for the energy states of gaseous monatomic iridium.

IrO_2 (c). From their vapor pressure data, Wohler and Witzmann[1] calculated $Qf=50$; Biltz[1] computed $Qf=52$ from the same data.

$IrCl_n$ (c). Wohler and Streicher[1] obtained dissociation pressure data on IrCl (c), $IrCl_2$ (c), and $IrCl_3$ (c).

$IrCl_6^{--}$ (aq.). The value for this substance is obtained from those for K_2IrCl_6 (aq.) and K^+ (aq.).

$IrCl_6^{---}$ (aq.). The values for K_3IrCl_6 (aq.) and K^+ (aq.) yield, for $IrCl_6^{---}$ (aq.), $Qf=187.2$. The electromotive force data of Terrey and Baker[1] on the cell reaction, Hg (liq.) $+Cl^-$ (aq.) $+IrCl_6^{--}$ (aq.) $=HgCl$ (c) $+IrCl_6^{---}$ (aq.), yield $Q=25.7$; whence, for $IrCl_6^{---}$ (aq.), $Qf=186.3$.

IrF_6 (liq.). For the heat of formation of this substance, Ruff and Fischer[1] reported the approximate value 130.

IrF_6 (g). Ruff and Fischer[1] reported $V=-8.50$.

OSMIUM

Os (c). Standard state.

Os (g). We have estimated the heat of sublimation to be -125. See Meggers and Laporte[1] concerning the energy states of gaseous monatomic osmium.

OsO_4 (c). von Wartenberg[1] determined the heat of combustion of osmium to form the tetroxide.

OsO_4 (liq.). von Wartenberg[1] found the heat of fusion to be -3.41 at 40°.

OsO_4 (g). von Wartenberg's[1] data yield -13.5 for the heat of sublimation of solid osmium tetroxide.

RHENIUM

Re (c). Standard state.

ReO_3 (c), Re_2O_7 (c). Roth and Becker[4, 5] measured the heat of combustion of rhenium (97.9 to 98.9% pure) in oxygen to form a mixture of the two oxides. The amount of rhenium burned to the lower oxide ranged from 1.5 to 13.8%, and that to the higher oxide ranged from 86 to 98%. These investigators calculated, for Re_2O_7 (c), $Qf=297.5\pm2.0$, and for ReO_3 (c), $Qf=82.5\pm8.0$.

$HReO_4$ (aq.). Roth and Becker[4] measured the heat of solution of R_2O_7 (c) in water at 20° at concentrations ranging from 9370 to 46,350 H_2O. For 9370 H_2O, $Q=11.23$, whence, for $HReO_4$(4700), $Qf=222.73$.

We have estimated values for the heat of dilution of aqueous $HReO_4$ from the above data of Roth and Becker.

ReO_4^- (aq.). This value is obtained from that for $HReO_4$ (∞).

PALLADIUM

Pd (c). Standard state.

Pd (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic palladium are from McLennan and Smith[1] and Shenstone.[1c, 4]

Pd (liq.). Violle[1a] measured the heat of fusion.

PdO (c). Biltz[8] computed the heat of formation of this substance from the dissociation pressure data of Wohler.[1]

Pd_2H (c). The data on the heat of formation of this compound are: Gillespie and Hall,[1] 8.86; Gillespie and Ambrose,[1] 9.28; Favre,[9] 8.9. See also Moutier.[1]

$Pd(OH)_2$ (c). Thomsen[15] measured the heat of reaction of Na_2PdCl_4 (aq.) with 2 NaOH (aq.) to be 12.55; Joannis[4] measured the heat of reaction of K_2PdBr_4 (aq) with 2 KOH (aq.) to be 9.02. These data yield, for $Pd(OH)_2$ (c), $Qf = 90.7$ and 89.1, respectively.

$Pd(OH)_4$ (c). Thomsen[15] measured the heat of reaction of K_2PdCl_6 (aq.) with 4 NaOH (aq.) to be 18.01; whence, for $Pd(OH)_4$ (c), $Qf = 155.0$.

$PdCl_2$ (c). Joannis[4] found $Q = 4\,72$ for the reaction, $PdCl_2$ (c) + 2 KCl (aq) = K_2PdCl_4 (aq.); while, for that with 2 HCl (aq.), Thomsen[15] found $Q = 4\,0$. These data yield, for $PdCl_2$ (c), $Qf = 43.5$ and $44\,2$, respectively.

$PdCl_4^{--}$ (aq.). This value is obtained from that for K_2PdCl_4 (aq.).

$PdCl_6^{--}$ (aq.). This value is obtained from that for K_2PdCl_6 (aq.).

H_2PdCl_6 (aq.). We have assumed the heat of ionization to be zero.

H_2PdCl_4 (aq.). Thomsen[15] measured the heat of neutralization of this acid with 2 NaOH (aq.) to be 27 25.

$PdBr_2$ (c). Joannis[4] reported $Qf = 24.9$.

$PdBr_4^{--}$ (aq.). This value is obtained from that for K_2PdBr_4 (aq.).

$PdI_2 \cdot H_2O$ (c). Joannis[4] measured the heat of reaction of K_2PdBr_4 (aq.) with 2 KI (aq) to form $PdI_2 \cdot H_2O$ (c) + 4 KBr (aq.) to be 18.40. For the reaction of K_2PdCl_4 (aq.) with 2 KI (aq.), Thomsen[15] found $Q = 22.56$. These data yield, for $PdI_2 \cdot H_2O$ (c), $Qf = 84.3$ and 86.5.

PdI_2 (c). We have estimated the heat of dissociation of the monohydrate.

$Pd(CN)_2$ (c). Joannis[4] measured the heat of reaction of K_2PdBr_4 (aq.) with 2 KCN (aq.) to be 47.14; whence, for $Pd(CN)_2$ (c), $Qf = -51.7$.

$PdX_2 \cdot nNH_3$ (c). Isambert[6] reported values for the heats of formation of the di- and tetrammines of the chloride and bromide.

Rhodium

Rh (c). Standard state.

Rh (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic rhodium are from Bacher and Goudsmit.[1]

Rh_mO_n (c). Wohler and Muller[2] obtained dissociation pressure data on RhO (c), Rh_2O (c), and Rh_2O_3 (c), from which we have estimated the heats of formation.

$RhCl_n$ (c). Wohler and Muller[2] obtained dissociation pressure data on RhCl (c), $RhCl_2$ (c), and $RhCl_3$ (c), from which we have estimated the heats of formation.

$RhCl_6^{---}$ (aq.). The value for this substance is obtained from that for Na_3RhCl_6 (aq.).

Ruthenium

Ru (c). Standard state.

Ru (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic ruthenium are from Bacher and Goudsmit.[1]

RuO_2 (c). Remy and Kohn[1] obtained dissociation pressure data on this substance.

$RuCl_3$ (c). Remy and Kohn[1] obtained dissociation pressure data on $RuCl_3$ (c). See also Wohler and Balz.[1]

Masurium

Ma (c). Standard state.

Nickel

Ni (c, III). Standard state.

Ni (c, II). For the heat of transition at the Curie point, 360°, the data are: Weiss, Piccard, and Carard,[1] −0.17; Laschtschenko,[2] −0.12; Wust, Meuthen, and Durrer,[1] −0.08; Umino,[4] −0.12; Laschtschenko,[5] −0.18. See also Pionchon,[2] Werner,[1] and Klinkhardt.[1]

Ni (c, I). There is supposed to be a transition at about 1130°, but the heat effect must be small as it has not been observed.

Ni (liq.). For the heat of fusion of nickel at 1452°, White[1] reported −4.34 and Umino[4] −4.07.

Ni (g). Jones, Langmuir, and Mackay[1] calculated the heat of sublimation of nickel to be −89.4; Millar[1] calculated the value −88.2; we have estimated the value −85.0. The energy states of gaseous monatomic nickel are evaluated from the data of Russell,[6] Menzies,[4] and Shenstone.[2]

NiO (c). The data on the heat of combustion of nickel to form NiO (c) are: Roth,[5] 58.9; Mixter,[11] 57.9; Ruff and Gersten,[4] 53; Dulong,[2] 59.7. Equilibrium data involving NiO (c) were obtained by Treadwell,[1] Watanabe,[1b] Pease and Cook,[1] Skapski and Dabrowski.[1] See also Wohler and Balz[2] and Foote and Smith.[1]

$Ni(OH)_2$ (c, ppt.). Thomsen[15] measured the heat of the reactions of $NiSO_4$(400) with $Ba(OH)_2$(400) and of $NiSO_4$(100) with 2 NaOH (100) to be 10.63 and 5.33, respectively; whence, for $Ni(OH)_2$ (c, ppt.) $Qf = 129.8$ and 129.8. Giordani and Mattias[1, 3] measured the heat of solution of $Ni(OH)_2$ (c) in aqueous HCl and in aqueous H_2SO_4 to be 20.65 and 22.16, respectively; whence, for $Ni(OH)_2$ (c), $Qf = 131$ and 133.

$Ni(OH)_3$ (c, ppt.). Thomsen[15] measured the heat of the reaction, 2 $NiCl_2$ (aq.) + NaOCl (aq.) + H_2O (liq.) + 4 NaOH (aq.) = 2 $Ni(OH)_3$ (c, ppt.) + 5 NaCl (aq.), and his data yield, for $Ni(OH)_3$ (c, ppt.), $Qf = 163.2$. Giordani and Mattias[1, 3] measured the heat of solution of $Ni(OH)_3$ (c) in aqueous H_2SO_4 to be 39.7.

NiF_2 (aq.). Petersen[1] measured the heat of reaction of $NiCl_2$ (aq.) with 2 AgF (aq.) to be 31.71; whence, for NiF_2 (aq.), $Qf = 171.4$. Mulert[1]

measured the heat of solution of $Ni(OH)_2$(c) in aqueous (20%) HF to be 28.0.

NiF_2 (c). The equilibrium data of Jellinek and Rudat[1] on the reaction, NiF_2 (c) $+H_2$ (g) $=2$ HF (g) $+$Ni (c), yield, for NiF_2 (c), $Qf^{800} = 157.5$.

$NiCl_2$ (aq.). Thomsen[15] found $Q = -15.17$ for the heat of solution of Ni (c) in 2HCl(400); whence, for $NiCl_2$(800), $Qf = 94.23$. Data on the heat of dilution of aqueous $NiCl_2$ were reported by Thomsen.[15]

$NiCl_2$ (c). Thomsen[15] measured the heat of solution.

$NiCl_2 \cdot H_2O$ (c). Sabatier[2] measured the heat of solution.

$NiCl_2 \cdot 4H_2O$ (c). Dissociation pressure data on the system, hexahydrate-tetrahydrate-water vapor, were obtained by Derby and Yngve[1] and Lescoeur.[2]

$NiCl_2 \cdot 6H_2O$ (c). Thomsen[15] measured the heat of solution. See also Berger and Crut,[1] Jellinek and Podjaski,[1] and Jellinek and Uloth[1] for equilibrium data.

Ni^{++} (aq.). This value is obtained from that for $NiCl_2$ (aq.).

$NiBr_2$ (aq.). From the values for the aqueous ions, we have computed, for $NiBr_2$ (aq.), $Qf = 72.4$. Fabre[1] reported the value 72.4.

$NiBr_2$ (c). Crut[1] measured the heat of solution. See also his equilibrium data.

$NiBr_2 \cdot 3H_2O$ (c). Crut[1] measured the heat of solution.

NiI_2 (aq.). This value is obtained from the ions.

NiI_2 (c). Mosnier[1] measured the heat of solution.

NiS (c). Thomsen[15] measured the heat of reaction of $NiSO_4$(400) with Na_2S(400) to be 15.08.

$NiSO_4$ (aq.). Thomsen[15] measured the heat of the reaction of $NiCl_2$(200) with H_2SO_4(200), and of $NiSO_4$(200) with 2HCl(100), to be 1.13 and 3.19, respectively; whence, for $NiSO_4$(200), $Qf = 231.1$.

$NiSO_4$ (c). We have estimated the heat of solution of this substance.

$NiSO_4 \cdot 7H_2O$ (c). Thomsen[15] measured the heat of solution. See also Lescoeur.[8]

NiS_2O_6 (aq.). The value for this substance is obtained from those for the ions.

$NiS_2O_6 \cdot 6H_2O$ (c). Thomsen[15] measured the heat of solution.

NiSe (c). Fabre[1] measured the heat of reaction of NiSe (c) with bromine water, and of $NiSO_4$ (aq.) with Na_2Se (aq.), to be 101.2 and 35.7, respectively; whence, for NiSe (c), $Qf = 12$ and 14.

NiTe (c). Fabre[3] measured the heat of reaction of NiTe (c) with bromine water to be 115.5.

$NiN_6 \cdot H_2O$ (c). Wohler and Martin[1] measured the heat of decomposition of this substance to be 89.5, the products being solid nickel, gaseous nitrogen, and gaseous water.

$Ni(NO_3)_2$ (aq.). This value is obtained from those for the ions.

$Ni(NO_3)_2$ (c). Guntz and Martin[1] measured the heat of solution.

$Ni(NO_3)_2 \cdot 6H_2O$ (c). Thomsen[15] measured the heat of solution.

$Ni(NO_3)_2 \cdot 6\,H_2O$ (liq.). Reisenfeld and Milchsach[1] determined the heat of fusion of the hexahydrate to be -10.6 at 60°.

$NiX_2 \cdot n\,NH_3$ (c). Ephraim[1, 2, 8, 9] and Ephraim and Jahnsen[1] obtained dissociation pressure data on the hexammines of $NiCl_2$, $NiBr_2$, and NiI_2. Biltz and Fetkenheuer,[1, 2] Biltz,[4, 9] and Biltz and Hüttig[2] obtained dissociation pressure data on the mono-, di-, and hexammines of $NiCl_2$ and $NiBr_2$ and on the di- and hexammines of NiI_2, and measured the following heats of solution: $NiCl_2 \cdot 6\,NH_3$ (c), 44.3 in HCl (aq.), 9.8 in NH_3 (aq.); $NiCl_2 \cdot 2\,NH_3$ (c), 19.5 in HCl (aq.), 13.9 in NH_3 (aq.); $NiCl_2 \cdot NH_3$ (c), 17.8 in HCl (aq.), 24.3 in NH_3 (aq.); $NiCl_2$ (c), 18.7 in HCl (aq.).

$Ni(NO_2)_2 \cdot 5\,NH_3$ (c). Ephraim[2] measured the dissociation pressures.

$Ni(NO_3)_2 \cdot 6\,NH_3$ (c). Ephraim[2] measured the dissociation pressures.

$NiF_2 \cdot H_2O \cdot nNH_3$ (c). Biltz and Rahlfs[2] obtained dissociation pressure data on the penta- and monoammines.

$Ni(ClO_3)_2 \cdot 6\,NH_3$ (c). Ephraim[2] and Ephraim and Jahnsen[1] measured the dissociation pressures.

$Ni(ClO_4)_2 \cdot 6\,NH_3$ (c). Ephraim[2] measured the dissociation pressures.

$Ni(IO_3)_2 \cdot 5\,NH_3$ (c). Ephraim and Jahnsen[1] measured the dissociation pressures.

$NiSO_4 \cdot nNH_3$ (c). Ephraim[2, 8] obtained dissociation pressure data on the ammines with $\frac{1}{2}$, 2, 4, and 6 NH_3.

$NiS_2O_6 \cdot nNH_3$ (c). Ephraim[2] measured the dissociation pressures of the penta- and hexammines.

$NiS_4O_6 \cdot 6\,NH_3$ (c). Ephraim[2] measured the dissociation pressures.

$Ni(H_2PO_2)_2 \cdot 6\,NH_3$ (c). Ephraim[2] measured the dissociation pressures.

$Ni(COOH)_2 \cdot 4\,NH_3$ (c). Ephraim[2] measured the dissociation pressures.

$Ni(C_2H_3O_2)_2 \cdot 4\,NH_3$ (c). Ephraim[2] measured the dissociation pressures.

$Ni(CNS)_2 \cdot 6\,NH_3$ (c). Ephraim[2] measured the dissociation pressures.

$Ni(NH_4)_2(SO_4)_2 \cdot 6\,H_2O$ (c). Caven and Ferguson[2] measured the dissociation pressures of the system, hexahydrate-dihydrate-water vapor.

NiC_3 (c). Roth's[5] data on the heat of combustion of nickel carbide yield $Qf = -9.2$. See also Ruff and Gersten.[2]

$Ni(CO)_4$ (liq.). From his vapor pressure data, Anderson[2] calculated the heat of vaporization.

$Ni(CN)_2$ (c, ppt.). Varet[4, 5] measured the heats of the reactions of $NiSO_4$ (aq.) with 2 KCN (aq.), $NiSO_4$ (aq.) with 2 NaCN (aq.), $Ni(NO_3)_2$ (aq.) with 2 KCN (aq.), and $Ni(NO_3)_2$ (aq.) with 2 NaCN (aq.) to be 31.6, 31.4, 31.0, and 30.9, respectively.

$Ni(CN)_4^{--}$(aq.). Varet[4, 5] measured the heat of solution of $Ni(CN)_2$ (c) in 2 KCN (aq.), 2 NaCN (aq.), Ba $(CN)_2$ (aq.), and Sr $(CN)_2$ (aq.), respectively.

$Ni(C_2H_3O_2)_2$ (aq.). This value is obtained from those for the ions.

$NiBr_2 \cdot 3\,CH_3OH$ (c). Lloyd, Brown, Bonnell, and Jones[1] measured the dissociation pressures.

$2\,NiI_2 \cdot PbI_2$ (c). Mosnier[1] measured the heat of solution.

$2\,NiI_2 \cdot PbI_2 \cdot 3\,H_2O$ (c). Mosnier[1] measured the heat of solution.

$NiBr_2 \cdot n\,HgBr_2$ (aq.). Varet[6] measured the heats of mixing $NiBr_2$ (aq.) with 1 and 2 moles of $HgBr_2$ (aq.).

(Ni+*n* Cu) (solid solution). White[2] measured the heat of fusion of monel metal, a solid solution of nickel and copper.

Cobalt

Co (c, III). Standard state.

Co (c, II). For the heat of transition at the Curie point, 460°, Umino[1a, 4] reported the values −0.13 and −0.06.

Co (c, I). For the heat of transition at 1150°, Umino[1a, 4] reported the values −0.07 and −0.12. See also Wust, Meuthen, and Durrer,[1] and Pionchon.[2]

Co (liq.). Umino[4] reported a value for the heat of fusion of cobalt.

Co (g). Millar[1] calculated the heat of sublimation at 25° to be −85.0. We have estimated the value for 2375°. See also Ruff and Kerlig.[1] The energy states of gaseous monatomic cobalt have been evaluated from the data of Catalan[3] and Findlay.[1]

Co^{++} (aq.). The value for this substance is obtained from that for $CoCl_2$ (aq.).

CoO (c). Mixter[11] determined the heat of combustion of cobalt to form CoO (c) to be 57.5. See also Dulong.[2] Mixter's[11] experiments with sodium peroxide probably lead to the formation of Na_2CoO_3, in which case his data yield, for CoO (amorp.), $Qf = 51$. The recent equilibrium data of Emmett and Schultz[1] on the reaction, CoO (c) $+ H_2$ (g) $=$ Co (c) $+ H_2O$ (g), yield, for CoO (c), $Qf = 56.2$. See also Glaser,[3] Chaudron,[1] and Wohler and Balz.[2]

Co_3O_4 (c). Mixter's[11] data on the reaction of Co_3O_4 (c) with sodium peroxide yield, for Co_3O_4 (c), $Qf = 196.6$. Biltz[8] computed $Qf = 196.2$ from the dissociation pressure data of Foote and Smith.[1] The agreement is probably fortuitous.

$Co(OH)_2$ (c). Thomsen[15] measured the heats of reaction of $CoSO_4$ (400) with $Ba(OH)_2$(400) and with 2 NaOH(200) to be 12.23 and 5.89, respectively.

$Co(OH)_3$ (c). Thomsen[15] measured the heat of the reaction, $2\,CoCl_2$ (aq.) + NaClO (aq.) + H_2O (liq.) + 4 NaOH (aq.) = $2\,Co(OH)_3$ (c) + 5 NaCl (aq.).

CoF_2 (aq.). Petersen[3] measured the heat of mixing $CoCl_2$ (aq.) with 2 AgF (aq.) to be 31.97.

CoF_2 (liq.). The high temperature equilibrium data of Jellinek and Rudat[1] on the reaction, CoF_2 (liq.) $+H_2$ (g) $=$ Co (c) $+2$ HF (g), yield the value $Qf^{700}=161$.

$CoCl_2$ (aq.). Thomsen[15] measured the heat of solution of Co (c) in 2 HCl (aq.) to be 16.35.

$CoCl_2$ (c). Thomsen[15] measured the heat of solution.

$CoCl_2 \cdot 2\,H_2O$ (c). Sabatier[2] measured the heat of solution.

$CoCl_2 \cdot 6\,H_2O$ (c). Thomsen[15] measured the heat of solution. See also the equilibrium data of Biltz,[6] Lescoeur,[2, 4] Crut,[1] Jellinek and Podjaski,[1] and Jellinek and Uloth.[1]

$CoBr_2$ (aq.). This value is obtained from those for the ions. Fabre[1] measured the heat of the reaction of Co (c) with bromine water to be 37.0.

$CoBr_2$ (c). Crut[1] measured the heat of solution to be 18.4; whence, for $CoBr_2$ (c), $Qf=54.6$. Crut's[1] data on the equilibrium, $CoBr_2$ (c) $+H_2$ (g) $=$ Co (c) $+2$ HBr (g), yield, for $CoBr_2$ (c), $Qf=56.9$.

$CoBr_2 \cdot 6\,H_2O$ (c). Crut[1] measured the heat of solution.

CoI_2 (aq.). This value is obtained from those for the ions. Pigeon[1] measured the heat of reaction of Co (c) with NaI_3 (aq.) to be 41 5.

CoI_2 (c). Mosnier[1] measured the heat of solution.

CoS (c, ppt.). Thomsen[15] measured the heat of the reaction of $CoSO_4$ (400) with Na_2S(400) to be 16.30. See also Jellinek and Zakowsky.[1]

Co_2S_3 (c). We have estimated this value.

$CoSO_4$ (aq.). Thomsen[15] measured the heat of reaction of $CoSO_4$(400) with $BaCl_2$(400) to be 5.69; and of $CoCl_2$(200) with H_2SO_4(200) and $CoSO_4$(200) with 2 HCl(100) to be 1.15 and 2.44. These data yield, for $CoSO_4$(400), $Qf=231.7$, and for $CoSO_4$(200), $Qf=231.6$.

$CoSO_4$ (c). We have estimated the heat of dehydration of the hexahydrate and the heat of dissociation of the diammine.

$CoSO_4 \cdot 6\,H_2O$ (c). Carpenter and Jette[1] measured the vapor pressures in the system, heptahydrate-hexahydrate-water vapor.

$CoSO_4 \cdot 7\,H_2O$ (c). Thomsen[15] measured the heat of solution.

CoSe (c). Fabre[1] measured the heat of reaction of CoSe (c) with bromine water to be 74.0 and of $CoSO_4$ (aq.) with Na_2Se (aq.) to be 33.1; whence, for CoSe (c), $Qf=13.3$ and 12.0, respectively.

CoTe (c). Fabre[1] measured the heat of reaction of CoTe (c) with bromine water to be 115.9.

$Co(NO_3)_2$ (aq.). The value for this substance is obtained from those for the ions.

$Co(NO_3)_2$ (c). Guntz and Martin[1] measured the heat of solution.

$Co(NO_3)_2 \cdot 6\,H_2O$ (c). Thomsen[15] measured the heat of solution.

$Co(NO_3)_2 \cdot 6\,H_2O$ (liq.). Reisenfeld and Milchsack[1] reported the heat of fusion to be -8.7 at 56°.

$CoX_2 \cdot nNH_3$ (c). Biltz and Hüttig[1, 2] and Biltz and Fetkenheuer[2] obtained dissociation pressure data on the ammines of $CoCl_2$ and $CoBr_2$ with 1, 2, and 6 NH_3 and those of CoI_2 with 2 and 6 NH_3, and measured

the following heats of solution in aqueous HCl: $CoCl_2 \cdot 6\,NH_3$ (c), **46.3**; $CoCl_2 \cdot 2\,NH_3$ (c), 19.6; $CoCl_2 \cdot NH_3$ (c), 17.5; $CoCl_2$ (c), 18.0. Ephraim[1, 9] measured the dissociation pressures of the hexammines of $CoCl_2$, $CoBr_2$, and CoI_2.

$CoF_2 \cdot H_2O \cdot nNH_3$ (c). Biltz and Rahlfs[2] obtained dissociation pressure data on the ammines with $\frac{1}{2}$, 1, and 5 NH_3.

$CoSO_4 \cdot nNH_3$ (c). Ephraim[8] obtained dissociation pressure data on the ammines with $\frac{1}{2}$, 2, 3, 4, and 6 NH_3.

$[Co \cdot (NH_3)_5 \cdot NO_3]\,(NO_3)_2$ (c). Lamb and Simmons[1] measured the heat of reaction of this substance with aqueous sodium sulfide, the cobalt product being Co_2S_3 (c).

$[Co \cdot (NH_3)_5 \cdot NO_3]\,(NO_3)_2$ (aq.). Lamb and Simmons[1] measured the heat of solution of the solid.

$[Co \cdot (NH_3)_5 \cdot NO_3]^{++}$ (aq.). This value is obtained from the aqueous nitrate.

$[Co \cdot (NH_3)_5 \cdot H_2O]\,(NO_3)_3$ (c). Lamb and Simmons[1] measured the heat of reaction of this substance with aqueous sodium sulfide, the product containing cobalt being Co_2S_3 (c).

$[Co \cdot (NH_3)_5 \cdot H_2O]\,(NO_3)_3$ (aq.). Lamb and Simmons[1] measured the heat of solution of the solid.

$[Co \cdot (NH_3)_5 \cdot H_2O]^{+++}$ (aq.). This value is obtained from those for the aqueous nitrate, chloride, and bromide.

$[Co \cdot (NH_3)_5 \cdot H_2O]\,X_3$ (c). Lamb and Simmons[1] measured the heats of reaction of the chloride and the bromide with aqueous sodium sulfide, the cobalt product being Co_2S_3 (c).

$[Co \cdot (NH_3)_5 \cdot H_2O]\,X_3$ (aq.). Lamb and Simmons[1] measured the heats of solution of the solid bromide and chloride.

$[Co \cdot (NH_3)_5 \cdot X]\,X_2$ (c). Lamb and Simmons[1] measured the heats of reaction of the chloride and the bromide with aqueous sodium sulfide, the cobalt product being Co_2S_3 (c).

$[Co \cdot (NH_3)_5 \cdot X]\,X_2$ (aq.). Lamb and Simmons[1] measured the heats of solution of the solid chloride and the bromide.

$[Co \cdot (NH_3)_5 \cdot Cl]^{++}$ (aq.). This value is obtained from the aqueous chloride.

$[Co \cdot (NH_3)_5 \cdot Br]^{++}$ (aq.). This value is obtained from the aqueous bromide.

$CoBr_2 \cdot 2\,NH_4Br$ (aq.). Varet[6] measured the heat of mixing $CoBr_2$ (aq.) with $2\,NH_4Br$ (aq.) to be 0.17.

$Co(NH_4)_2(SO_4)_2 \cdot 6\,H_2O$ (c). From dissociation pressure data, Caven and Ferguson[1] determined the heat of dissociation of the hexahydrate to the dihydrate.

Co_3C (c). The equilibrium data of Schenck, Krageloh, and Eisenstecken[1] yield $Qf = -11.3$.

$CoCO_3$ (c). de Carli[1] measured the heat of the reaction of $CoSO_4$(600) with Na_2CO_3(600) to be -4.04.

$CoX_2 \cdot n\,CH_3OH$ (c). Dissociation pressure data on $CoCl_2 \cdot 3\,CH_3OH$

(c), $CoBr_2 \cdot 3\,CH_3OH$ (c), and $CoBr_2 \cdot 2\,CH_3OH$ (c) were obtained by Lloyd, Brown, Bonnell, and Jones.[1]

$Co(C_2H_5SO_4)_2$ (aq.). Thomsen[15] measured the heat of reaction of aqueous cobalt sulfate with aqueous barium ethyl sulfate to be 5.76.

$2\,CoI_2 \cdot PbI_2$ (c). Mosnier[1] measured the heat of solution.

$2\,CoI_2 \cdot PbI_2 \cdot 3\,H_2O$ (c). Mosnier[1] measured the heat of solution.

$CoBr_2 \cdot n\,HgBr_2$ (aq.). Varet[6] measured the heat of mixing $CoBr_2$ (aq.) with $\frac{1}{2}$, 1, and 2 moles of $HgBr_2$ (aq.).

$CoCl_3 \cdot 6NH_3$ (c). Biltz[3] measured the dissociation pressures.

Iron

Fe (c). Normal iron at room temperature is taken as the standard state, and is labeled the α or IV form. The transition from IV to III, or α to β, is associated with a change in magnetic properties and takes place in the range from 725 to 785°, mainly at the Curie point, 769°. The data on this heat of transition are: Wust, Meuthen, and Durrer[1, 2] −0.348; Pionchon,[2] −0.298; Osmond,[1] −0.07; Laschtschenko,[2] −0.30; Durrer,[1] −0.28 and −0.31; Stansfield,[1] −0.05; Meuthen,[1] −0.31; Klinkhardt,[1] −0.375; Bredemeier,[1] −0.737; Oberhoffer and Grosse,[1] −0.14. See also Dinkler[1] and Weiss, Piccard, and Carard.[1] The transition from III to II, or β to γ, occurs at 906°, and is associated with a change in crystal properties, the forms being martensite and ferrite. The data on the heat of this transition are: Klinkhardt,[1] −0.214; Durrer,[1] −0.37; Meuthen,[1] −0.30; Stansfield,[1] −0.159; Laschtschenko,[1] −0.34; Osmond,[1] −0.21; Wust, Meuthen, and Durrer,[1, 2] −0.35; Oberhoffer and Grosse,[1] −0.38. For the heat of the transition from II to I, or γ to δ, which occurs at 1405°, the data are: Wust, Meuthen, and Durrer,[1, 2] −0.103; Bredemeier,[1] −0.108; Durrer,[1] −0.108. See also the review of Yap.[1]

Fe (liq.). The data on the heat of fusion of iron at its melting point, 1535°, are Umino,[3] −3.86; Oberhoffer and Grosse,[1] −3.60.

Fe (g). The vapor pressure data of Greenwood[3, 5] and Ruff and Bormann[1] were reviewed by Johnston, Fenwick, and Leopold[1] and yield −73.8 for the heat of vaporization at 2000°; whence at 18° the heat of sublimation becomes −89.0. For this latter Sherman[1] calculated −94, and Jones, Langmuir, and Mackay[1] reported −89. See also Millar.[1]

The energy states of gaseous monatomic iron have been evaluated from the data of Laporte,[1] Russell,[1, 2] White,[5] and Gilroy.[1]

Fe_3O_4 (c). The product of the combustion of iron in oxygen is principally Fe_3O_4. The data on the heat of combustion of iron are: Dulong,[2] 278; Andrews,[14] 275; Mixter,[15] 265.2; Ruff and Gersten,[3] 268.3; Ruff and Gersten,[2] 266.4; Baykoff and Ermiloff,[1] 275; Roth,[5] 266.9. See also Doepke.[1] Mixter's[15] data on the reaction with sodium peroxide yield, for Fe_3O_4 (c, III), $Qf = 265$. Berthelot's[70] data on the heat of solution of iron in aqueous HCl yield $Qf = 289$. The heats of transition of Fe_3O_4 (c) were measured by Millar.[6]

FeO (c). The values for the heat of combustion of FeO (c) to form

$\frac{1}{3}Fe_3O_4$ (c) are: LeChatelier,[8] 25.2; Roth,[5] 24.7. See also Ruff and Gersten.[2] Roth's[5] value yields, for FeO (c, I), $Qf=64.3$. Mixter's[15] data on the reaction with sodium peroxide yield $Qf=65.0$. The equilibrium data of Wohler and Gunther,[1] Chaudron,[1] and Groningen[1] on the reaction, $Fe\ (c)+H_2O\ (g)=FeO\ (c)+H_2\ (g)$, yield, for FeO (c, I) $Qf=62.7$. See also Tigerschoild,[1] Schreiner and Grimnes,[1] Wohler and Balz,[2] von Royen,[1] Treadwell,[1] and Eastman and Evans.[1] The equilibrium data of Wohler and Gunther,[1] Chaudron,[1] and Groningen[1] on the reaction, $3FeO\ (c)+H_2O\ (g)=Fe_3O_4\ (c)+H_2\ (g)$, yield, for FeO (c, I), $Qf=64.3$. From equilibrium data on the reaction, $FeO\ (c)+CO\ (g)=Fe\ (c)+CO_2\ (g)$, Garran[1] calculated, for FeO (c, I), $Qf=64.6$. See also Tigerschoild,[1] Matsubara,[1] and Chaudron.[1, 2, 3] Millar[6] measured the heat of transition.

Fe_2O_3 (c). For the heat of combustion of Fe_2O_3 (c) to form $\frac{2}{3}Fe_3O_4$ (c), LeChatelier,[8, 10] found -15 and Roth[5] -20.6. The latter value yields, for Fe_2O_3 (c), $Qf=198.5$. Mixter's[15] data on the reaction with sodium peroxide yield 194.6. Berthelot[70] measured the heat of solution of iron in HCl(4) to be 17.1. See also Walden,[1] Biltz,[8] Sosman and Hostetter,[1] and Treadwell.[1]

$Fe(OH)_2$ (c, ppt.). Thomsen[15] measured the heats of the reactions of $FeSO_4$ (aq.) with 2KOH (aq.) and with $Ba(OH)_2$ (aq.) to be 6.34 and 12.00, respectively; whence, for $Fe(OH)_2$ (c, ppt.), $Qf=135.9$.

$Fe(OH)_3$ (c, ppt.). Thomsen[15] measured the heat of the reaction of $FeCl_3$ (aq.) with 3NaOH (aq.) to be 24.5. See also Petersen[3] and Mixter.[15]

Fe^{++} (aq.). The value for aqueous ferrous ion is obtained from that for aqueous ferrous chloride.

$FeCl_2$ (aq.). Thomsen[15] and Richards, Rowe, and Burgess[1] measured the heat of solution of iron in 2HCl(200). Their data yield, for $FeCl_2(400)$, $Qf=100.18$ and 99.76, respectively. See also Favre and Silbermann[3] and Andrews.[3]

$FeCl_2$ (c). Thomsen[15] found $S=17.90_{400}$. See also Favre and Silbermann.[3]

$FeCl_2 \cdot nH_2O$ (c). Sabatier[2, 4] measured the heats of solution of the di- and tetrahydrates. Dissociation pressure data on the dihydrate were reported by Lescoeur.[7]

$FeCl_2$ (g). Maier's[1] vapor pressure data yield -32.1 for the heat of vaporization.

$FeCl_3$ (aq.). Thomsen[15] measured the heats of reaction of $FeCl_2$ (aq.) with HClO (aq.) and with Cl_2 (g) to form $FeCl_3$ (aq.) to be 54.44 and 55.00, respectively. See also Berthelot,[26] Doerinckel,[1] and Browne.[1] Data on the heat of dilution of aqueous ferric chloride were reported by Thomsen.[15] (The heat of mixing aqueous ferric chloride with aqueous HCl is large.)

Fe^{+++} (aq.). Pissarjewsky[1a] obtained data on the equilibrium, $Fe^{++}\ (aq.)+Ag^{+}\ (aq.)=Fe^{+++}\ (aq.)+Ag\ (c)$, and reported $Q=8.7$, whence,

for Fe^{+++} (aq.), $Qf=4.1$. Fleharty's[1] recent data on the equilibrium, $Fe^{++}(aq.)+\frac{1}{2}Hg_2^{++}(aq.)=Fe^{+++}(aq.)+Hg$ (liq.), yield $Q=10.0$; whence, for Fe^{+++} (aq.), $Qf=10.6$. From the values for $FeCl_3$ (aq.) and Cl^- (aq.), one obtains, for $Fe^{+++}(aq.)$, $Qf=9.3$.

$FeCl_3$ (c). Lemoine[1] measured the heat of solution.

$FeCl_3 \cdot nH_2O$ (c). Sabatier[2, 4] measured the heat of solution of the hydrate with $2\frac{1}{2}$ H_2O, and Lemoine[1] that of the hexahydrate.

Fe_2Cl_6 (g). Deville and Troost[1] have shown that the vapor of ferric chloride has the formula Fe_2Cl_6. The vapor pressure data of Stirnemann[1] yield -33.1 for the heat of sublimation of Fe_2Cl_6.

Fe_2Cl_6 (liq.). The vapor pressure data of Stirnemann[1] yield -11.3 for the heat of vaporization of the liquid.

FeF_2 (aq.). Petersen[3] measured the heat of mixing 2AgF(300) with $FeCl_2$(600) to be 31.76.

FeF_2 (liq.). The equilibrium data of Jellinek and Rudat[1] yield, for FeF_2 (liq.), $Qf^{800}=158$.

FeF_3 (aq.). Petersen[3] measured the heat of mixing $FeCl_3$(300) with 3HF(50) and FeF_3(300) with 3HCl(50), the heat of the reaction of 3AgF(200) with $FeCl_3$(600), and the heat of solution of $Fe(OH)_3$ (c) in aqueous HF. His data yield, for FeF_3(1200), $Qf=243.3$, and for FeF_3(300), $Qf=242.5$.

FeF_3 (liq.). The dissociation pressure data of Jellinek and Rudat[1] yield, for FeF_3 (liq.), $Qf^{700}=233$.

FeOCl (c). Stirnemann's[1] data on the equilibrium in the system, FeOCl (c) $-Fe_2O_3$ (c) $-Fe_2Cl_6$ (g), yield for the reaction, 6FeOCl (c) $=Fe_2Cl_6$ (g) $+2Fe_2O_3$ (c), $Q=-26.0$; whence, for FeOCl (c), $Qf=97.1$.

$Fe(ClO_3)_3$ (aq.). Thomsen[15] measured the heat of reaction of aqueous barium chlorate with aqueous ferric sulfate.

$FeBr_2$ (aq.). This value is obtained from the ions.

$FeBr_2$ (c). We have estimated the heat of solution.

$FeBr_3$ (aq.). The values for the ions yield $Qf=95.2$. Fabre[1] reported the low value 88.6, which may be attributed to incomplete reaction.

FeI_2 (aq.). This value is obtained from the ions.

FeI_2 (c). Mosnier[1] measured the heat of solution. See also Andrews.[3]

FeI_3 (aq.). This value is obtained from the ions.

FeS (c). The data on the directly measured heat of formation are: Mullenhoff,[1] 25.0; Mannheimer,[1] 22.8; Parravano and Cesaris,[1] 23.07. Mixter's[15] data on the reaction with sodium peroxide yield $Qf=19$. Berthelot[14] and Thomsen[15] measured the heat of reaction of aqueous ferrous sulfate with aqueous sodium sulfide, the latter's data yielding, for FeS (c), $Qf=23.4$. See also Jellinek and Zakowsky.[1]

FeS (liq.). For the heat of fusion, at 195°, Bornemann[1] reported -0.28 and Bornemann and Hegstenberg[1] -0.5.

FeS_2 (c). Mixter's[15] data on the heats of the reactions of pyrite and of marcasite with sodium peroxide yield identical values for the two crystal forms of FeS_2 (c), namely $Qf=35.5$. The data of Cavazzi[2] on the

heat of combustion of FeS_2 (c) yield the approximate value 44. See also the equilibrium data and calculations of Rudder and Ferrer,[1] Halferdahl,[1] Allen and Lombard,[1] and Kamura.[1] We have selected the value from Mixter's[15] data because of the difficulty of interpreting the equilibrium data in terms of a pure reaction.

$FeSO_4$ (aq.). Thomsen[15] reported $Q=3.60$ for the reaction, $FeCl_2(200) + H_2SO_4(200) = FeSO_4(200) + 2HCl(100)$; whence, for $FeSO_4(200)$, $Qf=235.94$. Data on the heat of dilution of aqueous ferrous sulfate were reported by Thomsen.[15]

$FeSO_4$ (c). deForcrand[64] measured the heat of solution. See also the equilibrium data of Keppeler and d'Ans[1] and Greulich.[1]

$FeSO_4 \cdot H_2O$ (c). deForcrand[64] measured the heat of solution.

$FeSO_4 \cdot 4H_2O$ (c). deForcrand[64] measured the heat of solution.

$FeSO_4 \cdot 7H_2O$ (c). The data on the heat of solution are: Thomsen,[15] -4.52_{400}; deForcrand,[64] $-4.32_{110}{}^{14}$. Dissociation pressure data on the heptahydrate were obtained by Cohen and Visser,[2] Schumb,[1] Precht and Kraut,[1] and Wiedemann.[1]

$Fe_2(SO_4)_3$ (aq.). Thomsen[15] measured the heat of reaction of aqueous barium chloride with aqueous ferric sulfate to be 27.43 per mole of ferric sulfate. His data yield, for $Fe_2(SO_4)_3(400)$, $Qf=653.0$. See also Berthelot,[50] Tamanaeff,[1] and Pissarjewsky.[2] Data on the heat of dilution of aqueous ferric sulfate were reported by Thomsen,[15] Lemoine,[1] and Berthelot.[5, 26]

$Fe(HSO_4)_3$ (600). Berthelot[7] measured the heat of mixing $3H_2SO_4$ (200) with $Fe_2(SO_4)_3(600)$.

FeSe (c). Fabre[1] measured the heat of reaction of FeSe (c) with bromine water to be 117.4, and of $FeSO_4$ (aq.) with Na_2Se (aq.) to be 30.1. His data yield, for FeSe (c), $Qf=14.0$ and 13.2.

FeTe (c). Fabre's[1] data on the heat of solution of ferrous telluride in bromine water yield, for FeTe (c), $Qf=8$.

Fe_4N (c). The equilibrium data of Emmett, Hendricks, and Brunauer[1] on the reaction, $2Fe_4N\ (c) + 3H_2\ (g) = 3Fe\ (c) + 2NH_3\ (g)$, yield $Q=24.1$ at 500°, whence, for Fe_4N (c), $Qf=-1.1$. See also Fowler and Hartog.[1, 1a]

$Fe(NO_3)_2$ (aq.). This value is obtained from the ions.

$Fe(NO_3)_3$ (aq.). Berthelot's[50] data on heats of mixing yield, for $Fe(NO_3)_3(800)$, $Qf=156.3$, and for $Fe(NO_3)_3(200)$, $Qf=157.4$. See also Noyes and Braun.[1]

$Fe(NO_3)_3 \cdot 9H_2O$ (c). Berthelot[9] measured the heat of solution.

$FeNOSO_4$ (aq.). Manchot[2] calculated the heat of solution of NO (g) in $FeSO_4$ (aq.) to be 11.9, from vapor pressure data. By direct measurement, Gay[1] (see Manchot[2]) found 10.14.

$FeNO^{++}$ (aq.). This value is obtained from that for $FeNOSO_4$ (aq.).

$Fe(NH_4)_2NO(SO_4)_2$ (aq.). Manchot,[2] from vapor pressure data, computed the heat of solution of NO (g) in $Fe(NH_4)_2(SO_4)_2$ (aq.) to be 11.9. By direct measurement, Gay[1] (see Manchot[2]) found 10.4.

$FeNOCl_2$ (aq.). Gay[1] (see Manchot[2]) found the heat of solution of gaseous nitric oxide in aqueous ferrous chloride to be 10.7.

$FeNH_4(SO_4)_2$ (aq.). Berthelot[5] measured the heat of mixing aqueous ferric sulfate with aqueous ammonium sulfate.

$(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$(c). Graham[2] measured the heat of solution.

$NH_4Fe(SO_4)_2 \cdot 12H_2O$ (c). Berthelot[151] measured the heat of solution. See also Ephraim and Wagner.[1]

$FeCl_2 \cdot nNH_3$ (c). Dissociation pressure data were obtained on the deca-, hexa-, di-, and monoammines by Biltz and Rahlfs,[1] on the hexammine by Ephraim,[1, 9] and on the di- and monoammines by Biltz and Hüttig.[1] See also Girardet[1] and Ephraim and Millman.[1] The existing data were summarized by Biltz, Klatte, and Rahlfs.[1]

$FeBr_2 \cdot nNH_3$ (c). Biltz[5] and Biltz and Hüttig[2] reported dissociation pressure data on the hexa-, di-, and monoammines. See also Ephraim.[9]

$FeI_2 \cdot nNH_3$ (c). The dissociation pressure data of Biltz and Hüttig[1] on the di- and hexammines were recalculated by Biltz and Rahlfs.[1] See also Ephraim.[9]

$FeSO_4 \cdot nNH_3$ (c). Ephraim[8] measured the dissociation pressures of the mono-, di-, tri-, tetra-, and hexammines.

$FeBr_3 \cdot 6NH_3$ (c). Ephraim and Millman[1] measured the dissociation pressures.

$FeF_2 \cdot H_2O \cdot nNH_3$ (c). Biltz and Rahlfs[1] measured the dissociation pressures of the hemi-, mono-, and pentammines.

Fe_3C (c). Data on the heat of combustion of iron carbide were reported by Ruff and Gersten,[2] Watase,[2, 4] Bergkoff and Ermiloff,[1] Brody, Jennings, and Hayes,[1] Roth,[5] and Yap and Liu.[1] These data were reviewed by Roth,[5] who concluded that for the reaction, $3Fe\,(c) + C\,(\beta \text{ graphite}) = Fe_3C\,(c)$, $Q = -5.4$; whence, for Fe_3C (c), $Qf = -5.2$ (since the standard state here is C (diamond)). See also Troost and Hautefeuille,[3] Campbell,[1, 2, 3] Maxwell and Hayes,[1] Schenck, Semiller, and Falcke,[1] and Kawakami.[1]

(Fe+nC) (solid solution). Yarroda, from indirect measurements, calculated the heat of solution of carbon in iron to be −13.5.

$Fe(CO)_5$ (liq.). Roth[5] found the heat of combustion of liquid iron carbonyl in oxygen to be 371.4, the products being CO_2 (g) and Fe_3O_4 (c). This gives, for $Fe(CO)_5$ (liq.), $Qf = 189.8$. Mittasch[1] found $Q = 57.1$ for the reaction, $Fe(c, \alpha) + 5CO\,(g) = Fe(CO)_5(liq.)$, whence, for $Fe(CO)_5$ (liq.), $Qf = 191.2$.

$Fe(CO)_5$ (g). For the heat of vaporization of iron carbonyl, Trautz and Badsteubner[1] found −9.38, Dewar and Jones −7.7. See also Eyber.[1]

$Fe(CO)_5$ (c). Mittasch[1] found the heat of fusion to be −3.25 at about −20°.

$FeCO_3$ (c). Berthelot[12] measured the heat of reaction of $FeSO_4$ (aq.) with Na_2CO_3 (aq.) to be −3.7, and, assuming that the precipitate was ferrous carbonate, his data yield, for $FeCO_3$ (c), $Qf = 180$. LeChatelier,[8, 10] reported the heat of combustion of ferrous carbonate to be zero;

Roth[5] reported the value 10.64. Using Roth's data one calculates, for $FeCO_3$ (c), $Qf = 172.8$.

$Fe_2(C_2O_4)_3$ (aq.). The data of Lemoine[1] on the heat of mixing aqueous ferric chloride with aqueous oxalic acid, and of aqueous ferric oxalate with aqueous hydrochloric acid, yield, for $Fe_2(C_2O_4)_3(100)$, $Qf = 610.4$. Data on the heat of dilution of aqueous ferric oxalate were reported by Lemoine.[1]

$Fe(C_2H_3O_2)_3$ (aq.). Thomsen[15] measured the heat of reaction of aqueous ferric sulfate with aqueous barium acetate to be 20.21. Berthelot[5] measured the heat of reaction of aqueous ferric acetate with aqueous potassium hydroxide, and the reciprocal heats of mixing involving Fe^{+++}, $C_2H_3O_2^-$, H^+, and Cl^-. Data on the heat of dilution of aqueous ferric acetate were reported by Berthelot.[5]

$H_4Fe(CN)_6$ (aq.). Berthelot[27] measured the heat of the reaction of 6HCN (aq.) with $Fe(OH)_2$ (c) in alkaline solution to form $H_4Fe(CN)_6$ (aq.), and his data yield, for the latter $Qf = -122\,3$.

$H_4Fe(CN)_6$ (c). Chretien and Guinchant[1] measured the heat of solution.

$H_3Fe(CN)_6^-$(aq.), $H_2Fe(CN)_6^{--}$(aq.), $HFe(CN)_6^{---}$(aq.), $Fe(CN)_6^{----}$ (aq.). The values for these substances are obtained from the respective aqueous potassium salts.

$H_3Fe(CN)_6$ (aq.). Berthelot[27] measured the heat of oxidation of aqueous ferrocyanic acid with bromine and with chlorine, his data yielding, for the ferricyanic acid, $H_3Fe(CN)_6$ (aq.), $Qf = -148.1$ and -148.4, respectively.

$H_2Fe(CN)_6^-$ (aq.), $HFe(CN)_6^{--}$ (aq.), $Fe(CN)_6^{---}$ (aq.). The values for these ions are obtained from the respective aqueous potassium salts.

