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# SCIENCE COURSE CONTENT
# and
# TEACHING APPARATUS

USED IN

SCHOOLS AND COLLEGES

*of the*

UNITED STATES

TO BE SUBMITTED

*to the*

MINISTERS OF EDUCATION

*of the*

DEVASTATED COUNTRIES

*of the*

UNITED NATIONS

ADDRESS OFFICIAL COMMUNICATIONS TO
THE SECRETARY OF STATE
WASHINGTON 25, D. C.

# DEPARTMENT OF STATE
WASHINGTON

In reply refer to
OIC

My dear Mr. Johnson:

Your letter of August 20, 1946 to Mr. Benton was delivered to me by Dr. Powers together with the excellent report Science Course Content and Teaching Apparatus Used in Schools and Colleges of the United States.

I want to commend you and your organization for having done a truly comprehensive and most helpful job. You have undoubtedly learned of Dr. Powers' conversations with members of the Department and others concerning the best use to be made of this report and the progress in negotiations for its private printing so that it may be made available in quantity not only for its original international purpose but to individuals and institutions in this country. I have given a copy of the original manuscript to Dr. Esther C. Brunauer, United States Representative to the Preparatory Commission of UNESCO so that it may be made available to the Preparatory Commission of UNESCO.

Those in the Department who had the opportunity to look over this report have been impressed with its quality and usefulness and I should like to thank you on behalf of the Department for having made it available. With best wishes for success in negotiations on its publication, I remain

Sincerely yours,

Charles A. Thomson, Adviser
Office of International Information
and Cultural Affairs

Philip G. Johnson, President,
National Science Teachers Association,
Fernow Hall, Cornell University,
Ithaca, New York.



**DEPARTMENT OF STATE**
**WASHINGTON**

May 4, 1946

My dear Dr. Johnson:

I have noted from a letter of April 10, 1946, addressed to me by Dr. S. R. Powers, that at the request of Dr. Grayson Kefauver a Committee of Scientists, in cooperation with the National Science Teachers Association and the Scientific Apparatus Makers of America, have been at work on a statement describing courses in science taught in the high schools and colleges of the United States, and which will include for each course described, a list of equipment appropriate for use in teaching this course. This statement was planned as a possible aid to Ministers of Education or other representatives of devastated countries whose educational institutions have suffered as a result of the war.

The Department of State will welcome receipt of this statement and it will be made available to the United States representative on the Preparatory Commission for appropriate action.

The Department appreciates the cooperation of the organizations and individuals which have contributed to this study.

Sincerely yours,

William Benton

Philip G. Johnson, Ph.D., President
National Science Teachers Association
United States Office of Education
Washington, D. C.

TEACHERS COLLEGE
COLUMBIA UNIVERSITY
NEW YORK 27, N. Y.

DIVISION OF INSTRUCTION
DEPARTMENT OF THE TEACHING OF
NATURAL SCIENCES

July 1, 1946

Dr. Philip G. Johnson, President
National Science Teachers Association
1201 Sixteenth Street, N.W.
Washington 6, D. C.

Dear Dr. Johnson:

I submit herewith the committee report on Science Course Content and Teaching Apparatus Used in Schools and Colleges in the United States as approved and adopted by unanimous vote of the Committee at its meeting in Buffalo, New York, on June 29, 1946.

The report was prepared under the general direction of a Central Committee composed of individuals with special interest and expertness in teaching science and mathematics at elementary, secondary or college levels. Policies and general methods were developed by this Central Committee. Sub-committees prepared course outlines which were submitted to Mr. John M. Roberts, President of the Scientific Apparatus Makers of America, for the assistance of this organization in the development of the initial apparatus lists. These lists were checked and revised by the sub-committees before final editing by the coordinator. For his work in carrying through the policies of the Central Committee and assembling the several parts of the report, special mention should be made of Mr. Ralph W. Lefler, Purdue University, who served as coordinator, and Mrs. Mary Elizabeth Tu, his secretary.

The Cooperative Committee on Science Teaching, an officially appointed committee of the American Association for the Advancement of Science, which is composed of representatives of the various scientific societies, including mathematics, was asked to act in an advisory capacity for the preparation of the secondary school part and to prepare the college portion of this report. The Cooperative Committee, through its membership did prepare and is responsible for the syllabus of college courses and curriculum appearing herein. Several Members of the Cooperative Committee also served on the Central Committee. Professor Karl Lark-Horovitz, Chairman of the Cooperative Committee, was exceedingly helpful, both in securing the whole-hearted cooperation of his committee for this report and for assisting the coordinator who is in his department of physics at Purdue University.

The members of the Committee have carried this project through to completion in the belief that through this work they were contributing important aid to the rehabilitation of educational institutions in war-torn countries.

Yours sincerely,

S. R. Powers

S. R. Powers
Chairman

# NATIONAL SCIENCE TEACHERS ASSOCIATION

1201 SIXTEENTH STREET N.W., WASHINGTON 6, D.C.

AN AFFILIATE OF THE
AMERICAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE

A DEPARTMENT OF THE
NATIONAL EDUCATION ASSOCIATION
OF THE UNITED STATES


July 1, 1946

Honorable William Benton
Assistant Secretary of State
Department of State
Washington, D. C.

Dear Mr. Benton:

Dr. Grayson Kefauver, while serving the Department of State, asked our Association for aid in preparation of a report on science teaching in the United States. It was his judgment that such a report would be of value in the rehabilitation of schools destroyed during the war.

I am pleased to submit to you the completed report entitled Science Course Content and Teaching Apparatus Used in Schools and Colleges of the United States.

The scientists and science educators who participated in this project hope that this report will prove useful as it is made available to the United States representative on the Preparatory Commission.