$FeCO(CN)_5^{---}$ (aq.). This value is obtained from that for the aqueous potassium salt.

$Fe_4(Fe(CN)_6)_3$ (c). Berthelot[27] measured the heat of reaction of aqueous ferrocyanic acid with ferric hydroxide to be 75.6, and the heat of reaction of aqueous KCN with aqueous ferrous and ferric sulfates to be 225.0; whence, for ferric ferrocyanide, $Qf = -322.5$ and -312.

$(NH_4)_4Fe(CN)_6 \cdot 3\,H_2O$ (c). Chretien and Guinchant[1] measured the heat of solution.

$(NH_4)_4Fe(CN)_6$ (aq.). Chretien and Guinchant[1] measured the heat of neutralization.

$Zn_2Fe(CN)_6$ (c). Joannis[1] measured the heat of reaction of $Na_4Fe(CN)_6$ (aq.) with $2\,ZnSO_4$ (aq.) to be 6.6 and that of $K_3Fe(CN)_6$ (aq.) with $2\,ZnSO_4$ (aq.) + HI (aq.) to be 21.2.

$H_3FeCO(CN)_5 \cdot H_2O$ (c). Muller[3] measured the heat of combustion.

$H_3FeCO(CN)_5$ (aq.). Muller[3] measured the heat of solution of the monohydrate.

Fe_3Si (c). Campbell[3] measured the heat of solution of Fe_3Si (c) and of Si (c) in aqueous cupric chloride to be 87 and 107, respectively. See also Osmond[2] and Troost and Hautefeuille.[2]

$FeSiO_3$ (c). LeChatelier[8, 10] and Wologdine[1] reported identical values, $Q = 5$, for the reaction, FeO (c) + SiO_2 (c) = $FeSiO_3$ (c). Le Chatelier[8, 10] also found $Q = -7.6$ for the reaction, $FeCO_3$ (c) + SiO_2 (c) = $FeSiO_3$ (c) + CO_2 (g). These data yield, for $FeSiO_3$ (c), $Qf = 272.6$ and 274.1, respectively.

$2\,FeI_2 \cdot PbI_2$ (c). Mosnier[1] measured the heat of solution.

$2\,FeI_2 \cdot PbI_2 \cdot 3\,H_2O$ (c). Mosnier[1] measured the heat of solution.

Manganese

Mn (c). The standard state is Mn (c, III). Umino[1] measured the heats of transition.

Mn (liq.). The data on the heat of fusion of manganese at its melting point, 1260°, are: Umino,[1] −3.56; Wust, Meuthen, and Durrer,[1] −2.0.

Mn (g). Vapor pressure data were reported by Greenwood[2, 5] and Ruff and Bormann.[1] These data yield −65 for the heat of vaporization at 1900°, or −75 for the heat of sublimation at 18°. Millar[1] calculated for the latter −58.

The values of the energy states of gaseous monatomic manganese are from Catalan.[2] See also Bacher and Goudsmit.[1]

Mn^{++} (aq.). This value is obtained from that for $MnCl_2$ (aq.).

Mn^{+++} (aq.). This value is obtained from that for $MnBr_3$ (aq.).

MnO (c). For the heat of formation of MnO (c) from solid manganese prepared from amalgam Guntz[12] reported 98.6. LeChatelier[10] and Roth[5] measured the heat of combustion of MnO (c, I) in oxygen to form $\frac{1}{3}\,Mn_3O_4$ (c), and obtained identical values, $Q = 18.5$, though the recent work of Roth is undoubtedly more accurate. This value yields, for MnO (c, I), $Qf = 96.5$. Millar[3] measured the heat of transition.

Mn_3O_4 (c). The heat of combustion of 3 Mn (c,III) in oxygen to form Mn_3O_4 (c) was measured by LeChatelier,[10] Ruff and Gersten,[2] and Roth[5] to be 318, 329.7, and 345.0, respectively.

Mn_2O_3 (c). From the equilibrium data of Meyer and Rötger[1] on the reaction, $6\,Mn_2O_3$ (c) = $4\,Mn_3O_4$ (c) + O_2 (g), Biltz[8] calculated $Q = -50.4$, whence, for Mn_2O_3 (c), $Qf = 238.3$. Equilibrium data on the reaction, $4\,MnO_2$ (c, I) = $2\,Mn_2O_3$ (c) + O_2 (g), were reported by Wohler and Balz,[2] Meyer and Rötger,[1] and Drucker and Huttner.[1] The latter investigators reported $Q = -26.0$, whence, taking the value 123 for MnO_2 (c, I), one obtains, for Mn_2O_3 (c), $Qf = 233$.

MnO_2 (c, ppt.). Thomsen[15] measured the heat of reaction of aqueous manganous sulfate with aqueous potassium permanganate, and the heat of reaction of MnO_2 (c, ppt.) with aqueous ferrous sulfate plus aqueous sulfuric acid. His data yield, for MnO_2 (c, ppt.), $Qf = 115.2$ and 115.9, respectively.

MnO_2 (c, I). The data of Mixter[11] on the reactions of Mn (c) and MnO_2 (c, I) with sodium peroxide, yield for MnO_2 (c, I), $Qf = 121\,2$. The equilibrium data of LeChatelier[10] on the reaction, $3\,MnO_2$ (c, I) = Mn_3O_4 (c) + O_2 (g), yield $Q = -48.0$; whence, for MnO_2 (c, I), $Qf = 131$.

MnO_2 (c, II). Millar[3] measured the heat of transition.

$Mn(OH)_2$ (c, ppt.). Thomsen[15] measured the heat of the reactions of $MnSO_4(400)$ with $Ba(OH)_2(400)$ and with 2 KOH(200) to be 10.31 and 4.91, respectively; whence, for $Mn(OH)_2$ (c, ppt.), $Qf = 163.42$ and 163.42. Berthelot[14] measured the heat of reaction of $MnCl_2(400)$ with 2 NaOH (200) to be 3.78, whence, for $Mn(OH)_2$ (c, ppt.), $Qf = 162.3$.

$Mn(OH)_3$ (c, ppt.). Petersen[3] measured the heat of mixing 2 MnF_3 (aq.) with 3 HF (aq.) and the heat of neutralization of ($2MnF_3 + 3$ HF) (aq.) with 9 NaOH (aq.) to be -0.01 and 94.82, respectively; whence, for $Mn(OH)_3$ (c, ppt.), $Qf = 221$.

MnO^-_4 (aq.). This value is obtained from that for $KMnO_4$ (aq.).

$HMnO_4$ (aq.). The heat of ionization of this acid is assumed to be zero.

MnF_2 (aq.). Petersen[3] measured the heat of reaction of $MnCl_2$ (aq.) with 2 AgF (aq.) to be 31 7.

MnF_3 (aq.). This value is obtained from the ions.

$MnF_3 \cdot 3$ HF (aq.). Petersen[3] measured the heat of mixing MnF_3 (aq.) with 3 HF (aq.) to be -0.01.

$MnCl_2$ (aq.). Thomsen[15] measured the heat of solution of solid manganese (0.994 Mn) in 2 HCl(50) to be 49.6; whence, for $MnCl_2(100)$, $Qf = 128$ 3. We have estimated the heat of dilution.

$MnCl_2$ (c). Thomsen[15] measured the heat of solution. See also the equilibrium data of Jellinek and Rudat[3] and Jellinek and Cloth.[1]

$MnCl_2 \cdot nH_2O$ (c). For the heat of solution of the dihydrate, Foote and Saxton[1] found 8 20_{300} and Sabatier[2] found 8.1. Thomsen[15] measured the heat of solution of the tetrahydrate.

H_2MnCl_6 (aq.). Berthelot[68] measured the heat of solution of Cl_2 (g) in concentrated aqueous 2 $HCl \cdot MnCl_2$ to be 9 2.

$MnBr_2$ (aq.). This value is obtained from the ions.

$MnBr_2$ (c). We have estimated the heat of solution to be 15.

$MnBr_2 \cdot nH_2O$ (c). Lescoeur[7] obtained dissociation pressure data on the di- and tetrahydrates.

$MnBr_3$ (aq.). Fabre[1] measured the heat of solution of manganese in bromine water to be 109.

MnI_2 (aq.). This value is obtained from the ions.

MnI_2 (c). Mosnier[1] measured the heat of solution.

$MnI_2 \cdot nH_2O$ (c). Lescoeur[1] obtained dissociation pressure data on the mono-, di-, tetra-, and hexahydrates.

MnS (c, ppt.). For the heat of the reaction of $MnCl_2(400)$ with $Na_2S(400)$, Berthelot[14] found $Q = 6$ 4 and Thomsen[15] found $Q = 7.78$. The latter figure yields, for MnS (c, ppt.), $Qf = 47.0$. See also Wologdine and Penkiewitsch[1] and Jellinek and Podjaski.[1]

$MnSO_4$ (aq.). Thomsen[15] measured the heats of reaction of $MnCl_2$ (200) with $H_2SO_4(200)$ and $MnSO_4(200)$ with 2 HCl(100), and of $MnSO_4(400)$ with $BaCl_2(400)$. His data yield, for $MnSO_4(400)$, $Qf = 264.91$ and 265.15. Thomsen[15] measured the heat of dilution.

$MnSO_4$ (c). Thomsen[15] measured the heat of solution.

$MnSO_4 \cdot nH_2O$ (c). Thomsen[15] measured the heats of solution of the mono- and pentahydrates. Dissociation pressure data on the heptahydrate were obtained by Bolte,[1] Schottky,[1] Hollmann,[1] Lescoeur,[4] Linebarger,[1] and Carpenter and Jette.[1]

$Mn_2(SO_4)_3$ (aq.). This value is obtained from the ions.

$Mn_2(SO_4)_3$ (c). Beck[1] measured the heat of solution.

MnS_2O_6 (aq.). This value is obtained from the ions.

$MnS_2O_6 \cdot 6\ H_2O$ (c). Thomsen[15] measured the heat of solution.

MnSe (c). Fabre[1] measured the heat of solution of MnSe (c) in bromine water to be 125.6, and the heat of reaction of $MnSO_4$ (aq.) with Na_2Se (aq.) to be 14.2; whence, for MnSe (c), $Qf = 34$ and 26.3, respectively.

MnN_6 (c). Wohler and Martin[1] measured the heat of decomposition of the azide to be 94.0.

Mn_3N_2 (c). Neumann, Kroger, and Kunz[1] measured the heat of solution of the nitride in aqueous (18 per cent) sulfuric acid to be 278.35, and Neumann, Kroger, and Hoebler[1] measured the direct heat of combination to be 57.2. The former data yield $Qf = 56.0$. See also Valensi.[1]

$Mn(NO_3)_2$ (aq.). Thomsen[15] measured the heat of reaction of $Mn(OH)_2$ (c) with HNO_3 (aq.) to be 22.90, whence, for $Mn(NO_3)_2$(400), $Qf = 147.8$.

$Mn(NO_3)_2$ (c). Guntz and Martin[1] measured the heat of solution.

$Mn(NO_3)_2 \cdot 6\ H_2O$ (c). Thomsen[15] measured the heat of solution.

$Mn(NO_3)_2 \cdot 6\ H_2O$ (liq.). Reisenfeld and Milchsack[1] measured the heat of fusion of the hexahydrate.

$Mn(NO_3)_2 \cdot 3\ H_2O$ (liq.). We have estimated the heat of dilution from 3 to 6 H_2O.

$Mn(NO_3)_2 \cdot 3\ H_2O$ (c). Morgan and Owens[1] measured the heat of fusion.

$MnF_2 \cdot H_2O \cdot nNH_3$ (c). Biltz and Rahlfs[2] measured the dissociation pressures of the ammines with 1 and 5 NH_3.

$MnX_2 \cdot nNH_3$ (c). Biltz and Hüttig[1] obtained dissociation pressure data on the mono-, di-, and hexammines of $MnCl_2$ and $MnBr_2$, and on the di- and hexammines of MnI_2. Ephraim[1, 9] obtained similar data on the hexammines of $MnCl_2$, $MnBr_2$, and MnI_2.

$MnSO_4 \cdot nNH_3$ (c). Ephraim[8] reported meager data on the ammines with $\frac{1}{2}$, 1, 2, 5, and 6 NH_3.

$MnBr_2 \cdot 2\ NH_4Br$ (aq.). Varet[6] measured the heat of mixing $MnBr_2$ (200) with 2 NH_4Br(100) to be 0.08.

$MnCl_2 \cdot 2\ NH_4Cl \cdot 2\ H_2O$ (c). Foote and Saxton[1] measured the heat of solution.

$MnSO_4 \cdot (NH_4)_2SO_4 \cdot nH_2O$ (c). Graham[2] measured the heat of solution of the hexahydrate. Ephraim and Wagner[1] reported the heat of dissociation of the hexahydrate to the dihydrate to be -11.2 per mole of water vapor.

$Mn_2(PO_4)_3$ (c, ppt.). Joly[3] and Berthelot[101] obtained data on the heats of reaction of $MnCl_2$(aq.) with various aqueous sodium phosphates. Because their published papers lack the details with which to make a proper interpretation of their data, we have given only the value for crystalline precipitated manganic phosphate.

Mn_3C (c). The data on the heat of combustion of Mn_3C (c) in oxygen to form Mn_3O_4 (c) and CO_2 (g) are: Ruff and Gersten,[2] 409.8; LeChatelier,[10] 411.2; Roth,[5] 419.8. These data yield, for Mn_3C (c), $Qf=29.7$, 28.3, and 19.7. See also Troost and Hautefeuille.[3]

$MnCO_3$ (c, ppt.). Thomsen[15] found $Q=-2.04$ for the reaction of $MnSO_4(400)$ with $Na_2CO_3(400)$; Berthelot[12] found $Q^{16}=-2.36$ for the reaction of $MnCl_2(200)$ with $Na_2CO_3(200)$. These data yield, for $MnCO_3$ (c, ppt.), $Qf=207.85$ and 207 67, respectively.

$MnCO_3$ (c). For the heat of combustion of $MnCO_3$ (c) in oxygen to form $\frac{1}{3}$ Mn_3O_4 (c) $+CO_2$ (g), the following values were reported: Wologdine,[1] -3.5; LeChatelier,[10] -5.1; Roth,[5] -9.8.

MnC_2O_4(c). Smith and Topley[1] measured the heat of solution in $HNO_3(9)$.

$MnC_2O_4 \cdot nH_2O$ (c). Smith and Topley[1] measured the heat of solution in $HNO_3(9)$ of the di- and trihydrates. Berthelot[9] measured the heat of reaction of $MnCl_2(100)$ with $K_2C_2O_4(100)$ to form the solid dihydrate to be 4.3.

$Mn(CHO_2)_2$ (aq.). Berthelot[9] measured the heat of neutralization of aqueous formic acid with $Mn(OH)_2$ (c) to be 21.4.

$Mn(CHO_2)_2$ (c). Berthelot[9] measured the heat of solution.

$Mn(CHO_2)_2 \cdot 2\,H_2O$ (c). Berthelot[9] measured the heat of solution.

$Mn(C_2H_3O_2)_2$ (aq.). Berthelot[9, 131] measured the heat of neutralization of $Mn(OH)_2$ (c) with aqueous acetic acid to be 22.1.

$Mn(C_2H_3O_2)_2$ (c). Berthelot[9, 131] measured the heat of solution.

$Mn(C_2H_3O_2)_2 \cdot 4\,H_2O$ (c). Berthelot[9, 131] measured the heat of solution.

$MnSiO_3$ (gls.). Mulert[1] measured the heat of solution of this substance in aqueous (20%) HF.

$MnSiO_3$ (c). Mulert[1] measured the heat of solution of this substance in aqueous (20%) HF. For the reaction, MnO (c) $+SiO_2$ (c, quartz) $=MnSiO_3$ (c), LeChatelier[10] reported $Q=2.7$. For the reaction, $MnCO_3$ (c) $+SiO_2$ (c, quartz) $=MnSiO_3$ (c) $+CO_2$ (g), Wologdine[1] and Wologdine and Penkiewitsch[1] reported $Q=19.6$. These data yield, for $MnSiO_3$ (c), $Qf=301.3$, 302.5, and 307.3, respectively.

$2MnI_2 \cdot PbI_2$ (c). Mosnier[1] measured the heat of solution.

$2MnI_2 \cdot PbI_2 \cdot 3\,H_2O$ (c). Mosnier[1] measured the heat of solution.

$MnBr_2 \cdot nHgBr_2$ (aq.). Varet[6] measured the heats of mixing $MnBr_2$ (aq.) with $\frac{1}{2}$, 1, and 2 moles of $HgBr_2$ (aq.).

Chromium

Cr (c). Standard state. Laschtschenko[1] reported a transition at 480° with $T=-0.13$, but no other investigator has found such a transition.

Cr (liq.). The data on the heat of fusion at 1600° are: Umino,[3] −3.65; Wust, Meuthen, and Durrer,[1] −1.66.

Cr (g). Greenwood[2, 5] reported the boiling point of chromium to be 2200°. We have estimated the heat of vaporization to be −76 at 2200°. The energy states of gaseous monatomic chromium have been evaluated from the data of Kiess,[1] Catalan and Sancho,[1] Russell,[6] and White.[3, 4, 5]

Cr_7H_2 (c). Sieverts and Gotta[2] reported the heat of dissociation of this hydride to be −3.7.

CrO_3 (c). Mixter[6, 16] measured the heat of reaction of CrO_3 (c) with Na_2O (c) to be 77 0, and of Cr (c) with Na_2O_2 (c) to be 158 8; whence, for CrO_3 (c), $Qf=141.1$. Combination of the heat of neutralization of CrO_3 (aq.) with 2 NaOH (aq), and of the heats of solution of CrO_3 (c) and Na_2CrO_4 (c) with Mixter's[6, 16] data on the reaction, Cr (c) $+3\ Na_2O_2$ (c) $=Na_2CrO_4$ (c) $+2\ Na_2O$ (c), $Q=158\ 8$, yields, for CrO_3 (c), $Qf=137.5$. Roth and Becker[1] measured the heats of the reactions, Cr (c) $+\frac{3}{4}\ O_2$ (g) $=\frac{1}{2}\ Cr_2O_3$ (c) and CrO_3 (c) $=\frac{1}{2}\ Cr_2O_3$ (c) $+\frac{3}{4}\ O_2$ (g), to be 144.4 and −3.5, respectively; whence, for CrO_3 (c), $Qf=147.9$.

Cr_2O_3 (c). Mixter[6, 16] measured the heats of the reactions, Cr_2O_3 (c) $+3\ Na_2O_2$ (c) $=2\ Na_2CrO_4$ (c) $+Na_2O$ (c) and $2\ CrO_3$ (c) $+2\ Na_2O$ (c) $=2\ Na_2CrO_4$ (c), to be 107.8 and 154.0, respectively; whence for the reaction, Cr_2O_3 (c) $+1\frac{1}{2}\ O_2$ (g) $=2\ CrO_3$ (c), $Q=-13\ 0$, and, for Cr_2O_3 (c), $Qf=265.6$. Roth and Becker[1] measured the heat of combustion of chromium in oxygen to form Cr_2O_3 (c) to be 288 9.

CrO_3 (aq.). The data on the heat of solution of CrO_3 (c) are: Briechner and Prins,[1] 2.47_{80}; Morges,[1] 2.2; Sabatier,[5] 1 9. Data on the heat of dilution of aqueous CrO_3 were reported by Briechner and Prins[1] and Morges.[1]

CrO_4^{--} (aq.). The value for this ion is obtained from Na_2CrO_4 (aq.) and K_2CrO_4 (aq.).

CrO (g). Ghosh[1] computed the energy of dissociation of CrO (g) from spectroscopic data.

$Cr_2O_7^{--}$ (aq.). This value is obtained from those for $Na_2Cr_2O_7$ (aq.) and $K_2Cr_2O_7$ (aq.).

$[CrX_{3-n}]X_n$ (aq.). Trivalent chromium salts form several distinct kinds of solutions: the purple solution, which is supposed to contain $[Cr\cdot 6\,H_2O]X_3$; the green solution, which is supposed to contain $[Cr\cdot 4\,H_2O\cdot X_2]X$; and others of less importance for the present purpose. In writing the formulas of the aqueous ions and molecules, we have omitted the water molecules, so that for the above molecules are written $[Cr]X_3$ and $[Cr\cdot X_2]X$ and the positive ions $[Cr]^{+++}$ and $[Cr\cdot X_2]^{+}$. The number of molecules of H_2O necessary to make the coordination number of chromium have the value 6 have been omitted in writing the formulas

of the aqueous ions and the aqueous molecules and in computing the respective heats of formation. When dichromates are reduced in acid solution, the product is the green solution containing $[Cr \cdot X_2]X$. Thomsen[15] found $Q=219.6$ for the reaction, $2\,CrO_3$ (aq.) $+6$ HCl (aq.) $+3(SnCl_2+2$ HCl) (aq.) $=3(SnCl_4+2[Cr\ Cl_2]Cl)$ (aq.) $+6\,H_2O$ (liq.); whence, for $[Cr \cdot Cl_2]Cl$ (aq.), $Qf=166.5$. Berthelot[96] found $Q=153.8$ for the preferable reaction, $K_2Cr_2O_7$ (aq.) $+$ 8 HCl (aq.) $+$ 6 HI (aq.) $=(2[Cr \cdot Cl_2]Cl+6$ HCl $+3$ KCl) (aq.) $+7\,H_2O$ (liq.) $+3\,I_2$ (c); whence, for $[Cr \cdot Cl_2]Cl$ (aq.), $Qf=173.6$. Neuman, Kroger, and Kunz[1] measured the heat of solution of chromium in HCl(8) to be 50.6; whence, assuming the product to be $[Cr \cdot Cl_2]Cl$ (aq.), one finds, for the latter, $Qf=167.3$. Recoura[3] measured the heat of reaction of [Cr] $(OH)_3$ (c, ppt.) with 3 HCl (aq.) to form $[Cr]Cl_3$ (aq., purple) to be 20.7. Bjérrum[1] computed the heat of the same reaction to be 21.2, from data on the hydrolysis constant. Recoura[3] measured the heat of reaction of 3 NaOH (aq.) with $[Cr]Br_3$ (aq.) and with $[Cr \cdot Br_2]Br$ (aq.).

$[Cr \cdot 6\,H_2O]Br_3$ (c, purple). Recoura[3] measured the heat of solution.

$[Cr \cdot 4\,H_2O \cdot Br_2] \cdot 2\,H_2O$ (c, green). Recoura[3] measured the heat of solution.

$[CrCl_2]Cl$ (c, rose). Recoura[3] measured the heat of solution.

$[Cr \cdot 4\,H_2O \cdot Cl_2]Cl$ (c, green). Higley[1] measured the heat of solution.

$[Cr \cdot 4\,H_2O \cdot Cl_2]Cl \cdot 2\,H_2O$ (c, green). Recoura[3] measured the heat of solution.

$[Cr \cdot 4\,H_2O \cdot Cl_2]Cl \cdot 6\,H_2O$ (c, green). Higley[1] measured the heat of solution.

$[Cr \cdot 6\,H_2O]Cl_3$ (c, purple). Recoura[3] measured the heat of solution.

$[Cr]^{+++}$ (aq., purple). This value is obtained from that for the aqueous chloride.

$[Cr]^{++}$ (aq.). This value is obtained from that for $CrCl_2$ (aq.).

$Cr_3O_{10}^{--}$ (aq.). We have estimated the heat of the reaction, $Cr_2O_7^{--}$ (aq.) $+CrO_3$ (aq.) $=Cr_3O_{10}^{--}$ (aq.).

H_2CrO_4 (aq.). We have taken this as equivalent to CrO_3 (aq.) $+H_2O$ (liq).

$[Cr \cdot Cl_2]^+$ (aq.). This value is obtained from that for the aqueous chloride.

$[Cr](OH)_3$ (c, ppt.). Recoura[3] measured the heat of reaction of $[Cr \cdot Cl_2]Cl$ (aq.) with 3NaOH (aq.)

$[Cr \cdot (OH)_2]OH$ (c, ppt.). Recoura[3] measured the heat of reaction of this substance with 3HCl (aq.).

$[Cr \cdot OH](OH)_2$ (c, ppt.). Recoura[3] measured the heat of reaction of this substance with 3HCl (aq.).

$[Cr \cdot (OH)_2]Cl$ (aq.). From data on the hydrolysis constant, Bjerrum[1] computed the heat of the reaction of this substance with HCl (aq.) to be 8.1.

$[Cr \cdot OH]Cl_2$ (aq.). From data on the hydrolysis constant, Bjerrum[1] computed the heat of reaction of this substance with HCl (aq.) to be 9.6.

$[Cr(OH)]^{++}$ (aq.). This value is obtained from that for the aqueous chloride.

$CrCl_2$ (aq.). Recoura[3] measured the heat of the reaction, $2CrCl_2$(aq.) $+\frac{1}{2}O_2$ (g) $+H_2O$ (liq.) $=2[Cr \cdot OH]Cl_2$ (aq.), to be 30.4.

$CrCl_2$ (c). Recoura[3] measured the heat of solution. See also Jellinek and Koop.[1]

$CrCl_2 \cdot 4H_2O$ (c, dark green). Recoura[3] measured the heat of solution.

$CrCl_2 \cdot 3H_2O$ (c, light green). Knight and Rich[1] studied the equilibrium between the tetra- and trihydrates.

CrI_2 (c). Recoura[3] measured the heat of solution.

CrI_2 (aq.). This value is obtained from the ions.

$[Cr]F_3$ (aq.). Petersen[3] measured the heat of reaction of $[Cr]F_3$ (aq.) with 3NaOH (aq.) to be 23.65.

$H_3[Cr]F_6$ (aq.). Petersen[3] measured the heat of reaction of $[Cr]F_3$ (aq.) with 3HF (aq.).

CrF_3 (c). Jellinek and Rudat[1] studied the equilibrium, $2CrF_2$ (c) $+F_2$ (g) $=2CrF_3$ (c), finding $Q=158.0$.

CrF_2 (c). Jellinek and Rudat,[1] from equilibrium data on the direct formation, Cr (c) $+F_2$ (g) $=CrF_2$ (c), computed $Qf=152$.

CrO_2Cl_2 (liq.). Berthelot[53, 54, 93] measured the heat of solution. See also Moles and Gomez.[1]

CrO_2Cl_2 (g). From data on the boiling point elevation, Beckmann[4] computed the heat of vaporization.

$[Cr]_2(SO_4)_3$ (aq., purple). Thomsen[15] measured the heat of neutralization of $[Cr](OH)_3$ (c, ppt.) with H_2SO_4 (aq.) to be 49.3; whence, for $[Cr]_2(SO_4)_3$ (aq., purple), $Qf=772.2$. Colson[2] measured the heat of reaction of $3BaCl_2$ (aq.) with $[Cr]_2(SO_4)_3$ (aq.) to be 19.95; whence, for $[Cr]_2(SO_4)_3$ (aq., purple), $Qf=772.3$.

$[Cr_2 \cdot (SO_4)_3]$ (aq., green). Colson[2] measured the heat of reaction of this solution with 6NaOH (aq.) to be 61.1; whence $Qf=757.4$. See also Recoura.[2]

$[Cr_2 \cdot (SO_4)_2]SO_4$ (aq., green). Colson[2] measured the heat of reaction of this substance with 6NaOH (aq.) to be 57.6; whence $Qf=760.9$. See also Recoura.[2]

$[Cr_2 \cdot SO_4](SO_4)_2$ (aq., green). Colson[2] measured the heat of reaction of this substance with 6NaOH (aq.) to be 50.7; whence, $Qf=767.8$. See also Recoura.[2]

$Cr_2(SO_4)_3$ (aq., "modified"). When heated, the purple aqueous chromic sulfate is hydrolyzed, and we have assumed that this "modified" solution is $([Cr_2 \cdot (SO_4)_2](OH)_2+H_2SO_4)$ (aq.). Colson[2] measured the heats of reaction of both hydrolyzed and normal solutions with 6NaOH (aq.) to obtain the difference in their heats of formation.

$Cr_2(SO_4)_3 \cdot 6H_2O$ (c, green). Colson[2] measured the heat of solution.

$[Cr \cdot 6H_2O]_2(SO_4)_3 \cdot nH_2O$ (c, purple). Senechal[1] and Recoura[2] measured the heats of solution of various hydrates. We have utilized Senechal's[1] data to distinguish the three hydrates with $n=2$, 3, and 5.

CrN (c). Neuman, Kroger, and Hawbler[1] reported $Qf=29.5$. See also Valenski.[1]

$(NH_4)_2CrO_4$ (aq.). Morges[1] measured the heat of reaction of $CrO_3(500)$ with $NH_4OH(100)$ to be 23.48. See also Berthelot.[95]

$(NH_4)_2CrO_4$ (c). Sabatier[5] measured the heat of solution.

$(NH_4)_2Cr_2O_7$ (aq.). Berthelot[95] measured the heat of reaction of $(NH_4)_2Cr_2O_7$ (aq.) with NH_4OH (aq.) and with 2KOH (aq.). See also Morges[1] and Moles and Gonzales.[1]

$(NH_4)_2Cr_2O_7$ (c). For the heat of solution, Moles and Gonzales[1] found -12.90_{340}[10] and Berthelot[95] -12.4[13].

$CrCl_2 \cdot nNH_3$ (c). Ephraim and Millman[1] obtained dissociation pressure data on the di- and triammines.

Cr_3C_2 (c). Heusler[1] studied the equilibrium, $3Cr_2O_3$ (c) $+13C$ (c) $=2Cr_3C_2$ (c) $+9CO$ (g), and calculated $Q=-297$.

$PbCrO_4$ (c). Goldblum and Stoffella[1] measured the heat of reaction of aqueous potassium chromate with aqueous lead nitrate to be 10.6. For the heat of the reaction of aqueous lead chloride with aqueous potassium chromate, Roth, Schwartz, and Buchner[1] found $Q=11.16$.

$2CrI_2 \cdot PbI_2$ (c). Mosnier[1] measured the heat of solution.

$2CrI_2 \cdot PbI_2 \cdot 3H_2O$ (c). Mosnier[1] measured the heat of solution.

MOLYBDENUM

Mo (c). Standard state.

Mo (g). Jones, Langmuir, and Mackay[1] reported values for the vapor pressure of solid molybdenum. The energy states of gaseous monatomic molybdenum are evaluated from the data of Catalan[1] and Meggers and Kiess.[1] See also Bacher and Goudsmit.[1]

MoO_3 (c). For the heat of formation of this substance, Moose and Parr[1] found 176.5, which value was obtained by combustion of molybdenum in oxygen in a bomb. For the same quantity, Delepine[2] found 167. Mixter's[10] data on the reaction of Mo (c) with $3Na_2O_2$ (c) and of MoO_3 (c) with Na_2O (c) yield $Q=205.3$ and 81.9, respectively; whence, for MoO_3 (c), $Qf=182.7$.

MoO_2 (c). Mixter[10] measured the heat of reaction of MoO_2 (c) with Na_2O_2 (c) to be 101.2.

H_2MoO_4 (aq.). Pechard[1] measured the heat of reaction of Na_2MoO_4 (aq.) with $H_2SO_4(400)$ to be 6.9.

MoO_3 (aq.). This is taken as equivalent to H_2MoO_4 (aq.) $-H_2O$ (liq.).

MoO_4 (aq.). Pissarjewsky[2, 4] measured the heat of reaction of MoO_3 (aq.) with H_2O_2 (aq.) to be 8.1.

MoO_5 (aq.). Pissarjewsky[2, 4] measured the heat of reaction of MoO_3 (aq.) with $2H_2O_2$ (aq.) to be 12.35.

$MoO_3 \cdot nH_2O$ (c) or $H_2WO_4 \cdot (n-1)H_2O$ (c). Hüttig and Kurre[1] obtained dissociation pressure data on the mono- and dihydrates of MoO_3.

MoO_4^{--} (aq.). This value is obtained from that for Na_2MoO_4 (aq.).

MoF_6 (c), MoF_6 (liq.). Ruff and Ascher[1] measured the vapor pressures of the solid and liquid.

$PbMoO_4$ (c). Tammann and Westerhold[1] calculated the heat of dissociation of $PbO \cdot MoO_3$ (c).

$CuMoO_4$ (c). Tammann and Westerhold[1] calculated the heat of dissociation of $CuO \cdot MoO_3$ (c).

$FeMoO_4$ (c). Tammann and Westerhold[1] calculated the heat of dissociation of $FeO \cdot MoO_3$ (c).

$Fe_2(MoO_4)_3 \cdot xH_2O$ (c). Tammann and Westerhold[1] calculated the heat of dissociation of the hydrated $Fe_2O_3 \cdot 3MoO_3 \cdot xH_2O$ (c) where x is unknown.

TUNGSTEN

W (c). Standard state.

W (g). Values for the vapor pressure of solid tungsten were computed by Jones, Langmuir, and Mackay[1] from data on the rate of loss of weight of heated tungsten wires. See also van Liempt.[2] The values for the energy states of gaseous monatomic tungsten are from Bacher and Goudsmit.[1]

WO_3 (c). For the heat of combustion of tungsten in oxygen to form WO_3 (c), Moose and Parr[1] found 195.7. See also Delepine and Hallopeau,[1] Delepine,[6] Wiess, Martin, and Stimmelmayr,[1] and van Liempt.[4] Mixter's[6] data on the heat of the reaction of W (c) with 3 Na_2O_2 (c) and of WO_3 (c) with Na_2O (c) yield $Q = 231.2$ and 94.70, respectively; whence, for WO_3 (c), $Qf = 195.8$.

WO_2 (c). Delepine and Hallopeau[1] measured the heat of combustion of WO_2 (c) to form WO_3 (c) to be 65.2; whence, for WO_2 (c), $Qf = 130.5$. From equilibrium studies, Shibata[2] calculated $Q = 11.5^{1000}$ for the reaction, $\frac{1}{2}WO_2$ (c) $+ CO$ (g) $= \frac{1}{2}W$ (c) $+ CO_2$ (g), whence, for WO_2 (c), $Qf = 115$. Similar data on the reaction, W (c) $+ 2H_2O$ (g) $= WO_2$ (c) $+ H_2$ (g), which was studied by Chaudron,[1, 2] yield $Q = 8.8$, whence, for WO_2 (c), $Qf = 124$.

W_2O_5 (c). Shibata[2] studied the equilibria, W_2O_5 (c) $+ CO$ (g) $= 2WO_2$ (c) $+ CO_2$ (g) and $2WO_3$ (c) $+ CO$ (g) $= W_2O_5$ (c) $+ CO_2$ (g), and calculated $Q = 4.7$ and 7.2, respectively; whence, for W_2O_5 (c), $Qf = 324$ and 331. Chaudron's[1] data on the equilibrium, $2WO_2$ (c) $+ H_2O$ (g) $= W_2O_5$ (c) $+ H_2$ (g), yield $Q = 4.0^{850}$; whence, for W_2O_5 (c), $Qf = 323$. See also Alterthum and Koref[1] and van Liempt.[3]

H_2WO_4 (c), or $WO_3 \cdot H_2O$ (c). Hüttig and Kurre[1] obtained data on the dissociation pressure.

H_2WO_4 (aq.). Pissarjewsky[2] measured the heat of solution of the solid in aqueous NaOH to be 13.7.

$WO_3 \cdot nH_2O_2$ (aq.). Pissarjewsky[2] measured the heat of mixing

H_2WO_4 (aq.) with 1, 2, and 3 moles of H_2O_2 (aq.) to be 0.9, 1.5 and 3.2, respectively.

WF_6 (c), WF_6 (liq.). Ruff and Ascher[1] measured the vapor pressures of the liquid and solid.

WS_2 (c). Parravano and Malquori[2] studied the equilibrium W (c) $+2\,H_2S$ (g) $=WS_2$ (c) $+2\,H_2$ (g), and computed $Q=73.4^{950}$.

$W(CN)_8^{----}$ (aq.), $W(CN)_8^{----}$ (aq.). Collenberg[1] reported $Q=16.85$ for the reaction, Hg (liq.) $+Cl^-$ (aq.) $+W(CN)_8^{----}$ (aq.) $=HgCl$ (c) $+$ $W(CN)_8^{----}$ (aq.).

$CuWO_4$ (c). Tammann and Westerhold[1] reported the heat of the reaction of CuO (c) with WO_3 (c) to be 12.1.

$CuWO_4 \cdot 2H_2O$ (c). Tammann and Westerhold[1] reported $Q=19.0$ for the reaction of CuO (c) with WO_3 (c) and $2H_2O$ (liq.).

$FeWO_4$ (c). Tammann and Westerhold[1] reported $Q=9.7$ for the reaction of FeO (c) with WO_3(c).

$FeWO_4 \cdot 3H_2O$ (c). Tammann and Westerhold[1] reported $Q=17.2$ for the reaction of FeO (c) with WO_3 (c) and $3H_2O$ (liq.).

$Fe_2(WO_4)_3 \cdot 8H_2O$ (c). Tammann and Westerhold[1] reported $Q=7.2$ for the reaction of Fe_2O_3 (c) with $3WO_3$ (c) and $8H_2O$ (liq.).

Uranium

U (c). Standard state.

U (g). We have estimated the heat of sublimation.

UO_3 (c). Mixter[14] measured the heats of the reactions, U (c) $+$ $3\,Na_2O_2$ (c) $=Na_2UO_4$ (c) $+2\,Na_2O$ (c) and UO_3 (c) $+Na_2O$ (c) $=Na_2UO_4$ (c), to be 341.8 and 96.1, respectively; whence, for UO_3 (c), $Qf=305.0$. Mixter[14] measured the heats of the reactions, $3\,U$ (c) $+4\,O_2$ (g) $=U_3O_8$ (c), U_3O_8 (c) $+Na_2O_2$ (c) $+2\,Na_2O$ (c) $=3\,Na_2UO_4$, and UO_3 (c) $+Na_2O$ (c) $=Na_2UO_4$ (c), to be 845.2, 285.1, and 96.1, respectively; whence, for UO_3 (c), $Qf=287.3$. Biltz and Fendius[1] measured the heat of solution of UO_3 (c) in ($FeCl_3+HCl$) (aq.) to be 20.8, and combining this with other unnamed data deduced, for UO_3 (c), $Qf=291.6$.

UO_2 (c). Mixter[14] measured the heat of the reaction, UO_2 (c) $+Na_2O_2$ (c) $=Na_2UO_4$ (c), to be 110.9.

U_3O_8 (c). Mixter[14] measured the heat of combustion of U (c) in oxygen to form U_3O_8 (c) to be 845.2, and measured the heat of the reaction, U_3O_8 (c) $+Na_2O_2$ (c) $+2\,Na_2O$ (c) $=3\,Na_2UO_4$ (c), to be 285.1. The latter reaction yields, for U_3O_8 (c), $Qf=857.8$.

$UO_3 \cdot nH_2O$ (c). Hüttig and Kurre,[1] from dissociation pressure data, computed the heats of dissociation of the hydrates with 2, $1\frac{1}{2}$, 1, and $\frac{1}{2}$ H_2O to be 15.0, 16.7, 20.2, and 26.6, respectively, per mole of H_2O (g). de Forcrand[58] measured the heats of solution of the anhydrous oxide and the mono- and dihydrates in 2 HNO_3 (110) to be 19.8, 14.85, and 12.38, respectively. Aloy[1] measured the heat of solution of the dihydrate to be 8.8 in 2 HBr(100), 8.4 in 2 HNO_3(100), 8.4 in 2 HCl(100), 9.5 in H_2SO_4(200), and 7.5 in 2 $HC_2H_3O_2$(100).

UO_2Cl_2 (aq.). Aloy[1] measured the heat of solution of $UO_3 \cdot 2\,H_2O$ (c) in 2 HCl(100) to be 8.4.

$UO_2(NO_3)_2$ (aq.). de Forcrand[58] measured the heat of solution of UO_3 (c) in 2 HNO_3(110) to be 19 8.

UO_2SO_4 (aq.). Aloy[1] measured the heat of solution of $UO_3 \cdot 2\,H_2O$ (c) in H_2SO_4(200) to be 9.5.

UO_2Br_2 (aq.). Aloy[1] measured the heat of solution of $UO_3 \cdot 2\,H_2O$ (c) in 2 HBr(100) to be 8.8.

$UO_2(C_2H_3O_2)_2$ (aq.). Aloy[1] measured the heat of solution of $UO_3 \cdot 2\,H_2O$ (c) in 2 $HC_2H_3O_2$(100) to be 7 5.

UO_2^{++} (aq.). This value is obtained from those for the aqueous chloride and nitrate.

$UO_2Cl_2 \cdot H_2O$ (c). Aloy[1] measured the heat of solution.

$UO_4 \cdot 2\,H_2O$ (c). Pissarjewsky[1] measured the heats of solution of $UO_3 \cdot H_2O$ (c) and of $UO_4 \cdot 2\,H_2O$ (c) in H_2SO_4(55) to be 15.35 and −0.11, respectively.

UF_6 (g). Ruff and Heinzelmann[1] measured the vapor pressure of the liquid.

UCl_3 (c), UCl_4 (c). Biltz and Fendius[1] reported the heats of solution of U (c), UCl_4 (c), and UCl_3 (c) in HCl(8) to be 144.4, 39.4, and 40.6, respectively; the heats of solution of UO_3 (c), UCl_4 (c), and UCl_3 (c) in ($FeCl_3$+HCl) (aq.) to be 20.8, 30.3, and 30.3, respectively; the heat of solution of Cl_2 (g) in ($FeCl_2$+UCl_3) (aq.) to be 42.8; the heat of solution of Cl_2 (g) in (ICl_3+UCl_4) (aq.) to be 13.5; and the heats of solution of UO_3 (c) and UCl_4 (c) in (ICl_3+HCl) (aq.) to be 20.7 and 60 2, respectively.

$U(SO_4)_2$ (c). Beck[1] measured the heat of reaction with NaOH (aq.) to be 56.5.

UO_2SO_4 (c). Beck[1] measured the heat of reaction of this substance with KOH (aq.) to be 42.3.

$UO_2SO_4 \cdot 3\,H_2O$ (c). Aloy[1] measured the heat of solution to be 5.1_{1000}. See also Favre and Silbermann.[3]

U_3N_4 (c). Neumann, Kroger, and Haebler[1] reported $Qf = 274$.

$UO_2(NO_3)_2$ (c). The data on the heat of solution are: de Forcrand,[58] $19.0_{220}{}^{12}$; Marketos,[1] 16.0.

$UO_2(NO_3)_2 \cdot H_2O$ (c). de Forcrand[58] measured the heat of solution.

$UO_2(NO_3)_2 \cdot 2\,H_2O$ (c). de Forcrand[58] measured the heat of solution.

$UO_2(NO_3)_2 \cdot 3\,H_2O$ (c). The data on the heat of solution are: Aloy,[1] -3.7_{1000}; de Coninck,[1] −3.8; de Forcrand,[58] $1.85_{220}{}^{12}$.

$UO_2(NO_3)_2 \cdot 6\,H_2O$ (c). The data on the heat of solution are: de Forcrand,[58] $-5.45_{220}{}^{12}$; Marketos,[1] −4.0.

UC_2 (c). From equilibrium data on the reaction, UO_2 (c) + 4 C (c) = UC_2 (c) + 2 CO (g), Heusler[1] calculated $Q = 174.6$.

$UO_2(C_2H_3O_2)_2 \cdot 2\,H_2O$ (c). Aloy[1] measured the heat of solution.

$UO_2NH_4(C_2H_3O_2)_3 \cdot 6\,H_2O$ (c). Aloy[1] measured the heat of solution.

UO_2CrO_4 (aq.). This value is obtained from the ions.

$UO_2CrO_4 \cdot 5\frac{1}{2} H_2O$ (c). Aloy[1] measured the heat of solution.

VANADIUM

V (c). Standard state.

V (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic vanadium are from Bacher and Goudsmit[1] and White.[3, 4]

V_2O_2 (c), V_2O_3 (c), V_2O_4 (c), V_2O_5 (c). Mixter[14] measured the heat of combustion of vanadium* in oxygen, the product being a mixture of oxides: V (c) $+2.13\ O_2$ (g) $= 0.74\ V_2O_4$ (c) $+ 0.26\ V_2O_5$ (c), $Q = 381$; V_2O_2 (c) $+ 1.2\ O_2$ (g) $= 0\ 60\ V_2O_4$ (c) $+ 0.40\ V_2O_5$ (c), $Q = 208.0$; V_2O_3 (c) $+ 0.7\ O_2$ (g) $= 0.60\ V_2O_4$ (c) $+ 0.40\ V_2O_5$ (c), $Q = 55\ 2$. Mixter[14] also measured the heat of reaction of vanadium and the various oxides of vanadium with the sodium oxides, and his data yield the following values: V_2O_5 (c) $+ Na_2O$ (c) $= Na_2O \cdot V_2O_5$ (c), $Q = 165$; V_2O_4 (c) $+ Na_2O_2$ (c) $= Na_2O \cdot V_2O_5$ (c), $Q = 174.6$; V_2O_3 (c) $+ 2\ Na_2O_2$ (c) $= Na_2O \cdot V_2O_5$ (c) $+ Na_2O$ (c), $Q = 214\ 8$; V_2O_2 (c) $+ 3\ Na_2O_2$ (c) $= Na_2O \cdot V_2O_5$ (c) $+ 2\ Na_2O$ (c), $Q = 340\ 3$; $2\ V$ (c) $+ 5\ Na_2O_2$ (c) $= Na_2O \cdot V_2O_5$ (c) $+ 4\ Na_2O$ (c), $Q = 441$.

Ruff and Friedrich[1] measured the heat of combustion of pure vanadium in oxygen, to form a mixture whose composition was not determined, to be 304. Ruff and Friedrich[1] also measured the heats of reaction with the sodium oxides; and their data yield the following values: V_2O_3 (c) $+ O_2$ (g) $= V_2O_5$ (c), $Q = 135$; V_2O_5 (c) $+ Na_2O_2$ (c) $= Na_2O \cdot V_2O_5$ (c), $Q = 20.0$ (this value is to be compared with the value obtained by Mixter[14] which is undoubtedly too large). Muller[5] studied the equilibrium, V_2O_5 (c) $+ H_2$ (g) $= V_2O_4$ (c) $+ H_2O$ (g), and calculated $Q = 117$. Ruff and Martin[1] and Muthmann, Wiess, and Riedebauch[1] measured the heat of combustion of vanadium (not very pure) in oxygen to form a mixture of oxides, whose composition was not determined, to be 250 5 and 313.0, respectively, per mole of vanadium.

The best correlation of all the foregoing data on the heats of the reactions involving the oxides of vanadium is obtained by selecting for V_2O_5 (c), $Qf = 437$; whence we have obtained as best values for the other oxides, V_2O_4 (c), V_2O_3 (c), and V_2O_2 (c), 383, 330, and 195, respectively.

VO_3^- (aq.), VO_4^- (aq.), VO_5^- (aq). These values are obtained from those for $NaVO_3$ (aq.), KVO_3 (aq.), KVO_4 (aq.), and $NaVO_5$ (aq.).

NH_4VO_3 (c). Matignon[12] measured the heat of reaction of NH_4VO_3 (c) with NaOH (aq.) to be 12.30 at 15°.

VCl_4 (liq.). Ruff and Friedrich[1] measured the heat of solution of this substance in $NaHO_2$(8) to be 161.8.

VCl_3 (liq.). Ruff and Friedrich[1] measured the heat of solution of the liquid trichloride in $NaHO_2$(8) to be 19.6.

*The older investigators did not have pure vanadium to work with; Mixter's[14] sample was 90% V, and those of Ruff and Martin[1] ranged from 84 to 97%.

$VOCl_3$ (c). Ruff and Friedrich[1] measured the heat of solution of this solid oxychloride in $NaHO_2$(8) to be 98.1.

VCl_2 (c). Ruff and Friedrich[1] measured the heat of combustion of this substance.

V_2F_3 (aq). Petersen[3] measured the heat of reaction of V_2F_3 (aq.) with 1, 2, and 3 NaOH (aq.) to be 8.31, 16.09, and 15.13, respectively.

$(NH_4)_3VF_8$ (aq). Petersen[3] found $Q=22.42$ for the reaction of this substance with 3 NaOH (aq.).

$V_2O_4 \cdot H_2O$ (c). Gain[1] reported 12.62 and 10.89 for the heats of solution in 2 H_2SO_4(55) of $V_2O_4 \cdot H_2O$ (c, rose) and $V_2O_4 \cdot H_2O$ (c, green), respectively. The heat of reaction of the resulting solutions with aqueous potassium hydroxide was found by Gain[1] to be 16.92 and 18.56, respectively.

Columbium

Cb (c). Standard state.

Cb_2O_5 (c). Muthmann, Weiss, and Riedebauch[1] measured the heat of combustion of columbium.

Tantalum

Ta (c). Standard state.

Ta_2O_5 (c). The data of Moose and Parr[1] yield 499.6 for the heat of combustion of tantalum to form Ta_2O_5 (c); Muthmann, Weiss, and Riedebauch[1] reported 308.

Protoactinium

Pa (c). Standard state.

Titanium

Ti (c). Standard state.

Ti (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic titanium are from Russell,[4] Russell and Lang,[1] Harrison and Engwicht,[1] and Harrison.[1]

TiO_2 (c, rutile III). Mixter's[8] data on the reactions of Ti (c) with 3 Na_2O_2 (c) and of TiO_2 (c, rutile) with Na_2O_2 (c) yield $Q=226$ and 50.3, respectively; whence, for TiO_2 (c, rutile III), $Qf=216.1$. Mixter's[13] data on the heat of combustion of titanium in oxygen yield $Qf=217.5$; those of Roth and Becker[2, 3] yield $Qf=218.7$; and those of Sieverts and Gotta[1] yield $Qf=220.7$. See also Weiss and Kaiser.[1]

TiO_2 (c, rutile II), TiO_2 (c, rutile I). Laschtschenko[1] reported values for the heats of transition of rutile.

TiO_2 (c, anatase). Laschtschenko[1] reported values for the heats of transition of anatase.

TiO_2 (amorphous). Mixter's[8, 13] data yield a value for the difference in heat content of rutile and the amorphous form of TiO_2.

TiO_2 (hydrated ppt.). We have estimated this value.

$TiCl_4$ (aq.). Thomsen[15] measured the heat of reaction of this substance with 4 NaOH (aq.) to be 47.66.

$TiCl_4$ (liq.). Thomsen[15] measured the heat of solution of the liquid to be 57.86_{2000}; Bock and Moser[1] found 59.0.

$TiCl_4$ (c). Latimer[1] reported a value for the heat of fusion.

$TiCl_4$ (g). The vapor pressure data of Arii[3] yield, for the heat of vaporization of the liquid, −8.62 at 136° and −8.97 at 18°.

$TiCl_3$ (c). Bock and Moser[1] reported the heats of solution of the brown and violet forms of this substance.

H_2TiF_6 (aq.). Thomsen[15] measured the heat of reaction of TiO_2 (hydrated ppt.) with 6 HF (aq.) to be 30.9.

TiC (c). Brantley and Beckman[1] studied the equilibrium, TiO_2 (c) + 3 C (c) = TiC (c) + 2 CO (g), and computed $Q = -45.9$ at 1573°.

$TiX_4 \cdot nPH_3$ (c). Holtje[1] reported the heats of the reactions, $TiCl_4$ (liq.) + PH_3 (g) = $TiCl_4 \cdot PH_3$ (c) and $TiCl_4 \cdot PH_3$ (c) + PH_3 (g) = $TiCl_4 \cdot 2\,PH_3$ (c), to be 18.6 and 10.8, respectively; and the heats of the analogous reactions with $TiBr_4$ to be 16.0 and 11.8, respectively.

$TiX_4 \cdot nH_2S$ (c). Biltz and Kennecke[1] obtained dissociation pressure data on the chloride and the bromide with 1 and 2 H_2S.

Zirconium

Zr (c). Standard state.

Zr (g). We have estimated the heat of sublimation. The values of the energy states of gaseous monatomic zirconium are from Kiess and Kiess.[1, 2]

ZrO_2 (c, monoclinic). For the heat of combustion of zirconium, Roth and Becker[1] reported the value 263.4, but from later and presumably more accurate experiments Roth and Becker[3] obtained the value 258.1. (The product formed in this last investigation was established to be the monoclinic form by X-ray studies.) For the same reaction, Sieverts, Gotta, and Halberstadt[1] reported $Q = 256.1$. See also Weiss and Neumann.[1]

ZrO_2 (c, ppt.). We have estimated the heat of hydration of ZrO_2 (c, monoclinic) to be −5.

$ZrCl_4$ (c). Beck[1] measured the heat of solution of this substance in aqueous ammonia to be 54.3, that is, for $ZrCl_4$ (c) + 4 NH_4OH (aq.) = ZrO_2 (c, ppt.) + 4 NH_4Cl (aq.) + 2 H_2O (liq.), $Q = 54.3$; whence, for $ZrCl_4$ (c), $Qf = 268.9$. Roth and Schwartz[1] and Roth and Becker[3] estimated a much lower value.

$ZrOSO_4 \cdot SO_3$ (c). Beck[1] measured the heat of solution of this substance in aqueous sodium hydroxide to be 36.7; Chauvenet[6] found 32.78 for the heat of solution in water. These data yield, for $ZrOSO_4 \cdot SO_3$ (c), $Qf = 566.3$ and 506.5.

$ZrOCl_2$ (aq.). Aqueous zirconium tetrachloride may be considered to be ($ZrOCl_2$ + 2 HCl) (aq.). The data of Chauvenet[5] suggested a value for the heat of neutralization of this solution: ($ZrOCl_2$ + 2 HCl) (aq.) + 2 NaOH (aq.) = ($ZrOCl_2$ + 2 NaCl) (aq.) + 2 H_2O (liq.), $Q = 27.0$, and $ZrOCl_2$ (aq.) + 2 NaOH (aq.) = ZrO_2 (c, ppt.) + 2 NaCl (aq.) + H_2O (liq.), $Q = 19.0$. These data yield, for $ZrOCl_2$ (aq.), $Qf = 272.5$.

ZrO^{++} (aq.). This value is obtained from that for $ZrOCl_2$ (aq.).

$ZrOBr_2$ (aq.). This value is obtained from those for the ions, ZrO^{++} (aq.) and Br^- (aq.).

$ZrOSO_4$ (aq.). This value is obtained from the aqueous ions.

$ZrO(NO_3)_2$ (aq.). This value is obtained from the aqueous ions.

$ZrOCl_2 \cdot nH_2O$ (c). Chauvenet[3] measured the heats of solution of the hydrates with 2, $3\frac{1}{2}$, 6, and 8 H_2O.

$ZrOBr_2 \cdot nH_2O$ (c). Chauvenet[6] measured the heats of solution of the hydrates with $3\frac{1}{2}$ and 8 H_2O.

$ZrO(NO_3)_2 \cdot nH_2O$ (c). Chauvenet and Nicolle[1] measured the heats of solution of the hydrates with 2, 3, $3\frac{1}{2}$, and 6 H_2O.

$ZrOSO_4 \cdot 4\,H_2O$ (c). Chauvenet[7] measured the heat of solution.

$ZrOSO_4 \cdot H_2SO_4$ (c). Chauvenet[7] measured the heat of solution.

ZrC (c). Prescott[1] studied the equilibrium, ZrO_2 (c) $+3$ C (c) $=$ ZrC (c) $+2$ CO (g), and calculated $Q^{25} = -160$.

Hafnium

Hf (c). Standard state.

HfO_2 (c, monoclinic). Roth and Becker[3] measured the heat of combustion of hafnium, to form monoclinic hafnium dioxide, to be 271.5.

Thorium

Th (c). Standard state.

Th (g). We have estimated the heat of sublimation. See also Andrews.[18]

ThO_2 (c). For the heat of combustion of thorium to form crystalline thorium dioxide, the data of von Wartenberg,[6] Chauvenet,[6] and Roth and Becker[3] yield 327.2, 330 2, and 292.6, respectively.

ThH_4 (c). Dissociation pressure data on thorium hydride were reported by Chauvenet[4] and Matignon and Delepine.[4]

$ThCl_4$ (aq.). Chauvenet[2] measured the heat of solution of thorium in aqueous (13%) HCl to be 238 5, whence, for $ThCl_4$ (aq.), $Qf = 392$.

$ThCl_4$ (c). For the heat of solution of solid thorium tetrachloride in water, Chauvenet[2] found 56 7 at 15° and von Wartenberg 53. For the heat of formation of $ThCl_4$ (c) by direct synthesis from a very impure sample of thorium, von Wartenberg[6] reported $Qf = 300$.

$ThCl_4 \cdot nH_2O$ (c). Chauvenet[2] measured the heats of solution of the di-, tetra-, penta-, and octahydrates.

Th^{++++} (aq.). This value is obtained from $ThCl_4$ (aq.).

$ThCl_3OH \cdot H_2O$ (c). Chauvenet[2] measured the heat of solution.

$ThOCl_2$ (c). Chauvenet[2] measured the heat of solution.

$Th(OH)_4$ (c, "soluble"). Chauvenet[2] measured the heat of solution in HCl(15).

$Th(OH)_4$ (c, "insoluble"). Chauvenet[2] measured the heat of solution in HCl(15).

$ThBr_4$ (aq.). This value is obtained from the ions.

$ThBr_4$ (c). Chauvenet[2] measured the heat of solution.

$ThBr_4 \cdot nH_2O$ (c). Chauvenet[2] measured the heats of solution of the hepta-, deca-, and dodecahydrates.

$ThOBr_2$ (c). Chauvenet[2] measured the heat of solution.

ThI_4 (aq.). This value is obtained from the ions.

$ThOI_2$ (c). Chauvenet[2] measured the heat of solution.

$ThOI_2 \cdot 3\frac{1}{2} H_2O$ (c). Chauvenet[2] measured the heat of solution.

$ThI_3OH \cdot 10 H_2O$ (c). Chauvenet[2] measured the heat of solution.

$Th(SO_4)_2$ (aq.). This value is obtained from the ions.

$Th(SO_4)_2$ (c). Beck[1] reported the improbably low value of 22.5 for the heat of reaction of solid thorium sulfate with aqueous sodium hydroxide. From his data, Beck derived in some unstated manner the value 115.5 for the heat of the reaction of ThO_2 (c) with $2\,SO_3$ (g). These values yield, for $Th(SO_4)_2$ (c), $Qf = 526.9$ and 596 respectively. We have estimated the value 632.

$Th(SO_4)_2 \cdot nH_2O$ (c). Koppel[1] determined the heat of hydration of the tetra- to the octahydrate from measurement of their heats of solution in aqueous potassium carbonate, and also from solubility measurements. The latter data yield 5 0 and −7.5 for the heats of solution of the tetra- and octahydrates.

$ThOSO_4$ (c). Wohler, Pluddemann, and Wohler[1] obtained dissociation pressure data on the reaction, $ThO_2 \cdot 2\,SO_3$ (c) $= ThO_2 \cdot SO_3$ (c) $+ SO_3$ (g).

Th_3N_4 (c). Neumann, Kroger, and Haebler[3] determined the heat of formation of this compound

$ThCl_4 \cdot 2\,NH_4Cl \cdot nH_2O$ (c). Chauvenet[1, 2] measured the heats of solution of the anhydrous double salt and of the decahydrate.

$ThCl_4 \cdot nNH_3$ (c). Chauvenet[1, 2] measured the heats of solution in aqueous HCl of these regular ammines with $n = 4$, 6, 7, 12, and 18.

$[Th \cdot 6\,NH_3]Cl_4 \cdot nNH_3$ (c). Chauvenet[1, 2] measured the heats of solution in aqueous HCl of these "coordination valence" ammines with $n = 0$, 1, 6, and 12.

ThC_2 (c). From equilibrium studies, Prescott and Hincke[1] computed $Q^{25} = -194.8$ for the reaction, ThO_2 (c) $+ 4\,C$ (c) $= ThC_2$ (c) $+ 2\,CO$ (g).

BORON

B (c). Standard state.

B (g). We have estimated the heat of vaporization. The energy states of gaseous monatomic boron have been evaluated from the data of Bowen,[2] Sawyer and Smith,[1] Millikan,[1] and Bowen and Millikan.[5]

BO (g). Mulliken[6] reported a value for the energy of dissociation.

BO_2^- (aq.), BO_3^{---} (aq.), $B_4O_7^{--}$ (aq.). The values for these ions are obtained from those for the respective sodium salts in aqueous solution.

B_2O_3 (gls.). For the heat of solution of this substance, Berthelot[50] reported 7.3, Ditte[1] gave 3.16. Mulert[1] found 29.6 for its heat of solution in aqueous HF.

B_2O_3 (aq.). This is taken as equivalent to $2\,H_3BO_3$ (aq.) $-3\,H_2O$ (liq.).

BH (g). Mulliken[6] reported a value for the energy of dissociation.

B_2H_6 (g). Stelzner and Niederschulte[1] obtained vapor pressure data.

HBO_2 (c). Gilbert and Levi[1] obtained dissociation pressure data on $B_2O_3 \cdot H_2O$ (c) $(=2\,HBO_2$ (c)).

H_3BO_3 (aq.). The data of Troost and Hautefeuille[4, 5] on the heat of solution of BCl_3 (g) in water yield $Q=70.3$, when corrected according to Berthelot.[50, 151] Berthelot[50, 151] measured the heat of solution of BCl_3 (liq.) in water to be 65.8 at 10°.

H_3BO_3 (c). The data on the heat of solution are: Thomsen,[15] -5.39_{400}; Berthelot,[52] -4.8_{200}[15]; Ditte,[1] -3.2; Linderstrom-Lang,[1] -5.0. See also Favre and Valson.[2]

$H_2B_4O_7$ (c). Gilbert and Levi[1] measured the dissociation pressures of $2\,B_2O_3 \cdot H_2O$ (c).

$H_2B_6O_{10}$ (c). Gilbert and Levi[1] measured the dissociation pressures of $3\,B_2O_3 \cdot H_2O$ (c).

$nB_2O_3 \cdot H_2O$ (c). Gilbert and Levi[1] reported dissociation pressure data on these hydrates with $n=4$, 5, 6, 7, and 8, but the existence of these as definite compounds has not been fully established.

BF_3 (aq.). Thomsen[15] measured the heat of mixing H_3BO_3 (aq.) with 3 HF (aq.).

HBF_4 (aq.). Thomsen[15] measured the heat of mixing H_3BO_3 (aq.) with 4 HF (aq.).

BF_4^- (aq.). The heat of ionization of aqueous HBF_4 is assumed to be zero.

BF_3 (g). Hammerl[2] measured the heat of solution of this gas.

BF_3 (liq.). Ruff and Bretschneider[1] measured the vapor pressure of the liquid. See also LeBoucher, Fischer, and Biltz.[1]

BCl_3 (g). The data of Troost and Hautefeuille,[4, 5] corrected according to Berthelot,[50, 151] yield for the reaction, B (c) $+1\frac{1}{2}\,Cl_2$ (g) $=BCl_3$ (g), $Q=89.1$.

BCl_3 (liq.). For the heat of vaporization of the liquid, Berthelot[50] reported -4.5[10]; the vapor pressure data of Stock and Priess[1] yield -6.34 at 18°.

BBr_3 (liq.). Berthelot[50, 151] measured the heat of reaction of BBr_3 (liq.) with 400 H_2O to be 83.8 at 11°.

BBr_3 (g). Stock and Russ[1] measured the vapor pressure of the liquid.

B_2H_5Br (liq.). Stock, Russ, and Priess[1] measured the vapor pressure.

$B(CH_3)_3$ (liq.). Stock and Zeidler[1] measured the vapor pressure.

B_2S_3 (c). Sabatier[3, 6] measured the heat of solution of this substance. See also Stock and Pappenberg.[1]

NH_4BO_2 (aq.). Berthelot[4] measured the heat of reaction of NH_3 (aq.) with H_3BO_3 (aq.) to be 8.93.

$(NH_4)_2HBO_3$ (aq.). Berthelot[4] measured the heat of reaction of $2\,NH_3$ (aq.) with H_3BO_3 (aq.) to be 11.55.

$(NH_4)_3BO_3$ (aq.). Berthelot[4] measured the heat of reaction of $3\,NH_3$ (aq.) with H_3BO_3 (aq.) to be 12.62.

CuB_2O_4 (c). Parravano and Malquori[4] studied the equilibrium, $6\,CuB_2O_4\,(c) = 3\,Cu_2O \cdot 2\,B_2O_3\,(c) + 4\,B_2O_3\,(c) + 1\frac{1}{2}\,O_2\,(g)$.

NH_4BO_3 (c). Tanatar[9] measured the heat of decomposition of ammonium perborate with sulfuric acid, and also its heat of solution.

ALUMINUM

Al (c). Standard state. Laschtschenko[5] reported a transition at 590°, but this has not been confirmed.

Al (liq.). The data on the heat of fusion at 658° are: Pionchon,[1] −2.13; Laschtschenko,[6] −1.92; Wust, Meuthen, and Durrer,[1] −2.54.

Al (g). We have estimated the heat of sublimation. See also Sherman[1] and Millar.[1] The energy states of gaseous monatomic aluminum have been evaluated from the data of Fowler,[3] Sawyer and Paschen,[1] Paschen,[6] Lyman,[1] and Soderquist.[1, 2]

Al_2O_3 (c). Berthelot,[127] Moose and Parr,[1] and Roth and Muller[4] measured the heat of combustion of aluminum in oxygen in a bomb. The data of the latter two modern investigations yield, for Al_2O_3 (c), $Qf = 376.9$ and 380.1, respectively. See also Mixter[16] and Baille and Fery.[1]

Al_2O_3 (g). Vapor pressure data were obtained by Ruff and Konschak.[1] See also Ruff and Schmidt[1] and Millar.[1]

AlH (g). Bengtsson and Rydberg[2] reported the energy of dissociation. See also Villars and Condon.[1]

$AlCl_3$ (aq.). The heat of solution of aluminum in aqueous hydrochloric acid was measured by Sommermeier,[1] Richards and Burgess,[1] Biltz and Hohorst,[1] and Richards, Rowe, and Burgess.[1] The data of the last named investigation yield, for $AlCl_3(600)$, $Qf = 244.7$.

Al^{+++} (aq.). This value is obtained from that for $AlCl_3$ (aq.). See also Latimer.[1]

$AlCl_3$ (c). The data on the heat of solution of this substance in water are: Thomsen,[15] 76.85_{1250}; Berthelot,[50] 76.3[9]; Baud,[1, 2] 77.6_{3000}[14]; Sabatier,[2] 78.

$AlCl_3$ (liq.). Maier[1] reported a value for the heat of fusion.

Al_2Cl_6 (g). The vapor of aluminum chloride is completely associated at low temperatures. The vapor pressure data of Maier[1] yield −27.5 for the heat of sublimation at 100°.

$AlCl_3$ (g). The meager vapor density data of Nilson and Patterson[2] yield about −40 for the heat of the reaction, $Al_2Cl_6\,(g) = 2\,AlCl_3\,(g)$.

$AlCl_3 \cdot 6\,H_2O$ (c). Sabatier[2] measured the heat of solution.

$Al(OH)_3$ (c). Baud,[1] Berthelot,[50] and Thomsen[15] measured the heat of reaction of $AlCl_3$ (aq.) with $3\,NH_4OH$ (aq.).

AlF_3 (aq.). Petersen[4] and Mulert[1] measured the heats of mixing $AlCl_3$ (aq.) with 3 HF (aq.) and AlF_3 (aq.) with 3 HCl (aq.).

H_3AlF_6 (aq.). Berthelot[151] and Mulert[1] measured the heat of mixing AlF_3 (aq.) with 3 HF (aq.).

AlF_3 (c). Baud[1] estimated the heat of solution.

$AlF_3 \cdot nH_2O$ (c). Baud[1] measured the heats of solution, in aqueous (19%) HF, of the hemihydrate and the "soluble" and "insoluble" forms of the hydrate with $3\frac{1}{2}$ H_2O.

$AlBr_3$ (aq.). Berthelot[50] measured the heat of reaction of this solution with 3 NH_4OH (aq.). See also Roos.[2]

$AlBr_3$ (c). For the heat of solution, Berthelot[50] found 85.3_{3000}[9] and Gustavson[1] 90.0.

$AlBr_3$ (liq.). For the heat of fusion of aluminum bromide, Fischer[2] found −2.7 at 98° and Pickering[12] −2.17 at 95°.

AlI_3 (aq.). This value is obtained from those for the ions.

AlI_3 (c). Berthelot[50] measured the heat of solution.

AlI_3 (liq.). Fischer[2] reported a value for the heat of fusion.

Al_2S_3 (c). Sabatier[1] measured the heat of the reaction, Al_2S_3 (c) $+6\,H_2O$ (liq) $=2\,Al(OH)_3+3\,H_2S$ (g), to be 75.0.

$Al_2(SO_4)_3$ (aq.). Thomsen[15] measured the heat of reaction of $Al_2(SO_4)_3$ (aq.) with 3 $BaCl_2$ (aq) and with 6 KOH (aq.).

$Al_2(SO_4)_3$ (c). Wohler, Pluddemann, and Wohler[1] measured the dissociation pressure of $Al_2O_3 \cdot 3\,SO_3$ (c) at various temperatures, and their data yield, for $Al_2(SO_4)_3$ (c), $Qf=713$. We have estimated, from the heat of dehydration of the hexahydrate, for $Al_2(SO_4)_3$ (c), $Qf=770$.

$Al_2(SO_4)_3 \cdot nH_2O$ (c). Favre and Silbermann[3] measured the heat of solution of the hexahydrate, and Favre and Valson[2] that of the octadecahydrate.

$AlCl_3 \cdot nSO_2$ (c). Baud[1] measured the heats of solution of these compounds with $\frac{1}{2}$ and 1 mole of SO_2, respectively.

$AlX_3 \cdot nH_2S$ (c). Biltz and Keunecke[1] obtained dissociation pressure data on $AlCl_3 \cdot H_2S$ (c), $AlBr_3 \cdot H_2S$ (c), $AlI_3 \cdot 4\,H_2S$ (c), and $AlI_3 \cdot H_2S$ (c). Baud[1] measured the heat of solution of $AlCl_3 \cdot \frac{1}{2}\,H_2S$ (c).

AlN (c). The data of Fichter and Jenny,[1] who measured the heats of combustion of Al (c) and AlN (c), yield, for the latter, $Qf=23$. Matignon[13] estimated $Qf=110$. The data of Prescott and Hincke,[1, 2] who studied the equilibria, $2\,Al_2O_3$ (c) $+9\,C$ (c) $=Al_4C_3$ (c) $+6\,CO$ (g) and $4\,AlN$ (c) $+3\,C$ (c) $=Al_4C_3$ (c) $+2\,N_2$ (g), yield, for $2\,Al_2O_3$ (c) $+6\,C$ (c) $+2\,N_2$ (g) $=6\,CO$ (g) $+4\,AlN$ (c), $Q=-277$, and for AlN (c), $Qf=80$.

$AlF_3 \cdot 2\,NH_4F \cdot 1\frac{1}{2}\,H_2O$ (c). Baud[1] measured the heat of solution.

$AlCl_3 \cdot nNH_3$ (c). Klemm and Tanke[1] reported the following heats of dissociation, from dissociation pressure data, per mole of gaseous ammonia, to the next lower ammine: tetradecammine, −7.8; heptammine, −10.2; hexammine, −13.1; pentammine, −17.7. Klemm and Tanke[1] measured the following heats of solution in HCl(20) at 0°: Hexammine, 73.4; pentammine, 65.1; triammine, 58.0; monammine, 60.3. Baud[1] reported the following heats of solution in water at 15°: hexammine,

6.35_{2400}; pentammine, 9.05_{2200}; triammine, 30.3_{2000}; monammine, 53.05. Baud[1] reported 7.94 for the heat of solution and −8.27 for the heat of dissociation of the nonammine, but the existence of this compound is doubtful. See also Ephraim and Millman.[1]

$AlCl_3 \cdot NH_4Cl \cdot 6\,NH_3$ (c). Baud[1] measured the heat of solution.

$AlCl_3 \cdot NH_4Cl$ (c). Baud[1] measured the heat of solution.

$AlBr_3 \cdot nNH_3$ (c). Klemm and Tanke[1] reported the following heats of dissociation: tetradecammine, −7.72; nonammine, −8.4; heptammine, −10.7; hexammine, −16.2. Klemm and Tanke[1] measured the following heats of solution in HBr(20) at 0°: hexammine, 66.4; pentammine, 60.2; triammine, 57.7; monammine, 66.9. See also Ephraim and Millman.[1]

$AlI_3 \cdot nNH_3$ (c). Klemm and Tanke[1] reported dissociation pressure data on the ammines with 20, 13, 9, and 7 NH_3. Klemm and Tanke[1] measured the heats of solution in HI(20) at 0° of the ammines with 6, 5, 3, and 1 NH_3. See also Ephraim and Millman.[1]

$NH_4Al(SO_4)_2 \cdot nH_2O$ (c). Favre and Silbermann[3] measured the heat of solution of the dodecahydrate. Ephraim and Wagner[1] obtained dissociation pressure data on the system, dodecahydrate-pentahydrate-water vapor, finding $D = -14.4$.

$AlX_3 \cdot PH_3$ (c). Holtje[1] obtained dissociation pressure data on the chloride, bromide, and iodide.

Al_4C_3 (c). Prescott and Hincke[1, 2] studied the equilibrium, $2\,Al_2O_3$ (c) $+ 9\,C$ (c) $= Al_4C_3$ (c) $+ 6\,CO$ (g), and calculated $Q = -539$; whence, for Al_4C_3 (c), $Qf = 60$. See also Berthelot.[126]

Al_2SiO_5 (c). Neumann[2] measured the heats of solution of andalusite, disthene, and sillimanite in aqueous (20%) HF.

$3\,Al_2O_3 \cdot 2\,SiO_2$ (c). Neumann[2] measured the heat of solution of mullite in aqueous (20%) HF.

$2\,AlCl_3 \cdot 3\,PbI_2 \cdot nH_2O$ (c). Mosnier[1] measured the heats of solution of the anhydrous salt and the decahydrate.

$AlCl_3 \cdot \frac{3}{4}\,ZnCl_2$ (c). Baud[1] measured the heat of solution.

$AlCl_3 \cdot AgCl$ (c). Baud[1] measured the heat of solution.

$AlCu_n$ (c). Rolla[2] measured the heats of solution in bromine water of AlCu (c), Al_2Cu (c), and $AlCu_3$ (c) to be 181.4, 365.9, and 303.7, respectively; for Al_2Cu (c), Roos[2] found 423.

Al_3Fe (c). Biltz and Haase[1] measured the heat of solution in HCl(8).

Al_nCo (c). Biltz and Haase[1] measured the heat of solution in HCl(8) of AlCo (c) and Al_5Co (c).

Scandium

Sc (c). Standard state.

Sc (g). We have estimated the heat of sublimation. The values of the energy states of gaseous monatomic scandium are from Russell and Meggers.[1]

Sc_2O_3 (c). Roth and Becker[3] estimated $Qf = 407$.

$ScCl_3$ (c). Roth and Becker[3] estimated $Qf = 202$.

Yttrium

Y (c). Standard state.

Y (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic yttrium are from Meggers and Russell.[1]

YCl_3 (c). We have estimated the value for the heat of formation of this substance to be 240. Roth and Becker[3] estimated 243.

YCl_3 (aq.). Matignon[7] measured the heat of solution of solid yttrium chloride.

$Y_2(SO_4)_3$ (aq.). Thomsen[15] measured the heat of reaction of this solution with 3 $BaCl_2$ (aq.).

$Y_2(SO_4)_3 \cdot 8\ H_2O$ (c). Thomsen[15] measured the heat of solution.

$Y(OH)_3$ (c). Thomsen[15] measured the heat of reaction of aqueous yttrium sulfate with aqueous barium hydroxide.

Y_2O_3 (c). Roth and Becker[3] estimated $Qf = 441$.

Y^{+++} (aq.). This value is obtained from that for aqueous yttrium chloride.

Lutecium

Lu (c). Standard state.

Ytterbium

Yb (c). Standard state.

Thulium

Tm (c). Standard state.

Erbium

Er (c). Standard state.

Er^{+++} (aq.). We have estimated the value for aqueous erbium ion.

$Er(C_2H_3O_2)_3$ (aq.). The value for aqueous erbium acetate is obtained from the ions.

$Er(OH)_3$ (c, ppt.). Thomsen[15] measured the heat of reaction of Er $(C_2H_3O_2)_3$(1500) with $1\frac{1}{2}$ $Ba(OH)_2$(400) to be 12 8.

$Er(C_2H_3O_2)_3 \cdot 4\ H_2O$ (c). Thomsen[15] measured the heat of solution.

Holmium

Ho (c). Standard state.

Dysprosium

Dy (c). Standard state.

Terbium

Tb (c). Standard state.

Gadolinium

Gd (c). Standard state.

Europium

Eu (c). Standard state.

Samarium

Sa (c). Standard state.

Sa^{+++} (aq.). We have estimated the value for aqueous samarium ion.

$SaCl_3$ (aq.). This value is obtained from those for the ions.

$SaCl_3$ (c). Matignon[5] measured the heat of solution.

Sa_2O_3 (c). Matignon[5] measured the heat of solution of the regular oxide to be 94.6 in HCl (aq.), and that of the oxide prepared from the oxalate to be 90 in HCl (aq.).

$SaCl_3 \cdot nNH_3$ (c). Matignon and Trannoy[1] obtained dissociation pressure data on the ammines with 1, 2, 3, 4, 5, 8, $9\frac{1}{2}$, and $11\frac{1}{2}$ NH_3.

Illinium

Il (c). Standard state.

Neodymium

Nd (c). Standard state.

Nd_2O_3 (c). Muthmann and Beck[1] measured the heat of combustion of neodymium to be 434.8. We have labeled this the "high temperature" form, and have estimated the heat of formation of the "low temperature" form (as prepared from neodymium nitrate, for example) to be 427.

$NdCl_3$ (aq.). Matignon[8, 17] measured the heat of solution of Nd_2O_3 (c, "low temperature"), prepared from the nitrate, to be 105.5 in HCl(110).

Nd^{+++} (aq.). This value is obtained from that of aqueous neodymium chloride.

$NdCl_3$ (c). Matignon[8, 17] measured the heat of solution.

$NdCl_3 \cdot 6\,H_2O$ (c). Matignon[8, 17] measured the heat of solution.

NdI_3 (aq.). Matignon[8, 17] measured the heat of solution of Nd_2O_3 (c, "low temperature"), prepared from the nitrate, to be 106.1 in HI(110).

NdI_3 (c). Matignon[8, 17] measured the heat of solution.

$Nd_2(SO_4)_3$ (aq.). Matignon[8, 17] measured the heat of solution of Nd_2O_3 (c, "low temperature"), prepared from the nitrate, to be 106.4 in H_2SO_4(220).

$Nd_2(SO_4)_3 \cdot nH_2O$ (c). Matignon[8, 17] measured the heats of solution of the anhydrous salt and the penta- and octahydrates.

Nd_2S_3 (c). Matignon[8, 17] measured the heat of solution of this sulfide in HCl(110).

$NdCl_3 \cdot nNH_3$ (c). Matignon and Trannoy[1] obtained dissociation pressure data on the ammines with 1, 2, 4, 5, 8, 11, and 12 NH_3.

Praseodymium

Pr (c). Standard state.

$PrCl_3$ (aq.). Sieverts and Gotta[2] measured the heat of solution of praseodymium in HCl(25) to be 168.9.

Pr^{+++} (aq.). This value is obtained from $PrCl_3$ (aq.).

$PrCl_3$ (c). Matignon[5] measured the heat of solution.

$PrCl_3 \cdot nH_2O$ (c). Matignon[5] measured the heats of solution of the mono- and heptahydrates.

Pr_2O_3 (c). Matignon[5] measured the heat of solution of this oxide in aqueous hydrochloric acid to be 106.2. By direct combustion of praseodymium, Muthmann and Beck[1] found $Qf = 417$.

$Pr(NO_3)_3$ (aq.). Prandtl and Huttner[1] measured the heat of solution of Pr_2O_3 (c) in $HNO_3(6)$ to be 109.5.

PrO_2 (c), Pr_6O_{11} (c). Prandtl and Huttner[1] measured the heats of solution of these oxides in $HNO_3(6)$. The products of the reaction were aqueous praseodymium nitrate and gaseous oxygen.

Cerium

Ce (c). Standard state.

CeO_2 (c). For the heat of combustion of cerium to form CeO_2 (c), the data of Moose and Parr,[1] Muthmann and Weiss,[1] and Hirsch[1] yield 233.4, 226, and 245, respectively.

$CeCl_3$ (aq.). The data on the heat of solution of cerium in aqueous hydrochloric acid are: Biltz and Pieper,[1] 164.9 in HCl(20), 166.4 in HCl(8); Neumann, Kroger, and Kunz,[1] 165.2 in HCl(20); Sieverts and Gotta,[2] 168.7 in HCl(25).

$CeCl_3$ (c). The heat of solution has been estimated by us.

Ce_3H_8 (c). Sieverts and Gotta[2] measured the heats of solution of Ce (c) in HCl(25) and of Ce_3H_8 (c) in HCl(50).

Ce^{+++} (aq.). This value is obtained from that for aqueous $CeCl_3$.

$Ce(OH)_3OOH$ (c). Pissarjewsky[1] measured the heat of reaction of this hydrated peroxide with aqueous sulfuric acid to be 30.0. The reaction is $2\,Ce(OH)_3OOH\,(c) + 3\,H_2SO_4\,(aq.) = (Ce_2(SO_4)_3 + H_2O_2)\,(aq.) + 6\,H_2O\,(liq.) + O_2\,(g)$.

$Ce_2(SO_4)_3$ (aq.). Thomsen[15] measured the heat of reaction of this solution with $3\,BaCl_2$ (aq.).

$Ce(SO_4)_2$ (c). Beck[1] reported the value for the heat of the reaction, $CeO_2\,(c) + 2\,SO_3\,(g) = Ce(SO_4)_2\,(c)$, to be 103.5, but there is probably a considerable uncertainty in it.

$Ce_2(SO_4)_3 \cdot 4\frac{18}{50}H_2O$ (c). Thomsen[15] measured the heat of solution.

CeN (c). Neumann, Kroger, and Kunz[1] measured the heat of solution in aqueous hydrochloric acid. See also Lipski.[1]

$CeCl_3 \cdot nNH_3$ (c). Barre[2] obtained dissociation pressure data on the ammines with 2, 4, 8, 12, and 20 NH_3.

$CeHg_4$ (c). The dissociation pressure data of Biltz and Meyer[2] yield $D = -19.9$ per mole of Hg (g).

Ce_3Al (c). Biltz and Pieper[1] measured the heat of solution in HCl (20). See also Zhukov.[2]

$CeAl_4$ (c). Biltz and Pieper[1] measured the heat of solution in HCl (20). Muthmann and Beck[1] reported the heat of combustion to be 832.

$CeZn_4$ (c). Muthmann and Beck[1] reported the heat of combustion to be 525.

LANTHANUM

La (c). Standard state.

La (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic lanthanum are from Bacher and Goudsmit.[1]

$LaCl_3$ (aq.). Neumann, Kroger, and Kunz[1] and Sieverts and Gotta[1] measured the heat of solution of lanthanum to be, respectively, 167.7 in HCl(20) and 164.5 in HCl(110); whence, for $LaCl_3$ (aq.), $Qf=284.4$ and 282.7, respectively.

$LaCl_3$ (c). Matignon[7] measured the heat of solution. See also Beck.[1]

La^{+++} (aq.). This value is obtained from that for aqueous lanthanum chloride.

La_2O_3 (c). For the heat of combustion of lanthanum in oxygen to form La_2O_3 (c), Moose and Parr,[1] Muthmann and Weiss,[1] and Kremers and Stevens[1] reported 457.0, 445, and 457, respectively. Matignon[7] and Beck[1] measured the heat of solution of La_2O_3 (c) to be, respectively, 114.6 in HCl(100) at 16° and 105 in HCl(8). These latter data yield, for La_2O_3 (c), $Qf=423$ and 441, respectively.

La_3H_8 (c). Sieverts and Gotta[1] measured the heats of solution of La (c) and La_3H_8 (c) in HCl(110).

La_2S_3 (c). Biltz[2] measured the heat of solution of this sulfide in HCl(9.4).

LaS_2 (c). Biltz[2] measured the heat of solution of this sulfide in HCl (9.4) to be 31.8.

$La_2(SO_4)_3$ (aq.). Thomsen[15] measured the heat of reaction of this solution with 3 $BaCl_2$ (aq.).

$La_2(SO_4)_3 \cdot 8\,H_2O$ (c). Thomsen[15] measured the heat of solution.

LaN (c). Neumann, Kroger, and Haebler[1] reported $Qf=71.0$, from direct measurement of the formation, and measured the heat of solution of LaN (c) in HCl(20) to be 127.1. This latter value yields, for LaN (c), $Qf=72.8$.

$LaAl_4$ (c). Muthmann and Beck[1] measured the heat of combustion of this alloy.

ACTINIUM

Ac (c). Standard state.

BERYLLIUM

Be (c). Standard state.

Be (g). We have estimated the heat of sublimation. The energy states of gaseous monatomic beryllium have been evaluated from the data of Bowen and Millikan,[3, 4] Paschen and Kruger,[2] Millikan and Bowen,[4] and Edlen and Ericson.[2]

Be (liq.). Oesterheld[1] reported a value for the heat of fusion.

BeH (g). The data of Watson[1, 2] yield values for the energies of excitation and of ionization of gaseous BeH, and for its energy of dissociation into gaseous atoms. See also Mulliken.[6]

BeO (g). Bengtsson[1] deduced the energy of dissociation into gaseous atoms, from spectroscopic data.

BeO (c). Mielenz and von Wartenberg[1] measured the heat of combustion of beryllium to be 136.0; Moose and Parr[1] found the value to be 134.5. See also Copeaux and Phillips.[1, 2]

$Be(OH)_2$ (c). Matignon and Marchal[4] measured the heat of reaction of the hydroxide with aqueous hydrochloric acid, and of aqueous beryllium chloride with aqueous sodium hydroxide. Thomsen[15] measured the heat of reaction of aqueous beryllium sulfate with aqueous potassium hydroxide.

BeF_2 (aq.). For the heat of solution of BeO (c) in aqueous (30%) HF, Matignon and Marchal[4] found 23.3 at 17°, and Copeaux and Phillips[1, 2] found 20.1. For the heat of solution of $Be(OH)_2$ (c) in aqueous (30%) HF, Matignon and Marchal[4] found 20.35; Mulert,[1] 20.47; and Petersen,[4] 19.7.

H_2BeF_4 (aq.). Matignon and Marchal[4] measured the heat of reaction of $Be(OH)_2$ (c) with 4 HF (aq.).

$BeCl_2$ (c). Mielenz and von Wartenberg[1] measured the heat of the reaction, Be (c) + Cl_2 (g) = $BeCl_2$ (c), to be 112.6.

$BeCl_2$ (aq.). The data on the heat of solution of $BeCl_2$ (c) in water are: Matignon and Marchal,[4] 51.1; Pollok,[1] 44.5. For the heat of solution of $BeCl_2$ (c) in HCl(9), Biltz and Messerknecht[2] found 44.1, and in HCl (aq.), Biltz, Klatte, and Rahlfs[1] found 48.6.

Be^{++} (aq.). This value is obtained from those for $BeCl_2$ (aq.) and BeF_2 (aq.).

$BeCl_2$ (g). Fischer and Rahlfs[2] measured the vapor pressure of the solid.

$BeCl_2(C_2H_5OH)$. Pollok[1] measured the heat of solution of solid beryllium chloride in ethyl alcohol.

$BeBr_2$ (aq.). This value is obtained from those for the ions.

$BeBr_2$ (c). Biltz and Messerknecht[2] and Biltz, Klatte, and Rahlfs[1] measured the heat of solution of solid beryllium bromide in aqueous hydrochloric acid.

$BeBr_2$ (g). Fischer and Rahlfs[2] measured the vapor pressure of the solid.

BeI_2 (aq.). This value is obtained from those for the ions.

BeI_2 (c). Biltz, Klatte, and Rahlfs[1] and Biltz and Messerknecht[2] measured the heat of solution of solid beryllium iodide in aqueous hydrochloric acid.

BeI_2 (g). Fischer and Rahlfs[2] measured the vapor pressure of the solid.

$BeSO_4$ (aq.). Thomsen[15] measured the heat of reaction of $BeSO_4$ (aq.) with $BaCl_2$ (aq.) to be 6.66; Matignon and Marchal[2] found 6.97.

$BeSO_4$ (c). Matignon and Marchal[2] measured the heat of solution of this solid in aqueous sodium hydroxide. Marchal[2, 5] measured the dissociation pressure of $BeO \cdot SO_3$ (c).

$BeSO_4 \cdot nH_2O$ (c). Matignon and Marchal[2] measured the heats of solution of the di- and tetrahydrates in water, and also of the tetrahydrate in aqueous sodium hydroxide. Thomsen[15] measured the heat of solution of the tetrahydrate. Krauss and Gerlach[1] obtained dissociation pressure data on the mono-, di, and tetrahydrates.

$BeX_2 \cdot 2\,H_2S$ (c). Blitz and Keunecke[1] measured the dissociation pressures of the bromide and iodide.

$Be(NO_3)_2$ (aq.). Thomsen[15] measured the heat of reaction of $BeSO_4$ (aq.) with $Ba(NO_3)_2$ (aq.).

$BeX_2 \cdot nNH_3$ (c). Blitz, Klatte, and Rahlfs[1] measured the heats of solution of the tetrammines of the chloride, bromide, and iodide in aqueous hydrochloric acid, and Biltz and Messerknecht[2] obtained similar data with HCl(9). Biltz and Messerknecht[2] obtained dissociation pressure data on the tetra-, hexa-, and dodecammines of the chloride, on the hexa- and decammines of the bromide, and on the hexa- and tridecammines of the iodide.

MAGNESIUM

Mg (c). Standard state.

Mg (g). Wehnelt and Musceleanu[1] measured directly the heat of vaporization of magnesium. Vapor pressure data were obtained by Ditte,[7] Greenwood,[3, 5] von Wartenberg,[4] Ruff and Hartmann,[1] and Hartmann and Schneider.[1] The values of the energy states of gaseous monatomic magnesium are from Fowler,[3] Turner,[1] and Soderqvist.[1]

Mg (liq.). Data on the heat of fusion of magnesium were reported by van Aubel,[1] Wehnelt and Musceleanu,[1] Awbery and Griffiths,[1] and Zalesenski and Zulenski.[1]

MgO (c). For the heat of combustion of magnesium, the data yield the following values: Moose and Parr,[1] 146.1; Muthmann and Weiss,[1] 143.5; Rogers,[1] 147.0; von Wartenberg,[6] 144.3.

MgH (g). Values for the energies of excitation and ionization, and for the energy of dissociation into gaseous atoms, were reported by Hulthen,[1] Watson,[2] and Mulliken.[6]

$Mg(OH)_2$ (c, ppt.). Thomsen[15] measured the heat of reaction of $MgSO_4$ (aq.) with $Ba(OH)_2$ (aq.), and of $MgSO_4$ (aq.) with 2 KOH (aq.). Berthelot[100] measured the heat of reaction of KOH (aq.) with $MgSO_4$ (aq.) and with $MgCl_2$ (aq.).

$Mg(OH)_2$ (c, brucite). Mixter's[17] data on the reactions with sodium peroxide yield -9.4 for the heat of the reaction, $Mg(OH)_2$ (c) $= MgO$ (c, brucite) $+ H_2O$ (liq.). See also Johnston.[5]

MgF (g). Johnson[3] reported a value for the energy of dissociation into gaseous atoms.

MgF_2 (c). Petersen[3] found $Q = 29.1$ for the reaction, $MgCl_2$ (aq.) $+ 2\,AgF$ (aq.) $= MgF_2$ (c) $+ 2\,AgCl$ (c). Guntz[1] found -1.7 for the heat of reaction of $MgSO_4$ (aq.) with 2 KF (aq.).

$MgCl_2$ (aq.). The following are the data on the heat of solution of magnesium: Richards, Rowe, and Burgess,[1] 110.2 in 2 HCl(200); Rich-

ards and Burgess,[1] 110.15 in 2 HCl(200); Biltz and Pieper,[1] 109.7 in 2 HCl(200) and 111.2 in 2 HCl(20); Tammann and Ohler,[1] 113.1 in 2 HCl (8.7); Blitz and Hohorst,[1] 113.1 in 2 HCl (8); Sieverts and Gotta,[1] 112.1 in 2 HCl(200). Data on the heat of dilution of aqueous magnesium chloride were reported by Thomsen,[15] Fricke and Havestadt,[1] Dunnington and Hoggard,[1] Arrhenius,[2] and Lange and Streeck.[1]

Mg^{++} (∞). This value is obtained from those for $MgCl_2$ (∞) and Cl^- (∞). See also Latimer.[2]

$MgCl_2$ (c). The data on the heat of solution are: Thomsen,[15] 35.90_{800}; Berthelot and Ilosvay,[1] 35 5.

$MgCl_2 \cdot nH_2O$ (c). Thomsen's[15] data on the hydrates yield for S_{400}: dihydrate, 20.4; tetrahydrate, 10.0; hexahydrate, 2.94. Berthelot and Ilosvay[1] and van't Hoff, Kenrick, and Dawson[1] measured the heat of solution of the hexahydrate. Vapor pressure data on the hexahydrate were reported by Lescoeur,[4, 7] Derby and Yngve,[1] and Biltz.[8]

$MgCl_2 \cdot 6\,H_2O$ (liq.). Reisenfeld and Milchsach[1] reported the heat of fusion of the hexahydrate.

$MgCl_2 \cdot MgO \cdot nH_2O$ (c). Andre[1] measured the heats of solution of the anhydrous solid and the hexa- and hexadecahydrates, but the order of his values seems irregular.

MgOHCl (c). Moldenhauer's[1] data on the equilibrium, $MgCl_2$ (c) $+H_2O$ (g) $=MgOHCl$ (c) $+HCl$ (g), yield $Q=5.1$.

$MgBr_2$ (aq.). The value for $MgBr_2$ (∞) is obtained from Mg^{++} (∞) and Br^- (∞). Data on the heat of dilution of aqueous magnesium bromide were reported by Lange and Streeck.[1]

$MgBr_2$ (c). Beketoff[5] measured the heat of solution.

$MgBr_2 \cdot nH_2O$ (c). Dissociation pressure data on the di- and hexahydrates were obtained by Lescoeur.[5]

MgI_2 (aq.). The value for MgI_2 (∞) is obtained from the ions. Thomsen[15] measured the heat of reaction of BaI_2 (aq.) with $MgSO_4$ (aq.), and his data yield, for MgI_2(800), $Qf=136.6$. We have estimated the heat of dilution of aqueous magnesium iodide.

MgI_2 (c). Beketoff[5] measured the heat of solution. See also Cambi and Devoto.[1]

$MgSO_4$ (aq.). Thomsen[15] measured the heats of mixing $MgCl_2$(200) with H_2SO_4(200), and $MgSO_4$(200) with 2 HCl(100), to be 0.93 and -2.59, respectively; whence, for $MgSO_4$(200), $Qf=325.28$. Thomsen[15] also measured the heat of reaction of $MgSO_4$ (aq.) with $BaCl_2$ (aq.). Ditte[5] measured the heat of solution of magnesium in aqueous sulfuric acid. Data on the heat of dilution of aqueous magnesium sulfate were reported by Thomsen,[15] Rümelin,[1] Lange and Messner,[2] and Lange and Streeck.[2]

$MgSO_4$ (c). The data on the heat of solution are: Thomsen[15], 20.28_{400}; Pickering,[3, 5] 20.32_{450}. Values were also reported by Berthelot and Ilosvay.[1]

$MgSO_4 \cdot nH_2O$ (c). Thomsen's[15] data yield the following values for S_{400}: monohydrate, 13.30; dihydrate, 11.05; tetrahydrate, 4.20; pentahydrate, 2.10; hexahydrate, 0.10; heptahydrate, −3.80. Pickering[3, 5] reported the following values for the heats of solution: monohydrate, 12.13_{450}^{22}; heptahydrate, -3.85_{450}. Berthelot and Ilosvay,[1] Favre,[7] and Graham[1] reported values for the heat of solution of the monohydrate, and van Deventer and van der Stadt[1] for the heptahydrate. Dissociation pressure data on these hydrates were reported by Frowein,[1] Lescoeur,[2, 4] Linebarger,[1] Cohen and Visser,[1] Hollmann,[1] Foote and Scholes,[1] Bolte,[1] Schumb,[1] Carpenter and Jette,[1] and Rolla and Accame.[1] Marchal[5] reported dissociation pressure data on $MgO \cdot SO_3$ (c).

$MgSO_3 \cdot nH_2O$ (c). Hartog[1] measured the heats of solution of the anhydrous salt and the tri- and hexahydrates in HCl(220).

MgS (aq.). Thomsen[15] measured the heat of reaction of H_2S (aq.) with $Mg(OH)_2$ (c).

MgS (c). Sabatier[1] measured the heat of solution of this solid sulfide in aqueous hydrochloric acid.

$Mg(HS)_2$ (aq.). Thomsen[15] measured the heat of reaction of $Mg(OH)_2$ (c) with $2\,H_2S$ (aq.).

MgS_2O_6 (aq.). Thomsen[15] measured the heat of reaction of $MgSO_4$ (aq.) with BaS_2O_6 (aq.).

$MgS_2O_6 \cdot 6\,H_2O$ (c). Thomsen[15] measured the heat of solution.

Mg_3N_2 (c). For the heat of solution of this nitride, Matignon[19] found 279.7 in H_2SO_4 (aq.); Moser and Herzner[1] 269.9 in H_2SO_4 (aq.); Neumann, Kroger, and Kunz,[1] 284.8 in HCl(20); Brunner[1] (see Neumann, Kroger, and Kunz[1]), 177.0 in water. Neumann, Kroger, and Haebler,[2] by direct measurement, found $Qf = 116$. These values yield, respectively, for Mg_3N_2 (c), $Qf = 137$, 127, 112, 108, and 116.

$Mg(NO_3)_2$ (aq.). Thomsen[15] measured the heat of reaction of $MgSO_4$ (200) with $Ba(NO_3)_2$(200) to be 4.94; whence, for $Mg(NO_3)_2$(400), $Qf = 208.8$. Data on the heat of dilution of aqueous magnesium nitrate were reported by Thomsen,[15] Dunnington and Hoggard,[1] Lange and Streeck,[2] and Hammerschmid and Lange.[1]

$Mg(NO_3)_2 \cdot 6\,H_2O$ (c). For the heat of solution of this hydrate, Thomsen[15] found -4.22_{400} and Pickering[8] -4.54_{400}.