Sincerely yours,

Philip G. Johnson, President
National Science Teachers Association

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National Science Teachers' Association
Dr. Philip G. Johnson, United States Office of Education
Dr. Morris Meister, Bronx High School of Science, New York

# ABBREVIATIONS

a.c. (A.C.) ..... Alternating Current
A.C.S. ..... American Chemical Society
Alc. ..... Alcohol
amp. ..... Ampere
anhyd. ..... Anhydrous
A.P.H.A. ..... American Public Health Association
Approx ..... Approximate
A.R. ..... Analytical Reagent
asst. ..... Assorted

b.p. ..... Boiling point
B. & S. ..... Brown & Sharp
B. & L ..... Bausch & Lomb
btl. ..... Bottle
bx. ..... Box
B.S C. ..... Bakelite Screw Cap

C ..... Centigrade
C ..... Cycle
calc. ..... Calcined
cap. (Cap.) ..... Capacity
cc ..... Cubic centimeter
cm ..... Centimeter
conc. ..... Concentrated
cp (C.P.) ..... Chemically pure
cryst. ..... Crystals
c.s. ..... Cork stoppered
c.s. ..... Cross section

d.c. (D.C.) ..... Direct Current
deg. ..... Degree
diam. ..... Diameter
dil. (Dil.) ..... Diluted
d.c.c. ..... Double cotton covered
d.p.s.t. ..... Double pole, single throw
doz. ..... Dozen

ea. ..... Each
E. & D. ..... Eaton & Dikeman
E. & M. ..... English & Metric
e.f. ..... Equivalent focal length
e.m.f. ..... Electromotive force
etc. ..... Et cetera (and so forth)
exp. ..... Experiment

F ..... Fahrenheit
F.B. ..... Flat Bottom

g. (gm.) ..... Gram
gal. ..... Gallon
Gen. Lab. ..... General Laboratory
gran. ..... Granulated
g.s. (G.S.) ..... Glass stoppered

hr. ..... Hour
H.W.D. ..... Hynson, Westcott & Dunning

ibid. ..... Ibidem (in the same place)
i.d. ..... Inside diameter
in. ..... Inch
Ind. ..... Indicator
i.p. ..... Iron pipe

**k.v.a.** ..... Kilovolt-ampere
**kg.** ..... Kilogram

l. ..... Liter
lab. ..... Laboratory
lb. ..... Pound
lg. (lge.) ..... Large
l.n. ..... Long neck
l.s. ..... Longitudinal section

med. ..... Medium
mf ..... Microfarad
mg ..... Milligram
MH ..... Magnetic moment x Field strength
ml ..... Milliliter
mm ..... Millimeter
m.p. (M.P.) ..... Melting point

N.B.S. ..... National Bureau of Standards
N.F. ..... National Formulary
n.m. ..... Narrow mouth
no. ..... Number

o.d. ..... Outside diameter
oz ..... Ounce

p. ..... Page
pkg. ..... Package
powd. ..... Powder
ppt. ..... Precipitated
pr. ..... Pair
pract. ..... Practical
prim. ..... Primary
pt. ..... Pint

qual ..... Quality
qt. ..... Quart

r.b. ..... Round bottom
R.P.M. ..... Revolutions per minute

s.c. ..... Screw cap
sec. ..... Section
s.g. (sp. gr.) ..... Specific gravity
S.H.M. ..... Simple harmonic motion
s.n. ..... Short neck
soln. ..... Solution
s.p.d.t. ..... Single pole, double throw
s.p.s.t. ..... Single pole, single throw
sp. ..... Species
spl. ..... Spool

tech. ..... Technical
temp. ..... Temperature
tert. ..... Tertiary
t.p. (TP) ..... Tested purity

U.S.P. ..... United State Pharmacopoeia

v. ..... Volt
vol. ..... Volume
v.p.s. ..... Vibrations per second
vs. ..... Versus

wh. ..... White
w.m. ..... Whole mount
w.m. ..... Wide mouth

yd. ..... Yard

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# KEY TO CATALOGUE NUMBERS

The apparatus lists contain the catalogue numbers of the member firms of the United States Scientific Export Association, Inc. ( a corporation operating under the Export Trade Act of the United States, approved April 10, 1918), 50 Broadway, New York 4, New York, and the catalogue numbers can be identified from the following tabulation:

CHAPCO — Chicago Apparatus Company, Chicago 22, Illinois

E & A — Eimer & Amend, New York 14, New York
Fisher Scientific Company, Pittsburgh 19, Pennsylvania

SARGENT — E. H. Sargent & Company, Chicago 11, Illinois

WELCH — W. M. Welch Manufacturing Company, Chicago 10, Illinois

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**By W. M. Welch Manufacturing Company**
**Chicago, Illinois**

# NATIONAL SCIENCE TEACHERS ASSOCIATION

1201 SIXTEENTH STREET N.W., WASHINGTON 6, D.C.

AN AFFILIATE OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

A DEPARTMENT OF THE NATIONAL EDUCATION ASSOCIATION OF THE UNITED STATES


January 28, 1947

United States Scientific Export Association, Inc.
50 Broadway
New York, New York

Dear Sirs:

The undersigned persons, who have been made responsible as a committee by their respective societies, hereby grant the United States Scientific Export Association the right to print and to distribute copies of a report prepared by the National Science Teachers Association with the cooperation of the Cooperative Committee on Science Teaching of the American Association for the Advancement of Science, entitled, "Science Course Content and Teaching Apparatus used in the Schools and Colleges of the United States".

It is understood that the report is to be printed in full as prepared, with the authority hereby granted for the addition of catalog numbers.

The committee wishes you success in your efforts to make this report available to those of the United Nations who are desirous of using it.