$Mg(NO_3)_2 \cdot 6\,H_2O$ (liq.). Reisenfeld and Milchsack[1] reported the heat of fusion of the hexahydrate.

$MgCl_2 \cdot nNH_3$ (c). Dissociation pressure data were reported on the mono- and diammines by Biltz and Hüttig[4] and Biltz, Klatte, and Rahlfs,[1] and on the hexammines by Ephraim,[9] Bonnefoi,[1] and Biltz and Stollenwerk.[2]

$MgCl_2 \cdot 2NH_3$ (aq.). Berthelot[100] estimated the heat of mixing $MgCl_2$ (aq.) with $2\,NH_3$ (aq.).

$Mg(NH_3)_2^{++}$ (aq.). This value is obtained from that for $MgCl_2 \cdot 2\,NH_3$ (aq.).

$MgBr_2 \cdot nNH_3$ (c). Biltz and Hüttig[4] and Biltz, Klatte, and Rahlfs[1]

obtained dissociation pressure data on the mono- and diammines, and Ephraim[9] on the hexammine.

$MgI_2 \cdot nNH_3$ (c). Biltz and Hüttig[4] and Biltz, Klatte, and Rahlfs[1] reported dissociation pressure data on the diammine, and Ephraim[9] on the hexammine.

$3\,MgSO_3 \cdot (NH_4)_2SO_3 \cdot nH_2O$ (c). Hartog[1] measured the heats of solution in HCl (aq.) of the hexa- and octadecahydrates.

$MgSO_4 \cdot (NH_4)_2SO_4 \cdot nH_2O$ (c). Berthelot[151] measured the heat of solution of the hexahydrate. See also Graham.[2] Caven and Ferguson[2] studied the equilibrium, hexahydrate-dihydrate-water vapor.

$Mg_3(PO_4)_2$ (c, ppt.). Berthelot[102, 145] measured the heat of the reaction, $2\,Na_3PO_4$ (aq.) $+ 3\,MgSO_4$ (aq.) $= Mg_3(PO_4)_2$ (c, ppt.) $+ 3\,Na_2SO_4$ (aq.).

$MgHPO_4$ (aq.). Berthelot[102, 145] measured the heat of the reaction of $MgSO_4$ (aq.) with Na_2HPO_4 (aq.).

$MgNH_4PO_4 \cdot 6\,H_2O$ (c). Berthelot[102, 145] measured the heat of mixing $MgCl_2 \cdot 2\,NH_3$ (aq.) with Na_2HPO_4 (aq.).

$Mg_3(AsO_4)_2$ (c, ppt.). Blarez[3] measured the heat of reaction of $2\,H_3AsO_4$ (aq.) with $3\,Mg(OH)_2$ (c).

$MgHAsO_4$ (aq.). Blarez[3] measured the heat of reaction of H_3AsO_4 (aq.) with $Mg(OH)_2$ (c).

$Mg(H_2AsO_4)_2$ (aq.). Blarez[3] measured the heat of reaction of $2\,H_3AsO_4$ (aq.) with $Mg(OH)_2$ (c).

$MgNH_4AsO_4 \cdot 6\,H_2O$ (c). Berthelot[102, 145] measured the heat of mixing $MgCl_2 \cdot 2\,NH_3$ (aq.) with H_3AsO_4 (aq.).

$MgCO_3$ (c). Berthelot[12] measured the heat of reaction of $MgSO_4$ (aq.) with Na_2CO_3 (aq.). Dissociation pressure data were obtained by Johnston,[5] Marcy and Kimek;[1] Brill,[2] Friedrich,[1] Hempel and Schubert,[1] Hedvall,[1] Grunberg,[1] Manchot and Lorenz,[1] and Centnerswer and Bruczs.[2] The calorimetric and the equilibrium data yield, for $MgCO_3$ (c), $Qf = 268.1$ and 265.1, respectively.

$MgCO_3 \cdot nH_2O$ (c). We have estimated the value for the monohydrate. Takahashi and Nukada[1] reported $Q^8 = 4.26$ for the reaction, $MgCO_3 \cdot H_2O$ (c) $+ 2\,H_2O$ (liq.) $= MgCO_3 \cdot 3\,H_2O$ (c).

$Mg(C_2H_3O_3)_2$ (aq.). deForcrand[3] measured the heat of reaction of $MgSO_4$ (aq.) with aqueous barium glycollate and aqueous lead glycollate to be 2.65 and 1.12, respectively.

$Mg(C_2H_3O_3)_2 \cdot nH_2O$ (c). deForcrand[3] measured the heats of solution of anhydrous magnesium glycollate and of the dihydrate.

$MgCl_2 \cdot 6\,CH_3OH$ (c). Lloyd, Brown, Bonnell, and Jones[1] reported dissociation pressure data on this alcoholate.

$Mg(NO_3)_2 \cdot 6\,CH_3OH$ (c). Lloyd, Brown, Bonnell, and Jones[1] reported dissociation pressure data on this alcoholate.

$MgCN_2$ (c). Franc and Hockward[1] measured the heat of combustion of magnesium cyanamide.

$Mg(CN)_2$ (aq.). Varet[3] measured the heat of reaction of $MgSO_4$ (aq.) with $Ba(CN)_2$ (aq.).

$MgSiO_3$ (c). Tschernobäeff[1] reported the heat of reaction of $MgCO_3$ (c) with SiO_2 (c). See also Marchal[1] and White.[1]

$MgZn_2$ (c). Roos[2] measured the heat of solution of this alloy in bromine water to be 322.1; Biltz and Hohorst[1] found the value 167.6 in HCl(8). See also von Wartenberg.[8]

Mg_2Sn (c). For the heat of solution of this alloy, Biltz and Holverscheit[1] reported 261 in ($FeCl_3$+HCl) (aq.). This value was later corrected to 251 by Biltz and Meyer.[2]

MgCd (c, II). For the heat of solution of this alloy, Roos[2] found 223.5 in bromine water; Biltz and Hohorst[1] found 123.7 in HCl (8).

MgCd (c, I). Roos[2] reported a value for the heat of transition at 243°.

$MgHg_4$ (c). Tammann and Ohler[1] measured the heat of solution of this alloy in HCl (9.3) to be 95.8.

Mg_4Al_3 (c). For the heat of solution of this alloy, Roos[2] found 111.7 in bromine water; Biltz and Hohorst[1] 779 in HCl (8).

Mg_nCe (c). Biltz and Pieper[1] reported the following heats of solution in HCl (20): MgCe (c), 260.5; Mg_3Ce (c), 477.3. See also Muthmann and Beck.[1]

$MgBr_2 \cdot nHgBr_2$ (aq.). Varet[2, 6] measured the heats of mixing $MgBr_2$ (aq.) with $\frac{1}{2}$, 1, and 2 moles of $HgBr_2$ (aq.).

$Mg(CN)_2 \cdot nHg(CN)_2$ (aq.). Varet[2, 6] measured the heats of mixing $Mg(CN)_2$ (aq.) with 1 and 2 moles of $Hg(CN)_2$ (aq.).

$HgX_2 \cdot 2Hg(CN)_2$ (aq.). Varet[2, 6] measured the heats of mixing $2Hg(CN)_2$ (aq.) with $HgCl_2$ (aq.), $HgBr_2$ (aq.), and HgI_2 (aq.), respectively.

$HgX_2 \cdot 2Hg(CN)_2 \cdot nH_2O$ (c). Varet[2, 6] measured the heats of solution of the chloride hexahydrate and the bromide and iodide octahydrates.

$MgWO_4$ (c). Tammann and Westerholt[1] reported $Q=3.4$ for the reaction of MgO (c) with WO_3 (c).

$MgMoO_4$ (c). Tammann and Westerholt[1] reported $Q=7.3$ for the reaction of MgO (c) with MoO_3 (c).

$6MgO \cdot 8B_2O_3 \cdot MgCl_2$ (c). For the heat of transition of boracite at 265°, Kroker[1] found −0.84, Mallard and LeChatelier[1] found −1.8.

Calcium

Ca (c, II). Standard state.

Ca (c, I). Eastman, Williams, and Young[1] and Zalesenski and Zulenski[1] reported values for the transition at 400°.

Ca (liq.). Data on the heat of fusion of calcium were reported by Randall and Tamale,[1] Moldenhauer and Roll-Hansen,[1] Bronsted,[2] and Zalesenski and Zulenski.[1]

Ca (g). Vapor pressure data on solid and liquid calcium were reported by Pilling,[1] Ruff and Hartman,[1] and Hartman and Schneider.[1] See also Randall and Tamale.[1] The values for the energy states of gaseous monatomic calcium are from Fowler[1] and Bowen.[5]

$CaCl_2$ (aq.). The data on the heat of solution of calcium in aqueous hydrochloric acid are: Guntz and Benoit,[1, 2] 129.8 in HCl(120) at 16°; Guntz and Bassett,[1, 2] 129.0 in HCl(120) at 9°; Biltz and Hohorst,[1] 130.1 in HCl(8). See also Thomsen,[15] Moissan,[1, 2] Bronsted,[2] and Copeaux and Phillips.[1] Data on the heat of dilution of aqueous $CaCl_2$ were reported by Thomsen,[15] Tucker,[1] Dunnington and Hoggard,[1] Lehtonen,[1] Nernst and Orthmann,[2] Richards and Dole,[1] and Lange and Streeck.[1]

Ca^{++} (∞). This value is obtained from those for $CaCl_2$ (∞) and Cl^- (∞).

CaO (c). The data on the heat of solution of calcium oxide in aqueous hydrochloric acid are: Bäckstrom,[1] 46.17 in HCl(55) at 25°; Berthelot,[22] 46.1 in HCl(330) at 16°; Matignon,[4] 47.0 in HCl(110); Thorvaldson, Brown, and Peaker,[1] 46 46 in HCl(200) at 20°; Copeaux and Phillips,[1] 46.1 in HCl(25); Thomsen,[15] 46.03 in HCl(200). Gautier's[1] values for the fused oxide and the oxide prepared at 1000°, 1200°, and 2000° are 46.54, 46.47, 46.40, and 46 51, respectively, in HCl(110).

CaO (g). Vapor pressure data were reported by Ruff and Schmidt[1] and Claasen and Veenemans.[1]

CaO (liq.). Washburn[1] reported the heat of fusion.

$Ca(OH)_2$ (aq.). Moissan[1, 2] and Guntz and Bassett[2] measured the heat of solution of calcium in water. The heat of neutralization of $Ca(OH)_2$ (aq.) with 2HCl (aq.) was measured by Thomsen,[15] Berthelot,[22] de Forcrand,[20] and Hess.[5]

$Ca(OH)_2$ (c). For the heat of solution of $Ca(OH)_2$ (c), Thomsen[15] found 30.49 in HCl(200), and Thorvaldson and Brown[1] found 30.82 in HCl(200) at 20°. See also Berthelot.[22] Direct measurements of the heat of the reaction, $CaO\ (c) + H_2O\ (liq.) = Ca(OH)_2\ (c)$, were made by Mannheimer,[1] Kohnert,[1] and Kohlschutter and Feilknecht,[1] who reported $Q = 15.30$, 15.18, and 15.30, respectively.

CaO_2 (c). Bergius,[1] from equilibrium studies, reported $Q = -5.4$ for the reaction, $CaO_2\ (c) = CaO\ (c) + \frac{1}{2} O_2\ (g)$. de Forcrand[29, 30] measured the heat of solution of CaO_2 (c) in HCl(100) to be 18.93.

$CaO_2 \cdot 8H_2O$ (c). de Forcrand[29, 30] reported $Q = 15.6$ for the reaction, $CaO_2\ (c) + 8H_2O\ (liq.) = CaO_2 \cdot 8H_2O\ (c)$.

CaH_2 (c). Guntz and Bassett[1] and Bronsted[2] measured the heat of solution of solid calcium hydride in aqueous HCl. Equilibrium data on the reaction, $CaH_2\ (c) = Ca\ (c) + H_2\ (g)$, were obtained by Brönsted[2] and Moldenhauser and Roll-Hansen,[1] and were reviewed by Lewis and Randall.[5] See also Kassarnowsky.[2]

CaH (g). Watson[2] reported, from spectroscopic data, the energy of dissociation into gaseous atoms. See also Hulthen.[1]

$Ca(OH)_2 \cdot H_2O_2$ (c). de Forcrand[29, 30] measured the heat of reaction of $Ca(OH)_2$ (aq.) with H_2O_2 (aq.) to be 6.85.

CaF_2 (c). Guntz[1] measured the heat of reaction of $Ca(OH)_2$ (aq.) with 2HF (aq.) to form CaF_2 (c) and $2H_2O$ (liq.).

CaF_2 (∞). This value is obtained from those for the aqueous ions.

CaF (g). Johnson[3] reported the energy of dissociation into gaseous atoms.

CaCl (c). Benoit[2] reported the value 72 2 for the heat of solution of CaCl (c) in aqueous HCl; which yields $Qf = 96.9$. Since the mixture $\frac{1}{2}$ $CaCl_2$ (c) + $\frac{1}{2}$ Ca (c) would have a heat of formation of 95.3, the existence of the subchloride, CaCl (c), appears doubtful.

$CaCl_2$ (c). The data on the heat of solution are: Thomsen,[15] 17.41_{200}; Person,[6] 19.4, Ditte,[10] 15.0; Baud,[1] $18\,17_{400}$[16]; Pickering,[8] 18.73_{400}; Berthelot and Ilosvay,[1] 17.6_{100}[12], Lehtonen,[1] 16.05_{200}[0]; de Forcrand,[57] 17.47[15]. See also Cambi and Devoto,[1] Lorenz and Winzer,[1] Jones and Taylor,[1] Fajans,[3] and Favre and Silbermann.[3]

$CaCl_2 \cdot H_2O$ (c). The data on the heat of solution are: Thomsen,[15] 12.1_{100}; Sabatier,[2] 11.7_{300}[21].

$CaCl_2 \cdot 2H_2O$ (c). Thomsen[15] measured the heat of solution.

$CaCl_2 \cdot 4H_2O$ (c). Thomsen[15] measured the heat of solution.

$CaCl_2 \cdot 6H_2O$ (c). The data on the heat of solution are: Thomsen,[15] $-4\,36_{400}$; Pickering,[8] -4.25_{100}; Ditte,[10] $-4\,5$[12]; van Deventer and van der Stadt,[1] $-4\,56$. See also van't Hoff, Kenrick, and Dawson.[1]

$CaCl_2 \cdot 6H_2O$ (liq.). Morgan and Benson[1] reported the heat of fusion of the hexahydrate to be 8.93.

$CaCl_2 \cdot 2CaO$ (c). Andre[1, 2] measured the heat of solution in HCl (aq.).

$CaCl_2 \cdot 3CaO \cdot nH_2O$ (c). Andre[1, 2] measured the heats of solution of the anhydrous basic chloride and of the tri- and hexadecahydrates in HCl (aq.). See also Tassilly.[1]

$Ca(ClO)_2$ (aq.). Neumann and Muller[1] measured the heat of reaction of $Ca(OH)_2$ (aq.) with HClO (aq.) and with Cl_2 (g).

$CaOCl_2$ (aq.). Ochi[2, 3, 4] measured the heat of the reaction of $CaOCl_2$ (aq.) with H_2O_2 (aq.).

$CaOCl_2$ (c). Ochi[2, 3, 4] measured the heat of solution. Neumann and Muller,[1] Hurter,[1] and Nydegger[1] measured the heat of reaction of CaO (c) with Cl_2 (g).

$CaOCl_2 \cdot H_2O$ (c). Ochi[2, 3, 4] measured the heat of solution.

$CaBr_2$ (aq.). The value for $CaBr_2$ (∞) is obtained from those for Ca^{++}(∞) and Br^-(∞). Data on the heat of dilution were reported by Lange and Streeck.[1]

$CaBr_2$ (c). The data on the heat of solution are: Thomsen,[15] $24\,5_{400}$; Varet,[2] 26.4_{400}[15]; Pickering,[8] 23.3_{800}. See also Cambi and Devoto.[1]

$CaBr_2 \cdot 6H_2O$ (c). Thomsen[15] measured the heat of solution.

$CaBr_2 \cdot 3CaO \cdot nH_2O$ (c). Tassilly[1, 2] measured the heats of solution of the tri- and hexadecahydrates in aqueous HBr.

CaI_2 (aq.). The value for CaI_2 (∞) is obtained from those for $Ca^{++}(\infty)$ and $I^-(\infty)$. We have estimated the heat of dilution.

CaI_2 (c). The data on the heat of solution are: Thomsen,[15] 27.70_{400}; de Forcrand,[57] 28.1_{200}[15]; Varet,[2] 27.6; Pickering,[8] 26.9_{800}.

$CaI_2 \cdot 8H_2O$ (c). Tassilly[1, 4] measured the heat of solution.

$CaI_2 \cdot 3CaO \cdot 16H_2O$ (c). Tassilly[1] measured the heat of solution.

CaS (aq.). This value is obtained from those for the ions.

CaS (c). Sabatier[1] measured the heat of solution in aqueous HCl. See also Taylor[1] and Sherman.[1]

$CaSO_3 \cdot 2H_2O$ (c). Bichowsky[4] reported $Q = 6.3$ for the reaction, $CaS_2O_3(aq.) + 2H_2O$ (liq.) $= CaSO_3 \cdot 2H_2O$ (c) $+ S$ (c).

CaS_2O_3 (aq.). The value for $CaS_2O_3(800)$ is obtained from those for the ions. Data on the heat of dilution were reported by Bichowsky.[4]

$CaSO_4$ (aq.). The value for $CaSO_4$ (∞) is obtained from those for $Ca^{++}(\infty)$ and $SO_4^{--}(\infty)$. Thomsen[15] measured the heat of neutralization of H_2SO_4 (aq.) with $Ca(OH)_2$ (aq.). See also Hess.[5] Data on the heat of dilution were reported by Lange and Messner[2] and Lange and Streeck.[2]

$CaSO_4 \cdot nH_2O$ (c). For the heat of solution of the dihydrate Thomsen[15] and Lange and Dürr[1] found -0.30 and -0.84_{4000}, respectively. Values for the heats of hydration of $CaSO_4$ (c, anhydrite), $CaSO_4$ (c, "soluble"), and the hemihydrate to the dihydrate were reported by Thomsen,[15] van't Hoff, Armstrong, Henrickson, Weigert, and Just,[1] Chassevent,[1] Mixter,[17] and de Forcrand.[14]

CaSe (c). Fabre[1] measured the heat of solution in aqueous HCl.

CaN_6 (c). Wohler and Martin[1] measured the heat of decomposition of calcium azide.

Ca_3N_2 (c). For the heat of solution of calcium nitride, Moser and Herzner[1] reported 261.6 and Guntz and Bassett[1, 2] reported 342.7. From measurement of the direct formation, Franck and Bodea[1] reported $Qf = 102\,6$.

$CaN_2O_2 \cdot 4H_2O$ (c). Berthelot[107] measured the heat of reaction of this tetrahydrate with aqueous $(Br_2 + KBr)$.

$Ca(NO_3)_2$ (aq.). The value for $Ca(NO_3)_2$ (∞) is obtained from those for $Ca^{++}(\infty)$ and $NO_3^-(\infty)$. Data on the heat of dilution were reported by Partington and Soper,[1] Nernst and Orthmann,[2] Rümelin,[1] Lange and Messner,[2] and Lange and Streeck.[2]

$Ca(NO_3)_2$ (c). The data on the heat of solution yield the following values for S_{400}: Thomsen,[15] 3.94; Pickering,[8] 3.94; Berthelot,[131] 3.2; Ewing, Rogers, Miller, and McGovern,[1] 3.96; Partington and Soper,[1] 3.92.

$Ca(NO_3)_2 \cdot nH_2O$ (c). The data on the heat of solution of the tetrahydrate yield the following values for S_{400}: Thomsen,[15] -7.25; Pickering,[8] -8.35; Ewing, Rogers, Miller, and McGovern,[1] -8.13; Berthelot,[131] -7.6. The data of Ewing, Rogers, Miller, and McGovern[1] yield the following values for S_{400}: trihydrate, -4.32; dihydrate, -3.35. Dissociation pressure data were reported by Lescoeur,[4] Ewing,[1] and Biltz.[8]

$Ca(NO_3)_2 \cdot 4H_2O$ (liq.). Data on the heat of fusion of the tetrahydrate were reported by Pickering[8] and Morgan and Owen.[1]

$Ca(NO_3)_2(C_2H_5OH)$. For the heat of solution of calcium nitrate in ethyl alcohol, Partington and Soper found $7.41_{200\ C_2H_5OH}{}^{25}$. See also Pickering.[8]

$Ca(NH_2)_2$ (c). Guntz and Benoit[1] measured the heat of solution of calcium amide in aqueous HCl.

$Ca(NO_3)_2 \cdot Ca(OH)_2 \cdot nH_2O$ (c). Werner[1] measured the heat of solution in aqueous HNO_3 of the anhydrous compound and of the hydrate with $2\frac{1}{2}$ H_2O.

$CaX_2 \cdot nNH_3$ (c). Hüttig[1] and Biltz, Klatte, and Rahlfs[1] reported values for the heats of dissociation of the mono,- di-, tetra-, and octammines of $CaCl_2$ and the mono-, di-, hexa-, and octammines of $CaBr_2$ and CaI_2; Ephraim[9] for the octammine of $CaCl_2$; Bonnefoi[1] for the di- and octammines of $CaCl_2$ and the hexammine of CaI_2; Isambert[2, 5] for the di-, tetra-, and octammines of $CaCl_2$. See also Isambert[13] and Antoine.[3]

$CaSO_4 \cdot (NH_4)_2SO_4 \cdot H_2O$ (c). Barre[1] measured the heat of solution.

$2CaSO_4 \cdot (NH_4)_2SO_4$ (c). Barre[1] measured the heat of solution.

$5CaSO_4 \cdot (NH_4)_2SO_4 \cdot H_2O$ (c). Barre[1] measured the heat of solution.

$Ca_3(PO_4)_2$ (colloidal). Berthelot[52, 54] measured the heat of reaction of H_3PO_4 (aq) with $1\frac{1}{2}$ $Ca(OH)_2$ (aq.) to be 29.2.

$Ca_3(PO_4)_2$ (c). Berthelot[52, 54] measured the heat of reaction of $1\frac{1}{2}$ $CaCl_2$ (aq.) with Na_3PO_4 (aq.).

$CaHPO_4$ (aq.). Berthelot[52, 54] measured the heat of reaction of H_3PO_4 (aq) with $Ca(OH)_2$ (aq.) to be 24.5.

$Ca(H_2PO_4)_2$ (aq.). Berthelot[52, 54] measured the heat of reaction of H_3PO_4 (aq) with $\frac{1}{2}$ $Ca(OH)_2$ (aq) to be 14.8.

$CaHPO_4 \cdot 2H_2O$ (c). Joly[3, 4] reported $Q = 2.9$ for the reaction, Na_2HPO_4 (aq.) + $2H_2O$ (liq.) + $CaCl_2$ (aq.) = $CaHPO_4 \cdot 2H_2O$ (c) + 2NaCl (aq.).

$Ca(H_2PO_4)_2 \cdot H_2O$ (c). We have estimated this value.

$Ca(H_2PO_4)_2 \cdot H_2O \cdot nNH_3$ (c). Stollenwerk[1] reported dissociation pressure data on the tetra-, di-, and monammines.

$Ca_3(AsO_4)_2$ (c, ppt.). Blarez[1] measured the heat of reaction of H_3AsO_4 (aq) with $1\frac{1}{2}$ $Ca(OH)_2$ (aq.) to be 29.5.

$CaHAsO_4$ (aq.). Blarez[1] measured the heat of reaction of H_3AsO_4 (aq.) with $Ca(OH)_2$ (aq.) to be 27.0.

$Ca(H_2AsO_4)_2$ (aq.). Blarez[1] measured the heat of reaction of H_3AsO_4 (aq.) with $\frac{1}{2}$ $Ca(OH)_2$ (aq.) to be 14.5.

CaC_2 (c). The data on the heat of solution of calcium carbide in dilute aqueous HCl are: de Forcrand,[21] 58.25[13]; Ruff and Josephy,[1] 60.8 in HCl(100). Guntz and Bassett[1] reported $Qf = 13.1$. Dissociation pressure data were reported by Ruff and Forster,[1] Krase and Yee,[1] and Franck and Hochwald.[1]

$CaCO_3$ (c, calcite). Thomsen[15] and Berthelot[12] measured the heat of

reaction of $CaCl_2$ (aq.) with Na_2CO_3 (aq.). Berthelot[15] measured the heat of solution of calcite in aqueous nitric acid. Bäckstrom[1] measured the heat of solution of calcite in HCl(50), saturated with CO_2, to be 3.24 at 25°. The heat of the direct reaction of lime with carbon dioxide was measured by Favre and Silbermann[2] and Dragert.[1] See also Franck and Hochwald[1] and Le Chatelier.[7] Dissociation pressure data were reported by Andrussow,[2] Smyth and Adams,[1] Lebeau,[1] Zavrieff,[1] Pott,[1] Reisenfeld,[1] Dutoit,[1] and Johnston.[2, 5] See also Bäckstrom.[1]

$CaCO_3$ (c, aragonite). For the heat of transition of aragonite to calcite the following values were reported: Favre and Silbermann,[2] 2.4; LeChatelier,[7] −0.3; Laschtschenko,[5] −2.7; Bäckstrom,[4] −0.33; Bäckstrom,[5] −0.04.

$Ca(HCO_3)_2$ (aq.). Randall and White[3] reviewed the data of Bäckstrom,[3] Cameron and Brezeale,[1] Cameron and Robinson,[1, 2] Cavazzi,[1] Ehlert and Hempel,[1] Engel,[1] Haehnel,[1, 2] Johnston,[3] Kendall,[2] McCoy and Smith,[1] Schloesing,[1] Wells,[1] and Frear, Johnston, and Kline,[1] on the solubility of calcium carbonate in aqueous carbonic acid, and concluded that $Q^{25}=8.6$ for the reaction, $CaCO_3$ (c, calcite) $+CO_2$ (g) $+H_2O$ (liq.) $=Ca(HCO_3)_2$ (aq.).

CaC_2O_4 (c). Berthelot[12] found $Q=8.1$[15] for the reaction, $K_2C_2O_4(200)+CaCl_2(200)=CaC_2O_4$ (c) $+2KCl(200)$.

$Ca(CHO_2)_2$ (aq.). Berthelot[9, 131] measured the heat of neutralization of aqueous formic acid with aqueous calcium hydroxide.

$Ca(CHO_2)_2$ (c). Berthelot[9, 131] measured the heat of solution of calcium formate.

$Ca(C_2H_3O_2)_2$ (aq.). The value for calcium acetate at infinite dilution has been obtained from those for the aqueous ions. Berthelot[9] measured the heat of neutralization of aqueous acetic acid with aqueous calcium hydroxide.

$Ca(C_2H_3O_2)_2$ (c). Berthelot[9] and Favre and Silbermann[3] measured the heat of solution.

$Ca(C_2H_3O_2)_2 \cdot H_2O$ (c). Berthelot[9] measured the heat of solution.

$Ca(C_2H_3O_3)_2$ (aq.). This value is obtained from those for the aqueous calcium and glycollate ions.

$Ca(C_2H_3O_3)_2 \cdot nH_2O$ (c). de Forcrand[3] measured the heats of solution of the anhydrous salt and the tri- and pentahydrates.

$Ca(C_2H_5O)_2$ (c). de Forcrand[13, 22] measured the heat of solution in HCl(110).

$Ca(C_2H_5O)_2 \cdot 2C_2H_5OH$ (c). de Forcrand[13, 22] measured the heat of solution in HCl(110).

$3CaO \cdot 4C_2H_5OH$ (c). de Forcrand[13, 22] measured the heat of solution in aqueous HCl.

$CaX_2 \cdot nC_2H_5OH$ (c). Bonnell and Jones[1] reported dissociation pressure data on the tri- and tetra-alcoholates of $CaCl_2$ and $CaBr_2$.

$CaCl_2 \cdot (CH_3)_2CO$ (c). Bagster[1] obtained dissociation pressure data on this compound.

$Ca(NO_3)_2 \cdot 2CH_3OH$ (c). Lloyd, Brown, Bonnell, and Jones[1] reported dissociation pressure data on this compound.

$Ca(CN)_2$ (aq.). Joannis[1] measured the heat of neutralization of aqueous calcium hydroxide with aqueous HCN.

$3CaO \cdot Ca(CN)_2 \cdot 15H_2O$ (c). Joannis[1] measured the heat of solution in aqueous HCl.

$CaCN_2$ (c). Franck and Hochwald[1] and Krase and Yee[1] measured the heat of the reaction, CaC_2 (c) $+N_2$ (g) $=CaCN_2$ (c) $+C$ (c), to be 72 and 98, respectively; whence, for $CaCN_2$ (c), $Qf=86.5$ and 112.5. The equilibrium data of Franck and Heimann[1] on the same reaction yield, for $CaCN_2$ (c), $Qf=85.9$. See also Thompson and Lombard[2] and Dotch.[1] The average of the data of Franck and Hochwald,[1] Kameyama and Oka,[2] and Kameyama[1] on the heat of combustion of $CaCN_2$ (c) yield, for the latter, $Qf=84.5$. The data of Krase and Yee[1] on the reaction, Ca_3N_2 (c) $+3C$ (c) $+2N_2$ (g) $=3CaCN_2$ (c), yield, for $CaCN_2$ (c), $Qf=102$. See also Cochet,[1] Badger,[1] LeBlanc and Eschmann,[1] Matignon,[9] and Landis.[1]

$CaSi_n$ (c). Wohler and Martin[1] measured the heats of combustion of CaSi (c) and $CaSi_2$ (c) to form $CaSiO_3$ (c) and $CaSiO_3$ (c) $+SiO_2$ (c), respectively.

$CaSiO_3$ (c). Tschernobaeff[1] and Tschernobaeff and Wologdine[1] reported $Q=-25\,3$ for the reaction, $CaCO_3$ (c) $+SiO_2$ (c) $=CaSiO_3$ (c) $+CO_2$ (g); whence, for $CaSiO_3$ (c), $Qf=373.1$. For the same reaction, LeChatelier[8, 10] reported $Q=-13.4$; whence, for $CaSiO_3$ (c), $Qf=385$. For the heat of solution of $CaSiO_3$ (c) in HCl (24.65) at 50°, Roth and Chall[1] found $Q=23\,04$, and for the reaction, CaO (c) $+SiO_2$ (c, α quartz) $=CaSiO_3$ (c), reported $Q^{50}=19\,66$; whence, for $CaSiO_3$ (c), $Qf=374.7$. The equilibrium data of Marchal[6] on the reaction, $CaSO_4$ (c) $+SiO_2$ (c) $=CaSiO_3$ (c) $+SO_3$ (g), yield $Q=-81.2$; whence, for $CaSiO_3$ (c), $Qf=369$. Wagner's[1] data on the heats of solution, in HCl (25), of the two forms of $CaSiO_3$ (c), wollastonite and pseudowollastonite, $Q=20.01$ and 21.27, respectively, yield for the latter, $Qf=376\,6$, and for the transition of the former into the latter, $T=-1.26$. See Allen, White, and Wright.[1]

Ca_2SiO_4 (c). Tschernobaeff[1] and Tschernobaeff and Wologdine[1] reported $Q=-56.7$ for the reaction, $2CaCO_3$ (c) $+SiO_2$ (c) $=Ca_2SiO_4$ (glass) $+2CO_2$ (g), whence, for Ca_2SiO_4 (c), $Qf=536.7$.

$CaSn_3$ (c). Biltz and Meyer[1] measured the heat of solution of this alloy in aqueous ($FeCl_3$ + HCl) to be 273. See also Biltz and Holverscheit.[1]

$CaI_2 \cdot 2\,PbI_2 \cdot nH_2O$ (c). Mosnier[1] measured the heats of solution of the anhydrous double salt and of the heptahydrate.

$CaZn_n$ (c). Roos[2] measured the heats of solution of $CaZn_{10}$ (c) and $CaZn_4$ (c) in bromine water to be 890.3 and 487.8, respectively. Biltz and Wagner[1] measured the heats of solution of $CaZn_{10}$ (c), $CaZn_4$ (c), Ca_2Zn_3 (c), and Ca_4Zn (c) in HCl (20) to be 381.0, 219.5, 307.8, and 512.0, respectively.

$CaCd_3$ (c). Roos[2] measured the heat of solution of this alloy in HCl(8).

$CaBr_2 \cdot n HgBr_2$ (aq.). Varet[2, 6] measured the heats of mixing $CaBr_2$ (aq.) with 1 and 2 $HgBr_2$ (aq.), respectively.

$Ca(CN)_2 \cdot n Hg(CN)_2$ (aq.). Varet[2, 6] measured the heats of mixing $Ca(CN)_2$ (aq.) with 1 and 2 $Hg(CN)_2$ (aq.), respectively.

$CaX_2 \cdot 2\,Hg(CN)_2$ (aq.). Varet[2, 6] measured the heats of mixing 2 $Hg(CN)_2$ (aq.) with $CaCl_2$ (aq.), $CaBr_2$ (aq.), and CaI_2 (aq.), respectively.

$CaX_2 \cdot 2\,Hg(CN)_2 \cdot n H_2O$ (c). Varet[2, 6] measured the heats of solution of the chloride hexahydrate, the bromide heptahydrate, and the iodide hexahydrate.

$Ca(CN)_2 \cdot n AgCN$ (aq.). Varet[5] measured the heats of mixing $Ca(CN)_2$ (aq.) with 1 and 2 AgCN (c), respectively.

$CaO \cdot Fe_2O_3$ (c). The equilibrium data of Marchal[6] yield $Q = -46$ for the reaction, Fe_2O_3 (c) + $CaSO_4$ (c) = $CaO \cdot Fe_2O_3$ (c) + SO_3 (g); whence, for $CaO \cdot Fe_2O_3$ (c), $Qf = 399$.

$Ca_2Fe(CN)_6$ (aq.). Joannis[1] measured the heat of reaction of $H_4Fe(CN)_6$ (aq) with 2 $Ca(OH)_2$ (aq.) to be 56.4.

$CaH_2Fe(CN)_6$ (aq.). Joannis[1] measured the heat of reaction of $H_4Fe(CN)_6$ (aq.) with $Ca(OH)_2$ (aq.) to be 28.4.

$Ca_2Fe(CN)_6 \cdot 12\,H_2O$ (c). Joannis[1] measured the heat of solution.

$CaWO_4$ (c). Tammann and Westerholt[1] calculated $Q = 39.8$ for the reaction, CaO (c) + WO_3 (c) = $CaWO_4$ (c).

$CaO \cdot n B_2O_3$ (c). Griveau[1] measured the heats of solution in aqueous HCl of these borates with $n = \frac{1}{3}$, $\frac{1}{2}$, 1, and 2.

$CaAl_3$ (c). Biltz and Wagner[1] measured the heat of solution of this alloy in HCl(8) to be 454.

$n CaO \cdot Al_2O_3$ (gls.). Tschernobaeff[1] reported $Q = 44.7$, 87.0, and 132.5 for the heats of the reactions of Al_2O_3 (c) with 1, 2, and 3 $CaCO_3$ (c), respectively.

$3\,CaCl_2 \cdot 4\,AlCl_3$ (c). Baud[1] measured the heat of solution.

$3\,CaO \cdot Al_2O_3 \cdot 2\,SiO_2$ (c). Tschernobaeff and Wologdine[1] reported $Q = 50.2$ for the reaction, 2 SiO_2 (c) + Al_2O_3 (c) + 3 CaO (c) = 3 CaO $\cdot Al_2O_3 \cdot 2\,SiO_2$ (c).

$CaO \cdot Al_2O_3 \cdot 6\,SiO_2$ (c, heulandite). Tschernobaeff and Wologdine[1] measured the heat of solution in aqueous (20%) HF.

Ca_3Mg_4 (c). Biltz and Hohorst[1] measured the heat of solution of this alloy in HCl(8). See also Roos.[2]

$CaCl_2 \cdot 2\,MgCl_2 \cdot 2\,H_2O$ (c). van't Hoff, Kenrick, and Dawson[1] measured the heat of solution.

$CaCO_3 \cdot MgCO_3$ (c). Mitchell[1] found the heat of solution of dolomite in aqueous HCl to be 31.6. Bäckstrom[2] calculated, from the equilibrium data of Marc and Limek,[1] $Q = 1.8$ for the reaction, $CaCO_3$ (c) + $MgCO_3$ (c) = $CaCO_3 \cdot MgCO_3$ (c).

STRONTIUM

Sr (c). Standard state.

Sr (g). Vapor pressure data were reported by Ruff and Hartmann[1] and Hartmann and Schneider.[1] We have estimated the value for the heat of sublimation from the latter data. The values for the energy states of gaseous monatomic strontium are from Hansen and Thorsen,[1] Saunders,[2] Russell and Saunders,[1] and Fowler.[1]

Sr (liq.). We have estimated the heat of fusion of strontium.

$SrCl_2$ (aq.). The data of Guntz and Benoit[2] yield for the heat of the reaction, Sr (c) + 2 HCl(140) = $SrCl_2$(280) + H_2 (g), $Q = 130.1$; whence, for $SrCl_2$(200), $Qf = 209.0$. Similar data on less pure samples of strontium were obtained by Thomsen[15] and Guntz and Roderer.[1] Data on the heat of dilution of aqueous strontium chloride were reported by Stearn and Smith,[1] Lehtonen,[1] Pratt,[1] Magie,[1] Dunnington and Hoggard,[1] and Lange and Streeck.[1]

Sr^{++} (∞). This value is obtained from those for $SrCl_2$ (∞) and Cl^- (∞).

$SrCl_2$ (c). The data on the heat of solution are: Thomsen,[15] 11.15_{400}; Berthelot,[7] 11.0; Berthelot and Ilosvay,[1] 11.1^{15}; Baud,[1] $11.4_{440}{}^{21}$; Pickering,[7] 11.27_{200}; Benoit,[2] $10.42_{HCl(aq)}{}^{15}$; Maier[2] (see Hüttig and Slonim[1]), $11.44_{400}{}^{17}$. See also Cambi and Devoto.[1]

SrO (c). Thomsen[15] measured the heat of solution of strontium oxide in 2 HCl(200) to be 56.97; whence, for SrO (c), $Qf = 141.5$. For the heat of solution of SrO (c) in water, Berthelot[22] reported 27.2 and de Forcrand[48] reported 29.7, 28.3, and 30.8. These values yield for SrO (c), $Qf = 143.6$, 141.1, 142.5, and 140.0, respectively.

SrO (g). We have estimated the heat of sublimation from the vapor pressure data of Tiede and Birnbauer.[1]

$Sr(OH)_2$ (aq.). Thomsen,[15] de Forcrand,[28] and Berthelot[22] measured the heat of neutralization of 2 HCl (aq.) with $Sr(OH)_2$ (aq.).

$Sr(OH)_2$ (c). The data on the heat of solution of solid strontium hydroxide are: Thomsen,[15] 11.64_{400}; Berthelot,[9] 9.6; Berthelot,[22] $37.68_{2HCl(330)}{}^{16}$; de Forcrand,[51] $10.33_{1100}{}^{15}$. See also Johnston[1, 4] and Jorrissen.[1]

$Sr(OH)_2 \cdot H_2O$ (c). de Forcrand[51] measured the heat of solution.

$Sr(OH)_2 \cdot 8\,H_2O$ (c). The data on the heat of solution are: de Forcrand,[51] $-14.27_{1100}{}^{15}$; Thomsen,[15] $12.99_{2HCl(200)}$; Berthelot,[22] $12.96_{2HCl(330)}{}^{16}$. See also Muller and Erzbach[1] and Lescoeur.[2]

SrO_2 (c). de Forcrand[28] measured the heat of solution in aqueous HCl.

$SrO_2 \cdot 9\,H_2O$ (c). de Forcrand[28] measured the heat of solution in aqueous HCl.

Sr_2O (c). Benoit[2] measured the heat of solution in aqueous HCl.

SrH_2 (c). Guntz and Benoit[1] measured the heat of solution in aqueous HCl. See also Kassarnowsky.[2]

SrF_2 (c). Petersen[3] measured the heat of reaction of 2 AgF (aq.) with $SrCl_2$ (aq.) to be 34 5. Guntz[1] measured the heat of neutralization of 2 HF (aq.) with $Sr(OH)_2$ (aq) to be 17.9.

SrF (g). Johnson[3] estimated the energy of dissociation into gaseous atoms, from spectroscopic data.

SrCl (c). Benoit[2] reported the heat of solution in aqueous HCl for this supposed subchloride.

$SrCl_2 \cdot H_2O$ (c). Maier[2] (see Hüttig and Slonim[1]) measured the heat of solution to be $6.02_{400}{}^{17}$; Thomsen[15] found 5.88_{100}.

$SrCl_2 \cdot 2\,H_2O$ (c). The data on the heat of solution in $400H_2O$ are: Maier[2] (see Hüttig and Slonim[1]), 2.57; Sabatier,[2] 2.07; Pickering,[7] 1.92; Thomsen,[15] 2.08.

$SrCl_2 \cdot 6\,H_2O$ (c). The data on the heat of solution yield the following values for S_{400}: Thomsen,[15] −7 50; Berthelot,[7] −7.3; Maier[2] (see Hüttig and Slonim[1]), −7.44. See also Favre and Silbermann.[3] Dissociation pressure data on the hexahydrate were reported by Schumb,[1] Hüttig and Slonim,[1] Andreae,[1] Frowein,[1] Cohen,[4] Schottky,[1] Lnebarger,[1] Lescoeur,[2] Schumb,[1] Baxter and Lansing,[1] Menzies,[2] and Biltz.[8]

$Sr(ClO)_2$ (aq.). Neumann and Muller[2] measured the heat of reaction of $Sr(OH)_2$ (aq) with Cl_2 (g) and with 2 HClO (aq.).

$SrCl_2 \cdot SrO \cdot nH_2O$ (c). Andre[1] measured the heats of solution of the mono- and nonahydrates.

$SrBr_2$ (aq.). The value for $SrBr_2$ (∞) is obtained from those for the aqueous ions. Data on the heat of dilution were reported by Lange and Streeck.[1]

$SrBr_2$ (c). The data on the heat of solution are: Thomsen,[15] 16.1_{400}; Tassilly,[1] 16.0^{20}; Maier[2] (see Hüttig and Slonim[1]), 16.25.[19] See also Favre and Valson[2] and Cambi and Devoto.[1]

$SrBr_2 \cdot H_2O$ (c). The data on the heat of solution yield the following values for S_{400}: Thomsen,[15] 9.90; Maier[2] (see Hüttig and Slonim[1]), 8.86.

$SrBr_2 \cdot 2\,H_2O$ (c). Thomsen[15] measured the heat of solution.

$SrBr_2 \cdot 4\,H_2O$ (c). Thomsen[15] measured the heat of solution.

$SrBr_2 \cdot 6\,H_2O$ (c). The existing data yield the following values for S_{400}: Thomsen,[15] −6.45; Maier[2] (see Hüttig and Slonim[1]), −7.11. Dissociation pressure data on the hexahydrate were reported by Trip,[1] Hüttig and Slonim,[1] and Lescoeur.[2]

$SrBr_2 \cdot SrO \cdot nH_2O$ (c). Tassilly[1] measured the heats of solution of the tri- and nonahydrates in aqueous HBr.

SrI_2 (aq.). The value for SrI_2 (∞) is obtained from those for the aqueous ions. We have estimated the heat of dilution of aqueous strontium iodide.

SrI_2 (c). For the heat of solution, Tassilly[1] found 20.5 and Maier[2] (see Slonim and Hüttig[1]) 20.6^{19}.

$SrI_2 \cdot nH_2O$ (c). Maier[2] (see Slonim and Hüttig[1]) measured the heats of solution of the mono-, di-, and hexahydrates. See also Tassilly.[1, 4]

Dissociation pressure data were reported by Trip[1] and Hüttig and Slonim.[1]

SrS (aq.). This value is obtained from those for the ions.

SrS (c). Sabatier[1] measured the heat of solution in aqueous HCl.

$Sr(HS)_2$ (aq.). Thomsen[15] measured the heat of reaction of $Sr(OH)_2$ (aq.) with $2\,H_2S$ (aq.).

$SrSO_4$ (aq.). The value for $SrSO_4(\infty)$ is obtained from the ions. Thomsen[15] measured the heat of reaction of $Sr(OH)_2$ (aq.) with H_2SO_4 (aq.). Chroustchoff and Martinoff[1] and Berthelot[9] measured the heats of reaction of $SrCl_2$ (aq.) with Na_2SO_4 (aq.) and of $SrSO_4$ (aq.) with 2 NaCl (aq.). We have estimated the values for the heat of dilution.

$SrSO_4$ (c). Barre[1] and Thomsen[15] reported the heat of solution of strontium sulfate to be 0.0.

SrS_2O_6 (aq.). This value is obtained from those for the aqueous ions.

$Sr(S_2O_6)_2 \cdot 4\,H_2O$ (c). Thomsen[15] measured the heat of solution.

$SrI_2 \cdot nSO_2$ (c). Ephraim and Kornblum[1] measured the dissociation pressures of $SrI_2 \cdot 2\,SO_2$ (c) and $SrI_2 \cdot 4\,SO_2$ (c).

SrSe (aq.). Fabre[1] measured the heat of neutralization of $Sr(OH)_2$ (aq.) with H_2Se (aq.).

SrSe (c). Fabre[1] measured the heat of solution.

SrN_6 (c). Wohler and Martin[1] measured the heat of decomposition of strontium azide to be 49.0.

Sr_3N_2 (c). Guntz and Benoit[1] measured the heat of solution of strontium nitride in aqueous HCl.

SrN_2O_2 (aq.). Berthelot[10] reported a value for the heat of neutralization of $Sr(OH)_2$ (aq.) with $H_2N_2O_2$ (aq.).

$SrN_2O_2 \cdot 5\,H_2O$ (c). Berthelot[10] measured the heat of solution of the pentahydrate in bromine water.

$Sr(NO_3)_2$ (aq.). Thomsen[15] and Berthelot[9] reported values for the heat of neutralization of $Sr(OH)_2$ (aq.) with $2\,HNO_3$ (aq.). The value for $Sr(NO_3)_2(\infty)$ is obtained from those for the ions. Data on the heat of dilution of aqueous strontium nitrate were reported by Pratt,[1] Thomsen,[15] Lange and Streeck,[2] and Hammerschmid and Lange.[1]

$Sr(NO_3)_2$ (c). The existing data yield the following values for S_{400}: Thomsen,[15] −4.62; Pickering,[7] −5.04; Berthelot,[9, 131] −5.1. See also Favre and Valson.[2]

$Sr(NO_3)_2 \cdot 4\,H_2O$ (c). The existing data yield for S_{400} the following values: Thomsen,[15] −12.30; Pickering,[7] −6.8 (?); Favre and Silbermann,[3] −11.7; Berthelot,[9] −12.1.

$Sr(NH_2)_2$ (c). Guntz and Benoit[1] measured the heat of solution in aqueous HCl.

$Sr \cdot 6\,NH_3$ (c). Biltz and Hüttig[3] measured the dissociation pressures.

$SrX_2 \cdot nNH_3$ (c). Hüttig[2] reported dissociation pressure data on the mono-, di-, and octammines of $SrCl_2$ and $SrBr_2$ and on the mono-, di-, hexa-, and octammines of SrI_2. Buffington[1] reported data on the di- and octammines of $SrCl_2$.

$SrSO_4 \cdot (NH_4)_2SO_4$ (c). Barre[1] measured the heat of solution.

$Sr_3(PO_4)_2$ (c, ppt.). Berthelot[52, 101] measured the heat of reaction of H_3PO_4 (aq.) with $1\frac{1}{2}$ $Sr(OH)_2$ (aq.). See also Joly.[4]

$SrHPO_4$ (aq.). Berthelot[52, 101] measured the heat of reaction of H_3PO_4 (aq.) with $Sr(OH)_2$ (aq.). See also Joly.[4]

$Sr(H_2PO_4)_2$ (aq.). Berthelot[52, 101] measured the heat of reaction of H_3PO_4 (aq.) with $\frac{1}{2}$ $Sr(OH)_2$ (aq.). See also Joly.[4]

$Sr_3(AsO_4)_2$ (c, ppt.). Blarez[1] measured the heat of reaction of H_3AsO_4 (aq.) with $1\frac{1}{2}$ $Sr(OH)_2$ (aq.).

$SrHAsO_4$ (aq.). Blarez[1] measured the heat of reaction of H_3AsO_4 (aq.) with $Sr(OH)_2$ (aq.).

$Sr(H_2AsO_4)_2$ (aq). Blarez[1] measured the heat of reaction of H_3AsO_4 (aq.) with $\frac{1}{2}$ $Sr(OH)_2$ (aq.).

$SrCO_3$ (c). Thomsen[15] found $Q=0.23$ for the reaction of $SrCl_2$(400) with Na_2CO_3(400). Dissociation pressure data were reported by Johnston[1, 4] and Dutoit.[1]

$Sr(HCO_3)_2$ (aq.). Randall and White[3] calculated, from the data of Haehnel,[1, 2] $Q=6.74$ for the reaction, $SrCO_3$ (c) $+CO_2$ (g) $+H_2O$ (liq.) $=Sr(HCO_3)_2$ (aq.), and from the data of McCoy and Smith,[1] $Q=1.94$ for the reaction, $SrCO_3$ (c) $+H_2CO_3$ (aq.) $=Sr(HCO_3)_2$ (aq.).

$Sr(CHO_2)_2$ (aq.). Thomsen[15] measured the heat of neutralization of aqueous formic acid with aqueous strontium hydroxide.

$Sr(CHO_2)_2$ (c). Berthelot[10, 131] measured the heat of solution of strontium formate.

$Sr(CHO_2)_2 \cdot 2\,H_2O$ (c). Berthelot[10, 131] measured the heat of solution.

$SrC_2O_4 \cdot 2\frac{1}{2}\,H_2O$ (c). Berthelot[10] found $Q=35.2$ for the reaction, $H_2C_2O_4$ (aq.) $+Sr(OH)_2$ (aq.) $+\frac{1}{2}$ H_2O (liq.) $=SrC_2O_4 \cdot 2\frac{1}{2}$ H_2O (c).

$Sr(C_2H_3O_2)_2$ (aq.). Berthelot[10, 131] measured the heat of neutralization of aqueous strontium hydroxide with aqueous acetic acid. The value for strontium acetate at infinite dilution is obtained from those for the aqueous ions.

$Sr(C_2H_3O_2)_2$ (c). Berthelot[10, 131] measured the heat of solution.

$Sr(C_2H_3O_2)_2 \cdot \frac{1}{2}\,H_2O$ (c). Berthelot[10, 131] measured the heat of solution.

$Sr(C_2H_3O_3)_2$ (aq.). de Forcrand[3] measured the heat of neutralization of aqueous glycollic acid with aqueous strontium hydroxide.

$Sr(C_2H_3O_3)_2$ (c). de Forcrand[3] measured the heat of solution.

$SrBr_2 \cdot 1\frac{1}{2}\,CH_3OH$ (c). Lloyd, Brown, Bonnell, and Jones[1] measured the dissociation pressures of this alcoholate.

$Sr(CN)_2$ (aq.). Joannis[1] measured the heat of neutralization of 2 HCN (aq.) with $Sr(OH)_2$ (aq.).

$Sr(CN)_2 \cdot 4\,H_2O$ (c). Joannis[1] measured the heat of solution.

$SrSiO_3$ (gls.). Tschernobaeff[1] reported $Q=-35.1$ for the reaction, $SrCO_3$ (c) $+SiO_2$ (c) $=SrSiO_3$ (gls.) $+CO_2$ (g).

$SrI_2 \cdot 2\,PbI_2 \cdot nH_2O$ (c). Mosnier[1] measured the heats of solution of the anhydrous double salt and of the heptahydrate.

$SrHg_\infty$ (liq.). The equilibrium data of Smith and Braley[1] yield 59.5 for the heat of solution of strontium in a very large amount of mercury.

$SrBr_2 \cdot n HgBr_2$ (aq.). Varet[6] measured the heats of mixing $SrBr_2$ (aq.) with $\frac{1}{2}$, 1, and 2 $HgBr_2$ (aq.), respectively.

$Sr(CN)_2 \cdot Hg(CN)_2$ (aq.). Varet[6] measured the heats of mixing $Sr(CN)_2$ (aq.) with 1 and 2 $Hg(CN)_2$ (aq.), respectively.

$SrX_2 \cdot 2\,Hg(CN)_2$ (aq.). Varet[6] measured the heats of mixing 2 $Hg(CN)_2$ (aq.) with $SrCl_2$ (aq.), $SrBr_2$ (aq.), and SrI_2 (aq.), respectively.

$SrX_2 \cdot 2\,Hg(CN)_2 \cdot nH_2O$ (c). Varet[6] measured the heats of solution of the chloride hexahydrate, the bromide hexahydrate, and the iodide heptahydrate.

$Sr(CN)_2 \cdot n AgCN$ (aq.). Varet[5] measured the heat of reaction of $Sr(CN)_2$ (aq.) with 1 and 2 AgCN (c), respectively.

$Sr(CN)_2 \cdot Ni(CN)_2$ (aq.). Varet[4] measured the heat of mixing $Sr(CN)_2$ (aq.) with $Ni(CN)_2$ (aq.).

$3\,SrCl_2 \cdot 4\,AlCl_3$ (c). Baud[1] measured the heat of solution.

$SrWO_4$ (c). For the reaction, SrO (c) + WO_3 (c) = $SrWO_4$ (c), Tammann and Westerholt[1] reported $Q = 56.4$ (?).

$Sr_3(FeCO(CN)_5)_2$ (aq.). Muller[9, 10] measured the heat of neutralization of $H_3FeCO(CN)_5$ (aq.) with $1\frac{1}{2}$ $Sr(OH)_2$ (aq.).

$Sr_3(FeCO(CN)_5)_2 \cdot nH_2O$ (c). Muller[9, 10] measured the heats of solution of the anhydrous salt and of the tetrahydrate.

BARIUM

Ba (c). Standard state.

Ba (liq.). We have estimated the heat of fusion.

Ba (g). We have estimated the heat of sublimation from the data of Ruff and Hartmann[1] and Hartmann and Schneider.[1] See also Sherman.[1] The energy states of gaseous monatomic barium are evaluated from the data of Hansen and Thorsen,[1] Russell and Saunders,[1] and Fowler.[3]

$BaCl_2$ (aq.). Guntz and Benoit[1, 2] found $Q = 128.4$ for the reaction, Ba (c) + 2 HCl(140) = $BaCl_2$(280) + H_2 (g), at 7°; whence, for $BaCl_2$ (200), $Qf = 207.3$. With less pure samples, Thomsen[15] and Guntz[3] measured the heat of solution of barium in aqueous HCl and Guntz[3] that in water. Data on the heat of dilution of aqueous barium chloride were reported by Pratt,[1] Magie,[1] Richards and Dole,[1] Lehtonen,[1] Perreu,[2] Smith, Stearns, and Schneider,[1] and Lange and Streeck.[1]

$Ba^{++}(\infty)$. This value is obtained from those for $BaCl_2(\infty)$ and $Cl^-(\infty)$.

BaO (c). de Forcrand[11, 48, 51] measured the heat of solution of barium oxide in 600 H_2O to be 35.64 at 15°. For the heat of solution of barium oxide in aqueous HCl, Berthelot[22] found 55.58 in 2 HCl(300) at 11°, and Thomsen[15] 62.30 in 2 HCl(200) at 18°.

BaO (g). Vapor pressure data were reported by Thompson and Armstrong[1] and Classen and Veeneman.[1]

BaO_2 (c). Berthelot[30, 61] measured the heat of solution of barium peroxide in aqueous HCl and in aqueous ($SnCl_2$+5 HCl). Dissociation pressure data on BaO_2 (c) were reported by LeChatelier[6] and Hildebrand,[1] and reviewed by Biltz[8] and Lewis and Randall.[5]

$BaO_2 \cdot nH_2O$ (c). Berthelot[61] measured the heat of solution of the mono- and decahydrates in aqueous HCl, and de Forcrand[26, 27] that of the decahydrate.

$BaO_2 \cdot H_2O_2$ (c). Berthelot[61] and de Forcrand[26, 27] measured the heat of solution in aqueous HCl.

$Ba(OH)_2$ (aq.). Data on the heat of neutralization of $Ba(OH)_2$ (aq.) with 2 HCl (aq.) were reported by Anderson and Noyes,[1] von Steinwehr,[1] Berthelot,[22] and Thomsen.[15] The value for barium hydroxide at infinite dilution is obtained from those for aqueous barium and hydroxyl ions.

$Ba(OH)_2$ (c). The data on the heat of solution of barium hydroxide are: Thomsen,[15] $12\,26_{800}$; Berthelot,[22] 40.0 and 38.0 in aqueous HCl; de Forcrand,[11, 48, 51] 11.60_{660}[15]. See also Johnston.[5]

$Ba(OH)_2 \cdot nH_2O$ (c). de Forcrand[11, 48, 51] measured the heat of solution of the monohydrate. For the heat of solution of the octahydrate, the data are: Thomsen,[15] $-15\,21_{800}$; Berthelot,[22] −13.0; de Forcrand,[51] -14.50_{660}[15]; Sill,[1] −15.8.

BaH_2 (c). For the heat of solution of barium hydride in aqueous HCl at 7°, Guntz and Benoit[1] found 87.6. See also Guntz[16] and Kassarnowsky.[1, 2]

Ba_2O (c). Benoit[2] measured the heat of solution in aqueous HCl.

BaF_2 (aq.). The value for infinite dilution is obtained from those for the aqueous ions.

BaF_2 (c). Petersen[3] measured the heat of reaction of $BaCl_2$ (aq.) with 2 AgF (aq.). Guntz[1] and Petersen[3] measured the heat of reaction of $Ba(OH)_2$ (aq.) with 2 HF (aq.). Petersen[3] reported the heat of solution of BaF_2 (c) to be −2.0.

$BaCl_2$ (c). Data on the heat of solution of barium chloride were reported by Thomsen,[15] Berthelot,[7, 22] Berthelot and Ilosvay,[1] Benoit,[2] Baud,[1] Schottky,[1] Kolosovskii,[5] and Lehtonen.[1] See also Cambi and Devoto.[1]

$BaCl_2 \cdot H_2O$ (c). Schottky[1] measured the heat of solution. Dissociation pressure data were reported by Foote and Scholes,[1] Lescoeur,[2] Muller-Erzbach,[1] and Trip[1] (see Hüttig and Slonim[1]).

$BaCl_2 \cdot 2\,H_2O$ (c). Data on the heat of solution of the dihydrate were reported by Thomsen,[15] Berthelot,[7] Favre and Silbermann,[3] Kolosovskii,[5] Perreu,[1] and Favre and Valson.[2] Dissociation pressure data were reported by Trip[1] (see Hüttig and Slonim[1]), Baxter and Cooper,[1] Menzies,[1] Foote and Scholes,[1] Schumb,[1] Frowein,[1] Schottky,[1] Cohen,[4] Muller-Erzbach,[3, 4] Partington,[1] and Lescoeur.[2]

$Ba(ClO)_2$ (aq.). Berthelot[26] and Neumann and Muller[2] measured the heat of reaction of $Ba(OH)_2$ (aq.) with Cl_2 (g), and Neumann and Muller[2] that of $Ba(OH)_2$ (aq.) with 2 HClO (aq.).

$Ba(ClO_2)_2$ (c). Bruni and Levi[1] reported the heat of dissociation of barium chlorite into barium chloride and oxygen.

$Ba(ClO_3)_2$ (aq.). Berthelot[29] and Thomsen[15] measured the heat of reduction of aqueous barium chlorate with aqueous sulfur dioxide. The value for $Ba(ClO_3)_2$ (∞) is obtained from those for the aqueous ions at infinite dilution.

$Ba(ClO_3)_2$ (c). Berthelot[9] measured the heat of solution.

$Ba(ClO_3)_2 \cdot H_2O$ (c). For the heat of solution, Thomsen[15] found -11.24_{600} and Berthelot[9] -11.48_{500}[10].

$Ba(ClO_4)_2$ (aq.). Thomsen[15] and Berthelot[79] measured the heat of neutralization of aqueous perchloric acid with aqueous barium hydroxide. The value for $Ba(ClO_4)_2$ (∞) is obtained from those for Ba^{++} (∞) and ClO_4^- (∞).

$Ba(ClO_4)_2 \cdot nH_2O$ (c). Berthelot[9] measured the heats of solution of the anhydrous salt and the trihydrate.

$BaCl_2 \cdot BaO \cdot nH_2O$ (c). Andre[1, 3] measured the heats of solution of the tri-, penta-, and octahydrates, but reported his results in terms of the heat of the reaction, $BaCl_2$ (c) + BaO (c) + nH_2O (liq.) = $BaCl_2 \cdot BaO \cdot nH_2O$ (c), without stating the values used for the heat of formation of BaO (c). However, the value of *Qf* for the pentahydrate can be computed from the data of Tassilly[4] who measured its heat of solution in aqueous HCl to be 18.5, and the differences between the various hydrates can then be obtained from the data of Andre.[1, 3]

$BaBr_2$ (aq.). The value for barium bromide at infinite dilution is obtained from those for the aqueous ions. Data on the heat of dilution of aqueous barium bromide were reported by Lange and Streeck.[1]

$BaBr_2$ (c). The data on the heat of solution are: Thomsen,[15] 4.98_{400}; Varet,[2] 4.0. See also Cambi and Devoto.[1]

$BaBr_2 \cdot H_2O$ (c). Dissociation pressure data were reported by Lescoeur[7] and Trip[1] (see Hüttig and Slonim[1]).

$Ba(BrO)_2$ (aq.). Berthelot[45] measured the heat of reaction of aqueous barium hydroxide with bromine.

$Ba(BrO_3)_2$ (aq.). These values are obtained from those for the ions.

$Ba(BrO_3)_2 \cdot H_2O$ (c). Greensfelder and Latimer[1] measured the heat of solution.

$BaBr_2 \cdot BaO \cdot nH_2O$ (c). Tassilly[5] measured the heats of solution of the di- and pentahydrates in aqueous HBr.

BaI_2 (aq.). The value for infinite dilution is obtained from those for the aqueous ions. We have estimated the heat of dilution.

BaI_2 (c). Tassilly[1, 3] measured the heat of solution. See also Cambi and Devoto.[1]

$BaI_2 \cdot nH_2O$ (c). Thomsen[15] measured the heat of solution of the heptahydrate. Dissociation pressure data on the hydrates with 1, 2, $2\frac{1}{2}$, and 7 H_2O were reported by Trip[1] (see Hüttig and Slonim[1]).

$Ba(IO_3)_2$ (aq.). This value is obtained from those for the aqueous ions.

$Ba(IO_3)_2$ (c). Chroustchoff[1] measured the heat of reaction of this salt with K_2SO_4 (aq.) to be −4.6.

$Ba(IO_3)_2 \cdot H_2O$ (c). Chroustchoff[1] measured the heats of reaction of $BaCl_2$ (aq.) with $2\,KIO_3$ (aq.), of $Ba(NO_3)_2$ (aq.) with $2\,KIO_3$ (aq.), and of $Ba(NO_3)_2$ (aq.) with $2\,HIO_3$ (aq.) to be 11.0, 10.6, and 13.5, respectively, at 13°. The iodate formed in these reactions is barium iodate monohydrate.

$BaI_2 \cdot BaO \cdot nH_2O$ (c). Tassilly[1] measured the heats of solution of the di- and nonahydrates in aqueous HI.

BaS (aq.). Thomsen[15] and Sabatier[1] measured the heat of neutralization of H_2S (aq.) with $Ba(OH)_2$ (aq.). The value for infinite dilution is obtained from those for the aqueous ions.

BaS (c). Sabatier[1] measured the heat of solution in aqueous HCl.

$BaSO_3$ (c). de Forcrand[3] measured the heat of reaction of H_2SO_3 (aq.) with $Ba(OH)_2$ (aq.).

$Ba(HSO_3)_2$ (aq.). de Forcrand[3] measured the heat of reaction of $Ba(OH)_2$ (aq.) with $2\,H_2SO_3$ (aq.).

$BaSO_4$ (c). Thomsen[15] measured the heats of the reactions of $Ba(OH)_2(400)$ with $H_2SO_4(400)$ and of $BaCl_2(400)$ with $H_2SO_4(400)$ to be 36.90 and 4.15, respectively; whence, for $BaSO_4$ (c), $Qf = 349.49$ and 349.20. See also Berthelot[9] and Muller.[10] Melcher[1] calculated the heat of solution of barium sulfate to be −6.0, from conductivity measurements at various temperatures.

BaS_2O_6 (aq.). Thomsen[15] measured the heat of reaction of BaS_2O_6 (aq.) with $H_2SO_4(400)$.

$BaS_2O_6 \cdot 2\,H_2O$ (c). Thomsen[15] measured the heat of solution.

BaS_2O_8 (aq.). Berthelot[107] measured the heat of reaction of BaS_2O_8 (aq.) with H_2SO_4 (aq.).

$BaS_2O_8 \cdot 4\,H_2O$ (c). Berthelot[107] measured the heat of solution.

BaS_4O_6 (aq.). This value is obtained from the ions.

$BaS_4O_6 \cdot 2\,H_2O$ (c). Portillo[1] measured the heat of solution.

$Ba(HS)_2$ (aq.). Thomsen[15] measured the heat of reaction of $Ba(OH)_2$ (aq.) with $2\,H_2S$ (aq.).

$BaSO_4 \cdot H_2SO_4$ (c). Volchowsky[1] measured the heat of solution.

$BaSO_4 \cdot 2\,H_2SO_4 \cdot H_2O$ (c). Volchowsky[1] measured the heat of solution.

$BaI_2 \cdot nSO_2$ (c). Ephraim and Kornblum[1] reported dissociation pressure data on $BaI_2 \cdot 2\,SO_2$ (c) and $BaI_2 \cdot 4\,SO_2$ (c).

BaSe (c). Fabre[1] measured the heat of solution in aqueous HCl.

$BaSeO_4$ (c). Metzner[1] measured the heat of reaction of $BaCl_2$ (aq.) with H_2SeO_4 (aq.).

$Ba(N_3)_2$ (aq.). Berthelot and Matignon measured the heat of neutralization of $2\,HN_3$ (aq.) with $Ba(OH)_2$ (aq.).

$Ba(N_3)_2$ (c). Berthelot and Matignon measured the heat of solution.

Ba_3N_2 (c). Guntz and Benoit[1] measured the heat of solution in aqueous HCl. See also Guntz.[16]

$Ba(NO_2)_2$ (aq.). Berthelot[28] measured the heat of reaction of $Ba(NO_2)_2$ (aq.) with H_2SO_4 (aq.).

$Ba(NO_2)_2$ (c). Berthelot[28] measured the heat of solution

$Ba(NO_2)_2 \cdot 2\,H_2O$ (c). Berthelot[28] measured the heat of solution.

$Ba(NO_3)_2$ (aq.). Thomsen[15] measured the heats of reaction of $H_2SO_4(400)$ with $Ba(OH)_2(400)$ and $Ba(NO_3)_2(400)$ to be 28.28 and 3.56, respectively; whence, for $Ba(NO_3)_2(800)$, $Qf = 227.19$ and 227.92. Berthelot[9, 12] reported $Q = 28.0$ and 5.2 for the reactions of $H_2SO_4(400)$ with $Ba(OH)_2(400)$ and of $Ba(NO_3)_2(400)$ with $K_2SO_4(400)$. Data on the heat of dilution of aqueous barium nitrate were reported by Pratt,[1] Bishop,[1] Stackelberg,[1] Lange and Streeck,[2] and Hammerschmid and Lange.[1]

$Ba(NO_3)_2$ (c). The data on the heat of solution are: Thomsen,[15] -9.47_{400}; Stackelberg,[1] -10.03_{1000}[16]; Berthelot,[9, 131] -9.28_{1000}[12].

BaNH (c). Guntz and Benoit[1] measured the heat of solution in aqueous HCl.

$Ba(NH_2)_2$ (c). Guntz and Benoit[1] measured the heat of solution in aqueous HCl.

$Ba \cdot 6\,NH_3$ (c). Biltz and Hüttig[2] measured the dissociation pressure.

$BaX_2 \cdot n NH_3$ (c). Dissociation pressure data on the octammine of barium chloride were reported by Hüttig and Martin[1] and Gillespie and Lurie.[1] Hüttig and Martin[1] reported dissociation pressure data on the ammines of $BaBr_2$ with 1, 2, 4, and 8 NH_3, and those of BaI_2 with 2, 4, 6, 8, 9, and 10 NH_3.

$Ba_3(PO_4)_2$ (c, ppt.). Berthelot and Louguinine[3] recomputed the data of Berthelot,[52] who measured the heat of reaction of H_3PO_4 (aq.) with $1\frac{1}{2}\,Ba(OH)_2$ (aq.) to form the crystalline precipitate and also to form the colloid, to be 60 8 and 78.2, respectively. See also Joly.[3, 4]

$BaHPO_4$ (aq.). Berthelot and Louguinine[3] recomputed Berthelot's[52] data on the heat of reaction of H_3PO_4 (aq.) with $Ba(OH)_2$ (aq.). See also Berthelot[101] and Joly.[3, 4]

$Ba(H_2PO_4)_2$ (aq.). Berthelot and Louguinine[3] recalculated the data of Berthelot[52] on the heat of reaction of H_3PO_4 (aq.) with $\frac{1}{2}\,Ba(OH)_2$ (aq.). See also Joly.[3, 4]

$BaH_2P_2O_6$ (aq.). Joly[3] measured the heat of reaction of $H_4P_2O_6$ (aq.) with $Ba(OH)_2$ (aq.) to be 35.4.

$Ba(H_2PO_2)_2$ (aq.). Thomsen[15] measured the heat of reaction of this substance with H_2SO_4 (aq.).

$Ba(H_2PO_2)_2 \cdot H_2O$ (c). Thomsen[15] measured the heat of solution.

$Ba_3(AsO_4)_2$ (c, ppt.). Blarez[2] measured the heat of reaction of H_3AsO_4 (aq.) with $1\frac{1}{2}\,Ba(OH)_2$ (aq.).

$BaHAsO_4$ (aq.). Blarez[2] measured the heat of reaction of H_3AsO_4 (aq.) with $Ba(OH)_2$ (aq.). See also Joly.[3]

$Ba(H_2AsO_4)_2$ (aq.). Blarez[2] measured the heat of reaction of H_3AsO_4 (aq.) with $\frac{1}{2}\,Ba(OH)_2$ (aq.).

$BaHAsO_3$ (aq.). Thomsen[15] measured the heat of reaction of H_3AsO_3 (aq.) with $Ba(OH)_2$ (aq.).

$Ba(H_2AsO_3)_2$ (aq.). Thomsen[15] measured the heat of reaction of H_3AsO_3 (aq.) with $\frac{1}{2}Ba(OH)_2$ (aq.).

$BaCO_3$ (c). Thomsen[15] measured the heats of reaction of $BaCl_2$ (aq.) with Na_2CO_3 (aq.) and with K_2CO_3 (aq.), and the heat of neutralization of H_2CO_3 (aq.) with $Ba(OH)_2$ (aq.). See also Berthelot.[9, 12] Dissociation pressure data were reported by Johnston,[5] Dutoit,[1] Abich,[1] Isambert,[4] Brill,[2] and Finkelstein.[1]

$BaO \cdot BaCO_3$ (c). Finkelstein[1] reported dissociation pressure data for the reaction, $2\,BaCO_3\,(c) = BaO \cdot BaCO_3\,(c) + CO_2\,(g)$.

$BaC_2O_4 \cdot H_2O$ (c). Berthelot[10] measured the heat of reaction of aqueous oxalic acid with aqueous barium hydroxide to form the monohydrate.

$Ba(HCO_3)_2$ (aq.). Randall and Tamale[2] reviewed the data of Schloesing,[1, 2] Hachnel,[1, 2] and McCoy and Smith[1] on the solubility of barium carbonate in aqueous carbonic acid, and calculated $Q = 7.86$ for the reaction, $BaCO_3\,(c) + CO_2\,(g) + H_2O\,(liq.) = Ba(HCO_3)_2\,(aq.)$.

$Ba(CHO_2)_2$ (aq.). Berthelot[31] measured the heats of reaction of $Ba(CHO_2)_2$ (aq.) with 2 HCl (aq.), of $BaCl_2$ (aq.) with $2\,HCHO_2$ (aq.), and of H_2SO_4 (aq.) with $Ba(CHO_2)_2$ (aq.).

$Ba(CHO_2)_2$ (c). Berthelot[7] measured the heat of solution of barium formate.

$Ba(C_2H_3O_2)_2$ (aq.). Thomsen[15] measured the heat of reaction of aqueous barium acetate with aqueous sulfuric acid. Berthelot[7, 9] and Thomsen[15] measured the heat of neutralization of aqueous barium hydroxide with aqueous acetic acid. The value for barium acetate at infinite dilution is obtained from those for the aqueous ions.

$Ba(C_2H_3O_2)_2$ (c). Berthelot[7, 9] measured the heat of solution.

$Ba(C_2H_3O_2)_2 \cdot 3\,H_2O$ (c). Berthelot[7, 9] measured the heat of solution.

$Ba(C_2H_3O_3)_2$ (aq.). The value for aqueous barium glycollate is obtained from those for the ions.

$Ba(C_2H_3O_3)_2$ (c). de Forcrand[3] measured the heat of solution of barium glycollate.

$3\,BaO \cdot 4\,CH_3OH$ (c). de Forcrand[2, 16, 18] measured the heat of solution in aqueous HCl.

$3\,BaO \cdot 4\,C_2H_5OH$ (c). de Forcrand[2, 16, 18] measured the heat of solution.

$Ba(C_2H_5O)_2$ (c). de Forcrand[2, 16, 18] measured the heat of solution.

$Ba(C_2H_5SO_4)_2$ (aq.). Thomsen[15] measured the heat of reaction of $Ba(C_2H_5SO_4)_2(400)$ with $H_2SO_4(400)$ to be 9.34.

$Ba(C_2H_5SO_4)_2 \cdot 2\,H_2O$ (c). Thomsen[15] measured the heat of solution.

$Ba(CN)_2$ (aq.). Joannis[1] measured the heat of neutralization of 2 HCN (aq.) with $Ba(OH)_2$ (aq.).

$Ba(CN)_2 \cdot nH_2O$ (c). Joannis[1] measured the heats of solution of the anhydrous salt and the mono- and dihydrates.

$BaSiO_3$ (gls.). Tschernobaeff[1] reported $Q = -41.0$ for the reaction, SiO_2 (c) $+ BaCO_3$ (c) $= BaSiO_3$ (gls.) $+ CO_2$ (g), from calorimetric experiments, and Jander[1] calculated $Q = -34.0$ for the same reaction from equilibrium data. These data yield, for $BaSiO_3$ (gls.), $Qf = 359$ and 366. See also Marchal.[1]

$Ba(CNO)_2$ (aq.). Lemoult[1] measured the heats of decomposition of aqueous barium cyanate with aqueous sulfuric acid and with aqueous nitric acid.

$Ba(CNO)_2$ (c). Lemoult[1] measured the heat of solution.

$BaSiF_6$ (c). Hantke[1] measured the heat of reaction of H_2SiF_6 (aq.) with $Ba(OH)_2$ (aq.), and also the dissociation pressures of $BaSiF_6$ (c).

$BaI_2 \cdot 2\,PbI_2 \cdot nH_2O$ (c). Mosnier[1] measured the heats of solution of the anhydrous double salt and the heptahydrate.

$BaBr_2 \cdot nHgBr_2$ (aq.). Varet[6] measured the heats of mixing $BaBr_2$ (aq.) with $\frac{1}{2}$, 1, and 2 $HgBr_2$ (aq.), respectively.

$Ba(CN)_2 \cdot nHg(CN)_2$ (aq.). Varet[2] measured the heats of mixing $Ba(CN)_2$ (aq.) with $\frac{1}{2}$, 1, and 2 $Hg(CN)_2$ (aq.), respectively.

$BaX_2 \cdot 2\,Hg(CN)_2$ (aq.). Varet[2, 6] measured the heats of mixing 2 $Hg(CN)_2$ (aq.) with $BaCl_2$ (aq.), $BaBr_2$ (aq.), and BaI_2 (aq.), respectively.

$BaX_2 \cdot 2\,Hg(CN)_2 \cdot nH_2O$ (c). Varet[2, 6] measured the heats of solution of the chloride pentahydrate, the bromide hexahydrate, and the iodide tetrahydrate.

$Ba(CN)_2 \cdot nAgCN$ (aq.). Varet[1] measured the heats of reaction of $Ba(CN)_2$ (aq.) with 1 and 2 AgCN (c), respectively.

$BaPtCl_6$ (aq.). This value is obtained from the ions. Gire[1, 3] measured the heat of reaction of aqueous barium chloroplatinate with cobalt.

$BaPtCl_6 \cdot nH_2O$ (c). Gire[1, 3] measured the heats of solution of the anhydrous salt and the hexahydrate, and the dissociation pressures of $BaPtCl_6$ (c).

$Ba_2Fe(CN)_6$ (aq.). Joannis[1] measured the heat of reaction of $H_4Fe(CN)_6$ (aq.) with 2 $Ba(OH)_2$ (aq.).

$BaH_2Fe(CN)_6$ (aq.). Joannis[1] measured the heat of reaction of $H_4Fe(CN)_6$ (aq.) with $Ba(OH)_2$ (aq.).

$Ba_2Fe(CN)_6 \cdot 6\,H_2O$ (c). Joannis[1] measured the heat of solution.

$Ba_3(FeCO(CN)_5)_2$ (aq.). Muller[9, 10] measured the heat of reaction of $H_3FeCO(CN)_5$ (aq.) with $1\frac{1}{2}$ $Ba(OH)_2$ (aq.)

$Ba_3(FeCO(CN)_5)_2 \cdot nH_2O$ (c). Muller[9, 10] measured the heats of solution of the anhydrous salt and of the undecahydrate.

$BaHFeCO(CN)_5$ (aq.). Muller[9, 10] measured the heat of reaction of $H_3FeCO(CN)_5$ (aq.) with $Ba(OH)_2$ (aq.).

$Ba(H_2FeCO(CN)_5)_2$ (aq.). Muller[9, 10] measured the heat of reaction of $H_3FeCO(CN)_5$ (aq.) with $\frac{1}{2}$ $Ba(OH)_2$ (aq.).

$Ba(CN)_2 \cdot Ni(CN)_2$ (aq.). Varet[4] measured the heats of mixing $Ba(CN)_2$ (aq.) with $Ni(CN)_2$ (aq.).

$BaCrO_4$ (c). Chroustschoff and Martinoff[1] found $Q=6.8$ for the reaction of $BaCl_2$ (aq.) with K_2CrO_4 (aq.).

$BaCl_2 \cdot 2\,AlCl_3$ (c). Baud[1] measured the heat of solution.

$3\,BaCl_2 \cdot AlCl_3$ (c). Baud[1] measured the heat of solution.

$BaMoO_4$ (c). Tammann and Westerholt[1] reported $Q=60.1$ for the reaction of BaO (c) with MoO_3 (c).

$BaWO_4$ (c). Tammann and Westerholt[1] reported $Q=73.5$ for the reaction of BaO (c) with WO_3 (c).

Radium

Ra (c). Standard state.

Lithium

Li (c). Standard state.

Li (liq.). Thum[1] reported for the heat of fusion the value -0.23; Sherman[1] calculated -0.115. Both of these values seem too low, because the entropy of fusion of the other alkali metals has the nearly constant value of 1.68 calories per degree per mole, and yields, for the heat of fusion, -0.77.

Li (g). Vapor pressure data were reported by Bogros[1] and Hartmann and Schneider.[1] Utilizing the data of the latter investigation, and neglecting the small effect due to the probable existence of some diatomic molecules in the vapor, we have calculated, for Li (g), $Qf=-39.0$. See also Sherman,[1] Joos and Hüttig,[1] and van Laar.[9]

The values for the energy states of the gaseous lithium atom are from the data of Ericson and Edlen[1] and Edlen and Ericson.[3] See also Bacher and Goudsmit.[1]

Li_2 (g). Loomis and Nusbaum[1] reported the energy of dissociation, Li_2 (g) $=2$ Li (g), with each substance in its normal state, to be 1.14 ± 0.03 volt-electrons.

LiOH (aq.). The heat of solution of Li (c) in water was measured by Thomsen,[15] Guntz,[3] Zukowsky,[1] and Moers.[1] These data have been recomputed, and give, respectively, for Li (c) $+H_2O$ (liq.) $=$ LiOH(200) $+\frac{1}{2}H_2$ (g), the following values for Q: 49.11, 53.09, 52.6, and 52.73. The value of Moers is taken as the best one, whence for LiOH(200), $Qf=121.10$. The existing data on the heat of dilution of aqueous LiOH (de Forcrand,[10, 48] Richards and Rowe[2]) were reviewed by Rossini,[3] who gave values from ∞ to 25 H_2O.

Li^+ (∞). The foregoing data give, for Li^+ (∞) $+OH^-$ (∞), $Qf=121.288$, whence, for Li^+ (∞), $Qf=66.628$.

LiOH (c). de Forcrand[44] measured the heat of solution of LiOH (c) in HCl(220), and later (de Forcrand[47]) its heat of solution in H_2O. His data yield, respectively, for Qf, 116.58 and 116.52. The average value, 116.55, gives $S=4.55_{200}$. Truchot[2] found $S=5.82_{400}$'. See also Johnston.[4]

$LiOH \cdot nH_2O$ (c). de Forcrand[50] measured the heat of solution of $LiOH \cdot \frac{1}{3} H_2O$ (c) and also (de Forcrand[44]) that of $LiOH \cdot H_2O$ (c)

Li_2O (c). de Forcrand[45] measured the heat of solution in water. See also Beketoff.[2]

$Li_2O \cdot \frac{3}{4} H_2O$ (c). de Forcrand[50] measured the heat of solution in water.

Li_2O_2 (aq.). de Forcrand[31] measured the heat of reaction of HCl (aq.) with Li_2O_2 (aq.), and of LiOH (aq.) with H_2O_2 (aq.). His data yield, respectively, $Qf = 159.5$ and 157.7.

Li_2O_2 (c). de Forcrand[31] measured the heat of solution in water.

LiH (c). The heat of formation of LiH can be computed from the difference in the heats of solution of Li (c) and LiH (c). The recalculated data of Guntz[13] and Moers[1] yield almost identical values: $Qf = 21.60$ and 21.59, respectively.

LiH (g). The dissociation pressure data of Hüttig and Krajewski,[1] Guntz,[13] and Ephraim and Michel[1] yield no reliable thermal values. Mulliken[6] reported 2.47 volt-electrons for the energy of dissociation of gaseous normal LiH into gaseous normal Li and H atoms.

The values for the energy states of gaseous LiH are from Mulliken.[6] See also Watson,[2] Nakamura,[1] and Jevons.[1]

$Li_2O_2 \cdot H_2O_2 \cdot 3\, H_2O$ (c). de Forcrand[31] measured the heat of solution of this compound in water to be -4.5.

LiF (aq.). Petersen[3] measured the heat of neutralization of HF(200) and LiOH(200). His data yield, for LiF(400), $Qf = 144.69$

Lange and Leighton[2] (see Robinson[1]) gave values for the heat of dilution of LiF (aq.) at 25°, and their data have been used to obtain values at 18° from ∞ to 100 H_2O.

$LiHF_2$ (aq.). Petersen[3] found, for $2\,HF(100) + LiOH(200) = LiHF_2(401) + H_2O$ (liq.), $Q = 16.35$; whence, for $LiHF_2(400)$, $Qf = 220.20$.

LiF (c). de Forcrand[12] measured the heat of solution.

LiF (liq.), LiF (g). Vapor pressure data were given by Ruff, Schmidt, and Mugdan,[1] and von Wartenberg and Schulz.[1] The latter investigators estimated $F = -6.0$. Taking $V = -52^{1600}$, we have computed, for $LiF\,(c) = LiF\,(g)$, $Q = -63$.

LiCl (aq.). The heat of neutralization of HCl (aq.) with LiOH (aq.) was measured by Thomsen,[15] Muller,[1] and Richards and Rowe.[3] The most accurate data are those of Richards and Rowe, and these have been recomputed by Rossini,[6] who gave $N = 14.077_{201}$. The data on the heat of dilution of LiCl (aq.) (Dunnington and Hoggard,[1] Lemoine,[2] Tucker,[1] Richards and Rowe[2]) were reviewed by Rossini,[5] who gave values from ∞ to 25 H_2O. Lange and Dürr[2] gave values at 25° for the heat of dilution to 3 H_2O, and Lemoine,[2] at 10°, to 4.63 H_2O. These data have been converted to 18° and used to obtain values from 25 to 3 H_2O.

LiCl (c). The existing data on the heat of solution of LiCl have been recomputed to give the following values for S_{200}: Thomsen,[15] 8.432;

Pickering,[8] 8.100; Bonnefoi,[1] 8.50; Haigh,[1] 8.349; Lange and Dürr,[2] 8.480; Maier[2] (see Slonim and Hüttig[1]), 8.33; Wasserman,[1] 8.544. The average of the values of Thomsen, Bonnefoi, Lange and Dürr, and Wasserman give 8.49 ± 0.03.

LiCl (liq.). Zemczuzny[1] calculated $F = -3.7^{613}$ from the freezing point depression. von Wartenberg and Schulz[1] estimated $F = -5.0$.

LiCl (g). The vapor pressure data of Ruff and Mugdan[1] and von Wartenberg and Schulz[1] yield $V = -37\ 3^{1200}$. Visser[1] interpreted the spectral fluorescent limit as dissociation, obtaining $D^z = -97$.

LiCl(CH_3OH), LiCl(C_2H_5OH). Lemoine[2] measured the heat of solution of LiCl (c) in various amounts of methyl alcohol at 18°, and of ethyl alcohol at 12°.

LiClO (aq.). Neumann and Müller[2] measured the heat of reaction of Cl_2 (g) with LiOH (aq.), and of LiOH (aq.) with HClO (aq.). Their data yield, respectively, $Qf = 91.98$ and 92.63, for LiClO (aq.).

LiCl · nH_2O (c). Bogorodskii[1] measured the heats of solution of the mono- and dihydrates. Maier[2] (see Slonim and Hüttig[1]) measured the heat of solution of the monohydrate. Hüttig and Reuscher[1] measured the temperature coefficient of the dissociation pressures of the mono-, di-, and trihydrates.

LiBr (aq.). The heat of neutralization of HBr (aq.) with LiOH (aq.) was measured by Richards and Rowe.[3] Their data have been recomputed, giving $N = 14.040_{201}$. The heat of dilution of LiBr (aq.) at 25° was measured by Lange and Messner[2] in the very dilute region, and by Lange and Schwartz[1] in the concentrated range. Their data have been converted to 18° to give values from ∞ to 3 H_2O.

LiBr (c). The data on the heat of solution of LiBr (c) have been recomputed to give the following values for S_{200}: Bodisko,[2] 11.39; Lange and Schwartz,[1] 11.37; Maier[2] (see Slonim and Hüttig[1]), 11.51.

LiBr (liq.). We have estimated the heat of fusion.

LiBr (g). The vapor pressure data of Ruff and Mugdan[1] and von Wartenberg[1] yield $V = -36.5^{1200}$. Visser,[1] from the spectral fluorescent limit, computed $D^z = -78.4$.

LiBr · nH_2O (c). Maier[2] (see Slonim and Hüttig[1]) measured the heats of solution of the mono- and dihydrates. Hüttig and Reuscher[1] measured the temperature coefficient of the dissociation pressures of the mono-, di-, and trihydrates.

LiI (aq.). The accurate data of Richards and Rowe[3] have been recomputed, giving $N = 13.972_{201}$, whence, for LiI(200); $Qf = 79.907$. From $Li^+(\infty) + I^-(\infty)$, one obtains, for LiI ($\infty$), $Qf = 79.998$. Using these two values, and extrapolating the series of curves representing the heats of dilution of LiF, LiCl, and LiBr, we have computed values of the heat of dilution of LiI (aq.) from ∞ to 100 H_2O.

LiI (c). The data on the heat of solution of the LiI (c) have been recomputed to give the following values for S_{200}: Bodisko,[1] 14.83; Maier[2] (see Slonim and Hüttig[1]), 14.80; Mosnier,[1] 14.93 We have selected

14.83 as the best value, whence, for LiI (c), $Qf=65.08$. Beketoff[8] measured the heats of solution of LiCl (c) + NaI (c), LiI (c) + NaCl (c), LiCl (c) + KI (c), and LiI (c) + KCl (c). From his data one finds, for LiI (c), $Qf=65.15$ and 65.10, respectively.

LiI (liq.). We have estimated the heat of fusion.

LiI (g). The vapor pressure data of Ruff and Mugdan[1] yield $V=-34.3^{1000}$.

LiI · nH$_2$O (c). Maier[2] (see Slonim and Hüttig[1]) measured the heats of solution of the mono-, di-, and trihydrates. Hüttig and Pohle[1] measured the temperature coefficient of the dissociation pressures of the hemi-, mono-, di-, and trihydrates.

Li$_2$SO$_4$ (aq.). Thomsen[15] measured the heat of neutralization of LiOH(200) with H$_2$SO$_4$(400). Zukowsky[1] measured the heat of solution of Li (c) in H$_2$SO$_4$(626). Thomsen's[15] data yield $N=31.27_{802}$, whence, for Li$_2$SO$_4$(800), $Qf=348.57$ and for Li$_2$SO$_4$ (∞), $Qf=348.97$; whereas, from $2Li^+(\infty)+SO_4^{--}(\infty)$, one finds 349.056. The heat of dilution of Li$_2$SO$_4$ (aq.) was measured in the very dilute range by Lange and Streeck,[1] whose data have been used to obtain values at 18° from ∞ to 200 H$_2$O.

Li$_2$SO$_4$ (c, II). The existing data yield the following values for S_{200}: Thomsen,[15] 5.96; Pickering[2, 3] 6.18.

Li$_2$SO$_4$ (c, I). Hare[1] measured the heat of transition.

Li$_2$SO$_4$ · H$_2$O (c). The existing data have been recomputed to give the following for S_{400}: Thomsen,[15] 3.41; Pickering,[3] 3.26.

LiI · nSO$_2$ (c). Ephraim and Kornblum[1] measured the temperature coefficient of the dissociation pressures of LiI · SO$_2$ (c) and LiI · 2SO$_2$ (c).

Li$_2$Se (aq.). Fabre[1] measured the heat of neutralization of LiOH(220) with H$_2$Se (g). His data yield, for Li$_2$Se(440), $Qf=95.3$.

Li$_2$Se · nH$_2$O (c). Fabre[1] measured the heats of solution of Li$_2$Se (c) and Li$_2$Se · 9H$_2$O (c).

Li$_3$N (c). Guntz[14] measured the heat of solution.

LiNO$_3$ (aq.). The recomputed (see Rossini[6]) data of Richards and Rowe[3] give $N=13.931_{201}$. The heat of dilution data of Richards and Rowe,[2] 25 to 400 H$_2$O, were extrapolated to ∞ H$_2$O by Rossini,[5] and we have extrapolated in the concentrated region to 3 H$_2$O.

LiNO$_3$ (c). The data on the heat of solution of LiNO$_3$ (c) have been recomputed to give the following values for S_{200}: Thomsen,[15] 0.273; Berthelot, 0.331; Pickering,[8] 0.329; Haigh,[1] 0.340.

LiNO$_3$ (liq.). Goodwin and Kalmus[1] measured the heat of fusion.

LiNO$_3$ · 3H$_2$O (c). Morgan and Benson[1] found, from measurement of the constant of the freezing point lowering, $F^{20.9}=-8.7$. This gives, at 18°, $F=-8.4$, which is equivalent to S_3.

LiNO$_3$(C$_2$H$_5$OH). Pickering[8] measured the heat of solution of LiNO$_3$ (c) in ethyl alcohol.

LiNH$_2$ (c). Guntz and Benoit[1] measured the heat of solution in HCl (aq.).

$Li(NH_3)_4$ (liq.). Kraus[1] and Benoit[1] measured the temperature coefficient of the dissociation pressure.

Li_2NH (c). Guntz and Benoit[1] measured the heat of solution in HCl (aq.).

Li_2C_2 (c). The heat of solution in water was measured by Guntz.[15]

Li_2CO_3 (aq.). Muller[1] measured the heat of reaction between 2HCl(90) and Li_2CO_3(1800); de Forcrand[49] that between 2LiOH(100) and CO_2(1800). Their data yield, respectively, for Li_2CO_3(2000), Qf =293.31 and 293.27.

$LiHCO_3$ (aq.). Muller[1] measured the heat of reaction between 2HCl(90) and 2LiHCO$_3$(980). Combination of these data with his values for the reaction between 2HCl(90) and Li_2CO_3(1800), gives, for the heat of reaction between Li_2CO_3(1800) and H_2CO_3(2000) to form 2LiHCO$_3$ (1000), Q = 1 93. Using, for Li_2CO_3(1800), Qf from Muller's data, gives, for LiHCO$_3$(1900), Qf=231.38.

Li_2CO_3 (c). de Forcrand[49] measured the heat of solution in water.

$LiCH_3O$(60 CH_3OH). de Forcrand[16] measured the heat of solution of Li (c) in methyl alcohol.

$LiC_2H_3O_2 \cdot nH_2O$ (c). The vapor pressure of the hydrates was measured at various temperatures by Lescoeur.[6]

LiC_2H_5O(60 C_2H_5OH). de Forcrand[16] measured the heat of solution of Li (c) in ethyl alcohol.

LiCN (aq.). Varet[3] measured the heat of neutralization of LiOH (110) with HCN(110).

Li_2SiO_3 (gls.). Tschernobaeff[1] measured the heat of reaction between SiO_2 and Li_2CO_3 in a bomb using carbon as the auxiliary combustible material.

Li_2SiF_6 (aq.). Truchot[2] measured the heat of reaction between SiF_4 (g) and 2LiF (c), and between H_2SiF_6 (aq.) and 2LiOH (aq.). His data yield, respectively, for Qf, Li_2SiF_6(220), 676.9, and Li_2SiF_6(1320) 680.9.

Li_2SiF_6 (c). Truchot[2] measured the heat of solution.

$2LiI \cdot PbI_2 \cdot nH_2O$ (c). Mosnier[1] measured the heats of solution of the anhydrous salt and the tetrahydrate.

$nLiCl \cdot ThCl_4 \cdot mH_2O$ (c). Chauvenet[2] measured the heats of solution of $LiCl \cdot ThCl_4 \cdot 8H_2O$ (c) and of $2LiCl \cdot ThCl_4$ (c).

$LiHg_{99}$ (liq.). Lewis and Keyes[2] computed the partial molal heat of solution of Li (c) in $LiHg_{99}$ (liq.) from the temperature coefficient of the electromotive force of cells.

$LiHg_n$ (c). Zukowsky[1] measured the heat of solution of Li and its solid amalgams in H_2SO_4 (aq.).

$nLiBr \cdot HgBr_2$ (aq.). Varet[6] measured the heat of mixing, in various proportions, of LiBr (aq.) with $HgBr_2$ (aq.).

$nLiCN \cdot Hg(CN)_2$ (aq.). Varet[2] measured the heat of mixing of LiCN (aq.) with $Hg(CN)_2$ (aq.).

nLiX · Hg(CN)$_2$ (aq.). Varet[2] measured the heat of mixing of LiCl (aq.) with Hg(CN)$_2$ (aq.), LiBr (aq.) with Hg(CN)$_2$ (aq.), and LiI (aq.) with Hg(CN)$_2$ (aq.).

LiX · Hg(CN)$_2$ · 3½ H$_2$O (c). Varet[2] measured the heats of solution of the bromide and the iodide.

LiX · nNH$_3$ (c). Bonnefoi[1] measured the heats of solution of the mono-, di-, tri-, and tetrammines of LiCl and LiBr, and also the temperature coefficient of their dissociation pressures. Biltz and Hansen[1] measured the temperature coefficient of the dissociation pressures of the ammines of LiCl containing 4 and 5 moles of NH$_3$; and of LiI with 1, 2, 3, 4, 5, and 6½ moles of NH$_3$; and of LiI with 1, 2, 3, 4, 5, 5½, and 7 moles of NH$_3$. Ephraim[5] obtained similar but discordant data on LiI · 4NH$_3$ (c).

LiX · nCH$_3$NH$_2$ (c), LiX · n(CH$_3$)$_2$NH (c), LiX · nC$_2$H$_5$NH$_2$ (c). Bonnefoi[1] measured the heats of solution of LiCl · nCH$_3$NH$_2$ (c) with 1, 2, and 3 moles of CH$_3$NH$_2$, of LiCl · (CH$_3$)$_2$NH (c), and of LiCl · nC$_2$H$_5$NH$_2$ (c) with 1, 2, and 3 moles of C$_2$H$_5$NH$_2$, and also obtained data on the temperature coefficient of the dissociation pressures of LiCl · nCH$_3$NH$_2$ (c) with 1, 2, and 3 moles of CH$_3$NH$_2$, and of LiCl · nC$_2$H$_5$NH$_2$ (c), with 1, 2, and 3 moles of C$_2$H$_5$NH$_2$. Simon and Glauner[1] measured, at various temperatures, the dissociation pressures of LiCl · nCH$_3$NH$_2$ (c) with 1, 2, 3, and 4 moles of CH$_3$NH$_2$, of LiBr · nCH$_3$NH$_2$ (c) with 1, 2, 3, 4, and 5 moles of CH$_3$NH$_2$, of LiI · nCH$_3$NH$_2$ (c) with 1, 2, 3, and 3½ moles of CH$_3$NH$_2$ of LiCl · n(CH$_3$)$_2$NH (c) with 1, 2, and 3 moles (CH$_3$)$_2$NH, of LiBr · n(CH$_3$)$_2$NH (c) with ½, 1, 2, 3, 4, and 5 moles of (CH$_3$)$_2$NH, and of LiI · n(CH$_3$)$_2$NH (c) with ½, 1, 1½, 2, 3, and 5 moles of (CH$_3$)$_2$NH.

Sodium

Na (c). Standard state.

Na (liq.). The data on the heat of fusion are: Griffiths,[1] −0.634; Rengade,[5] −0.627; Iitaka,[1] −0 598; Joannis,[2] −0.73; Bernini,[1, 2, 3] −0.41; Bridgman,[2] −0.69.