Very truly yours,

Philip G. Johnson
National Science Teachers Association

Morris Meister
President National Science Teachers Association and Member of A.A.A.S. Cooperative Committee

S. R. Powers
National Science Teachers Association

K. Lark-Horovitz
Chairman A.A.A.S. Cooperative Committee and Member of National Science Teachers Association

R. W. Lefler
Secretary A.A.A.S. Cooperative Committee and Member of National Science Teachers Association

The organization of topics in certain textbooks is quite representative of existing practice in the organization of the courses for which these books were prepared. Some of the course and laboratory outlines which follow are based upon the table of contents of specific books.

We are indebted to the authors and publishers of the books which have been used in preparing the following course outlines:

General Botany (p. 63): Transeau, E. N., Sampson, H. C., and Tiffany, L. H., **Textbook of Botany,** Harper and Brothers, New York, 1940.

General Chemistry Laboratory Experiments (pp. 81-82): Hopkins, B. Smith, Copley, M. J., and Schirmer, F. B. **Laboratory Exercises and Problems in General Chemistry,** D. C. Heath and Company, Boston, 1942.

Intermediate Physics—Mechanics (pp. 137-39): Crew, Henry, and Smith, Keith Kuenzi, **Mechanics for Students of Physics and Engineering,** Macmillan Company, New York, 1930.

Modern Physics (pp. 144-46): Physics Staff of the University of Pittsburgh, **Atomic Physics,** John Wiley and Sons, New York, 1944.

General Zoology (pp. 159-60): Hyman, Libbie Henrietta. **General Zoology** University of Chicago Press, Chicago, 1919.

Comparative Vertebrate Anatomy (p. 166): Hyman, Libbie Henrietta. **Comparative Vertebrate Anatomy,** University of Chicago Press, Chicago, 1922.

# A REPORT
*to the*
# DEPARTMENT OF STATE
*on*
# SCIENCE COURSE CONTENT AND TEACHING APPARATUS USED IN SCHOOLS AND COLLEGES
*of the*
# UNITED STATES
# TO BE SUBMITTED
*to the*
# MINISTERS OF EDUCATION
*of the*
# DEVASTATED COUNTRIES
*of the*
# UNITED NATIONS



The world is now engaged in a program of rehabilitation, attempting to repair the ravages of war and to build a better world. Reestablishing cultural and educational pursuits is as vital to world welfare as is the replacement of the means of physical existence. The fact that there are countries where children and youth cannot be educated is disturbing. Those concerned with the part which science can play in education cannot remain complacent when so vital an area of modern culture suffers the danger of neglect. Since science teaching is peculiarly dependent upon adequate laboratory facilities and apparatus, it is appropriate that science educators in the United States consider the problem of adequate facilities and apparatus required for an effective program of science instruction. At a time when science is playing an ever-increasing part in the life of man, those interested in science education must do all in their power to help rebuild and expand science education everywhere in the world.

It is a relatively simple task to compile and transmit lists of apparatus and blueprints of classrooms and laboratories commonly provided for a program of science education in the United States. Yet such lists would have little meaning unless they were accompanied by a description of the course content and a statement of aims which the laboratory materials are designed to serve. Furthermore, individual courses themselves are part of a sequence of courses related to the total pattern of education in the United States. While there are many variations in this pattern, all of the patterns include certain distinctive features which determine the content of courses and the methods of teaching.

## Distinctive Features of Education in the United States

### Education for All Children

**The development of the educational program of the United States has been guided by a fundamental premise, namely, that the general welfare of its people demands a maximum amount of education for every individual, appropriate to his desires and abilities.** Thus there is legislation which requires school attendance at least to the age of sixteen in 44 of the 48 states.[1] Actually, a fairly large number of youth remain in school beyond the age prescribed by law. There is a steadily growing belief that those of ability should be educated through college and even through professional and graduate schools at public expense.

While the idea of universal education has not been completely achieved, each decade has witnessed progress toward this goal. The extent of the achievement is evidenced by the facts that (1) 92.5 per cent of youth fourteen years of age were enrolled in school in 1940, (2) 68.7 per cent of youth sixteen and seventeen years of age were enrolled in school in 1940,[2] (3) the high school enrollment in 1939-40 for the ninth to twelfth years of school equalled 73 per cent of the total population fourteen to seventeen years of age,[3] (4) the high school graduates of 1940 (representing completion of twelve years of education) totaled 50.7 per cent of the population seventeen years of age,[4] and (5) the college enrollment in 1939-40 (representing more than twelve years of education) equalled 15 per cent of the population in the age group from eighteen to twenty-one.[5]

The foregoing has resulted in a large and heterogeneous school population, which has led schools to offer a variety of curricular and administrative adaptations. These have influenced science offerings and instructional practices.

**Equality of educational opportunity through free schools** is a thoroughly established trend in educational policy in the United States. Private schools of various types have made and today make major contributions to education throughout the country; but the public school, maintained by various divisions of government, is the primary educational institution in terms of serving the great mass of children and youth. This is evidenced by the facts that in 1939-40 (1) 89.7 per cent of the total enrollment in elementary schools appeared in the public schools,[6] (2) 93.5 per cent of the total enrollment in secondary schools appeared in the public schools,[7] and (3) 53.5 per cent of all regular resident college enrollments were in institutions under public control.[8] The vast majority of teachers' colleges are publicly controlled.[9]

The system of free public education in the United States, below the college and university level, is in all essential respects a rather well recognized sequence of stages with opportunity for all children to progress from each stage to the succeeding one. With the diversity of schools in the nation, cer-