Na (g). We have calculated the heat of sublimation of sodium to form the monatomic gas from the vapor pressure-temperature data, taking due account of the appreciable amount of Na$_2$ molecules contained in the actual vapor at equilibrium. The vapor pressure data used are those of Edmonson and Egerton,[1, 2] Rodebush and Walters,[1] Rodebush,[2] Rodebush and de Vries,[1] Rodebush and Henry,[1] Haber and Zisch,[1] Ladenberg and Minkowski,[1] and Gibhart.[1] See also Kroner,[1] Hackspill,[1] van Laar,[9] and Simon and Zeidler.[1] Our value for the heat of sublimation, Na (c) = Na (g), is −25.9 at 18° Sherman[1] calculated −25.8.

The values for the energy states of the sodium atom are taken from Fowler,[3] Bacher and Goudsmit,[1] and Sodergvist.[1]

Na$_2$ (g). Loomis and Nusbaum[3] and Nusbaum and Loomis[1] reported the energy of dissociation, Na$_2$ (g) = 2 Na (g), with each substance in its normal state, to be 0.76 ± 0.02 volt-electrons. The values for the energy

states of gaseous diatomic sodium are from Mulliken,[6] Loomis,[1] Loomis and Wood,[1] Fredrichson and Watson,[1] Fredrichson,[1] Wiezel and Kulp,[1] and Kimura and Uchida.[1]

NaOH (aq.). The heat of solution of Na (c) in water was measured by Thomsen,[15] Joannis,[2] Rengade,[1] and Hagen and Sieverts.[1] Their recomputed data give, respectively, for Na (c) $+H_2O$ (liq.) $=$NaOH(200) $+\frac{1}{2}H_2$ (g), the following values, for Q: 43.56 ± 0.02, 43.08 ± 0.20, 44.00 ± 0.23, and 44.42 ± 0.21. Selecting 43.7 as the best value, we have obtained, for NaOH(100), $Qf = 112.1$. The existing data on the heat of dilution of NaOH (aq.) from 25 to 3200 H_2O (Richards and Rowe,[2] Pratt,[1] Richards and Gucker[1]) were reviewed by Rossini,[5] who gave values from 25 to ∞ H_2O. For the concentrated region, the data of Thomsen,[15] Berthelot,[20] Sabatier,[1] de Forcrand,[35] Richards and Rowe,[2] and Richards and Hall[2] have been utilized to obtain values from 25 to 3 H_2O.

$Na^+(\infty)$. The foregoing data give, for $Na^+(\infty) + OH^-(\infty)$, $Qf = 112.139$; whence, for $Na^+(\infty)$, $Qf = 57.479$. Allmand and Pollock,[1] from measurements of the electromotive force of cells at various temperatures, found, for Na (c) $+$ HgCl (c) $=$ NaCl (c) $+$ Hg (liq.), $Q = 66.74$. Using our values for the heats of formation of HgCl (c) and $Cl^-(\infty)$, and the heat of solution and dilution of NaCl, these data give, for $Na^+(\infty)$, $Qf = 57.48$.

NaOH (c, II). The data on the heat of solution of NaOH (c, II) yield the following values for S_{200}: Thomsen,[15] 9.96; Berthelot,[20] 10.01; de Forcrand,[35] 10.18.

NaOH $\cdot n H_2O$ (c). de Forcrand[35] measured the heats of solution of NaOH $\cdot \frac{1}{2} H_2O$ (c), NaOH $\cdot \frac{2}{3} H_2O$ (c), NaOH $\cdot \frac{3}{4} H_2O$ (c), and NaOH $\cdot H_2O$ (c); Berthelot[20] that of NaOH $\cdot$ 0.76 H_2O (c); and Pickering[12] that of NaOH $\cdot H_2O$ (c). The values calculated from the data of de Forcrand are taken as the best. For NaOH $\cdot H_2O$ (c), the following values for S_{200} were computed: de Forcrand,[35] 5.09; Pickering,[12] 5.08. See also Shibata.[1]

NaOH (c, I). Hevesy[1] measured the heat of transition.

Na_2O (c). The data of Rengade[3] and Matsiu and Nakata[1] yield, respectively, for S_{200}, 56.48 and 56.20. We have taken the average as the best value. Beketoff[1] found $S = 55$ to 56.

Na_3O (c). de Forcrand[25] measured the heat of solution.

Na_2O_2 (c). de Forcrand[25] measured the heat of solution in HCl (aq.).

$NaHO_2$ (aq.). Joyner[1] measured the heat of mixing $NaHO_2$ (aq.) with HNO_3 (aq.)

NaH (c). de Forcrand[43] measured the heat of solution of NaH (c). Hagen and Sieverts[1] measured the heats of solution of Na (c) and of NaH (c). These data yield, respectively, for NaH (c), $Qf = 17.9$, and 12.7 ± 0.3. The dissociation pressure data of Keyes[1] yield $Qf = 14.4$. From the dissociation pressure data of Troost and Hautefeuille,[8] Moutier[1] calculated $Qf = 13$. See also Zhukov.[2]

NaH (g). The value for the energy of dissociation of normal gaseous NaH into normal gaseous Na and H atoms is from Hori.[6] See also Mulli-

ken.[6] The values for the energy states of gaseous NaH are from Hori.[6] See also Mulliken[6] and Jevons.[1]

NaF (aq.). Thomsen[15] and Mulert[1] measured the heat of neutralization of HF (aq.) with NaOH (aq.). Their data yield respectively: NaF (400), $Qf = 135.50$; NaF(70), $Qf = 138.1$. We have selected Thomsen's value, since it gives a more concordant value for $F^-(\infty)$. We have estimated the heat of dilution of NaF (aq.) in the range 100 to ∞ H_2O.

NaF (c). The heat of solution was measured by Guntz.[1]

NaF (liq.). Plato[2] measured the heat of fusion.

NaF (g). The vapor pressure data of von Wartenberg and Schulz[1] and Ruff, Schmidt, and Mugdan[1] yield $V = -57^{1300}$.

$NaHF_2$ (aq.). Thomsen[15] measured the heat of mixing NaF(200) with HF(200).

$NaHF_2$ (c). The data of Guntz[1] and de Forcrand[60] yield identical values for S_{400}.

NaCl (aq.). The heat of neutralization of NaOH (aq) with HCl (aq.) was measured by Hess,[5] Andrews,[2, 7, 11] Favre and Silbermann,[3] Favre,[3] Berthelot,[4] Thomsen,[15] Muller,[1] von Steinwehr,[1] Mathews,[1] Mathews and Germann,[1] Ellingson,[1] Keyes, Gillespie, and Mitsukuri,[1] Richards and Rowe,[3] and Gillespie, Lambert, and Gibson.[1] The data of the last two named investigations were recomputed by Rossini,[6] giving $N = 13.996_{201}$. Biltz and Haase[1] measured the heat of solution of Na (c) in excess HCl(8). The data on the heat of dilution of NaCl (aq.) from 25 to ∞ H_2O, (Pratt,[1] Richards and Rowe,[2] Lange and Messner,[2] Lange and Robinson,[1] Thomsen,[15] van Deventer and van der Stadt,[1] Laksonen,[2] Backlung,[1] Magie,[1] Stearn and Smith[1]) were reviewed by Rossini,[5] who gave values from ∞ to 25 H_2O. For the concentrated region, the data of Wust and Lange,[2] Lipsett, Johnson, and Maass,[1] Randall and Bisson,[1] Stackelberg,[1] Sandonnini and Gerosa,[1] Scholz,[1] Laksonen,[2] and Allmand and Pollock[1] have been utilized to obtain values from 25 to 10 H_2O.

NaCl (c). The existing data on the heat of solution have been recomputed to give the following values for S_{200}: Winkelmann,[1] −1.14; Berthelot,[10] −1.18; Ostwald,[2] −1.235; Berthelot and Ilosváy,[1] −1.153; Thomsen,[15] −1.185; Pickering,[7] −1.210; Scholz,[1] −1.31; Varet,[2] −1.27; Stackelberg,[1] −1.106; Varali-Thevenet,[1] −1.225; Brönsted,[4] −1.164; Zemczuzny and Rambach,[1] −1.22; Randall and Bisson,[1] −1.219; Laksonen,[2] −1.255; Sandonnini and Gerosa,[1] −1.240; Wust and Lange,[2] −1.210; Lipsett, Johnson, and Maass,[1] −1.206; and Cohen and Kooy,[1] −1.203. We have taken the average of the values of Randall and Bisson, −1.219, Wust and Lange, −1.210, Lipsett, Johnson, and Maass, − 1.206, and Cohen and Kooy, −1.203, obtaining -1.210 ± 0.005.

NaCl (liq.). The data on the heat of fusion of sodium chloride at its melting point are: Plato,[2] −7.23; Hare,[1] −7.23; Zemczuzny and Rambach,[1] −5.7; Roth and Bertram,[1] −7.41.

NaCl (g). Vapor pressure data were given by Fiock and Rodebush,[1] Hackspill and Grandadam,[1] Horiba and Baba,[1] von Wartenberg and

Albrecht,[1] and Ruff and Mugdan.[1] We have selected $V=-43.5$,[1200] whence the heat of sublimation at 18° becomes −57.1. See also Beutler and Polanyi,[1] Reis,[2] and van Laar.[9]

NaClO (aq.). Favre,[1] Berthelot,[151] Thomsen,[15] and Neumann and Müller[2] measured the heat of reaction between Cl_2 (g) and NaOH (aq.). Their data yield, respectively, for NaClO(800), $Qf=83$, 84, 83.28, and 82.73. Thomsen[15] and Neumann and Müller[2] also measured the heat of neutralization of NaOH (aq) with HClO (aq.), their data yielding, respectively, NaClO(800), $Qf=83.40$, and NaClO(400), $Qf=83.56$.

$NaClO_3$ (aq.). Thomsen[15] measured the heat of neutralization of NaOH (aq.) with $HClO_3$ (aq.). His data give, for $NaClO_3$(400), $Qf=78.25$. The heat of dilution in the very dilute region was measured at 25° by Lange and Robinson.[2] We have converted their data to 18° and extrapolated to 200 H_2O.

$NaClO_3$ (c). The data of Berthelot[2] yield $S=-5.1_{300}$, and those of Bronsted,[10] $S=-5.32_{400}$, giving $Qf=83.4$ and 83.57, respectively. From electromotive force measurements over a range of temperatures, Bronsted[10] found, for KCl (c) + $NaClO_3$ (c) = $KClO_3$ (c) + NaCl (c), $Q=1.52$. Taking the other values as known, we have obtained, for $NaClO_3$ (c), $Qf=83.64$.

$NaClO_4$ (aq.). The data of Berthelot,[79] who measured the heat of neutralization of $HClO_4$ (aq.), yield, for $NaClO_4$(660), $Qf=97.53$. We have estimated the heat of dilution from 400 to ∞ H_2O.

$NaClO_4$ (c). Berthelot[79] measured the heat of solution.

NaBr (aq.). The heat of neutralization of HBr (aq.) with NaOH (aq.) was measured by Berthelot[10] and Richards and Rowe.[3] The latter data have been recomputed to give $N=13.923_{201}$. The heat of dilution of NaBr (aq) was measured by Wust and Lange,[2] Lange and Robinson,[1] van Deventer and van der Stadt,[2] and Dunnington and Hoggard.[1] These data have been utilized to obtain values from ∞ to 6 H_2O.

NaBr (c). The data on the heat of solution have been recomputed to give the following values for S_{200}: Favre and Valson,[2] 0.0; Berthelot,[10] −0.04; Thomsen,[15] −0.19; Varet,[2] −0.58; Wust and Lange,[2] −0.61.

NaBr (liq.). We have estimated the heat of fusion.

NaBr (g). Vapor pressure data were reported by von Wartenberg and Albrecht[1] and Ruff and Mugdan.[1] See also von Wartenberg and Schulz,[1] van Laar,[3] and Beutler and Polanyi.[1] We have calculated $V=-38.8$,[1250] and −53 8 for the heat of sublimation at 18°. Franck, Kuhn, and Rollefson,[1] from the spectral absorption limit, computed $D^s=-91$, for NaBr (g). See also Visser.[1]

NaBr · 2 H_2O (c). The data on the heat of solution yield the following values for S_{200}: Favre and Valson,[2] −4.9; Berthelot,[10] −4.31; Thomsen,[15] −4.59.

NaBrO (aq.). Thomsen[15] measured the heat of reaction of Br_2 (g) with 2 NaOH(400). His data yield for NaBrO (aq.), $Qf=78.67$. Berthelot's[81] data on the same reaction are apparently uncertain.

$NaBrO_3$ (aq.). From the ions, we have obtained for $NaBrO_3$ (∞), $Qf = 68.68$. The data of Lange and Robinson,[2] who measured the heat of dilution in the very dilute range of concentration at 25°, have been converted to 18° and extrapolated to 200 H_2O.

NaI (aq.). The heat of neutralization of HBr (aq.) with NaOH (aq.) was measured by Berthelot[10] and Richards and Rowe.[3] The latter data have been recomputed, giving $N = 13\,855_{201}$. The heat of dilution data of Wust and Lange[2] and Lange and Robinson,[2] at 25°, have been used to obtain values at 18° from ∞ to 5 H_2O.

NaI (c). The heat of solution data yield the following values for S_{200}: Favre and Valson,[2] 1.7(?); Berthelot,[10] 1.552; Thomsen,[15] 1.147; Pickering,[8] 1.392; Varet,[2] 1 280; Mosnier,[1] 1.40; and Wust and Lange,[2] 1.555.

NaI (liq.). We have estimated the heat of fusion.

NaI (g). Vapor pressure data were reported by von Wartenberg and Albrecht[1] and Ruff and Mugdan.[1] We have taken $V = -38.6^{1100}$ and calculated −50.4 for the heat of sublimation at 18°. Sommermeyer[1] calculated, from the spectral absorption limit of sodium iodide vapor, $D^z = -70$.

NaI · 2 H_2O (c). The data on the heat of solution yield the following values for S_{200}: Favre and Valson,[2] −5.7(?); Berthelot,[10] −3.80; and Thomsen,[15] −3 98.

NaI(C_2H_5OH). Pickering[8] measured the heat of solution of sodium iodide in ethyl alcohol.

$NaIO_3$ (aq.). From the ions, we have obtained for $NaIO_3$ (∞), $Qf = 111.98$. The heat of dilution was measured at 25° by Lange and Robinson.[2]

Na_2S (aq.). Berthelot[14] measured the heat of neutralization of H_2S (aq.) with 2 NaOH (aq.); Thomsen[15] and Sabatier,[1] that of H_2S (g) with 2 NaOH (aq). Their data yield for $Na_2S(400)$, $Qf = 104.98$, 105.20, and 104 98, respectively. Sabatier[1] also measured the heat of mixing Na_2S (aq.) with 2 HCl (aq), and of the reaction of Na_2S (aq.) with I_2 (s). These latter data yield $Qf = 105.3$ and 104.1, respectively. Sabatier[1] measured the heat of dilution of Na_2S (aq.) from 20 to 400 H_2O. We have estimated the values to infinite dilution.

Na_2S (c). The existing data yield the following values for S_{400}: Sabatier,[1] 15.19; and Rengade and Costeaunu,[1] 15.5(?).

Na_2S (liq.). Friedrich[1] gave $F = -1.65,^{920}$ from the freezing point lowering constant.

$Na_2S \cdot nH_2O$ (c). Sabatier[1] measured the heats of solution of the hydrates with $4\frac{1}{2}$, 5, and 9 moles of H_2O.

NaHS (aq.). Berthelot[14] measured the heat of reaction of NaOH (110) with H_2S(880); Thomsen[15] that of NaHS(400) with NaOH(400); Sabatier[1] that of NaHS(1470) with HCl(110). These data yield the following values for NaHS(400): 61.28, 61.49, 61.32, and 61.75. Sabatier[1]

measured the heat of dilution of aqueous NaHS from 4 to 200 H_2O. We have estimated the values to infinite dilution, assuming no dissociation of HS^- (aq.).

$NaHS \cdot nH_2O$ (c). Sabatier[1] measured the heats of solution of the anhydrous salt and the dihydrate.

NaS_n (aq.). Sabatier[1] measured the heat of reaction of I_2 with Na_2S_2 (aq.), Na_2S_3 (aq.), and Na_2S_4 (aq.), respectively.

Na_2S_4 (c). Sabatier[1] measured the heat of solution.

Na_2SO_3 (aq.). Thomsen[15] measured the heat of reaction of H_2SO_3 (400) with 2 NaOH (200); de Forcrand[4] that of H_2SO_3 (220) with 2 NaOH (150), and of Na_2SO_3 (550) with 2 HCl (110). These data yield for Na_2SO_3 (∞), $Qf = 263\,2$, $264\,2$, and 265.1, respectively. We have estimated the heat of dilution.

$Na_2SO_3 \cdot nH_2O$ (c). de Forcrand[4] measured the heats of solution of the anhydrous salt and the heptahydrate. Arii,[1] from vapor pressure data, calculated, for Na_2SO_3 (c) $+ 7\,H_2O$ (liq.) $= Na_2SO_3 \cdot 7\,H_2O$ (c), $Q = 2.67$.

$NaHSO_3$ (aq.). Thomsen,[15] de Forcrand,[4] and Lindner[1] measured the heat of reaction of NaOH (aq.) with H_2SO_3 (aq.). Their data yield the following values for Qf: Thomsen, $NaHSO_3$(600), 206.30; de Forcrand, $NaHSO_3$(370), 207.12; Lindner, $NaHSO_3$(600), 206.17; Lindner $NaHSO_3$(111), 207.15. de Forcrand[4] also measured the heat of mixing $NaHSO_3$ (aq.) with NaOH (aq.), and of Na_2SO_3 (aq.) with H_2SO_3 (aq.). These latter data yield for $NaHSO_3$(500), $Qf = 205.6$ and 206.40.

Na_2SO_4 (aq.). The heat of neutralization of H_2SO_4 (aq.) with NaOH (aq.) was measured by Favre and Silbermann,[3] Andrews,[2, 7, 11] Favre,[3] Hess,[5] Thomsen,[15], Berthelot,[4] Recoura,[2] Mathews and Germann,[1] Richards and Rowe,[4] and Thorvaldson, Brown, and Peaker.[1] The data of the last six investigations yield, respectively, for Na_2SO_4(400), $Qf = 330.69$, 330.68, 331.4, 330.1, 331 06, and 331 06 Thomsen[15] measured the heat of mixing 2 NaCl (100) with H_2SO_4(200) and of Na_2SO_4(200) with 2 HCl (100). Subtraction of these heats of reaction gives that for 2 NaCl (100) + H_2SO_4(200) = Na_2SO_4(200) + 2 HCl (100); whence we have obtained the value for Na_2SO_4(200). In another pair of such "double decomposition" experiments, Thomsen[15] used twice the dilutions. His data yield, for Na_2SO_4(400), $Qf = 330.68$ and 331.02. Berthelot[4] performed similar "double decomposition" experiments, and his data yield, for Na_2SO_4(400), $Qf = 331.25$ from Na^+, SO_4^{--}, H^+, NO_3^-, and $Qf = 331.07$, from Na^+, SO_4^{--}, H^+, Cl^-. The data of Thomsen,[15] Varali-Thevenet,[1] and Lange and Streeck[1] have been used to obtain values for the heat of dilution of Na_2SO_4 (aq.) from ∞ to 50 H_2O.

Na_2SO_4 (c, II). The data on the heat of solution yield the following values for S_{400}: Thomsen,[15] 0.257; Tilden,[2] 0.25; Pickering,[5] -0.09. Other data on the heat of solution, lacking in most cases necessary information as to temperatures and concentration, were reported by Graham,[1] Favre and Valson,[2] Berthelot,[10] Berthelot and Ilosvay,[1] and Varali-Thevenet.[1] Mixter[6] measured, in a bomb calorimeter, the hea-

of the reaction, $3\,Na_2O_2\,(c)+S\,(c)=Na_2SO_4\,(c)+2\,Na_2O\,(c)$, and his data yield $Qf=328.4$. See also Ruff and Friedrich.[1]

Na_2SO_4 (c, I). For the heat of transition, see Hullner and Tammann[1] and Hare.[1]

Na_2SO_4 (liq.). Hare[1] determined the heat of fusion.

$Na_2SO_4 \cdot 10\,H_2O$ (c). The heat of solution data yield the following values for S_{400}: Thomsen,[15] -18.76; Tilden,[2] -18.53; Pickering,[5] -19.15; Berthelot,[10] -18.85; Favre and Valson,[2] $-18.9(?)$; Perreu,[1] -18.6.

$NaHSO_4$ (aq.). Thomsen[15] and Berthelot[6] measured the heat of mixing $Na_2SO_4(200)$ with $H_2SO_4(200)$ to be -1.870 and -2.10, respectively. Taking -1.90 gives for $NaHSO_4(200)$, $Qf=270.29$. The data of Thomsen[15] yield values for the heat of dilution from 10 to 800 H_2O.

$NaHSO_4$ (c). For S_{200}, the data of Thomsen[15] yield 1.25 and those of Berthelot 1.3.

$NaHSO_4 \cdot H_2O$ (c). Favre[8] measured the heat of solution.

$Na_2S_2O_5$ (aq.). We have taken equal to zero the heat of the reaction, $2\,HSO_3^-\,(aq.)=S_2O_5^{--}\,(aq.)+H_2O\,(liq.)$.

$Na_2S_2O_5$ (c). de Forcrand[4] measured the heat of solution in water and in NaOH (aq.). These data give, for $Na_2S_2O_5$ (c), $Qf=349.2$ and 348.8, respectively.

$Na_2S_2O_3$ (aq.). Thomsen[15] measured the heat of reaction of $Na_2S_2O_3$ (aq.) with HClO (aq); Berthelot[103] that of $Na_2S_2O_3$ (aq.) with KBr_3 (aq.). Their data yield, respectively, for $Na_2S_2O_3$ (aq.), $Qf=260.5$ and 263.7. Bichowsky[3] measured the heat of mixing aqueous CaS_2O_3 with concentrated aqueous HCl, forming rhombic sulfur. Assuming the reaction, $S_2O_3^{--}\,(aq.)=SO_3^{--}\,(aq.)+S\,(c, rhombic)$, his data, $Q=-3.94$, yield, for $S_2O_3^{--}$ (aq.), $Qf=145.1$; whence, for $Na_2S_2O_3$ (aq.) $Qf=260.1$. Thomsen measured the heat of mixing aqueous $Na_2S_2O_3$ with aqueous HCl to be -2.2. Assuming the same reaction as before we have obtained, for $Na_2S_2O_3$ (aq.), $Qf=261.8$.

$Na_2S_2O_3$ (c). The data of Berthelot[92] yield $S=2.0_{440}$; Fogh[1] found $S=1.4$.

$Na_2S_2O_3 \cdot 5\,H_2O$ (c, α). The data of Thomsen[15] and Berthelot[108] yield, for S_{400}, -11.33 and -10.6, respectively.

$Na_2S_2O_3 \cdot 5\,H_2O$ (c, β). Muller[11] measured the heat of solidification of the supercooled liquid, and found, for the α and β forms of the solid, respectively, $F^{17.5}=-9.3$ and -8.0; whence, for the α to β transition, $T=-1.3^{17.5}$.

$Na_2S_2O_3$ (5). Qf for this substance is obtained from the foregoing data.

$Na_2S_2O_6$ (aq.). The value for this substance is obtained from those for the ions.

$Na_2S_2O_6 \cdot nH_2O$ (c). Thomsen[15] measured the heats of solution of the anhydrous salt and the dihydrate.

$Na_2S_3O_6$ (aq.). Berthelot[108] measured the heat of reaction of $Na_2S_3O_6$ (aq.) with KBr_3 (aq.). His data yield $Qf = 394.6$.

$Na_2S_3O_6 \cdot 3\,H_2O$ (c). Berthelot[108] measured the heat of solution.

$Na_2S_4O_6$ (aq.). Thomsen[15] and Berthelot[108] measured the heat of the reaction, $2\,Na_2S_2O_3$ (aq.) $+ I_2$ (c) $= (2\,NaI + Na_2S_4O_6)$ (aq.). Their data yield, for $Na_2S_4O_6$ (aq.), $Qf = 387.3$ and 388.1, respectively. Berthelot[108] also measured the heat of reaction between $Na_2S_4O_6 \cdot 2\,H_2O$ (c) and KBr_3 (aq.) (with the formation of sulfate), and the heat of solution of the dihydrate; and from these data we have obtained, for $Na_2S_4O_6$ (aq.), $Qf = 387.2$.

$Na_2S_4O_6 \cdot 2\,H_2O$ (c). Berthelot[108] measured the heat of solution.

$NaI \cdot nSO_2$ (c). From measurement of the dissociation pressure at various temperatures, Ephraim and Kornblum[1] found for $n = 4$, $D = -9.63$, and for $n = 2$, $D = -10.0$; de Forcrand and Taboury,[1] found for $n = 2$, $D = -10.25$.

Na_2Se (aq.). Fabre[1] measured the heat of neutralization of NaOH (220) with H_2Se (g) and H_2Se(4000), respectively. His data yield for Qf, Na_2Se(440), 77.12; Na_2Se(4400), 78.64.

$Na_2Se \cdot nH_2O$ (c). Fabre[1] measured the heats of solution of the anhydrous salt and of the hydrates with $4\frac{1}{2}$, 9, and 16 moles of H_2O.

NaHSe (aq.). Fabre[1] measured the heat of the reaction of H_2Se (aq.) with NaOH (aq.), and of NaHSe (aq.) with NaOH (aq.). These data yield, respectively, $Qf = 31.24$ and 30.81, for NaHSe (aq.).

Na_2SeO_3 (aq.). Thomsen[15] measured the heat of neutralization of H_2SeO_3 (aq.) with NaOH (aq.). His data yield, for Na_2SeO_3(800), $Qf = 238.22$.

$NaHSeO_3$ (aq.). Thomsen[15] found $Q = 14.76$ for the reaction, NaOH (400) $+ H_2SeO_3$(800) $= NaHSeO_3$(1200) $+ H_2O$ (liq.).

Na_2SeO_4 (aq.). The data of Thomsen[15] yield $N = 30.41_{800}$, and those of Metzner,[2] $N = 31.05_{440}$; whence we have computed, for Na_2SeO_4(800), $Qf = 260.99$ and for Na_2SeO_4(440), $Qf = 261.41$.

$NaHSeO_4$ (aq.). Thomsen[15] and Metzner[2] measured the heat of mixing Na_2SeO_4 (aq.) with H_2SeO_4 (aq.). Their data yield, respectively, $NaHSeO_4$(400) $Qf = 201.72$ and $NaHSeO_4$(220), $Qf = 201.79$.

Na_2SeO_4 (c). Mixter[10] measured, in a bomb calorimeter, the heat of reaction between amorphous Se and Na_2O_2 to be 95 9.

Na_2TeO_4 (c). As for the foregoing, Mixter[10] found 149.7.

$NaNO_3$ (aq.). The heat of neutralization of NaOH (aq.) with HNO_3 (aq.) was measured by Hess,[6] Andrews,[11] Favre and Silbermann,[3] Favre,[3] Thomsen,[15] Berthelot,[4] Mathews and Germann,[1] and Richards and Rowe.[3] The accurate data of Richards and Rowe were recomputed by Rossini,[6] giving $N = 13.929_{201}$. The data on the heat of dilution of $NaNO_3$ from infinite dilution to 25 H_2O, (Pratt,[1] Richards and Rowe,[2] Nernst and Naude,[1] Lange and Robinson[2]) were reviewed by Rossini,[5] who gave values from ∞ to 25 H_2O. The data of Stahlberg,[1] Stackelberg,[1] and van Deventer and van der Stadt[1] have been utilized to obtain values from

25 to 5 H_2O. Other data on the heat of dilution were given by Bishop,[1] Rümelin,[1] and Mondain-Monval.[3]

$NaNO_3$ (c). The existing data on the heat of solution have been recomputed to give the following values for S_{200}: Winkelmann,[1] −4.91; Berthelot,[10, 131] −4.83; Tilden,[2] −4.91; Zawidski and Schagger,[1] −5.02; Thomsen,[15] −5.03; Scholz,[1] −5.05; Stackelberg,[1] −5.04; Varali-Thevenit,[1] −4.84; Haigh,[1] −4.95; and Mondain-Monval,[3] −4.86. The average of these values is -4.94 ± 0.07. Brönsted,[10] by measuring the electromotive force of cells at various temperatures, found, for KCl (c) + $NaNO_3$ (c) = NaCl (c) + KNO_3 (c), $Q = 0.340$. Anticipating the values for KCl (c) and KNO_3 (c), we have computed for $NaNO_3$ (c), $Qf = 111.72$. This corresponds to $S = -4.965_{200}$.

$NaNO_2$ (c). The data of Matignon and Marchal[3] and Swietoslawski[6] yield identical values for the heat of solution.

$NaNH_2$ (c). de Forcrand[24] measured the heat of solution in water.

$NaNH_3$ (c). Joannis[3] found $D = -5.19$.[20]

$NaX \cdot nNH_3$ (c). Joannis[6] measured the temperature coefficient of the dissociation pressure of $NaCl \cdot 5\,NH_3$ (c); Biltz and Hansen[1] measured those of $NaCl \cdot 5\,NH_3$ (c), $NaBr \cdot 5\frac{1}{4}\,NH_3$ (c), $NaBr \cdot 5\frac{3}{4}\,NH_3$ (c), $NaI \cdot 4\frac{1}{2}\,NH_3$ (c), and $NaI \cdot 6\,NH_3$ (c).

$Na_2SO_4 \cdot (NH_4)_2SO_4 \cdot H_2O$ (c). Matignon and Meyer[1] measured the heat of solution.

$NaPO_3$ (aq.). Thomsen[15] and Giran[1] measured the heat of neutralization of HPO_3 (aq.) with NaOH (aq.). Their data give, respectively, $NaPO_3(600)$, $Qf = 292\,67$, and $NaPO_3$ (aq$_4$), $Qf = 293.08$.

$NaPO_3$ (c). Giran[1] measured the heat of solution.

$Na_nH_{3-n}PO_3$ (aq.). Thomsen[1] measured the heat of mixing H_3PO_3 (400). with 1, 2, and 3 moles of NaOH(200), respectively, forming $NaH_2PO_3(600)$, $Na_2HPO_3(800)$, and $Na_3PO_3(1000)$.

$NaH_2PO_3 \cdot nH_2O$ (c). Amat[1] measured the heats of solution of NaH_2PO_3 (c) and $NaH_2PO_3 \cdot 2\frac{1}{2}\,H_2O$ (c).

$Na_2HPO_3 \cdot nH_2O$ (c). Amat[1] measured the heats of solution of the anhydrous salt and the pentahydrate.

$Na_nH_{2-n}PO_2$ (aq.). Thomsen[15] measured the heat of mixing H_3PO_2 (250) with 1 and 2 moles of NaOH(200), respectively.

$Na_3PO_4 \cdot 12\,H_2O$ (c). Joly[4] measured the heat of solution.

Na_3PO_4 (c). The data of Mixter,[9] who measured the heat of reaction between $1\frac{1}{2}$ Na_2O (c) and $\frac{1}{2}$ P_2O_5 (c), in a bomb calorimeter, yield $Qf = 446$. We have obtained, by estimating the heat of dehydration of the dodecahydrate, $Qf = 457$.

Na_3PO_4 (aq.). The data of Thomsen[15] and Berthelot and Louguinine[3] yield, respectively, $N = 34.10_{903}$ and $N = 33.45_{663}$; whence, for Na_3PO_4 (800), we have computed $Qf = 471.54$ and 470.53. Berthelot and Louguinine[3] measured the heat of dilution from 330 to 1980 H_2O.

NaH_2PO_4 (aq.). Thomsen[15] and Berthelot and Louguinine[3] measured the heat of mixing H_3PO_4 (aq.) with NaOH (aq.). Their data yield,

respectively, $NaH_2PO_4(300)$, $Qf=364.64$, and $NaH_2PO_4(440)$, $Qf=364.68$. Berthelot and Louguinine[3] measured the heat of mixing $NaH_2PO_4(440)$ with $HCl(110)$ and of $H_3PO_4(440)$ with $NaCl(110)$, their data yielding, for $NaH_2PO_4(440)$, $Qf=365.03$.

Na_2HPO_4 (aq.). Thomsen[15] and Berthelot and Louguinine[3] measured the heat of mixing H_3PO_4 (aq.) with 2 NaOH (aq.); Berthelot and Louguinine[3] measured the heat of mixing $Na_2HPO_4(440)$ with NaOH (aq.). These data yield, respectively, for $Na_2HPO_4(400)$, $Qf=420.81$, 419.93, and 420.43. Berthelot and Louguinine[3] measured the heat of dilution of Na_2HPO_4 (aq.) from 220 to 880 H_2O.

$Na_2HPO_4 \cdot nH_2O$ (c). Thomsen[15] and Pfaundler[2] measured the heats of solution of the anhydrous salt and the hydrates with 7 and 12 moles of H_2O. Thomsen[15] also measured that of the dihydrate. Their data yield for S_{400} the following respective values, for Thomsen and Pfaundler: for Na_2HPO_4 (c), 5.65, 5.37; dihydrate, −0.38, ...; heptahydrate, −11.60, −11.38; dodecahydrate, −22.74, −22.53. See also Perreu.[1] Muller-Erzbach[4] measured the temperature-dissociation pressure relationship for the heptahydrate.

$NaH_3P_2O_7$ (aq.). Thomsen[15] and Giran[1] found, respectively, NaOH (400) + $H_4P_2O_7$(800), $N=14.38$; NaOH (aq.) + $H_4P_2O_7$ (aq.), $N=15.29$.[?]

$NaH_3P_2O_7 \cdot nH_2O$ (c). Giran[1] measured the heats of solution of the anhydrous salt and the monohydrate.

$Na_2H_2P_2O_7$ (aq.). Thomsen[15] and Giran[1] found, respectively, 2 NaOH(200) + $H_4P_2O_7$(800), $N=28.64$[17 5]; 2 NaOH (aq.) + $H_4P_2O_7$ (aq.), $N=29.94$.[?] Favre and Silbermann[3] also measured this heat of neutralization.

$Na_2H_2P_2O_7 \cdot nH_2O$ (c). Giran[1] measured the heats of solution of the anhydrous salt and the hexahydrate

$Na_3HP_2O_7$ (aq.). Giran[1] found $N=43.05$.[?]

$Na_3HP_2O_7 \cdot nH_2O$ (c). Giran[1] measured the heats of solution of the anhydrous salt and the mono- and hexahydrates.

$Na_4P_2O_7$ (aq.). Thomsen[15] found $N=52.74_{1600}$; Giran,[1] $N=50.91$.[?]

$Na_4P_2O_7 \cdot nH_2O$ (c). Thomsen[15] measured the heats of solution of the anhydrous salt and the decahydrate.

$Na_2H_2P_2O_5$ (c). Amat[1] measured the heats of solution, in aqueous H_2SO_4, of $Na_2H_2P_2O_5$ (c) and of 2 NaH_2PO_3 (c). The difference yields, for $Na_2H_2P_2O_5$ (c) + H_2O (liq.) = 2 NaH_2PO_3 (c), $Q=4.80$.

$Na_2H_2P_2O_5$ (aq.). Amat[1] measured the heat of solution.

$Na_nH_{4-n}P_2O_6$ (aq.). Joly[2] measured the heat of mixing $H_4P_2O_6(330)$ with 1, 2, 3, and 4 moles of NaOH(220), respectively.

$NaNH_4HPO_4$ (aq.). Berthelot and Louguinine[3] measured the heat of mixing $NaH_2PO_4(440)$ with $NH_3(110)$.

$Na(NH_4)_2PO_4$ (aq.). Berthelot and Louguinine[3] measured the heat of mixing $NaNH_4HPO_4(550)$ with $NH_3(110)$.

$Na_2NH_4PO_4$ (aq.). Berthelot[146] measured the heat of mixing $Na_2HPO_4(440)$ with $NH_3(110)$.

$NaNH_4HPO_4 \cdot 4\,H_2O$ (c). Thomsen[15] measured the heat of solution.

$Na_nH_{3-n}AsO_4$ (aq.). Thomsen[15] measured the heat of mixing H_3AsO_4 (200) with 1, 2, and 3 moles of NaOH(100), respectively.

$Na_3AsO_4 \cdot 12\,H_2O$ (c). Joly[4] measured the heat of solution.

Na_3AsO_4 (c). The data of Mixter,[9] who measured in a bomb calorimeter the heat of reaction between As (c) and $2\frac{1}{2}$ Na_2O_2 (c), yield $Qf=361$. By estimating the heat of dehydration of the dodecahydrate, we have obtained $Qf=366$.

$Na_nH_{3-n}AsO_3$ (aq.). Thomsen[15] measured the heat of mixing of H_3AsO_3(200) with 1, 2, and 3 moles of NaOH (aq.), respectively.

Na_3SbO_4 (c). The data of Mixter[9] on the reaction of Sb (c) with $2\frac{1}{2}$ Na_2O_2 (c) yield $Qf=349$.

Na_3SbO_4 (aq.). We have estimated $S=11$.

$3\,Na_2S \cdot Sb_2S_3$ (aq.). Berthelot[99] measured the heat of reaction of $3\,Na_2S \cdot Sb_2S_3$ (aq.) with 6 HCl (aq.).

Na_3BiO_4 (c). The data of Mixter[9] yield $Qf=284$.

Na_2C_2 (c). de Forcrand[23] measured the heat of solution of Na_2C_2 (c) in H_2SO_4 (aq.); Matignon[16] that in HCl (aq.). Their data yield, respectively, $Qf=-4.4$ and -4.06.

$NaHC_2$ (c). Matignon[16] measured the heat of solution in water and in HCl (aq.). His data yield, respectively, $Qf=-25\,19$ and -25.05.

Na_2CO_3 (aq.). Berthelot[4] and Thomsen[15] measured the heat of reaction of CO_2(aq.) with 2 NaOH (aq.); Muller[1] that of Na_2CO_3 (aq.) with 2 HCl (aq.). Their data yield, respectively, for Na_2CO_3(200), $Qf=276.0$, 276.24, and 275.7. Berthelot[4] performed some "double decomposition" experiments, and his data yield the following values for Na_2CO_3(200): from Na^+, CO_3^{--}, H^+, $C_2H_3O_2^-$, 276.1; from Na^+, CO_3^{--}, H^+, SO_4^{--}, 267.4; and from Na^+, CO_3^{--}, H^+, NO_3^-, 276 8. Data on the heat of dilution were reported by Thomsen,[15] Perreu,[2] and Laksonen.[1] These data covered the range as dilute as 200 H_2O. Values to infinite dilution have been estimated. See also Swallow and Alty.[1]

Na_2CO_3 (c, II). The data on the heat of solution have been recomputed to give the following values for S_{200}: Favre and Valson,[2] ?; Berthelot,[10] 6.0; Ostwald,[1] 5.80; Berthelot and Ilosvay,[1] 5.8; Tilden,[2] 5.74; Thomsen,[15] 5.88; Pickering,[7] 5.70; Donnan and Hope,[1] 5.85. See also Swallow and Alty.[1]

Na_2CO_3 (c, I). Doelter[1] quoted Wegscheider[1] as giving $T=0.4_{\rightarrow II}{}^{450}$.

Na_2CO_3 (liq.). Sackur[1] determined the heat of fusion from freezing point lowering data.

$Na_2CO_3 \cdot H_2O$ (c). For S_{200}, the data of Thomsen[15] yield 2 50, those of Donnan and Hope[1] 1.95. The dissociation pressure data of Caven and Sand[1] give $Qf=341.6$.

$Na_2CO_3 \cdot 7\,H_2O$ (c). For S_{200}, the data of Thomsen[15] yield -10.50, those of Donnan and Hope[1] -10.55.

$Na_2CO_3 \cdot 10\,H_2O$ (c). The heat of solution data yield the following values for S_{200}: Favre and Valson,[2] ?; Tilden,[2] -14.82; Thomsen,[15]

−15.91; Pickering,[7] −15.91; Donnan and Hope,[1] −15.25; and Perreu,[1] −16.0.

$NaHCO_3$ (aq.). Berthelot[4] measured the heat of mixing $CO_2(1600)$ with $NaOH(110)$; Thomsen[15] that of $NaHCO_3(200)$ with $NaOH(200)$; Muller[1] that of $NaHCO_3(1000)$ with $HCl(90)$. Their data yield, respectively, $NaHCO_3(1700)$, $Qf=222.41$, $NaHCO_3(200)$, $Qf=222.67$, and $NaHCO_3(1000)$, $Qf=222.0$.

$NaHCO_3$ (c). The data of Berthelot[10] yield $S=-4.1_{300}$, whence $Qf=226.4$. The dissociation pressure data of Caven and Sand[1] yield the same value.

$Na_2C_2O_4$ (aq.). The heat of neutralization of aqueous oxalic acid with aqueous NaOH was measured by Berthelot[7] and Thomsen.[15] Their data yield, respectively, $Na_2C_2O_4$ (aq.), $Qf=310.92$, and $Na_2C_2O_4(600)$, $Qf=310.58$. Berthelot[7] also performed 2 pairs of "double decomposition" experiments, his data yielding for $Na_2C_2O_4(220)$, $Qf=311.42$ from Na^+, $C_2O_4^{--}$, H^+, SO_4^{--}, and $Qf=311.30$ from Na^+, $C_2O_4^{--}$, H^+, $C_2H_3O_2^-$. Roth and Eymann[1] measured the heat of neutralization of aqueous NaOH with solid oxalic acid containing 26.7% of H_2O, and the heat of solution of the latter. Their data yield for $Na_2C_2O_4(1120)$, $Qf=310.39$.

$Na_2C_2O_4$ (c). Berthelot[10] measured the heat of solution.

$NaHC_2O_4$ (aq.). Berthelot[6] measured the heat of mixing $Na_2C_2O_4$ (220) with $H_2C_2O_4(220)$; Berthelot[7] and Thomsen[15] that of mixing $H_2C_2O_4$ (aq.) with NaOH (aq.). Their data yield, respectively, $NaHC_2O_4(400)$, $Qf=252.5$, $NaHC_2O_4(400)$, $Qf=252.43$, and $NaHC_2O_4$ (220), $Qf=252.50$.

$NaHC_2O_4 \cdot nH_2O$ (c). Berthelot[10, 131] measured the heat of solution of the anhydrous salt and its monohydrate.

$NaCHO_2$ (aq.). Thomsen[15] measured the heat of neutralization of aqueous formic acid with aqueous NaOH; Berthelot[7] performed 2 pairs of "double decomposition" experiments involving H^+, Cl^-, Na^+, CHO_2^- Their data yield, respectively, $NaCHO_2(400)$, $Qf=157.29$, $NaCHO_2(165)$, $Qf=157.25$, and $NaCHO_2(110)$, $Qf=157.19$.

$NaCHO_2$ (c). Berthelot[10] measured the heat of solution of sodium formate.

$NaC_2H_3O_2$ (aq.). The heat of neutralization of aqueous acetic acid with aqueous NaOH was measured by Berthelot,[7] Thomsen,[15] and Richards and Mair.[1] These data yield, respectively, for $NaC_2H_3O_2(200)$, $Qf=175.38$, 175.08, and 175.237. Data on the heat of dilution were reported by Berthelot[5] and Thomsen.[15] Richards and Gucker[1] measured the heat of dilution in the range 25 to 1600 H_2O. We have extrapolated these data to infinite dilution, and, using the data of Gnesotto and Fabris,[1] who obtained a value for the heat of fusion of $NaC_2H_3O_2 \cdot 3\,H_2O$ (c), we have extended the values to 3 H_2O.

$NaC_2H_3O_2$ (c). The data on the heat of solution of sodium acetate yield the following values for S_{200}: Berthelot,[7, 131] 4.0; Thomsen,[15] 3.88; and Pickering,[7] 3.95.

$NaC_2H_3O_2 \cdot 3\,H_2O$ (c). The heat of solution data yield the following values for S_{200}: Berthelot,[7, 131] −4.61; Thomsen,[15] −4.86; Pickering,[7] −4.77; and Calvet,[1] −4.72.

$NaC_2H_3O_2(C_2H_5OH)$. Pickering[8] measured the heat of solution of sodium acetate in ethyl alcohol.

$NaCH_3O(CH_3OH)$, $NaC_2H_5O(C_2H_5OH)$. de Forcrand[16] measured the heat of solution of Na (c) in methyl alcohol and in ethyl alcohol. See also Cavalier.[1]

$NaC_2H_3O_3$ (aq.). de Forcrand[3] measured the heat of neutralization of aqueous glycollic acid.

$NaC_2H_3O_3 \cdot nH_2O$ (c). de Forcrand[3] measured the heats of solution of the anhydrous salt, the hemihydrate, and the dihydrate of sodium glycollate.

$NaC_2H_3O_3 \cdot HC_2H_3O_3$ (c). de Forcrand[3] measured the heat of solution of sodium acid glycollate.

$NaC_2H_3O_4$ (aq.). de Forcrand[3] measured the heat of neutralization to form sodium glyoxylate.

$NaC_2H_3O_4$ (c). de Forcrand[17] measured the heat of solution of sodium glyoxylate.

$NaC_2H_5O_2$ (aq.). de Forcrand[6a] measured the heat of solution of liquid ethylene glycol in aqueous NaOH.

$NaC_2H_5O_2$ (c). de Forcrand[6a] measured the heat of solution of sodium glycol.

$NaC_2H_5O_2 \cdot C_2H_6O_2$ (c). de Forcrand[6a] measured the heat of solution of sodium glycol-glycol.

$NaC_2H_5O_2 \cdot CH_3OH$ (c). de Forcrand[6a] measured the heat of solution of sodium glycol-methanol.

$NaC_2H_5O_2 \cdot C_2H_5OH$ (c). de Forcrand[6a] measured the heat of solution of sodium glycol-ethanol.

$NaC_2H_5SO_4$ (aq.). Thomsen[15] measured the heat of the reaction, $Na_2SO_4(400) + Ba(C_2H_5SO_4)_2(800) = BaSO_4\ (c) + 2\,NaC_2H_5SO_4(600)$.

$Na_2S_2O_5 \cdot C_2H_2O_2 \cdot 2\,H_2O$ (c). de Forcrand[3] measured the heat of solution.

NaCN (aq.). The data of Thomsen[15] yield $N = 2.75_{200}$.

$NaCN \cdot nH_2O$ (c). Joannis[1] measured the heat of solution of the anhydrous salt, the hemihydrate, and the dihydrate.

NaCNO (c). Lemoult[1] measured the heat of solution of NaCNO (c) in HCl (aq.) and in HNO_3 (aq.).

NaCNO (aq.). Lemoult[1] measured the heat of solution of NaCNO (c) in water.

$NaCN_2H$ (aq.). Lemoult[1] measured the heat of neutralization of HCN_2H (c), and of HCN_2H (aq.), with NaOH (aq.).

NaCNS (aq.). Joannis[1] measured the heat of neutralization, his data yielding $N = 14.04$. The heat of dilution was measured by Partington and Soper[1] in the range 3.55 to 330 H_2O. We have extrapolated the values to infinite dilution.

NaCNS (c). The data of Vrzhesnevskii[1] and Partington and Soper[1] yield, respectively, for S_{200}, -1.77 and -1.80.

NaCNS(C_2H_5OH). Partington and Soper[1] measured the heat of solution of NaCNS (c) in various amounts of ethyl alcohol.

Na_2SiO_3 (c). The data of Tammann[3] (quoted by Mulert[1]), who measured the heat of solution in 20% HF (aq.), yield $Qf=371.2$. Matignon[11] measured the heat of mixing Na_2SiO_3 (c) with HCl (aq.), his data yielding $Qf=351$.

Na_2SiO_3 (gls.). In a bomb calorimeter, Mixter[5] measured the heat of reaction of Si (c) with $2\,Na_2O_2$ (c) and of SiC (c) with $4\,Na_2O_2$ (c); Tschernobaeff[1] that of SiO_2 (α Quartz) with Na_2CO_3 (c). Their data yield, respectively, $Qf=373.5$, 374.7, and 348.

Na_2SiF_6 (aq.). Thomsen[15] and Hantke[1] measured the heat of neutralization of H_2SiF_6 (aq.) with 2 NaOH (aq.).

$NaHSiF_6$ (aq.). Thomsen[15] measured the heat of mixing H_2SiF_6 (200) with NaOH(200).

Na_2SiF_6 (c). The data of Hantke[1] yield $S=-10.3$. Truchot[2] measured the heat of reaction of SiF_4 (g) with 2 NaF(110).

Na_nSn_m (c). Biltz and Holverscheit[1] measured the heats of solution, in HCl(8) containing $FeCl_3$ (aq.), of $NaSn_2$ (c), NaSn (c), Na_4Sn_3 (c), Na_2Sn (c), Na_4Sn (c), and of their respective component parts.

Na_2SnO_3 (c). Mixter[7] measured the heat of reaction of Sn (c) with $2\,Na_2O_2$ (c).

Na_4SnO_4 (aq.). Thomsen[15] measured the heat of mixing $SnCl_4$(400) with 8 NaOH(100).

Na_2PbO_3 (c). Mixter[8] measured the heat of reaction of Pb (c) with $2\,Na_2O_2$ (c) and of PbO_2 (c) with Na_2O (c). His data yield $Qf=202.4$ and 203.2, respectively.

$2\,NaI\cdot PbI_2\cdot nH_2O$ (c). Mosnier[1] measured the heats of solution of the anhydrous salt, the tetrahydrate, and the hexahydrate.

$2\,Na_2S_2O_3\cdot PbS_2O_3$ (aq.). Fogh[1] measured the heat of mixing PbS_2O_3 (c) with $2\,Na_2S_2O_3$ (aq.).

$2\,Na_2S_2O_3\cdot PbS_2O_3$ (c). Fogh[1] measured the heat of solution.

Na_2ZnO_2 (c). Mixter[11] measured the heat of reaction of Zn (c) with Na_2O_2 (c).

$Na_2Zn(SO_4)_2\cdot nH_2O$ (c). Graham[3] measured the heats of solution of the anhydrous salt and of the tetrahydrate.

$NaCd_n$ (c). Biltz and Haase[1] measured the heats of solution of Na (c), Cd (c), $NaCd_2$ (c), and $NaCd_5$ (c) in HCl(8).

Na_2CdO_2 (c). Mixter[15] measured the heat of reaction of Cd (c) with Na_2O_2 (c).

$NaHg_n$ (liq.). Berthelot[56] measured the heat of solution of $NaHg_{25}$ (liq.) in HCl(330); von Wartenberg[3] measured the heat of solution of Na (c) in 164 Hg (liq.). Their data yield, respectively, $NaHg_{25}$ (liq.), $Qf=19.6$, and $NaHg_{164}$ (liq.), $Qf=20.2$. The heat of dilution of $NaHg_n$ (liq.) with Hg (liq.) was measured by Cady[1] and Richards and Conant.[1]

$NaHg_n$ (c). Berthelot[55] measured the heat of solution of $NaHg_{1.03}$ (c) in water, and also (Berthelot[56]) of the solid amalgams, with $n=1.05$, 2.15, 4.05, and 6.0, in HCl(330). von Wartenberg[8] measured the heat of solution of Na_3Hg (c) in Hg (liq.). Biltz and Meyer[2] measured the heats of solution, in HCl(8), of the solid amalgams, with $n=\frac{1}{3}$, $\frac{2}{3}$, 1, $1\frac{1}{7}$, 2, and 4.

***n*NaBr · $HgBr_2$ (aq.).** Varet[6] measured the heats of mixing $HgBr_2$ (4400) with 1, 2, 4, and 8 moles of NaBr(220), respectively.

4 Na_2S · HgS (aq.). Berthelot[115] measured the heat of mixing 6 Na_2S (aq.) with $HgCl_2$ (aq.).

***n*NaCN · $Hg(CN)_2$ (aq.).** Varet[2] measured the heat of mixing $Hg(CN)_2$(440) with 1 and 2 moles of NaCN(110), respectively.

***n*NaX · $Hg(CN)_2$ (aq.).** Varet[2] measured the heat of mixing $Hg(CN)_2$ (440) with 1 and 2 moles of NaCl(110), NaBr(110), and NaI(110), respectively.

NaX · $Hg(CN)_2$ · *n*H_2O (c). Varet[2] measured the heats of solution of NaCl · $Hg(CN)_2$ · $1\frac{1}{4}$ H_2O (c), NaBr · $Hg(CN)_2$ · 2 H_2O (c), and NaI $Hg(CN)_2$ · 2 H_2O (c).

Na_2O · CuO_2 (c). Mixter[12] measured the heat of reaction of Na_2O_2 (c) with CuO (c).

Na_2CO_3 · $CuCO_3$ · *n*H_2O (c). de Carli[1] measured the heats of solution of the anhydrous salt and the trihydrate in HCl(314).

Na_2O_2 · Ag_2O (c). Mixter[12] measured the heat of reaction of Na_2O_2 (c) with Ag_2O (c).

$Na_3Ag(S_2O_3)_2$ (aq.). Fogh[1] measured the heat of mixing $AgNO_3$ (110) with 5 $Na_2S_2O_3$(220).

***n*NaCN · AgCN (aq.).** Varet[5] measured the heats of dissolving AgCN (c) in NaCN(550), 2 NaCN(220), 2 NaCN(330), and 2 NaCN(1320), respectively.

Na_2PtCl_4 (aq.). Thomsen[15] measured the heat of reaction of Na_2PtCl_6 (900) with 2 CuCl (c).

Na_2PtCl_6 (aq.). Thomsen[15] measured the heat of neutralization. His data yield $N=27.02_{1200}$, with $Qf=280.0$. Thomsen[15] measured the heat of reaction of Na_2PtCl_6 · 6 H_2O (c) with 2 Co (c) in HCl (aq.); Gire,[2] that of Na_2PtCl_6 (aq.) with 2 Co (c). Their data yield, respectively, $Qf=280.6$ and 285.9. The dissociation pressure data of Gire,[1] together with the heat of solution, yield $Qf=278$.

Na_2PtCl_6 (c). Thomsen[15] found $S=8.49_{800}^{17.6}$; Gire,[2] $S=7.09_{4200}^{17}$.

Na_2PtCl_6 · *n*H_2O (c). Thomsen[15] measured the heats of solution of the dihydrate and the hexahydrate.

Na_2PtBr_6 (aq.). Thomsen[15] measured the heat of reaction of Na_2PtBr_6 (aq.) with 2 Co (c).

Na_2PtBr_6 · *n*H_2O (c). Thomsen[15] measured the heats of solution of the anhydrous salt and the hexahydrate.

Na_2PtI_6 (aq.). Pigeon[1] measured the heats of reaction of Na_2PtI_6 (aq.), and of 2 I_2 (c), with 2 Co (c) in NaI (aq.)

Na_2IrCl_6 (aq.). Ogawa[1] gave, for Na_2IrCl_6 (aq.) + NaCl (aq.) + Hg (liq.) = Na_3IrCl_6 (aq.) + HgCl (c), $Q = 2.21$.

Na_3RhCl_6 (aq.). Gire[2] measured the heat of reaction of Na_3RhCl_6 (aq.) with 1½ Co (c).

Na_3RhCl_6 (c). Gire[2] found $S = 7.83_{6000}^{19}$. His data[1] on the dissociation pressure yield $Qf = 353$.

$Na_3RhCl_6 \cdot 12\ H_2O$ (c). Gire[2] measured the heat of solution.

Na_2MnO_4 (c). Mixter[11] measured the heat of reaction of Mn (c) with 3 Na_2O_2 (c).

2 NaBr · $MnBr_2$ (aq.). Varet[6] measured the heat of mixing $MnBr_2$ (220) with 2 NaBr (110).

$Na_2SO_4 \cdot MnSO_4 \cdot nH_2O$ (c). Graham[3] measured the heats of solution of the anhydrous salt and the dihydrate.

$Na_3FeCO(CN)_5$ (aq.). Muller[8] found $N = 41.6$.

$Na_3FeCO(CN)_5 \cdot nH_2O$ (c). Muller[8] measured the heats of solution of the anhydrous salt and the heptahydrate.

Na_2CoO_3 (c). Mixter[11] measured the heat of reaction of Co (c) with 2 Na_2O_2 (c).

2 NaBr · $CoBr_2$ (aq.). Varet[6] measured the heat of mixing $CoBr_2$ (220) with 2 NaBr (110).

$Na_2Ni(CN)_4$ (aq.). Varet[6] measured the heat of solution of $Ni(CN)_2$ (c) in 2 NaCN (aq.).

Na_2CrO_4 (aq.). Thomsen[15] found $N = 24.72_{800}^{18.9}$; Morges,[1] $N = 23.68_{440}^{19.5}$. Their data yield, respectively, Na_2CrO_4 (800), $Qf = 322.27$, and Na_2CrO_4 (440), $Qf = 321.4$.

$Na_2CrO_4 \cdot nH_2O$ (c). Berthelot[95] measured the heats of solution of the anhydrous salt, the tetrahydrate, and the decahydrate.

Na_2CrO_4 (10). The data of Berthelot[51] yield, for $Na_2CrO_4 \cdot 10\ H_2O$ (c), $F = -12.3$; those of Morgan and Benson,[1] $F = -15.2^{19.9}$. We have selected $F = -15.0$, which yields the value of Qf for Na_2CrO_4 (10).

$Na_2Cr_2O_7$ (aq.). Thomsen[15] and Morges[1] measured the heat of mixing CrO_3 (aq.) with NaOH (aq.). Their data yield, respectively, $Na_2Cr_2O_7$ (1200), $Qf = 465.62$, and $Na_2Cr_2O_7$ (660), $Qf = 465.54$.

Na_2MoO_4 (aq.). Pechard[1] and Pissarjewsky[2] measured the heat of neutralization of H_2MoO_4 (c) with NaOH (aq.), the latter using an excess of NaOH (aq.). Their data yield, respectively, Na_2MoO_4 (880), $Qf = 358.6$, and Na_2MoO_4 (440), $Qf = 355.64$. Pechard[1] performed a "double decomposition" experiment involving Na^+, MoO_4^{--}, H^+, SO_4^{--}, his data yielding, for Na_2MoO_4 (440), $Qf = 358.4$.

Na_2MoO_4 (c, II). Mixter[10] measured the heat of reaction of Mo (c) with 3 Na_2O_2 (c).

Na_2MoO_4 (c, I). Hare[1] measured the heat of transition.

Na_2WO_4 (aq.). Pissarjewsky[2] measured the heat of neutralization of H_2WO_4 (c) with excess NaOH (aq.).

Na_2WO_4 (c, II). Mixter[6] measured the heat of reaction of W (c) with 3 Na_2O_2 (c).

Na_2WO_4 (c, I). Hare[1] measured the heat of transition.

$NaVO_3$ (aq.). Ruff and Friedrich[1] measured the heat of solution of V_2O_5 (c) in ($22\frac{3}{4}$ NaOH + 8 H_2O_2) (177).

$(Na_2O_2)_2 \cdot UO_4 \cdot 9\,H_2O$ (c). Pissarjewsky[2] measured the heat of solution of this hydrate in 5 H_2SO_4(55), and the heat of mixing (UO_2SO_4 + H_2SO_4) (aq.) with 2 Na_2SO_4(310).

$(Na_2O_2)_2 \cdot UO_4$ (c). Pissarjewsky[2] measured the heat of solution of $(Na_2O_2)_2 \cdot UO_4 \cdot 9\,H_2O$ (c) in water.

$Na_2U_2O_7 \cdot 1\frac{1}{2}\,H_2O$ (c). Pissarjewsky[2] measured the heat of solution of this hydrate in 4 H_2SO_4(55).

$NaVO_3$ (aq.). Matignon[12] measured the heat of reaction of V_2O_5 (c) with 2 NaOH (aq.) to be 38.3 at 15°.

Na_2UO_4 (c). Mixter[14] measured the heats of the reactions, U (c) + 3 Na_2O_2 (c) = Na_2UO_4 (c) + 2 Na_2O (c), UO_3 (c) + Na_2O (c) = Na_2UO_4 (c), UO_2 (c) + Na_2O_2 (c) = Na_2UO_4 (c), and U_3O_8 (c) + Na_2O_2 (c) + 2 Na_2O (c) = 3 Na_2UO_4 (c), to be 341.8, 96.1, 110.9, and 285.1, respectively; whence, for Na_2UO_4 (c), Qf = 500.4, 487.2, 486.7, and 482.8.

nNaCl · $ThCl_4$ · $m$$H_2O$ (c). Chauvenet[2] measured the heats of solution of 2 NaCl · $ThCl_4$ (c) and NaCl · $ThCl_4$ · 10 H_2O (c).

$NaBO_2$ (aq.). Berthelot[4] measured the heat of mixing H_3BO_3(220) with NaOH(110); later, Berthelot[13] performed a "double decomposition" experiment with Na^+, BO_2^-, H^+, Cl^-; and again (Berthelot[50]) measured the heat of mixing H_3BO_3(220) with NaOH(110). His data yield, respectively, for $NaBO_2$(330), Qf = 233.1, 233.4, and 231.7. Thomsen[15] measured the heat of mixing H_3BO_3(150) with NaOH(150) and performed a "double decomposition" experiment involving Na^+, BO_2^-, H^+, SO_4^{--}. His data yield, respectively, $NaBO_2$(300), Qf = 231.6, and $NaBO_2$(150), Qf = 232.1.

$Na_2B_4O_7$ (aq.). Berthelot[4] and Thomsen[15] measured the heat of mixing 4 H_3BO_3 (aq.) with 2 NaOH (aq.). Their data yield, respectively, $Na_2B_4O_7$(1100), Qf = 753.5, and $Na_2B_4O_7$(900), Qf = 752.6.

$Na_2B_4O_7$ (c). Favre and Valson[2] measured the heat of solution.

$Na_2B_4O_7 \cdot 10\,H_2O$ (c). The data of Thomsen[15] yield $S = -25.8_{1600}$; those of Favre and Valson[2] $S = -22.2$.

Na_3BO_3 (aq.). Thomsen[15] found $N = 10.32_{600}{}^{18\,3}$.

Na_3BO_3 (c). Mixter[6] measured the heat of reaction of B_2O_3 (c) with 3 Na_2O (c).

$NaBO_3 \cdot 4\,H_2O$ (c). Tanatar[9] found $S = -11.56$ in water and $S = -8.98$ in H_2SO_4(200).

$NaAlO_2$ (c). Mixter[16] measured the heat of reaction of Al_2O_3 (c) with Na_2O (c).

3 NaF · AlF_3 (aq.). The data of Baud[1] yield the heat of mixing AlF_3 (aq.) with 3 NaF (aq.).

3 NaF · AlF_3 · $3\frac{1}{2}\,H_2O$ (c). Baud[1] measured the heat of mixing AlF_3 (660) with 3 NaF(220) to form 3 NaF · AlF_3 · $3\frac{1}{2}$ H_2O (c).

3 NaF · AlF$_3$ (c, II). Baud[1] measured the heats of solution of 3 NaF · AlF$_3$(c) and of 3 NaF · AlF$_3$ · 3½ H$_2$O (c) in HF (aq.).

3 NaF · AlF$_3$ (c, I). Roth and Bertram[1] measured the heat of transition.

3 NaF · AlF$_3$ (liq.). Roth and Bertram[1] measured the heat of fusion.

***n*NaCl · AlCl$_3$ (c).** Baud[1] measured the heats of solution of NaCl · AlCl$_3$(c), 3 NaCl · AlCl$_3$ (c), and 3 NaCl · 2 AlCl$_3$ (c).

NaAl(SO$_4$)$_2$ · 12 H$_2$O (c). Ephraim and Wagner[1] measured the vapor pressure at various temperatures.

NaCl · AlCl$_3$ · 6NH$_3$ (c). Baud[1] measured the heat of solution.

Na$_2$O · Al$_2$O$_3$ · *n*SiO$_2$ (c). Mulert[1] measured the heats of solution of Na$_2$O · Al$_2$O$_3$ · 3 SiO$_2$ (c, natrolite) and of Na$_2$O · Al$_2$O$_3$ · 4 SiO$_2$ (c, dehydrated analcite) in 20% HF (aq.).

***n*Na$_2$SO$_4$ · CaSO$_4$ · *m*H$_2$O (c).** Barre[1] measured the heats of solution of CaSO$_4$ · Na$_2$SO$_4$ (c), CaSO$_4$ · 2 H$_2$O (c) + Na$_2$SO$_4$ (c), 2 Na$_2$SO$_4$ · CaSO$_4$ · 2 H$_2$O (c), and 2 Na$_2$SO$_4$ (c) + CaSO$_4$ · 2 H$_2$O (c).

NaSrPO$_4$ · 9 H$_2$O (c). Joly[4] measured the heat of reaction of Na$_3$PO$_4$ (aq.) with SrCl$_2$ (aq.).

NaSrAsO$_4$ · 9 H$_2$O (c). Joly$_4$ measured the heat of reaction of Na$_3$AsO$_4$ (aq.) with SrCl$_2$ (aq.).

NaBaPO$_4$ · 9 H$_2$O (c). Joly[4] measured the heat of reaction of Na$_3$PO$_4$ (aq.) with BaCl$_2$ (aq.).

NaBaAsO$_4$ · 9 H$_2$O (c). Joly[4] measured the heat of reaction of Na$_3$AsO$_4$ (aq.) with BaCl$_2$ (aq.).

NaLiClI(c, melt). Beketoff[8] measured the heats of solution of the melt, of LiCl (c) + NaI (c), and of LiI (c) + NaCl (c).

Potassium

K (c). Standard state.

K (liq.). The data on the heat of fusion yield the following values: Joannis,[2] −0.61; Rengade,[4] −0.574; Bridgman,[2] −0.501.

K (g). The vapor pressure of potassium was measured by Kroner,[1] Fiock and Rodebush,[1] Edmondson and Egerton,[1, 2] and Killian.[1] See also van Laar[9] and Rodebush.[2] Following the same procedure as with sodium, we have calculated that the amount of K_2 in potassium vapor at these temperatures is less than 1%. For the heat of vaporization of K (liq.), we have selected $V = -20.00 + 0.0025(t + 273.1)$; whence, for K (g), $Qf = -19.80$.

The values for the energy states of gaseous monatomic potassium are from Fowler,[3] de Bruin,[1, 4] and Bowen.[1, 5] See also Braunbek[1] and Bacher and Goudsmit.[1]

K$_2$ (g). Nusbaum and Loomis[1] and Loomis and Nusbaum[2] reported the energy of dissociation, K$_2$ (g) = 2 K (g), with each substance in its normal state, to be 0.51 ± 0.02 volt-electrons. See also Carelli and Pringsheim,[1] Crane and Christy,[1] and Ditchburn.[1] The values for the

energy states of gaseous diatomic potassium are from Mulliken.[6] See also Jevons.[1]

KOH (aq.). The heat of solution of K (c) in water was measured by Favre and Silbermann,[3] Thomsen,[15] Joannis,[2] and Rengade.[1] The data of the last three investigations yield for the reaction, K (c) $+H_2O$ (liq.) $=KOH(200)+\frac{1}{2}H_2$ (g), the respective values, $Q=48.1\pm0.3$, 45.83 ± 0.28, and 46.42 ± 0.15. We have selected 46.4, whence for KOH(200), $Qf=114.8$. The heat of dilution of KOH (aq.) was measured by Berthelot,[20] Sabatier,[1] Thomsen,[15] de Forcrand,[55] Pratt,[1] and Richards and Rowe.[2] The data in the range from 25 to 400 H_2O were reviewed by Rossini,[5] who gave values from ∞ to 25 H_2O. The other data have been utilized to obtain values from 25 to 3 H_2O.

K^+ (∞). From the foregoing data we have computed, for K^+ (∞) $+OH^-$ (∞), $Qf=114.930$; whence, for K^+ (∞), $Qf=60.27$.

KOH (c, II). The heat of solution data yield the following values for S_{200}: Berthelot,[10] 12.76; Thomsen,[15] 13.18; and de Forcrand,[34] 12.80.

KOH · nH_2O (c). Berthelot[20] measured the heats of solution of the hydrates with $\frac{1}{8}$ and 2 moles of H_2O; de Forcrand,[34] those with 0.25, 0.535, 0.91, 1.16, and 1.55 moles of H_2O.

KOH (c, I). Hevesy[1] determined the heat of transition.

KOH (g). von Wartenberg and Albrecht[1] gave $V=-32.45^{1500}$.

K_2O (c). Rengade[3] measured the heats of solution of K (c) and K_2O (c). The difference gives, for K_2O (c) + H_2 (g) = 2 K (c) $+H_2O$ (liq.), $Q=-17.8$; whence, for K_2O (c), $Qf=86.2$. Beketoff's[2] data on the heat of solution of K_2O (c), yield $Qf=94(?)$.

K_2O_n (c). de Forcrand[66] measured the heats of solution of K_2O_3 (c) and K_2O_4 (c) in H_2SO_4 (aq.).

KH (c). Moutier[1] calculated the heat of dissociation from the dissociation pressure data of Troost and Hautefeuille.[8] Keyes[1] computed D from his data on the dissociation pressure. Kasarnowsky and Proskurnin[1] reported that Monossohn measured the heats of solution of K (c) and KH (c), and found, for the latter, $Qf=8$ to 10. The data of Moutier and Keyes yield, respectively, for KH (c), $Qf=14.7$ and 9.8.

KF (aq.). Guntz[1] and Mulert[1] measured the heat of neutralization of HF (aq.) with KOH (aq.). Their data yield, respectively, KF(400), $Qf=138.12$, and KF (80), $Qf=140.7$. Berthelot and Guntz[2] measured the heat of mixing HCl(110) with KF(110) and of HF(110) with KCl(110); whence, for KF(110), $Qf=138.70$. The heat of dilution was measured by Lange and Eichler,[1] Lange and Messner,[2] de Forcrand,[58] and Guntz.[1]

KF (c). The heat of solution data yield the following values for S_{200}: Guntz,[1] 3.60; de Forcrand,[12, 58] 4.20; and Lange and Eichler,[1] 3.85.

KF (liq.). According to Plato,[2] the heat of fusion is -6.27.[880]

KF (g). The vapor pressure was measured by Ruff, Schmidt, and Mugdan[1] and von Wartenberg and Schultz.[1] See also van Laar.[9]

KF · 2 H_2O (c). The data on the heat of solution yield the following

values for S_{200}: Guntz[1], −1.05; de Forcrand,[58] −2.11; and Lange and Eichler,[1] −1.96.

KF · 4 H_2O (c). de Forcrand[58] measured the heat of solution.

KHF_2 (aq.). Guntz[1] measured the heat of mixing KOH (aq.) with 2 HF (aq.) and of HF (aq.) with KF (aq.), his data yielding, respectively, KHF_2 (aq.), $Qf = 213.38$, and $KHF_2(400)$, $Qf = 213.53$. Guntz[1] also measured the heat of dilution of KHF_2 (aq.) from 28 to 222 H_2O. We have extrapolated his data to infinite dilution, assuming no dissociation of HF_2^- (aq.).

KHF_2 (c). The data of Guntz[1] and de Forcrand[60] yield identical values for the heat of solution.

KF · nHF (c). Guntz[4] measured the heats of solution of KF · 2 HF (c) and KF · 3 HF (c).

KCl (aq.). The heat of neutralization of HCl (aq.) with KOH (aq.) was measured by Hess,[1, 5] Andrews,[2, 7, 11] Favre and Silbermann,[3] Favre,[3] Berthelot,[10, 19, 4, 84] Thomsen,[15] Muller,[1, 10] Richards and Rowe,[3] and Gillespie, Lambert, and Gibson.[1] The data from the last two investigations were recomputed by Rossini,[6] giving $N = 14.085_{201}$. The heat of dilution of KCl (aq.) was measured by van Deventer and van der Stadt,[1] Scholz,[3] Stackelberg,[1] Varali-Thevenet,[1] Rümelin,[1] Bishop,[1] Brönsted,[9] Magie,[1] Colson,[5] Pratt,[1] Stearns and Smith,[1] Richards and Rowe,[2] Laksonen,[1] Mondain-Monval,[3] Wust and Lange,[1] Sandonnini and Gerosa,[1] Nernst and Orthmann,[1, 2] Harrison and Perman,[1] Nernst and Naudè,[1] Holluta and Werner,[1] Lange and Leighton,[1] and Partington and Soper.[1] The modern data on the dilute range were reviewed by Rossini,[5] who gave values from ∞ to 25 H_2O.

KCl (c). The data on the heat of solution of KCl (c) have been recomputed to give the following values for S_{200} (the value following the investigator's name shows the data before conversion to 18° and 200 H_2O): Andrews,[14] −...; Winkelmann,[1] $-5.02_{132}{}^0$, −4.37; Berthelot,[10] $-4.19_{200}{}^{21}$, −4.31; Rechenberg,[1] $-4.43_{200}{}^{18\,2}$, −4.44; Ostwald,[1] $-4.56_{278}{}^{17}$, −4.50; Berthelot and Ilosvay,[1] $-4.30_{104}{}^{18}$, −4.36; Thomsen,[15] $-4.427_{200}{}^{18}$, −4.427; Pickering,[7] $-4.480_{400}{}^{18}$, −4.467; Scholz,[1] $-5.28_{220}{}^0$; −4.48; Stackelberg,[1] $-4.291_{100}{}^{18}$, −4.362; Varali-Thevenet,[1] $-5.52_{415}{}^0$, −4.79; Zemczuzny and Rambach,[1] $-4.433_{100}{}^{18?}$, −4.45(?); Brönsted,[9] $-4.404_{200}{}^{19.7}$, −4.466; Haigh,[1] $-4.321_{400}{}^{20\text{-}22}$, −4.44; Colson,[5] $-4.545_{220}{}^{17.9}$, −4.542; Cohen, Heldermann, and Moesveld,[1] $-4.398_{200}{}^{18}$, −4.398; Laksonon,[2] $-5.28_{220}{}^0$, −4.57; Mondain-Monval,[3] $-4.27_{100\text{-}200}{}^{18}$, −4.30; Wust and Lange,[1] $-4.123_{50}{}^{25}$, −4.500; Gire,[1] $-4.66_{250}{}^{11.5}$, −4.41; Sandonnini and Gerosa,[1] $-4.508_{214}{}^{18?}$, −4.51(?); Holluta and Werner,[1] $-4.517_{90.3}{}^{18.5}$, −4.59; Cohen and Kooy,[1] $-4.373_{200}{}^{20}$, −4.447; Partington and Soper,[1] $-4.266_{180}{}^{25}$, −4.518; Roth and Eymann,[1] $-4.322_{150}{}^{21}$, −4.448; Lange and Monheim,[2] $-4.694_{500}{}^{12.5}$, −4.453; Agostini,[1] $-4.314_{300}{}^?$ and $-4.32_{800}{}^?$, (?). We have selected as the best value for S_{200}, the average of those from the data of Cohen and Kooy, −4.447, Roth and Eymann, −4.448, and Lange and Monheim, −4.453.

There is an old value by Andrews[16] for the heat of the reaction K (c) $+\frac{1}{2}$ Cl_2 (g) = KCl (c).

KCl (liq.). The data on the heat of fusion are: Zemczuzny and Rambach,[1] −4.69; Plato,[1] −6.41.

KCl (g). The vapor pressure was measured by Hackspill and Grandadam,[1] Fiock and Rodebush,[1] Horiba and Baba,[1] Jackson and Morgan,[1] Ruff and Mugdan,[1] and von Wartenberg and Albrecht.[1] We have taken $V = -38.4^{1200}$. From the spectral absorption limit, Franck, Kuhn and Rollefson[1] calculated, for KCl (g), $D^z = -103$.

KClO (aq.). Berthelot[151] measured the heat of reaction of KOH (aq.) with HClO (aq.), and also (Berthelot[26]) of 2 KOH (aq.) with Cl_2 (aq.). Neumann and Muller[2] performed similar experiments. Their data yield the following values, respectively, for KClO (aq.), 85.81, 86.74, 86.36, and 85.44.

$KClO_3$ (aq.). From the ions, we have computed, for $KClO_3(\infty)$, $Qf = 81.02$. The data of Stackelberg[1] give the heat of dilution from 125 to 500 H_2O. We have estimated the values to ∞ H_2O.

$KClO_3$ (c). The data on the heat of solution yield the following values for S_{400}: Berthelot,[10] −9.36; Thomsen,[15] −10.18; Stackelberg,[1] −10.15. Frankland[1] measured, in a bomb calorimeter, the heat of decomposition of $KClO_3$ (c) into KCl (c) and O_2 (g). Thomsen[15] also determined the heat of decomposition of $KClO_3$ (c), his data yielding $Qf = 94.65$.

$KClO_4$ (c). Berthelot and Vielle[4] determined the heat of decomposition of $KClO_4$ (c) into KCl (c) and O_2 (g), in a bomb calorimeter using potassium picrate and ammonium picrate as the auxiliary combustibles. Their data yield, for $KClO_4$ (c), $Qf = 110.9$ and 113.0, respectively.

$KClO_4$ (aq.). The heat of solution data have been recomputed to give the following values for S: Berthelot,[79] -11.54_{300}; Stackelberg,[1] -12.30_{1000}, and -11.81_{500}; Noyes and Samet,[1] -12.27_{460}; and Latimer and Ahlberg,[1] -12.62_{1800}. We have estimated the heat of dilution from 200 to ∞ H_2O, utilizing the data on the heat of solution, which were obtained at various concentrations.

KBr (aq.). The heat of neutralization of HBr (aq.) with KOH (aq.) was measured by Berthelot,[10] Thomsen,[15] and Richards and Rowe.[8] The data of Richards and Rowe have been recomputed, giving $N = 14.061_{201}$. Data on the heat of dilution were reported by Wust and Lange,[2] Rümelin,[1] Dunnington and Hoggard,[1] and Berthelot.[83]

KBr (c). The data on the heat of solution have been recomputed, giving the following values for S_{200}: Berthelot,[10] −5.15; Berthelot and Ilosvay,[1] −5.01; Thomsen,[15] −5.091; Scholz,[1] −5.07; Brönsted,[4] −5.110; Walden,[3] −5.085; and Wust and Lange,[2] −5.119.

KBr (liq.). The value for the heat of fusion has been estimated.

KBr (g). The vapor pressure of KBr was measured by Fiock and Rodebush,[1] von Wartenberg and Albrecht,[1] and Ruff and Mugdan.[1] We have taken Fiock and Rodebush's value, $V = -40.1^{1000}$. See also Sommermeyer[1] and Franck, Kuhn, and Rollefson.[1]

KBrO (aq.). Thomsen[15] measured the heat of reaction between Br_2 (1400) and 2 KOH (40). His data yield, for KBrO (aq.), $Qf = 81.70$. Berthelot's[81] data on the reaction between bromine and aqueous KOH are apparently uncertain.

$KBrO_3$ (aq.). Thomsen found $N = 13.77_{801}$. The heat of dilution from 200 to ∞ H_2O has been estimated.

$KBrO_3$ (c). The heat of solution data yield the following values for S_{400}: Berthelot,[45] −9.32; Thomsen,[15] −10.12; and Stackelberg,[1] −9.87.

KI (aq.). The heat of neutralization of HI (aq.) with KOH (aq.) was measured by Berthelot,[10] Thomsen,[15] and Richards and Rowe.[3] The data of Richards and Rowe have been recomputed, giving $N = 13.975_{201}$. The heat of dilution was measured by Wust and Lange[2] and Dunnington and Hoggard.[1]

KI (c). The data on the heat of solution yield the following values for S_{200}: Berthelot,[10] −5.00; Berthelot and Ilosvay,[1] −4.99; Thomsen,[15] −5.197; Scholz,[1] −5.05; Walden,[3] −5.206; and Wust and Lange,[2] −5.168. We have selected as the best value the average of those of Thomsen, Walden, and Wust and Lange.

KI (g). Vapor pressure data were reported by Fiock and Rodebush,[1] Ruff and Mugdan,[1] and von Wartenberg and Albrecht.[1] See also Mayer,[3] Weinberg,[2] and Reis.[1] We have selected $V = -37.6^{900}$. From Franck, Kuhn, and Rollefson's[1] value for KI (g) = K (g) + I (g), calculated from the spectral absorption limit, we have computed, for KI (g), $Qf = 30.3$; while from Mayer's[3] value for KI (g) = K^+ (g) + I^- (g), we have computed, for KI (g), $Qf = 28.2$. See also Sommermeyer.[1]

KI (methyl alcohol, ethyl alcohol, acetonitrite, acetone). Walden[3] measured the heat of solution of KI (c) in these liquids.

KI_3 (c). Berthelot[64] measured the heat of solution of KI_3 (c) and of KI (c) in H_2O, and of I_2 (c) in KI (aq.).

KIO_3 (aq.). Berthelot[42] and Thomsen[15] measured the heat of neutralization of HIO_3 (aq.) with KOH (aq.). Their data yield, respectively, $N = 14.10_{440}$ and 13.80_{800}, giving, for KIO_3(800), $Qf = 115.00$ and 114.85. From Berthelot's[45] measurement of the heat of reaction of 3 I_2 (c) with 6 KOH(220), we have calculated, for KIO_3 (aq.), $Qf = 114.5$. Some few data on the heat of dilution of KIO_3 (aq.), from 110 to 500 H_2O, were reported by Berthelot[45] and Stackelberg.[1] We have estimated the values to 100 H_2O and to infinite dilution.

KIO_3 (c). The data on the heat of solution yield the following values for S_{400}: Berthelot,[45] −5.57; Thomsen,[15] −6.78; and Stackelberg,[1] −6.61.

KIO_4 (aq.). The data of Thomsen[15] yield $N = 5.13_{1200}$.

KH_4IO_6, $K_2H_3IO_6$, $K_3H_2IO_6$ (aq.). Thomsen[15] measured the heat of mixing H_5IO_6(600) with 1, 2, and 3 moles of KOH(600), respectively.

$KIO_3 \cdot HIO_3$ (aq.). Thomsen[15] measured the heat of mixing KIO_3 (800) with HIO_3(800).

$KIO_3 \cdot HIO_3$ (c). Berthelot[45] measured the heat of solution.

KI · KCl (c, fresh melt). Beketoff[8] measured the heats of solution of the fresh melt and of KCl (c) + KI (c).

K_2S (aq.). Sabatier[1] measured the heat of neutralization of 2 KOH (200) with H_2S (g). His data yield, for $K_2S(400)$, $Qf = 110.4$. Sabatier[1] measured the heat of dilution from 7 to 400 H_2O. We have estimated the heat of dilution from 400 to ∞ H_2O to be zero.

K_2S (c). Sabatier[1] found $S = 10_{580}$, Favre and Silbermann,[3] $S = 10.6$, Rengade and Costeanu,[1] $S = 22.6_{400}$'.

$K_2S \cdot nH_2O$ (c). Sabatier[1] measured the heats of solution of the dihydrate and the pentahydrate.

K_2S_n (aq.). Sabatier[1] measured the heats of reaction of I_2 (c) with $K_2S_{3\frac{1}{2}}$ (aq.), and K_2S_4 (aq.), respectively.

$K_2S_{3\frac{1}{2}}$ (c). Sabatier[1] measured the heat of solution.

$K_2S_4 \cdot nH_2O$ (c). Sabatier[1] measured the heats of solution of the anhydrous salt, the hemihydrate, and the dihydrate.

KHS (aq.). Sabatier[1] measured the heat of reaction of H_2S (aq.) with KOH (aq.), and of KHS (aq.) with KOH (aq.). His data yield, for KHS(200), $Qf = 64.07$ and 64.47, respectively. The heat of dilution was measured by Sabatier[1] from 2.8 to 200 H_2O. We have estimated the value to ∞ H_2O, assuming no dissociation of HS^- (aq.).

$KHS \cdot nH_2O$ (c). Sabatier[1] measured the heats of solution of KHS (c) and $KHS \cdot \frac{1}{2} H_2O$ (c).

K_2SO_4 (aq.). Berthelot[4, 7] and Thomsen[15] each measured the heat of neutralization of H_2SO_4 (aq.) with KOH (aq.), and performed a number of pairs of "double decomposition" experiments involving K_2SO_4 (aq.). Muller[10] measured the heat of neutralization of $H_2SO_4(55)$ with KOH (aq.) of various concentrations. Brönsted,[10] from electromotive force measurements, obtained the heat of the reaction, KCl (c) + $\frac{1}{2}$ Na_2SO_4 (c) = NaCl (c) + $\frac{1}{2}$ K_2SO_4 (c), whence, by using the heat of solution of K_2SO_4 (c), we have obtained a value for K_2SO_4 (aq.). The foregoing data have been recomputed to give the following values for $K_2SO_4(400)$: Berthelot, neutralization, 336.46; Berthelot, "double decomposition," K^+, SO_4^{--}, Na^+, OH^-, 336.25; Berthelot, "double decomposition," K^+, SO_4^{--}, H^+, Cl^-, 337.05; Berthelot, "double decomposition," K^+, SO_4^{--}, H^+, NO_3^-, 336.01; Berthelot, "double decomposition," K^+, SO_4^{--}, Na^+, Cl^-, 336.37; Berthelot, "double decomposition," K^+, SO_4^{--}, Na^+, NO_3^-, 335.91; Thomsen, neutralization, 336.05; Thomsen, "double decomposition," K^+, SO_4^{--}, H^+, NO_3^-, 336.69; Thomsen, "double decomposition," K^+, SO_4^{--}, Na^+, OH^-, 336.12; Thomsen, "double decomposition," K^+, SO_4^{--}, H^+, Cl^-, 336.56; Thomsen, "double decomposition," K^+, SO_4^{--}, H^+, Cl^-, 336.33; Muller, neutralization, 336.58; Brönsted, Qf of solid + heat of solution, 336.44. There are old values of the heat of neutralization by Hess,[5] Andrews,[7, 2] Favre and Silbermann,[3] and Favre.[3] The heat of dilution of K_2SO_4 (aq.) was measured by Lange and Streeck,[1] Mondain-Monval,[3] Brönsted,[9] Rümelin,[1] Varali-Thevenet,[1] and Scholz.[1]

K_2SO_4 (c, II). The data on the heat of solution yield the following values for S_{400}: Favre and Silbermann,[8] (?); Favre,[8] (?); Berthelot,[10] (?); Berthelot and Ilosvay,[1] (?); Tilden,[2] −6.13; Pickering,[2] −6.54; Thomsen,[15] −6.33; Scholz,[1] −6.72; Varali-Thevenet,[1] −6.76; Brönsted,[9] −6.38; Mondain-Monval,[3] −6.60 (?); Cohen and Kooy,[1] −6.444. We have taken the average of the values from Pickering, Thomsen, Brönsted, and Cohen and Kooy.

$KHSO_4$ (aq.). Berthelot[6] and Thomsen[15] measured the heat of mixing H_2SO_4 (aq.) with K_2SO_4 (aq.). Their data yield, for $KHSO_4(200)$, $Qf = 273.02$ and 273.20, respectively. The heat of dilution of $KHSO_4$ (aq.) was measured by Berthelot[6] and Thomsen.[15]

$KHSO_4$ (c, III). The data on the heat of solution yield the following values for S_{200}: Graham,[2] (?); Favre,[8] (?); Berthelot,[10] −3.0 (?); Thomsen,[15] −3.75.

$KHSO_4$ (c, II), $KHSO_4$ (c, I). Bridgman[7] determined the heats of transition.

$KHSO_3$ (aq.). Berthelot[92] measured the heat of mixing $H_2SO_3(275)$ with $KOH(110)$. His data yield, for $KHSO_3(385)$, $Qf = 209.70$.

K_2SO_4 (c, I). Hare[1] measured the heat of transition.

K_2SO_3 (aq.). Berthelot[92] measured the heat of neutralization of H_2SO_3 (aq.) with KOH (aq.). His data yield, for $K_2SO_3(500)$, $Qf = 271.2$.

K_2SO_3 (c). Berthelot[92] measured the heat of solution. The data of Martin and Metz,[1] who measured the heat of reaction, in a bomb calorimeter, between K_2SO_3 (c), Mg (c), and O_2 (g), yield $Qf = 273$.

$K_2SO_3 \cdot H_2O$ (c). Berthelot[92] measured the heat of solution.

$K_2S_2O_5 \cdot nH_2O$ (c). Berthelot[94] measured the heats of solution of the anhydrous salt and the hemihydrate.

$K_2S_2O_3$ (c). Berthelot[93] measured the heat of solution. The data of Martin and Metz,[1] who measured, in a bomb calorimeter, the heat of the reaction, $K_2S_2O_3$ (c) + Mg (c) + $2\frac{1}{2}$ O_2 (g) = K_2SO_4 (c) + $MgSO_4$ (c), yield $Qf = 283$.

$K_2S_2O_6$ (c). The data of Martin and Metz[1] (see $K_2S_2O_3$ (c)) yield $Qf = 415.8$. The data of Thomsen[15] on the reaction, $K_2S_2O_6$ (c) = K_2SO_4 (c) + SO_2 (g), yield $Qf = 413.7$.

$K_2S_2O_6$ (aq.). Thomsen[15] measured the heat of solution of $K_2S_2O_6$ (c).

$K_2S_2O_7$ (c). Berthelot[4] measured the heat of solution of $K_2S_2O_7$ (c) in H_2O to form 2 $KHSO_4$ (aq.).

$K_2S_2O_7$ (aq.). Berthelot[4] measured the heat of solution of $K_2S_2O_7$ (c) in H_2O, taking the initial heat of solution, i. e., before $S_2O_7^{--}$ (aq.) was hydrated to 2 HSO_4^- (aq.).

$K_2S_2O_8$ (aq.). The value of Qf for this substance is computed from those for the aqueous ions.

$K_2S_2O_8$ (c). Berthelot[107] measured the heat of solution.

$K_2S_3O_6$ (c). Berthelot[108] measured the heat of reaction of $K_2S_3O_6$ (c) with KBr_3 (aq.). His data yield $Qf = 411.2$. The data of Martin and Metz[1] (see $K_2S_2O_3$ (c)) yield $Qf = 402$.

$K_2S_3O_6$ (aq.). The data of Berthelot[103] and Thomsen[15] yield, respectively, $S = -12.45_{650}$ and -12.38_{500}.

$K_2S_4O_6$ (c). The data of Martin and Metz[1] (see $K_2S_2O_3$ (c)) yield $Qf = 393$. Thomsen[15] measured the heat of solution.

$K_2S_4O_6$ (aq.). This value is obtained from those for the aqueous ions.

$K_2S_5O_6$ (aq.). Berthelot[103] measured the heat of reaction of $K_2S_5O_6$ (aq.) with 10 KBr_3 (aq.), and also of $K_2S_5O_6$ (aq.) with 3 NaOH (aq.). His data yield, respectively, $Qf = 398.1$ and 400.7.

$K_2S_5O_6$ (c). The data of Martin and Metz[1] (see $K_2S_2O_3$(c)) yield $Qf = 386$. We have estimated 408.

$K_2S_5O_6 \cdot 1\frac{1}{2}\,H_2O$ (c). Berthelot[103] measured the heat of solution.

$KI \cdot 4\,SO_2$ (c). Ephraim and Kornblum[1] found $D = -9.67$.

K_2Se (aq.). Fabre[1] measured the heat of reaction of H_2S (g) with 2 KOH(220), and of H_2S(4000) with 2 KOH(220). His data yield, for K_2Se(440), $Qf = 82.72$, and for K_2Se(4400), $Qf = 83.76$.

$K_2Se \cdot nH_2O$ (c). Fabre[1] measured the heats of solution of the anhydrous salt and of the hydrates, with 9, 14, and 19 moles of H_2O.

KHSe (aq.). The data of Fabre,[1] who measured the heat of mixing KOH (aq.) with H_2Se(4000), yield, for KHSe(4200), $Qf = 34.03$.

K_2SeO_4 (aq.). The data of Metzner[2, 1] yield $N = 31.19_{440}$, whence for K_2SeO_4(440), $Qf = 266.95$. We have estimated the heat of dilution to ∞ H_2O.

$KHSeO_4$ (aq.). Metzner[2, 1] found, for the heat of mixing H_2SeO_4 (220) with K_2SeO_4(220), $Q^{15} = -1.24$.

K_2TeO_3 (aq.). Metzner[1, 2] found, for the heat of solution of TeO_2 (c) in KOH (aq.), $Q^{15} = 22.76$.

K_2TeO_4 (aq.). The data of Metzner[1, 2] yield $N = 31.24_{220}$.

KNO_3 (aq.). The heat of neutralization of HNO_3 (aq.) with KOH (aq.) was measured by Hess,[6] Andrews,[2, 7, 11] Favre and Silbermann,[3] Favre,[3] Berthelot,[4] Thomsen,[15] and Richards and Rowe.[3] The data of Richards and Rowe were recomputed by Rossini,[6] giving $N = 14.165_{201}$. Data on the heat of dilution of KNO_3 (aq.) were given by Winklemann,[1] Scholz,[1] Stackelberg,[1] Varali-Thevenet,[1] Rümelin,[1] Bishop,[1] Colson,[5] Pratt,[1] Richards and Rowe,[2] Mondain-Monval,[3], Nernst and Orthmann,[1] Nernst and Naudè,[1] Roth,[11] Roth and Eymann,[1] Roth and Muller,[5] and Lange and Monhein.[2] The modern data in the dilute range were reviewed by Rossini,[5] who gave values from ∞ to 25 H_2O.

KNO_3 (c, III). The data on the heat of solution have been recomputed to give the following values for S_{200}: Person,[6] (?); Winkelmann,[1] −8.42; Berthelot,[10] (?); Tilden,[2] −8.12; Thomsen,[15] −8.49; Pickering,[7] −8.41; Scholz,[1] −8.51; Stackelberg,[1] −8.43; Varali-Thevenet,[1] −8.28; Haigh,[1] −8.28; Colson,[5] −8.65; Mondain-Monval,[3] −8.3; Holluta and Werner,[1] −8.57; Berenger-Calvet,[1] −8.25; Zawidski and Schogger,[1] (?); Roth,[11] −8.282; Roth and Muller,[5] −8.467; Cohen and Kooy,[1] −8.395; Roth and Eymann,[1] −8.399; Lange and Monhein,[1] −8.404. We have taken the average of the last three values.

KNO_3 (c, II), KNO_3 (c, I). Potassium nitrate shows a change of crystal form at about 128°. According to Bridgeman's[6a] analysis, there are really two transitions with $T=0.62_{I\rightarrow II}^{126}$ and $1.17_{II\rightarrow III}^{128}$. See also Bellati and Romanese.[3]

KNO_3 (liq.). Data for obtaining the heat of fusion were recorded by Person[1] and Goodwin and Kalmus.[1]

KNH_3 (c). Joannis[3] found $D=-6.4$.

$KX\cdot nNH_3$ (c). Biltz and Hansen[1] measured the temperature coefficient of the dissociation pressure for $KBr\cdot 4NH_3$ (c), $KI\cdot 4NH_3$ (c), and $KI\cdot 6NH_3$ (c).

KH_2PO_4 (c). Graham[1] measured the heat of solution.

KH_2AsO_4 (c). Graham[1] measured the heat of solution.

K_2CO_3 (aq.). Berthelot[4] measured the heat of mixing CO_2 (aq.) with 2KOH (aq.); Muller[1] that of mixing K_2CO_3 (aq.) with 2HCl (aq.). Their data yield, respectively, for $K_2CO_3(1800)$, $Qf=280.61$, and for $K_2CO_3(1950)$, $Qf=280.66$. Data on the heat of dilution were given by Berthelot,[4] Thomsen,[15] Rümelin,[1] and de Forcrand.[52] We have estimated the values from 400 to ∞ H_2O.

K_2CO_3 (c). The data on the heat of solution yield the following values for S_{400}: Berthelot,[10] 6.8 (?); Berthelot and Ilosvay,[1] 6.66; Ostwald,[1] 6.64; Thomsen,[15] 6.59.

K_2CO_3 (liq.). Sackur[1] reported the heat of fusion.

$K_2CO_3\cdot nH_2O$ (c). Thomsen[15] measured the heats of solution of $K_2CO_3\cdot\frac{1}{2}H_2O$ (c) and $K_2CO_3\cdot 1\frac{1}{2}H_2O$ (c). Berthelot's[10] measurement of the heat of solution of the latter lacks adequate information as to concentration and temperature.

$KHCO_3$ (aq.). Berthelot[4] measured the heat of mixing CO_2 (aq.) with KOH (aq.); Muller[1] that of mixing $KHCO_3$ (aq.) with HCl (aq.). Their data yield, respectively, for $KHCO_3(1900)$, $Qf=225.01$, and for $KHCO_3(1000)$, $Qf=224.96$.

$KHCO_3$ (c). The data of Berthelot[10] and de Forcrand[53] yield for the the heat of solution, -5.2_{400} and -5.2_{220}, respectively. The dissociation pressure data of Caven and Sand[2] yield $Qf=228.9$.

$5(K_2CO_3\cdot 1\frac{1}{2}H_2O)\cdot 4KHCO_3$ (c). de Forcrand[54] measured the heat of solution.

$K_2C_2O_4$ (aq.). Berthelot[10] measured the heat of neutralization of $H_2C_2O_4(220)$ with $2\,KOH(110)$. Berthelot and Guntz[1] measured the heat of mixing $KF(110)$ with $\frac{1}{2}H_2C_2O_4(220)$, and of $HF(110)$ with $\frac{1}{2}K_2C_2O_4(220)$. Their data yield, respectively, for $K_2C_2O_4(440)$, $Qf=316.16$, and for $K_2C_2O_4(220)$, $Qf=316.5$.

$K_2C_2O_4$ (c). Berthelot[10] measured the heat of solution of potassium oxalate.

$K_2C_2O_4\cdot H_2O$ (c). For the heat of solution, the data of Berthelot[10] and Thomsen[15] yield, respectively, $-7.57_{400?}$ and -7.52_{800}.

$KCHO_2$ (aq.). Berthelot[8] measured the heat of neutralization of aqueous formic acid with KOH (aq.), and performed "double decom-

position" experiments involving K^+, CHO_2^-, H^+, Cl^-. His data yield, respectively, for $KCHO_2(480)$, $Qf=159.67$, and for $KCHO_2(330)$, $Qf=160.18$.

$KCHO_2$ (c). Berthelot[10] measured the heat of solution of potassium formate.

$KC_2H_3O_2$ (aq.). Berthelot[10] and Berthelot and Guntz[1] performed "double decomposition" experiments involving K^+, $C_2H_3O_2^-$, H^+, Cl^- and K^+, $C_2H_3O_2^-$, H^+, F^-, respectively. Their data yield, for $KC_2H_3O_2(110)$, $Qf=178.43$ and 177.69. Thomsen[15] measured the heat of dilution of aqueous potassium acetate from 5 to 200 H_2O. We have estimated the values to infinite dilution.