[1] Maris M. Profitt and David Segel, School Census, Compulsory Education, Child Labor: State Laws and Regulations (U. S. Office of Education, Bulletin 1945, No. 1), Washington, D. C., 1945, pp. 14-15.
[2] U. S. Office of Education, Federal Security Agency, Statistical Summary of Education, 1939-40 (Biennial Survey of Education in the United States, 1939-40), Washington, D. C., 1943, Vol. II, Chapter I, p. 6.
[3] Ibid., p. 12.
[4] Ibid., p. 19.
[5] Ibid., p. 30.
[6] Ibid., pp. 16-17.
[7] Ibid., p. 17.
[8] U. S. Office of Education, Federal Security Agency, Statistics of Higher Education, 1939-40 and 1941-42 (Biennial Surveys of Education in the United States, 1938-40 and 1941-42), Washington, D. C., 1944, Vol. II, Chapter IV, p. 14.
[9] Ibid. Also U. S. Office of Education, Statistical Summary of Education, 1939-40, p. 44.

tain exceptions to the above generalization can be cited; but the characteristic pattern includes (1) an elementary school system of at least six years, serving all children of approximately six to twelve years of age, with one teacher largely responsible for instruction at a particular grade level, (2) a secondary school system serving youth of approximately twelve to eighteen years of age under departmentalized instruction and providing curricula differentiated in varying degrees as the student progresses toward the upper grades. This pattern has placed upon the school the responsibility of providing programs of sufficient flexibility and variety to meet the needs of children and youth of extremely varied abilities and interests. It is important to remember that in this pattern the transition from one level to another is accomplished within a single school system. Class conditioning by channeling youth through different school systems is, as a result, largely although not entirely avoided.

**The typical secondary school in the United States is a comprehensive school,** providing different curricula for a varied student body. While a considerable number of specialized secondary schools exist in cities having several high schools, the great majority of secondary schools are of the comprehensive nature. The range of interest and ability found in an unselected group of children and adolescents is so great that there is obvious necessity, as pupils progress in school, to provide for differentiated programs of study. This is accomplished through the provision of different curricula in the comprehensive school, or by the establishment of specialized and vocational schools. The purposes of the comprehensive high school may be described as (1) to provide all students with the elements of a general education, and (2) to provide means for discovering special abilities and for beginning the specialized training of these abilities.

The specialized high school is a school above the junior high school level designed to meet the needs, interests, and abilities of a particular portion of the school population. Specialized secondary schools emphasize such areas as science, music, and art; and their work is largely preparatory for further education. The range of general competence is narrower in the specialized school, but the level of competence in the particular area is generally higher. Specialization makes possible a greater degree of homogeneity. This creates a teaching environment in which the rate of progress can be greater and curriculum enrichments more varied. Also, individualized teaching and activity become more feasible. Integrations among subject areas are more readily accomplished, and creative achievements are more frequent.[10]

The vocational school[10] is a particular type of specialized terminal school directed toward the development of skills in occupations below the professional level. These schools, or the vocational departments in the comprehensive school, provide curricula directed toward training in homemaking, trade and industrial, distributive,[11] and agricultural occupations. The curricula of vocational schools are usually terminal at the end of the twelfth year, but may extend for an additional one or two years. The vocational education program includes extensive part-time education directed toward the improvement of the adult worker. The enrollment in all-day vocational schools or classes operated under state plans for the year ending June 30, 1940, was 1,026,000,[12] whereas the secondary full-time day school enrollment for the same year

[10]Board of Education of the City of New York, Specialized High Schools in New York City, New York, 1946, 264 pp.
[11]Distributive occupations: those occupations concerned with making available to consumers the goods and services produced by others, for example, retail and wholesale selling, jobbing, and the various types of advertising. Carter V. Good (ed.), Dictionary of Education, New York, 1945, p. 137.
[12]U. S. Office of Education, Statistical Summary of Education, 1939-40, p. 48.

was 7,113,000,[13] indicating that less than 15 per cent of secondary day students were enrolled in vocational curricula.

All secondary schools provide a background in general education which includes study in such fields as English, social studies,the sciences, and mathematics. The actual course content in these fields is influenced by the curriculum of which it is a part. Thus many vocational schools provide adapted courses in the sciences which emphasize the principles and applications of particular value to the trade or trades being taught.

**A wide diversity of instructional practices and offerings exists within the general pattern of education in the United States.** Wide variations exist in size, legal control, financial support, and environment among the schools of the country. Legal control of the public schools does not rest with the Federal government but in the hands of authorities of the separate states and territories, although a certain amount of Federal revenue[14] goes to the support of these schools, largely in the field of vocational education.[15] In practice, broad authority over schools has been delegated to local government units.

In 1937-38 approximately 20 per cent of the secondary school students of the nation were attending schools enrolling 200 or fewer students, while approximately 12 per cent were attending schools enrolling 2,500 or more students.[16] The ratio of the state average annual expenditures for each pupil (in average daily attendance) between the extremes of the poorer and wealthier states is approximately 1 to 6.[17] Because of this difference in annual expenditure per pupil, there is a great deal of difference in equipment available, the training of teachers, and the effectiveness of instruction.

Such uniformity as exists in education in the United States, and it is considerable, has developed through the voluntary cooperation of educational institutions, accrediting agencies (such as the North Central Association and College Entrance Examination Board) and associations of educational workers (such as the National Education Association). Policies which function nationally have been derived from voluntary coordination by these groups, but attempts to impose uniformity upon schools operating under widely varied conditions have generally met with public disfavor.

The elementary and secondary schools of the United States are designed to provide a general education for all, and a differentiated and specialized education to meet the varied needs and interests of individuals. Science education in the elementary and secondary schools can be properly evaluated and understood only in the light of these broad purposes.

## The Science Program in the Schools

### The Curriculum

The study of the sciences, taught as part of the educational offering of the schools of the United States, is directed toward giving the citizen an intelligent understanding of his environment. Further, it provides the individual with a method of attack and analysis broadly applicable to social and economic as well as scientific problems.

Science education begins in the early grades with a course called **elemen-**

[13] Ibid., p. 12.
[14] Ibid., pp. 23-24.
[15] Ibid., pp. 47-48.
[16] "Study of Public High Schools by Size," **Education for Victory**, Vol. II, No. 19 (April 3, 1944), pp. 18-19.
[17] U. S. Office of Education, **Statistical Summary of Education, 1939-40**, pp. 23-24.

**tary science** (offered by an increasing number of schools), which cuts across the conventional boundaries of the individual sciences, thus integrating information, ideas and experiences from the physical and biological sciences. By means of such integration the child is more readily introduced to the natural science aspects of the world as it really is.

In the seventh, eighth, and ninth grades a course called **general science** has been steadily establishing itself. This course continues the child's experience with science phenomena in the environment, and attempts to develop on a maturer level an appreciation of and the ability to apply intelligently certain important science ideas. While a variety of different courses have been developed in both elementary and general science, there is a prevailing body of common content.

Beyond the ninth grade, **biology** is comonly offered in the tenth year and **physics** and **chemistry** offered in either order in the eleventh and twelfth years. About 60 per cent of those graduating from high school have had courses in biology, about 25 per cent have had courses in physics, and about 30 per cent have had courses in chemistry.[18] Physics and chemistry are more topically organized than is biology, but all three are well established both as to content and procedure.

In addition to these secondary school sciences, some other courses of long standing will still be found in a few of the schools, for example, physiography and physiology, and botany and zoology, which in some cases follow biology. New courses, such as meteorology, photography, aviation, and consumer science, have been added in a few cases.

### The Trend Toward Fusion and Integration

The development of curricula to meet the needs of general education for all youth has resulted in the trend toward the fusion of special subjects within an area into broad comprehensive courses.

The course in general science is an attempt to relate materials drawn from various sciences as a means of bringing reality into the educational experiences of children. The tenth grade course in biology integrates materials drawn from botany, zoology, and physiology. Some schools have developed a physical science course which parallels the fusion of botany and zoology into biology; the fusion of physics and chemistry into a single course provides a broad view of the nature and organization of the physical world and a more mature approach to the scientific concepts than was possible in the earlier general science offering. Other schools go even further in generalizing the physical sciences by combining physics, chemistry, geology, meteorology, and astronomy into a single course, thus carrying the general-science pattern on into the senior high school. The course in fused or generalized physical science in no way replaces the sequential courses in physics and chemistry for those students preparing for advanced training in specialized science fields. However, there is a growing belief[19] that for the purposes of general education, the course in fused or generalized science is preferable to the course in chemistry or physics for all students whose major interests and abilities are outside the realm of science, even for those students who will go on to college.

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[18] U. S. Office of Education, **Offerings and Registrations in High School Subjects, 1933-34** (Bulletin 1938, No. 6), Washington D. C., 1938.

[19] **Educational Policies Commission, Education for All American Youth**, National Education Association of the U.S.A., Washington, D.C., 1944. Also Harvard Committee Report **General Education in a Free Society**, Harvard University Press, Cambridge, 1945.

The trend toward fusion or integration has in some cases extended even beyond this point by incorporating content from different areas, such as science and social studies, into a single broad program of study. This greater degree of integration is predicated on the needs of the citizen in a democracy. A fuller understanding of life problems becomes increasingly necessary in a shrinking world inhabited by people differing widely in race, color, politics, economics, and social relationships. Thus certain important biological concepts can be better developed if they are related to certain concepts in the social studies. Experience indicates that the biology teacher alone frequently teaches these concepts as dogma. When these areas of biology and the social studies are brought together, what emerges is greater than the sum of the parts. The student then can more readily relate these larger socio-biological concepts to his own experience, and consequently he finds it easier to connect his understanding, and to some extent his behavior, with the direct experiences of the laboratory.

In the elementary school the total program of work is sometimes organized around certain central topics or centers of child interest. Under this pattern of curriculum organization, ordinarily referred to as the "activity program" or the "core program," subject matter content is drawn from all the fields of study which can contribute to practice in dealing with issues as they arise in student experience. Thus subject matter from science, social studies, arithmetic, literature, art, and shop might be used in the study of a major topic, such as transportation or any other common aspect of the environment.

### Science Education for All Children

The ways of living throughout the world in the future will in a large measure be determined by science. Events of the war have emphasized this conclusion. Science and technology are conditioning the very basis of our life and education in the United States is accepting the subject matter and the method of science, both broadly conceived. Many scientists and educators believe that a better understanding of the part that science is playing in the world is an essential basis for a study of social problems. Men and women who know more about the functioning of the human body will make a healthier population. Our natural resources will be better preserved if we provide for a better appreciation of the interdependence of living things, including their relationship to the environment. The solution of the utilities problem depends partly on a more widespread knowledge of the energy concept. Similarly, a solution of the housing problem depends partly upon more widespread knowledge about the materials in the crust of the earth. While greater understanding is not always a guarantee of desired conduct, one cannot deny that it is essential for intelligent behavior in a democracy. Thus education for **all** may be thought of as **science** education for all. If a program of universal education gives a prominent position to science, it is due to the importance which it has assumed in our life.

Provision is now made for the cultivation of science talent, which has been depleted during the war years. Science education for all and a special education for those possessing science talent are equally necessary. This can be accomplished by teaching science effectively to more people. There would be no point in cultivating science-talented youth in a free society if that society did not have a broad basic understanding of science and its applications. Scientifically trained minds will only function well if they serve the needs of people. There would be little reason for the existence of men of science without people who can understand the results of their efforts and labor.