$KC_2H_3O_2$ (c). The data of Thomsen[15] and Berthelot[10, 131] yield, for the heat of solution of potassium acetate, 3.34_{200} and 3.37_{200}, respectively.

$KCH_3O(CH_3OH)$. de Forcrand[16] measured the heat of solution of K (c) in methyl alcohol.

$KC_2H_5O(C_2H_5OH)$. de Forcrand[16] and van Deventer and Reicher[2] measured the heat of solution of K (c) in ethyl alcohol. Their data, respectively, yield for KC_2H_5O (60 C_2H_5OH), $Qf=116.49$, and for KC_2H_5O (427 C_2H_5OH), $Qf=117.64$.

$KC_2H_3O_3$ (aq.). de Forcrand[3] measured the heat of neutralization of aqueous glycollic acid.

$KC_2H_3O_3 \cdot n\,H_2O$ (c). de Forcrand[3] measured the heats of solution of the anhydrous salt and the hemihydrate of potassium glycollate.

KCN (aq.). Berthelot[27] measured the heat of neutralization of HCN(110) with KOH(110). His data yield $N=2.93_{220}$. Thomsen[15] measured the heat of dilution from $62\frac{1}{2}$ to 150 H_2O.

KCN (c). The data of Berthelot[10] and Thomsen[15] yield, respectively, for the heat of solution, -2.93_{200} and -3.08_{1740}.

KCNO (aq.). The data of Berthelot[100] yield $N=12.2$.

KCNO (c). The heat of solution was measured by Berthelot.[10]

KCNS (aq.). The data of Joannis[1] yield $N=14.0$. Partington and Soper[1] measured the heat of dilution at 25° in the range 2.3 to 200 H_2O. We have converted their data to 18° and extrapolated to infinite dilution.

KCNS (c). The heat of solution data yield the following values for S_{200}: Joannis,[1] −5.98; Wrzesnewsky,[1] −6.22; Partington and Soper,[1] −6.00.

$KCNS \cdot nSO_2$ (c). Ephraim and Kornblum[1] found for $n=\frac{1}{2}$, $D=-11.3$, and for $n=1$, $D=-9.9$.

K_2SiF_6 (c). Truchot[2] measured the heat of reaction of $H_2SiF_6(330)$ with 2KOH(110), and of SiF_4 (g) with 2KF (aq.); Hantke,[1] that of $H_2SiF_6(220)$ with 2KOH(110). Their data yield, respectively, for K_2SiF_6 (c), $Qf=683.9$, 684.5, and 682.1.

K_2SnCl_6 (aq.). Thomsen[15] measured the heat of mixing 2KCl(150) with $SnCl_4(300)$.

K_2SnCl_6 (c). The heat of solution was measured by Thomsen.[15]

$K_2SnCl_6 \cdot H_2O$ (c). Thomsen[15] measured the heat of solution.

$KCl \cdot nPbCl_2 \cdot mH_2O$ (c). Brönsted,[10] from electromotive force measurements, determined the heat of reaction of KCl(c) with $PbCl_2$(c) and H_2O (liq.) to form $KCl \cdot 2\,PbCl_2$ (c) and $KCl \cdot PbCl_2 \cdot \frac{1}{3}\,H_2O$ (c), respectively.

$2KI \cdot PbI_2 \cdot nH_2O$ (c). Berthelot[89] measured the heats of solution of the anhydrous salt and the dihydrate.

$4KI \cdot 3PbI_2 \cdot nH_2O$ (c). Berthelot[89] measured the heats of solution of $4KI \cdot 3PbI_2$ (c, fresh melt) and the hexahydrate.

$K_2SO_4 \cdot PbSO_4$ (c). The data of Barre,[1] who measured the heats of solution of $K_2SO_4 \cdot PbSO_4$ (c) and of K_2SO_4 (c) $+ PbSO_4$ (c), and Brönsted,[9] who measured the heats of solution of the double salt and of K_2SO_4 (c) in $Pb(NO_3)_2$ (aq.), yield, for K_2SO_4 (c) $+ PbSO_4$ (c) $= K_2SO_4 \cdot PbSO_4$ (c), $Q = -0.02$ and 5.30, respectively. From electromotive force measurements, Brönsted[9] found $Q = 5.09$.

$K_2Zn(SO_4)_2 \cdot nH_2O$ (c). Thomsen[15] measured the heats of solution of the anhydrous salt, the dihydrate, and the hexahydrate. The first data on the anhydrous salt and the hexahydrate were obtained by Graham.[2] The vapor pressure data of Caven and Ferguson[2] yield, for the hexahydrate, $Qf = 1010.9$.

$2KCN \cdot Zn(CN)_2$ (c). Berthelot[114] measured the heat of solution.

KHg_n (liq.). The data of Berthelot,[56] Lewis and Keyes,[1] and Smith and Ball,[1] yield, respectively: $n = 57.5$, $Qf = 25.6$; $n = 86.5$ $Qf = 26.0$; $n = 145$, $Qf = 25.9$.

KHg_n (c). Berthelot[55] measured the heat of solution of $KHg_{2.59}$ (c) in H_2O and in HCl(200), and (Berthelot[56]) of four solid amalgams, with n ranging from 1.45 to 12.0, in HCl(300).

$nKCl \cdot HgCl_2$ (aq.). Berthelot[83] measured the heat of mixing $HgCl_2$ (440) with $\frac{1}{2}$, $\frac{3}{4}$, 1, 2, and 4 moles of KCl(110), respectively; Thomsen[15] that of $HgCl_2$ (c) with 2KCl(150).

$nKCl \cdot HgCl_2 \cdot mH_2O$ (c). Berthelot[83] measured the heats of solution of $KCl \cdot HgCl_2$ (c) and its monohydrate, $2KCl \cdot HgCl_2$ (c), $4KCl \cdot 3HgCl_2$ (c) and its trihydrate, and $2KCl \cdot HgCl_2 \cdot H_2O$ (c). Thomsen[15] also measured the heat of solution of the last named compound and, for it, their data yield the values: Thomsen, -16.43_{600}; Berthelot, -16.53_{970}.

$nKBr \cdot HgBr_2$ (aq.). Berthelot[83] measured the heats of mixing KBr(110) with $HgBr_2$(4400); Varet[6] of KBr(220) with $HgBr_2$(4400). Thomsen[15] measured the heat of solution of $HgBr_2$ (c) in 2KBr(150).

$nKBr \cdot HgBr_2 \cdot mH_2O$ (c). Berthelot[83] measured the heats of solution of $KBr \cdot HgBr_2$ (c) and of its monohydrate, in 5 KBr(110). Thomsen[15] measured the heat of solution of $2\,KBr \cdot HgBr_2$ (c).

$nKI \cdot HgI_2$ (aq.). Berthelot[85] measured the heat of solution of HgI_2 (c, red) in 2, 3, 4, and 6 moles of KI(110); Thomsen[15] that in 2 KI(200) $+ 500\,H_2O$.

$nKI \cdot HgI_2 \cdot mH_2O$ (c). Berthelot[83] measured the heats of solution of $KI \cdot HgI_2$ (c) and of its monohydrate, in 13 KI(110); Thomsen[15] that of $2\,KI \cdot HgI_2$ (c) in water.

***n*KCN · Hg(CN)$_2$ (aq.).** Berthelot[85] measured the heats of mixing Hg(CN)$_2$(440) with ½, 1, 2, 4, 8, and 16 moles of KCN(110); Varet[2] that with 1 and 2 moles of KCN(110).

2 KCN · Hg(CN)$_2$ (c). Berthelot[10] measured the heat of solution.

***n*KCl · Hg(CN)$_2$ (aq.).** Berthelot[86] measured the heats of mixing Hg(CN)$_2$(440) with ½, 1, 2, 4, and 8 moles of KCl(110); Varet[2] that with 2 moles of KCl(110).

KCl · Hg(CN)$_2$ · *n*H$_2$O (c). Berthelot[85] measured the heat of solution of the anhydrous salt and of its monohydrate.

***n*KBr · Hg(CN)$_2$ (aq.).** Berthelot[83] measured the heats of mixing Hg(CN)$_2$(440) with ½, 1, 2, 4, and 8 moles of KBr(110); Varet[2] those with 1 and 2 moles of KBr(110).

KBr · Hg(CN)$_2$ · *n*H$_2$O (c). Berthelot[83] measured the heats of solution of the anhydrous salt and the hydrate with 1½ moles of H$_2$O.

***n*KI · Hg(CN)$_2$ (aq.).** Berthelot[83] measured the heats of mixing Hg(CN)$_2$(440) with ½, 1, 2, 4, and 8 moles of KI(110); Varet[2] that with 2 moles of KI(110).

KI · Hg(CN)$_2$ · *n*H$_2$O (c). Berthelot[83] measured the heats of solution of the anhydrous salt and the hydrate with ½ H$_2$O.

KCl · CuCl$_2$ (c). Vriens[1] measured the heat of solution of this double salt; Agostini,[1] that of the double salt, of CuCl$_2$ (c), and of KCl (c). Their data yield, respectively, $Qf = 159.8$ and 162.4.

2 KCl · CuCl$_2$ (c). The electromotive force data of Brönsted[10] yield $Qf = 244.78$.

2 KCl · CuCl$_2$ (c). Bouzat and Chauvenet[2] measured the heat of solution of 2 KCl · CuCl$_2$ (c); Agostini[1] that of 2 KCl · CuCl$_2$ (c), of KCl (c), and of CuCl$_2$ (c). Their data yield, respectively, $Qf = 265.7$ and 266.2.

2 KCl · CuCl$_2$ · 2 H$_2$O (c). Bouzat and Chauvenet[2] measured the heat of solution, as did Vriens[1] and Favre and Valson.[1] The data of Bouzat and Chauvenet, and Vriens, yield, respectively, $Qf = 407.5$ and 407.0.

K$_2$Cu(SO$_4$)$_2$ (c, α) (prepared below 130°). The data of Thomsen[15] and Pickering[4] yield, respectively, for the heat of solution: 9.48_{600} and 9.67_{800}.

K$_2$Cu(SO$_4$)$_2$ (c, β) (prepared between 180 and 200°). The data of Pickering[4] yield $S = 6.23_{800}$.

K$_2$Cu(SO$_4$)$_2$ (c, fused). The data of Pickering[4] yield $S = 8.37_{800}$. Graham[2] also measured the heat of solution.

K$_2$Cu(SO$_4$)$_2$ · 2 H$_2$O (c). The data of Thomsen[15] yield $S = -1.17_{600}$.

K$_2$Cu(SO$_4$)$_2$ · 6 H$_2$O (c). Data on the heat of solution were reported by Graham[2] and Favre.[8] The data of Thomsen[15] and Pickering[5] yield $S = -13.50_{600}$ and -13.77_{800}, respectively. The dissociation pressure data of Caven and Ferguson[1] yield $Qf = 962.7$.

K$_2$Cu(CO$_3$)$_2$ (c). Pickering[11] measured the heat of solution of three crystalline forms of this double salt in HCl(35).

$nKX \cdot n'AgX \cdot mH_2O$ (c). Berthelot[86] measured the heats of solution of KCl·AgCl (c), KBr·AgBr (c), 3 KBr·AgBr·½ H_2O (c), KI·AgI·¼ H_2O (c), 2 KI·AgI·½ H_2O (c), 3 KI·AgI (c), 3 KI·AgI·½ H_2O (c), and 3 KI·2 AgI·H_2O (c).

$KAg(CN)_2$ (aq.). Varet[5] measured the heat of solution of AgCN (c) in KCN(550).

$KAg(CN)_2$ (c). Berthelot[10] measured the heat of solution of $KAg(CN)_2$ (c), and the heat of mixing $AgNO_3$(440) with 2 KCN(110).

$K_2Ag(CN)_3$ (aq.). Varet[5] measured the heats of solution of AgCN (c) in 2 KCN(110), 2 KCN(165), and 2 KCN(660), respectively.

$KAu(CN)_2$ (aq.). Biltz and Wien[1] measured the heat of solution of AuCl (c) in excess KCN (aq.).

$K_2Ni(CN)_4$ (aq.). Varet[5] measured the heat of solution of $Ni(CN)_2$ (c) in 2 KCN (aq.).

$K_2CO_3 \cdot CoCO_3 \cdot nH_2O$ (c). de Carli[1] measured the heats of solution of the anhydrous salt and the tetrahydrate in HCl(314).

$KFe(SO_4)_2$ (aq.). Thomsen[15] measured the heat of mixing $KFe(SO_4)_2$(600) with 3 KOH(400).

$K_2Fe(SO_4)_2$ (aq.). Berthelot[100] measured the heat of mixing $FeSO_4$ (220) with K_2SO_4(220).

$K_3Fe(SO_4)_3$ (aq.). Berthelot[100] measured the heat of mixing $Fe_2(SO_4)_3$(660) with $3K_2SO_4$(220).

$K_2Fe(SO_4)_2 \cdot 6\ H_2O$ (c). The data of Graham[1] yield $S = 10.3_{200}$.

$K_2Fe(SO_4)_2 \cdot 4\ H_2O$ (c). Caven and Ferguson[2] measured the dissociation pressure of the hexahydrate at various temperatures. Their data yield $D = -10.4$.

$K_nH_{3-n}Fe(CN)_6$ (aq.). Joannis[1] measured the heat of reaction of $K_4Fe(CN)_6$ (aq.) with ½ Br_2 (liq.), $K_4Fe(CN)_6$ (aq.) with ½ Cl_2 (g), $H_3Fe(CN)_6$ (aq.) with KOH (aq.), and $H_3Fe(CN)_6$ (aq.) with 2KOH (aq.). These data yield, respectively, the values for the heats of formation of $K_3Fe(CN)_6$ (aq.), $KH_2Fe(CN)_6$ (aq.), and $K_2HFe(CN)_6$ (aq.).

$K_3Fe(CN)_6$ (c). Joannis[1] measured the heat of solution.

$K_4Fe(CN)_6$ (aq.). The data of Joannis,[1] Muller,[2] and Chretien and Guinchant[1] yield, respectively, for N: 55.1; 56.08_{1390}; 57.5_{5200}. Muller's[2] data yield, for $K_4Fe(CN)_6$ (aq.), $Qf = 119.50$.

$K_nH_{4-n}Fe(CN)_6$ (aq.). Muller[2] measured the heat of mixing $H_4Fe(CN)_6$ (aq.) with 1, 2, and 3 moles of KOH (aq.).

$K_4Fe(CN)_6$ (c). Berthelot[10] found $S = -11.96_{510}$[12]; Schottky,[1] $S = -12.39_{1000}$[17].

$K_4Fe(CN)_6 \cdot 3\ H_2O$ (c). Berthelot[10] found $S = -16.92_{590}$[11]; Schottky,[1] $S = -15.69_{1000}$[17].

$K_3FeCO(CN)_5$ (aq.). Muller[9] found $N = 42.0$.

$K_3FeCO(CN)_5 \cdot nH_2O$ (c). Muller[9] measured the heats of solution of the anhydrous salt and the hydrate with 3½ H_2O.

$KMnO_4$ (aq.). Thomsen[15] measured the heats of reaction of 2 $KMnO_4$ (aq.) with 10 $FeCl_2$ (aq.), with 5 H_2O_2 (aq.), and with 5 $SnCl_2$ (aq.),

respectively, and his data yield, for $KMnO_4$ (aq.), the average value $Qf = 182.5$.

$KMnO_4$ (c). The data of Thomsen[15] yield -10.42_{500} and -10.10_{700} for the heat of solution.

$KReO_4$ (aq.). Roth and Becker[4] measured the heat of neutralization of $HReO_4$ (aq.), and gave the value $N_\infty{}^{20} = 13.5 \pm 0.1$. Converted to 18°, this value becomes 13.61 ± 0.1. From the ions we have calculated, for $KReO_4$ (∞), $Qf = 284.5$. We have estimated the heat of dilution of aqueous $KReO_4$ from the data of Roth and Becker[4] on the heat of solution of the solid salt.

$KReO_4$ (c). The data of Roth and Becker[4] yield -13.88_{3600} for the heat of solution.

$K_2Mn(SO_4)_2 \cdot nH_2O$ (c). Thomsen[15] measured the heats of solution of the anhydrous salt, the dihydrate, and the tetrahydrate.

K_2PdCl_4 (aq.). Thomsen[15] measured the heat of reaction of K_2PdCl_4 (1400) with Co (c) and 2 CuCl (c), respectively; Joannis,[4] that of K_2PdCl_4 (aq.) with 2 CuCl (c). Their data yield, respectively, $Qf = 247.8$, 248.9, and 251.4.

K_2PdCl_4 (c). Thomsen[15] found $S = -13.64_{800}{}^{19.5}$; Joannis,[4] $S = -4.6$ (?).

K_2PdCl_6 (c). Thomsen[15] measured the heat of reaction of K_2PdCl_6 (c) with 4 KI (400), and with 4 CuCl (c) in water. His data yield, respectively, $Qf = 291.26$ and 292.95.

K_2PdCl_6 (aq.). Thomsen[15] estimated the heat of solution.

K_2PdBr_4 (aq.). Joannis[4] measured the heat of reaction of Pd (c) with Br_2 (liq.) and 2 KBr (aq.).

K_2PdBr_4 (c). Joannis[4] measured the heat of solution.

K_2PtCl_4 (c). Thomsen[15] measured the heat of reaction of K_2PtCl_4 (c) with Co (c) in water.

K_2PtCl_4 (aq.). Thomsen[15] measured the heat of solution of K_2PtCl_4 (c).

K_2PtCl_6 (aq.). Thomsen[15] measured the heat of reaction of Na_2PtCl_6 (c) with 2 KCl (100); Gire[2] that of K_2PtCl_6 (aq.) with 2 Co (c). Their data yield, respectively, $Qf = 286.2$ and 289.7.

K_2PtCl_6 (c). The data of Thomsen[15] yield for the reaction, Na_2PtCl_6 (aq.) + 2 KCl (aq.) = K_2PtCl_6 (c) + 2 NaCl (aq.), $Q = 13.42$. Hence, $S = -13.42$. Gire[2] found $S = -12.15_{6600}{}^{12.5}$. Gire's[1] data on the dissociation pressure of K_2PtCl_6 (c) yield $Qf = 291$.

K_2PtBr_4 (aq.). Thomsen[15] measured the heat of reaction of K_2PtBr_4 (1500) with Br_2 (liq.), and of K_2PtBr_4 (750) with Co (c). His data yield, respectively, $Qf = 210.77$ and 210.72.

K_2PtBr_4 (c). Thomsen[15] measured the heat of solution.

K_2PtBr_6 (c). Thomsen[15] measured the heat of reaction of K_2PtBr_6 (c) with 2 Co (c) in water.

K_2PtBr_6 (aq.). Thomsen[15] measured the heat of solution of K_2PtBr_6 (c).

K_2IrCl_6 (c). The data of Gire[1] on the dissociation pressure-temperature relationship yield $Qf = 286$.

K_2IrCl_6 (aq.). Gire[2] measured the heat of solution of K_2IrCl_6 (c).

K_3IrCl_6 (aq.). Gire[2] measured the heat of the reaction, K_2IrCl_6 (aq.) $+\frac{1}{2}$ Co (c) $+$KCl (aq.) $= (K_3IrCl_6 + \frac{1}{2}\ CoCl_2)$ (aq.).

K_3IrCl_6 (c). Gire[2] measured the heat of solution. His data (Gire[1]) on the dissociation pressure yield $Qf = 373$.

K_2CrO_4 (aq.). The data of Morges[1] yield $N = 22.78_{440}$; those of Sabatier[5] yield $N = 25.4_{440}$. The heat of dilution was measured by Roth, Schwartz, and Buchner.[1]

K_2CrO_4 (c, II). Graham[2] and Morges[1] measured the heat of solution, the data of the latter yielding $S = -5.25_{543}$.

K_2CrO_4 (c, I). Hare[1] measured the heat of transition.

$K_2Cr_2O_7$ (aq.). Morges[1] measured the heat of mixing CrO_3(220) with KOH(110); Berthelot,[95] $K_2Cr_2O_7$(660) with 2 KOH(110), and 2 K_2CrO_4 (220) with 2 HCl(110); Sabatier,[5] CrO_3(220) with KOH(110), and $K_2Cr_2O_7$(220) with 2 KOH(110). Their data yield, respectively, for $K_2Cr_2O_7$(400), $Qf = 469.8$, 471.6, 471.4, 471.8, and 471.8. The data of Stackelberg[1] give the heat of dilution.

$K_2Cr_2O_7$ (c). The data on the heat of solution yield the following values for S_{400}: Graham,[2] (?); Morges,[1] -16.61; Berthelot,[95] -16.20; Thomsen,[15] -16.70; Stackelberg,[1] -16.68. We have selected the average of the last two values.

$KCl \cdot CrO_3$ (c). Morges[1] measured the heat of solution.

$K_2Cr_2O_7 \cdot CrO_3$ (c). Graham[2] measured the heat of solution.

$KCr(SO_4)_2$ (aq.). Thomsen[15] measured the heat of mixing $KCr(SO_4)_2$(600) with 3 KOH(400).

$KCr(SO_4)_2 \cdot nH_2O$ (c). Thomsen[15] measured the heat of solution of the dodecahydrate. Kraus, Fricke, and Querengasser[1] measured the vapor pressures of the various hydrates over a range of temperature.

KNH_4CrO_4 (aq.). Sabatier[5] measured the heat of mixing $K_2Cr_2O_7$ (440) with 2 NH_3(110).

KNH_4CrO_4 (c). Sabatier[5] measured the heat of solution.

K_2MoO_4 (aq.). Pechard[1] found, for H_2MoO_4 (c) $+2$ KOH(440), $N = 24.1$.

$2\,KCl \cdot UOCl_2 \cdot 2\,H_2O$ (c). Aloy[1] measured the heat of solution.

KVO_5 (aq.). This value is obtained from those for the aqueous ions.

KVO_3 (aq.), KVO_4 (aq.). Pissarjewsky[4] measured the heat of mixing KVO_3 (aq.) with 2 H_2O_2 (aq.) and H_2O_2 (aq.), respectively.

KVO_3 (c), KVO_4 (c). Pissarjewsky[4] measured the heats of solution.

$nKCl \cdot ThCl_4 \cdot mH_2O$ (c). Chauvenet[2] measured the heats of solution of 2 KCl $\cdot$ $ThCl_4$ (c) and $KCl \cdot ThCl_4 \cdot 9\,H_2O$ (c).

$3\,KF \cdot AlF_3$ (aq.). The data of Baud[1] yield for the heat of mixing 3 KF (aq.) with AlF_3 (aq.), $Q = -1.51$.

$3\,KF \cdot AlF_3 \cdot nH_2O$ (c). Baud[1] measured the heats of solution of the anhydrous salt and the hydrate with $3\frac{1}{2}$ H_2O.

nKCl · AlCl$_3$ (c). Baud[1] measured the heats of solution of KCl · AlCl$_3$ (c), 3 KCl · AlCl$_3$ (c), and 3 KCl · 2 AlCl$_3$ (c).

KCl · AlCl$_3$ · 6 NH$_3$ (c). Baud[1] measured the heat of solution.

KAl(SO$_4$)$_2$ (aq.). Thomsen[15] measured the heat of mixing KAl(SO$_4$)$_2$(600) with 3 KOH(400).

KAl(SO$_4$)$_2$ · nH$_2$O (c). Favre and Silbermann[3] and Thomsen[15] measured the heat of solution of the dodecahydrate, the latter's data yielding $S = -10.10_{800}$. The heats of dehydration have been calculated from the vapor pressure data of Kraus, Fricke, and Querengasser.[1] See also Ephraim and Wagner.[1]

K$_2$O · Al$_2$O$_3$ · nSiO$_2$ (solid). Mulert[1] measured the heats of solution, in 20% HF (aq.), of K$_2$O · Al$_2$O$_3$ · 4 SiO$_2$ (c, leucite), of K$_2$O · Al$_2$O$_3$ · 6 SiO$_2$ (c, adular), and of K$_2$O · Al$_2$O$_3$ · 6 SiO$_2$ (gls.); Tammann (as reported by Mulert[1]) those of K$_2$O · Al$_2$O$_3$ · 4 SiO$_2$ (c, leucite), of K$_2$O · Al$_2$O$_3$ · 4 SiO$_2$ (gls.), of K$_2$O · Al$_2$O$_3$ · 6 SiO$_2$ (c, microcline), and of K$_2$O · Al$_2$O$_3$ · 6 SiO$_2$ (gls.). For the first substance the respective data yield, $Qf = 1379.8$ and 1374.7; for the last substance, $Qf = 1754.9$ and 1738.0.

nKCl · MgCl$_2$ · mH$_2$O (c, fresh melt). Berthelot and Ilosvay[1] measured the heats of solution of the fresh melts of KCl · MgCl$_2$ (c), KCl MgCl$_2$ · 6 H$_2$O (c), 2 KCl · MgCl$_2$ (c), and 4 KCl · MgCl$_2$ (c).

K$_2$Mg(SO$_4$)$_2$ (c) (prepared below 150°). Pickering[4] found $S = 11.53_{800}$; Thomsen,[15] $S = 10.62_{600}$.

K$_2$Mg(SO$_4$)$_2$ (c) (fresh melt). The data of Berthelot and Ilosvay,[1] and Pickering[4] yield, respectively, for S_{800}, 6.92 and 7.30.

K$_2$Mg(SO$_4$)$_2$ · 2 H$_2$O (c). Thomsen[15] measured the heat of solution.

K$_2$Mg(SO$_4$)$_2$ · 4 H$_2$O (c). Caven and Ferguson[2] measured the dissociation pressure over a range of temperature, finding $D = -10.4$.

K$_2$Mg(SO$_4$)$_2$ · 5 H$_2$O (c). Thomsen[15] measured the heat of solution.

K$_2$Mg(SO$_4$)$_2$ · 6 H$_2$O (c). The data on the heat of solution yield for S_{800}: Graham,[2] (?); Thomsen,[15] −10.10; Pickering,[5] −9.94.

2 KCl · CaCl$_2$ (c) (fresh melt). Berthelot and Ilosvay[1] measured the heat of solution.

K$_2$SO$_4$ · nCaSO$_4$ · H$_2$O (c). Barre[1] measured the heats of solution of the following: K$_2$SO$_4$ · CaSO$_4$ · H$_2$O (c), K$_2$SO$_4$ (c) + CaSO$_4$ · 2 H$_2$O (c), K$_2$SO$_4$ · 5 CaSO$_4$ · H$_2$O (c), and K$_2$SO$_4$ (c) + 5 (CaSO$_4$ · 2 H$_2$O) (c).

KCaFeCO(CN)$_5$ · 5 H$_2$O (c). Lecocq[1] measured the heat of combustion in a bomb calorimeter, finding $Q = 2152$.

K$_2$SO$_4$ · SrSO$_4$ (c). Barre[1] measured the heats of solution of K$_2$SO$_4$ SrSO$_4$ (c) and of K$_2$SO$_4$ (c) + SrSO$_4$ (c).

KLiClI (c) (fresh melt). Beketoff[8] measured the heats of solution of the fresh melt, of LiCl (c) + KI (c), and of LiI (c) + KCl (c).

NaCl · KCl (c) (fresh melt). Beketoff[8] measured the heats of solution of the fresh melt and of NaCl (c) + KCl (c).

KNaClI (c) (fresh melt). Beketoff[8] measured the heats of solution of the fresh melt, of NaCl (c) + KI (c), and of NaI (c) + KCl (c).

Na_nK_m (liq.). Joannis[2] measured the heats of solution of Na (c), K (c), NaK (liq.), NaK_2 (liq.), NaK_3 (liq.), and Na_2K (liq.) in water.

Na_2KPO_4 (aq.). Berthelot and Louguinine[3] measured the heat of mixing $Na_2HPO_4(220)$ with KOH(110).

3 KCNS · NaCNS (c). Wrzesnewsky[1] measured the heats of solution of KCNS (c), of NaCNS (c), and of 3 KCNS · NaCNS (c).

Rubidium

Rb (c). Standard state.

Rb (liq.). The data on the heat of fusion are: Rengade,[4] -0.524^{39}; Bridgman,[1] -0.552^{39}.

Rb (g). Vapor pressure data were reported by Hackspill[1] and Killian.[1] See also van Laar.[9] The values for the energy states of gaseous monatomic rubidium are from Fowler,[3] Miller and Laporte,[1] and Bacher and Goudsmit.[1]

RbOH (aq.). The heat of solution of Rb (c) in water was measured by Beketoff[3] and Rengade.[1] Their data yield, respectively, for Rb (c) $+H_2O$ (liq.) $=$ RbOH(200) $+\frac{1}{2}H_2$ (g), $Q=48.2$ and 47.3. Taking the latest value, we have obtained, for LiOH(200), $Qf=115.7$. de Forcrand[55] measured the heat of dilution of RbOH (aq.) from 3.18 to 223 H_2O. We have estimated the heat of dilution from 200 to ∞ H_2O to be zero.

Rb^+ (∞). The foregoing data give for Rb^+ (∞) $+OH^-$ (∞), $Qf=115.7$; whence, for Rb^+ (∞), $Qf=61.04$.

RbOH · nH_2O (c). de Forcrand[44] measured the heats of solution of RbOH (c, II), RbOH · 0.613 H_2O, and RbOH · H_2O (c); and later (de Forcrand[55]) that of RbOH · 2 H_2O (c).

RbOH (c, I). Hevesy[1] measured the heat of transition.

Rb_2O (c). Rengade[3] measured the heat of solution in H_2O. The similar data of Beketoff[3] are somewhat doubtful.

Rb_2O_n (c). de Forcrand[66] estimated the heats of formation of Rb_2O_2 (c) and Rb_2O_4 (c).

RbH (c). Kasarnowsky[1] quoted unpublished values of Monossohn, giving $Qf=12$.

RbF (aq.). From the ions, we have obtained, for RbF (∞), $Qf=139.24$. Lange and Monheim[2] measured the heat of dilution of RbF (aq.) in the very dilute region, and their data have been converted to 18° giving values from ∞ to 100 H_2O.

RbF (c). de Forcrand[57] measured the heat of solution.

RbF (liq.). We have estimated the heat of fusion.

RbF (g). The vapor pressure of RbF was measured by Von Wartenberg and Schulz[1] and Ruff, Schmidt, and Mugdan.[1]

RbF · nH_2O (c). de Forcrand[59] measured the heats of solution of RbF · $\frac{1}{3}H_2O$ (c) and RbF · $1\frac{1}{2}H_2O$ (c).

$RbHF_2$ (aq.). From the ions, we have obtained $Qf=214.4$.

$RbHF_2$ (c). de Forcrand[60] measured the heat of solution.

RbCl (aq.). From the ions, we have obtained, for RbCl (∞), $Qf = 100.727$. The heat of dilution has been estimated from ∞ to 100 H_2O.

RbCl (c). The data on the heat of solution have been recomputed to give the following values for S_{200}: de Forcrand,[46] −4.36; Zemczuzny and Rambach,[1] −4.43; Haigh,[1] −4.34.

RbCl (liq.). We have estimated the heat of fusion.

RbCl (g). Vapor pressure data were reported by von Wartenberg and Schulz[1] and Ruff and Mugdan.[1] See also Sommermeyer.[1]

RbBr (aq.). From the ions, we have obtained, for RbBr (∞), $Qf = 89.71$. We have estimated the heat of dilution in the range ∞ to 100 H_2O.

RbBr (c). de Forcrand[57] measured the heat of solution.

RbBr (liq.). Plato[1, 2] measured the heat of fusion.

RbBr (g). Vapor pressure data were reported by von Wartenberg and Schulz[1] and Ruff and Mugdan.[1]

RbI (aq.). From the ions, we have obtained for RbI (∞), $Qf = 74.41$. We have estimated the heat of dilution from ∞ to 100 H_2O.

RbI (c). The data on the heat of solution yield the following values for S_{200}: de Forcrand,[12, 57] −6.55; Mosnier,[1] −5.86.

RbI (liq.). We have estimated the heat of fusion.

RbI (g). Vapor pressure data were reported by von Wartenberg and Schulz[1] and Ruff and Mugdan.[1] Sommermeyer,[1] from absorption spectra of RbI(g), estimated $D^z = -77.5$.

Rb_2S (aq.). Rengade and Costeaunu[2] measured the heat of neutralization of RbOH (aq.) with H_2S (aq.). Their data yield, for Rb_2S(550), $Qf = 112.5$. From the ions, we have obtained for Rb_2S (∞), $Qf = 112.08$.

Rb_2S (c). Rengade and Costeaunu[2] measured the heat of solution.

Rb_2SO_4 (aq.). deForcrand[46] measured the heat of neutralization of RbOH (aq.) with H_2SO_4 (aq.) His data, combined with the heat of dilution, give, for Rb_2SO_4 (∞), $Qf = 337.64$. From the ions, we have obtained 337.88. Lange and Streeck[1] measured the heat of dilution at 25°. We have used their data to obtain values at 18° from ∞ to 200 H_2O.

Rb_2SO_4 (c). deForcrand[46] measured the heat of solution.

$RbHSO_4$ (aq.). deForcrand[46] measured the heat of reaction of RbOH(110) with H_2SO_4(220), and of $RbHSO_4$(330) with RbOH(110). His data yield, for $RbHSO_4$(330), $Qf = 274.09$ and 274.42, respectively.

$RbHSO_4$ (c). deForcrand[46] measured the heat of solution.

$RbI \cdot 4SO_2$ (c). The data of Ephraim and Kornblum[1] and deForcrand and Taboury,[1] on the temperature coefficient of the dissociation pressure, give, respectively, $D = -10.1$ and -10.1.

$RbNO_3$ (aq.). From the ions, we have computed for $RbNO_3$ (∞), $Qf = 110.23$. We have estimated the heat of dilution for the range ∞ to 100 H_2O.

$RbNO_3$ (c, II). Haigh[1] measured the heat of solution.

$RbNO_3$ (c, I). Bridgman[6a] measured the heat of transition.

$RbX \cdot nNH_3$ (c). Biltz and Hansen[1] measured the temperature coefficient of the dissociation pressures of $RbBr \cdot 3NH_3$(c) and $RbI \cdot 6NH_3$(c).

Rb_2CO_3 (aq.). deForcrand[49] measured the heat of neutralization of RbOH (aq.) with CO_2 (aq.) His data, together with the heat of dilution, give for Rb_2CO_3 (∞), $Qf = 282.76$. From the ions, we have obtained 282.58. deForcrand[52] measured the heat of dilution of Rb_2CO_3(aq.), from 5.76 to 226 H_2O. We have estimated the heats of dilution to 2000 and ∞ H_2O.

Rb_2CO_3 (c). deForcrand[49, 52] measured the heat of solution, and LeBeau[1] obtained data on the dissociation pressure at various temperatures.

$Rb_2CO_3 \cdot nH_2O$ (c). deForcrand[52] measured the heats of solution of Rb_2CO_3 with 1, $1\frac{1}{2}$, and $3\frac{1}{2}$ moles of H_2O.

$RbHCO_3$ (aq.). deForcrand[53] measured the heat of reaction of RbOH(110) with CO_2(1800). His data yield for $RbHCO_3$(1800), $Qf = 225.91$.

$RbHCO_3$ (c). deForcrand[53] measured the heat of solution. His data yield $Qf = 230.44$. The data of Caven and Sand[2] on the dissociation pressure at various temperatures yield $Qf = 232.8$.

$3(Rb_2CO_3 \cdot 1\frac{1}{2} H_2O) \cdot 2\,RbHCO_3$ (c). de Forcrand[54] measured the heat of solution.

RbCNS (aq.). From the ions, we have obtained $Qf = 42.0$.

RbCNS (c). The heat of solution is estimated to be -14.

$RbCNS \cdot \frac{1}{2} SO_2$ (c). Ephraim and Kornblum[1] reported $D = -10.6$.

$2RbI \cdot PbI_2 \cdot nH_2O$ (c). Mosnier[1] measured the heats of solution of the anhydrous salt and the tetrahydrate.

$2RbCl \cdot CuCl_2 \cdot nH_2O$ (c). Bouzat and Chauvenet[2] measured the heats of solution of the anhydrous salt and the dihydrate.

$nRbCl \cdot ThCl_4 \cdot mH_2O$ (c). Chauvenet[2] measured the heat of solution of $2RbCl \cdot ThCl_4$ (c), $2RbCl \cdot ThCl_4 \cdot 9H_2O$ (c), and $4RbCl \cdot ThCl_4$ (c).

$RbAl(SO_4)_2 \cdot nH_2O$ (c). For the dodecahydrate we have estimated the heat of solution to be -11. The heats of dissociation of the various hydrates have been calculated from the dissociation pressure data of Kraus, Fricke, and Querengasser[1] and Ephraim and Wagner.[1]

Cesium

Cs (c). Standard state.

Cs (liq.). The data on the heat of fusion are: Rengade,[1] $-0.501^{28.5}$; Bridgman,[1] -0.51.[28]

Cs (g). Vapor pressure data were reported by Hackspill,[1] Kroner,[1] Scott,[1] and Langmuir and Kingdom.[1] See also Boer and Dippel,[1] van Laar,[9] and Egerton.[3] The values for the energy states of gaseous monatomic cesium are from Fowler,[3] Miller and Laporte,[1] and Bacher and Goudsmit.[1]

CsOH (aq.). The heat of solution of Cs (c) in water was measured by Beketoff[4, 6] and Rengade.[1] Their data yield, for Cs (c) + H_2O (liq.) = CsOH(200) + $\frac{1}{2}H_2$ (g), $Q = 51 \pm 1$ and 48.32 ± 0.10, respectively. Taking Rengade's value, we have computed, for CsOH(200), $Qf = 116.7$. deForcrand[55] measured the heat of dilution of CsOH (aq.) from 2.16 to 222 H_2O. We have estimated the heat of dilution from 200 to ∞ H_2O to be zero.

$Cs^+(\infty)$. From the foregoing data we have obtained for $Cs^+(\infty) + OH^-(\infty)$, $Qf = 116.7$; whence, for $Cs^+(\infty)$, $Qf = 62.04$.

CsH (c). Kasarnowsky[2] quoted unpublished values of Monossohn, giving $Qf = 12$.

CsOH (c, II). The heat of solution was measured by deForcrand[44] and by Beketoff.[4] Their values yield, for S, 16.56_{110} and 16.0_{380}, respectively.

CsOH (c, I). Hevesy[1] measured the heat of transition.

$CsOH \cdot H_2O$ (c). deForcrand[44] measured the heat of solution.

Cs_2O (c). The heat of solution in H_2O was measured by Beketoff[6] and Rengade.[1, 3] Their values yield $S = 83.1_{3400}$ and 72.2_{1800}, respectively.

Cs_2O_4 (c). deForcrand[56] measured the heat of solution in H_2SO_4 (aq.).

CsF (aq.). From the ions, we have obtained, for CsF (∞), $Qf = 140.24$. We have estimated the heat of dilution from 800, 200, and 100 H_2O to ∞ H_2O.

CsF (c). The heat of solution was measured by deForcrand.[57]

CsF (liq.). We have estimated the heat of fusion.

CsF (g). Vapor pressure data were reported by von Wartenberg and Schulz[1] and Ruff, Schmidt, and Mugdan.[1]

$CsF \cdot nH_2O$ (c). deForcrand[59] measured the heats of solution of $CcF \cdot \frac{2}{3} H_2O$ (c) and $CsF \cdot 1\frac{1}{2} H_2O$ (c).

$CsHF_2$ (aq.). From the ions, we have computed $Qf = 215.4$.

$CsHF_2$ (c). The heat of solution was measured by deForcrand.[60]

CsCl (aq.). From the ions, we have obtained, for CsCl (∞), $Qf = 101.727$. The heat of dilution was measured by Richards and Rowe[3] at 18° from 25 to 400 H_2O, and by Lange and Messner[1] at 25° in the very dilute region. The latter values have been converted to 18° and combined with the former to give values from 25 to ∞ H_2O.

CsCl (c, II). The data on the heat of solution of CsCl (c) in H_2O yield the following values for S_{200}: deForcrand,[40] −4.61; deForcrand,[12, 57] −4.54; Haigh,[1] −4.37.

CsCl (c, I). Zemczuzny and Rambach[1] measured the heat of transition.

CsCl (liq.). We have estimated the heat of fusion.

CsCl (g). Vapor pressure data were reported by von Wartenberg and Schulz,[1] Ruff and Mugdan,[1] and Fiock and Rodebush.[1]

CsBr (aq.). From the ions, we have obtained, for CsBr (∞), Qf

$=90.71$. The heat of dilution has been estimated for the range ∞ to 100 H_2O.

CsBr (c). The heat of solution was measured by deForcrand.[12, 57]

CsBr (liq.). We have estimated the heat of fusion.

CsBr (g). Vapor pressure data were reported by von Wartenberg and Schulz[1] and Ruff and Mugdan.[1] Sommermeyer[1] calculated, from absorption spectra, $D^s = -89.8$.

CsI (aq.). From the ions, we have obtained, for CsI (∞), $Qf = 75.41$. We have estimated the heat of dilution from ∞ to 100 H_2O.

CsI (c). The heat of solution was measured by deForcrand.[12, 57] His data give $S_{110} = -8.12$; whence, for CsI (c), $Qf = 83.90$. Beketoff[8] measured the heats of solution of NaCl (c) + CsI (c), NaI (c) + CsCl (c), KCl (c) + CsI (c), and KI (c) + CsCl (c). His data yield two identical values for the heat of formation of CsI (c), namely 83.88.

CsI (liq.). We have estimated the heat of fusion.

CsI (g). Vapor pressure data were reported by von Wartenberg and Schulz[1] and Ruff and Mugdan.[1] We have taken $V = -36.0^{1000}$ or $Vs = -46.7$ at 18°; whence $Qf = 37.2$. Mayer's[3] data for the reaction, $Cs^+(g) + I^-(g) = CsI\ (g)$, give, for CsI (g), $Qf = 38.2$. From the limit of the absorption spectrum, Franck, Kuhn, and Rollefson[1] calculated $D^s = -75.0$; whence $Qf = 30.5$. Sommermeyer,[1] from similar data, gave $D^s = -77.8$; whence $Qf = 33.3$. See also Visser.[2]

CsI_3 (c), CsI_4(c). Foote, Bradley, and Fleischer[1] obtained dissociation pressure data on these substances.

Cs_2S (aq.). From the ions, we have obtained, for Cs_2S (∞), $Qf = 114.08$.

Cs_2S (c). Rengade and Costeaunu[1] measured the heat of solution.

Cs_2SO_4 (aq.). deForcrand[46] measured the heat of neutralization of LiOH (aq.) with H_2SO_4 (aq.). His data, together with the heat of dilution, yield, for Cs_2SO_4 (∞), $Qf = 339.56$. From the ions, we have obtained 339.88. The heat of dilution of Cs_2SO_4 (aq.) was measured at 25° in the very dilute range by Lange and Streeck.[1] Their values have been converted to 18° and extrapolated to 200 H_2O.

Cs_2SO_4 (c). deForcrand[46] measured the heat of solution.

$CsHSO_4$ (aq.). deForcrand[46] measured the heat of reaction between $CsOH(110) + H_2SO_4(220)$, and between $CsHSO_4(330) + CsOH(110)$. His data yield for $CsHSO_4(330)$, $Qf = 275.47$ and 275.79, respectively.

$CsHSO_4$ (c). deForcrand[46] measured the heat of solution.

$CsI \cdot 4SO_2$ (c). Ephraim and Kornblum[1] and deForcrand and Taboury[1] found $D = -10.9$ and -9.9, respectively.

$CsNO_3$ (aq.). From the ions, we have computed, for $CsNO_3$ (∞) $Qf = 111.23$. Values for the heat of dilution were given for the range 2ℓ to 400H_2O by Richards and Rowe,[2, 3] and we have extrapolated their values to ∞ H_2O.

$CsNO_3$ (c, II). Haigh[1] measured the heat of solution.

$CsNO_3$ (c, I). Bridgman[6a] measured the heat of transition.

Cs_2CO_3 (aq.). deForcrand[49] measured the heat of neutralization of CsOH (aq.) with CO_2 (aq.). His data yield, for Cs_2CO_3(2000), $Qf = 284.81$; whence (with an estimated heat of dilution to ∞ H_2O), for Cs_2CO_3 (∞), $Qf = 284.85$. From the ions, we have obtained 284.58. deForcrand[52] measured the heat of dilution from 7.59 to 228 H_2O. We have estimated the values to 2000 and ∞ H_2O.

Cs_2CO_3 (c). deForcrand[49] measured the heat of solution, and Lebeau[1] the dissociation pressure at various temperatures.

$Cs_2CO_3 \cdot 3\frac{1}{2} H_2O$ (c). deForcrand[52] measured the heat of solution.

$CsHCO_3$ (aq.). deForcrand[53] measured the heat of the reaction of CsOH(110) with CO_2(1800). His data yield, for $CsHCO_3$(1900), $Qf = 227.16$.

$CsHCO_3$ (c). deForcrand[53] measured the heat of solution. His data give $Qf = 231.0$. Caven and Sand[2] found, from dissociation pressures, $D = -29\ 0$; whence $Qf = 241$.

$5Cs_2CO_3 \cdot 2CsHCO_3 \cdot nH_2O$ (c). deForcrand[54] measured the heats of solution of $5Cs_2CO_3 \cdot 2CsHCO_3 \cdot 10H_2O$ (c) and $5Cs_2CO_3 \cdot 2CsHCO_3 \cdot 17\frac{1}{2}H_2O$ (c).

$CsCNS \cdot \frac{1}{2}SO_2$ (c). Ephraim and Kornblum[1] found $D = -10.1$.

$2CsCl \cdot CuCl_2 \cdot nH_2O$ (c). Bouzat and Chauvenet[2] measured the heats of solution of the anhydrous salt and the dihydrate.

$nCsCl \cdot ThCl_4 \cdot mH_2O$ (c). Chauvenet[2] measured the heats of solution of $2CsCl \cdot ThCl_4$ (c), $2CsCl \cdot ThCl_4 \cdot 8H_2O$ (c), and $4CsCl \cdot ThCl_4$(c).

$CsAl(SO_4)_2 \cdot nH_2O$ (c). We have assumed that the heat of solution of $CsAl(SO_4)_2 \cdot 12\ H_2O$ (c) is -11.5, by analogy. The heats of dissociation of the various hydrates have been calculated from the vapor pressure measurements of Krause, Fricke, and Querengasser[1] and Ephraim and Wagner.[1]

CsLiClI (c, melt). Beketoff[8] measured the heats of solution of CsLiClI (c, melt) and of CsI (c) + LiCl (c).

CsNaClI (c, melt). Beketoff[8] measured the heats of solution of the melt and of NaCl (c) + CsI (c).

CsKClI (c, melt). Beketoff[8] measured the heats of solution of the melt and of KCl (c) + CsI (c).

Element 87

M (c). Standard state.

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COMPOUNDS

As indicated on page 15, the formula of the substance, written according to the standard arrangement given on page 16, determines (1) the element under which the compound will be listed and (2) the position the compound will occupy in that section. In the table, all locations are exact; in the text, all main locations are exact and the sublocations are approximately in the proper order. The index for the elements is given below.

ELEMENTS

	TABLE	TEXT		TABLE	TEXT
Actinium	111	337	Germanium	55	254
Aluminum	106	331	Gold	80	296
Antimony	41	224	Hafnium	103	328
Argon	17	171	Helium	17	171
Arsenic	39	223	Holmium	109	334
Barium	126	355	Hydrogen	20	174
Beryllium	112	337	Illinium	110	335
Bismuth	42	228	Indium	61	263
Boron	105	329	Iodine	25	189
Bromine	24	185	Iridium	82	299
Cadmium	67	272	Iron	89	308
Calcium	117	343	Krypton	18	171
Carbon	43	229	Lanthanum	111	337
Cerium	111	336	Lead	58	257
Cesium	168	402	Lithium	131	362
Chlorine	22	179	Lutecium	109	334
Chromium	95	318	Magnesium	113	339
Cobalt	87	305	Manganese	92	314
Columbium	101	326	Masurium	84	302
Copper	73	283	Mercury	69	276
Dysprosium	109	334	Molybdenum	97	321
Erbium	109	334	Neodymium	110	335
Europium	109	335	Neon	17	171
Fluorine	21	178	Nickel	84	302
Gadolinium	109	334	Nitrogen	32	206
Gallium	60	263	Osmium	82	300

	TABLE	TEXT
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Palladium	83	300
Phosphorus	37	218
Platinum	81	298
Polonium	31	206
Potassium	150	384
Praseodymium	110	335
Protoactinium	101	326
Radium	130	362
Radon	18	172
Rhenium	82	300
Rhodium	83	301
Rubidium	165	400
Ruthenium	84	302
Samarium	109	335
Scandium	108	333
Selenium	30	202
Silicon	54	252
Silver	77	290
Sodium	137	367
Strontium	122	351
Sulfur	27	193
Tantalum	101	326
Tellurium	31	205
Terbium	109	334
Thallium	62	264
Thorium	104	328
Thulium	109	334
Tin	56	255
Titanium	101	326
Tungsten	98	322
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Vanadium	100	325
Xenon	18	172
Ytterbium	109	334
Yttrium	108	334
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Zirconium	102	327