In practice, the preparation of specialists has had the first claim on the attention of our teachers. Science instruction "for all" has been less well done, in spite of the American ideal of "education for all." The contribution of science to the thought pattern of the citizen has been enormously accelerated by the war. There is, therefore, a need for increased emphasis on science education for all.

### The Physical Plant

The physical needs of the school with reference to science will be determined by the curriculum and the individual courses of study. A science room must be designed to serve two related purposes. First, it is a place where the pupil participates in first-hand **experiences** which add meaning to and give better understanding of phenomena. Secondly, a science room must provide a setting for problem-solving activities.

The rooms provided are usually the following:

1. **The Science Classroom.** In the elementary school the regular classroom is equipped to provide for the special needs of the elementary science offering. Space is provided for animal cages, containers for growing plants, and an aquarium. Some schools use a portable demonstration table which may be moved from room to room and which contains the physical science equipment. In some cases, classrooms are provided with water, electrical and gas outlets, and a table or case for special exhibits or science materials and appropriate demonstrations.

In the high school the science classroom, seating about 36 students, contains a demonstration table equipped with gas, water, and electricity, and additional furniture depending upon the specific science taught in the room.

2. **The Combination Science Room and Laboratory.** In some elementary schools a special room is provided which becomes the "science center" for the school. This room functions as a combination classroom and individual project room. It is provided with all of the essential facilities needed for simple experimentation on the part of children and under the guidance of the teacher.

General science and biology are usually taught in the same type of room, a classroom containing student tables equipped with electrical and gas outlets and special tables for live plants and animals.

Two types of combination rooms are used in the teaching of physics and chemistry. The first type is a large room equipped with a lecture-demonstration table and a seating area at one end and laboratory tables occupying the rest of the room. A second type contains laboratory tables arranged so as to enable a class to recite, watch teacher demonstrations, or do individual laboratory work.

3. **The Specialized Laboratory.** Similar laboratory tables are used for both physics and chemistry; these are equipped with outlets for electricity, gas and water. The laboratory, which can be darkened, provides suitable storage space for necessary apparatus, bulletin board and blackboard space, and exhibit tables or cabinets.

4. **Miscellaneous Rooms.** Certain miscellaneous science rooms such as plant and animal growing rooms, museums, libraries, offices, storage and preparation rooms, and photographic dark-rooms are to be found. The science department may have its own special room in which to show motion pictures, slides, etc., or may use a more general visual-aids room provided for the entire school.

Science clubs sometimes use special rooms but commonly carry on their activities in the regular science rooms.

Some of the larger high schools provide a small auditorium equipped for performing science demonstrations and used when it is necessary to bring several classes together for special lectures or other activities beyond the scope of a single science class.

Classrooms and laboratories can usually be darkened so that projection equipment can be set up and operated with much the same effectiveness as the regular teaching demonstrations.

### Equipment

The equipment lists which are associated with the various categories of science instruction include general departmental equipment, demonstration apparatus, and student laboratory apparatus. The emphasis in this report has not been to suggest a minimum list of equipment, but rather to indicate a representative list of what is used in the United States for effective teaching.

The general departmental equipment includes essential tools and raw materials for building teaching aids and for the assembly and maintenance of equipment; the storage batteries and generators for supplementary electrical service; the laboratory support rods, clamps, etc.; general laboratory glassware; projection equipment, and other similar materials.

The demonstration apparatus listed for each course is usually supplemented by the effective teaching aids that can be built by the teacher, with which all teachers are acquainted. Books suggesting ideas for such aids to class demonstration are available in each science teaching field.

Student laboratory apparatus is indicated for each course. The quality of the apparatus provided must be adequate for the purpose to be achieved by the experiment.

## VISUAL INSTRUCTION EQUIPMENT
### for
### The Elementary and Secondary School

The equipment listed here is perhaps adequate for a school of 1000 pupils. For larger schools appropriate changes will have to be made in the quantities indicated.

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| | 3955 | 1 | Lantern Slide Projector Complete with 12" E. F. Lens | $74.10 |
| 78205 | 3950N | 2 | Extra Bulb, 500-watt, 115-volt, prefocus base | 4.80 |
| 78280A | 3960A | 1 | Opaque Projector Complete with 18" E. F. Lens to cover 6" x 6" area | 114.00 |
| 78205 | 3950N | 2 | Extra Bulb, 500-watt, 115-volt prefocus base | 4.80 |
| 78304A | 3936 | 2 | Screen 6' x 6' White Opaque | 24.00 |
| | 3967B | 1 | Strip Film Projector to accommodate single and double frame film | 65.00 |
| | 3969 | 2 | Extra Bulb, 150-watt, 115-volt prefocus base | 2.60 |
| | 3970 | 1 | 2" x 2" Slide Projector Complete with blower | 37.00 |
| | 3971 | 1 | Silent 16mm Motion Picture Projector Complete with universal motor for 105-125-volt A.C. and D.C. | 200.00 |
| | 3972 | 2 | Extra Bulb, 750-watt, 115-volt prefocus base | 8.00 |
| 78350C | 3596B | 2 | Screen 36" x 48" Tripod Model | 80.00 |
| | 3985 | 1 | Silent-Sound 16 mm. motion picture projector complete with universal motor for 105-125 volt A.C. and D.C. | 500.00 |

## EQUIPMENT, APPARATUS, TOOLS, AND SUPPLIES FOR THE TEACHING OF SCIENCE IN THE ELEMENTARY SCHOOL

Science, in the elementary school, is a study, at the level of the children's ability, of the biological and physical environment. There is no standard course but there is general agreement on aims, purposes and methods. Equipment and apparatus used in elementary science ranges from nearly none up to what may be described as elaborate. The accompanying list is representative of schools in which definite provisions have been made for a specialized room and a special science teacher. In most schools of the United States, science is taught in the regular classroom by the regular class teacher, using selected equipment from the accompanying list.

The specialized science room, when it exists in the elementary school, is usually a combination classroom and laboratory, to which classes go for laboratory study and special demonstrations. Science instruction is not limited to activities in the specialized science room but is carried on in the regular classroom as well. Each classroom may be equipped with aquaria, terraria, and potted plants, frequently used pieces of apparatus, and living animals (a pair of canaries, which need not be singers, is highly recommended for the lower grades). The specialized science room can then become a source room to which pupils and teachers go for apparatus, tools and supplies that cannot be conveniently maintained in each room.

Most of the equipment and apparatus in the science room should be large, and markings should be plainly visible. There is a special need for large pulleys (large enough so that children may lift each other with them), inclined planes, thermometers (with red fluid that can be seen at a distance of ten or twelve feet), and scales (plainly calibrated).

It does not seem feasible to distinguish in this report between equipment and apparatus that should be purchased and that which should be made by pupils and teachers. We report here those items which representative teachers find useful. It is desirable from the educational point of view that some equipment be made in the classroom. A portion of the science should be taught using the outdoors, where almost no equipment is necessary. Teachers often supplement the equipment and supplies purchased from the apparatus supply houses with teaching material, both living and inanimate, collected in the community.

The classroom should be large (20 to 30 square feet for each child) and well lighted. The window shades should be constructed and installed in such a manner that the room can be darkened. The number of tables and chairs needed will depend upon the number of children to be served. There should be shelves and drawers (preferably a store room) and one or more filing cabinets. There should be ample blackboard and bulletin board space and a projection screen (movable or painted on the wall).

## ELEMENTARY SCHOOL SCIENCE

### EXPERIENCES WHICH SCIENCE IN THE ELEMENTARY SCHOOL SHOULD PROVIDE*

I. Air

- What the air is made of
- The air pushes on us from all directions
- The air contains water
- The air contains germs
- Rain, snow, sleet, hail, frost, dew, etc.

II. Water

- The water cycle
- Water is necessary for life
- Some germs live in water
- Means of purifying water

*The experiences listed are suggestive rather than exhaustive. The order in which they should be studied is optional.

III. Rocks and soil
- Soil is made from rocks
- Kinds of soil
- Wind and water may carry the soil away
- Coal, oil, gas and other products come from beneath the soil

IV. Plants
- The growth of plants—Plants must have the necessary cnemical elements; plants must have water; plants must have sunlight; roots grow down, shoots grow up
- There are many kinds of plants
- Plants grow in communities
- Man has some control over plant communities
- Man's dependence upon plants

V. Animals
- Feeding habits
- Breeding habits
- There are many kinds of animals
- Plants and animals are interdependent
- Man's dependence upon animals

VI. The area of health
- The human body as a machine—Consumption and use of energy; elimination of waste
- Cause, treatment and prevention of common ailments—Headaches, stomach disorders, colds
- Communicable diseases—Causes; symptoms; prevention
- Public health—Personal cleanliness; clean playgrounds; clean streets; clinics

VII. Energy
- The sun is a source of energy
- Kinds of energy
- Energy may be changed from one kind to another
- Man's use of energy

VIII. Electricity and magnetism
- Static
- Current
- Production
- Distribution

IX. Machines
- Simple
- Compound

X. The solar systems
- Relationship of the earth and sun
- Relationship of the earth and other planets
- Other bodies in the solar system

XI. The stellar system
- Bodies beyond the solar system
- The nature of stars
- Man's use of knowledge about the stars
- Space

# APPARATUS AND SUPPLIES

The apparatus and supplies listed here will provide for an elementary school of 200 pupils. Where the school to be supplied is larger appropriate increases in quantities will have to be made.

## A. Essential Required Equipment:

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 36215 | 8327 | 1 | Animal cage, Vaughan, collapsible | $12.50 |
| 36220 | 8327 | 1 | Animal cage, 25 x 15 x 12" | 20.00 |
| 94862 | 8327D | 1 | Observation ant house | 5.00 |
| 36415 | 8325A | 2 | Aquaria, 6 gallon cap | 17.00 |
| 94116A | 8346A | 1 | Terrarium, all glass and cover | 15.10 |
| 43230 | 1236 | 1 | Barometer, aneroid, "Weatherguide" | 7.50 |
| 50200 | 4752 | 3 | Burner, Bunsen, adjustable | 2.25 |
| 74100 | 5126 | 1 | Heater, electric | 7.25 |
| 56600 | 4900 | 6 | Clamps, Burette | 2.40 |
| 63400C | 1882 | 1 | Compass, 1" | .75 |
| 11360 | 1869 | 1 | Compass (mounted magnetic needle) | 1.10 |
| 11490A | 1848A | 1 | Iron filings in sifter top | .30 |
| 63470 | 1835 | 1 | pkg. Darning needles | .25 |
| 14580B | 2924 | 2 | Bells, door, electric | 2.70 |
| 15170 | 2439 | 1 | Flash light | 1.15 |
| 11820 | 1925 | 1 | Glass friction rod | .45 |
| 1110B | 1823 | 1 | Magnet, Horseshoe | .40 |
| 11890 | 1933 | 1 | Wool Friction Rod pad | .50 |
| 11020 | 1813 | 1 pr. | Magnets, permanent, in box | 1.20 |
| 11810 | 1929 | 1 | Friction rod, ebonite | .45 |
| 10230 | 1663 | 1 | Bar, compound | .85 |
| 15170X | 2430 | 6 | Bulbs, flash light | 1.08 |
| 14960 | 2428 | 6 | Sockets, miniature light | .90 |
| 14605 | 2970 | 3 | Buttons, push | .60 |
| 94014B | 8493 | 3 | Rings, feeding | .90 |
| 96520B | 9345 | 3 | Pots, flower, 2" | .30 |
| 96520C | 9345 | 3 | Pots, flower, 3" | .45 |
| 96520D | 9345 | 3 | Pots, flower, 4" | .48 |
| 96520F | 9345 | 3 | Pots, flower, 6" | .72 |
| 96522D | 9346 | 3 | Saucers for above pots 4" | .35 |
| 96522E | 9346 | 3 | Saucers for above pots 5" | .45 |
| 96522F | 9346 | 3 | Saucers for above pots 6" | .50 |
| 96522G | 9346 | 3 | Saucers for above pots 8" | 1.00 |
| 94030 | 8340D | 1 | Aquarium net, student | .50 |
| 79905C | 5572 | 5 | Support stand, complete with rings, 24" | 9.25 |
| 79905D | 5572 | 1 | Support stand, complete with rings, 36" | 2.50 |
| 78800C | 5510 | 12 ft. | Tubing, rubber, ¼" | 1.44 |
| 78800D | 5510 | 12 ft. | Tubing, rubber, ⅛" | 1.20 |
| 40580 | 4053 | 2 | Balance, household, 24 lb. by 1 oz | 6.20 |
| 40802 | 4086 | 3 | Balance, spring, 24 lb. by 1 oz | 11.25 |
| 96500A | 9730 | 1 | Can, sprinkling, 1 gal. | 1.25 |
| 24840B | 7018 | 1 | Globe, standard world, 18" | 6.25 |
| 24850 | 7070 | 1 | Washington School Minerals | 5.75 |
| 22750A | 3468 | 3 | Prisms, 60° glass | 3.00 |
| 14770 | 2991 | 2 | Switches, knife SPDT | 1.00 |
| 22470 | 3510 | 3 | Mirrors, plain | .60 |
| 76195B | 8032 | 2 | Glasses, Reading, 3" | 2.50 |
| 66515 | 2238 | 12 | Drycells, #6 | 6.00 |
| 14790 | 2993 | 4 | Switches, knife, double pole, double throw | 3.40 |
| 18100 | 2632 | 1 | Telephone receiver | 3.50 |
| 18110 | 2634 | 1 | Telephone transmitter | 2.50 |
| 20060 | 3229 | 1 | Forks, set of four, tuning, C', E', F', G' | 7.00 |
| 56540 | 4894 | 4 | Clamps, Universal support | 5.40 |
| 56840 | 4910 | 4 | Clamp holder | 3.60 |
| 5250 | 1424 | 1 | Pump, hand, vacuum-pressure | 6.00 |
| 67304 | 3068 | 1 | Voltmeter, pocket | 3.25 |

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 42570A | 4182 | 1 | Ring handle weight, 1 lb. | $ .85 |
| 42570B | 4182 | 1 | Ring handle weight, 2 lb. | 1.25 |
| 42470C | 4182 | 1 | Ring handle weight, 5 lb. | 1.75 |
| 75600A | 1166A | 2 | Battery jar 4 x 5" | 1.40 |
| 75600C | 1166A | 2 | Battery jar 6 x 8" | 2.30 |
| 64310 | 4972C | 3 | Crucible, Coor's, No. 2 | 1.20 |
| 44300 | 4516P | 6 | Beakers, Pyrex, 100 ml | 1.20 |
| 44300 | 4516P | 6 | Beakers, Pyrex, 250 ml | 1.02 |
| 44300 | 4516P | 6 | Beakers, Pyrex, 600 ml | 1.74 |
| 71240 | 5143P | 2 | Funnels, Pyrex, 75 mm | .88 |
| 70400 | 5100P | 6 | Flasks, Florence, Pyrex, 500 ml | 1.74 |
| 73760 | 5241P | 1 lb. | Glass tubing, Pyrex, 6 mm | .75 |
| 73760 | 5241P | 1 lb. | Glass tubing, Pyrex, 10 mm | 1.25 |
| 73760 | 5241P | 1 lb. | Glass tubing, Pyrex, 12 mm | .70 |
| 22870 | 3440 | 1 | Set of 6 Demonstration Lenses | 2.50 |
| 22550 | 3524 | 3 | Mirror, Concave-convex | 1.40 |
| 65270A | 8386P | 6 | Petri dishes, Pyrex 100 x 15 mm | 2.28 |
| 80062C | 5671 | 4 | Thermometer, C & F, red liquid | 5.60 |
| 80070C | 5680 | 1 | Thermometer, C & F, 360° | 2.75 |
| 6200 | 1206 | 1 | Torricellian tube | 1.25 |
| 80890D | 5750 | 6 | Watch glasses, 3" | .39 |
| 80650F | 5628P | 12 | Test tubes, Pyrex, 6 x ¾" | .60 |
| 98612 | 8020 | 2 | Simple magnifiers on tripod stand | 8.50 |
| 8380 | 780 | 1 set | Double sheave block and tackle with rope | 9.50 |
| 8170 | 756 | 2 | Pulleys single bakelite | .80 |
| 8175 | 758 | 2 | Pulleys double bakelite | 1.10 |
| 8180 | 760 | 2 | Pulleys triple bakelite | 1.60 |
| | | | Total | $256.47 |

B. **Tools:**

| | | | | |
|---|---|---|---|---|
| 27260 | 308A | 1 set | Chest of 20 tools | $ 25.00 |
| 26960 | 105 | 1 | Saw, adjustable hack | 1.50 |
| 26970B | 109 | 3 | Blades, hack saw | .34 |
| 27110 | 282 | 1 | Iron, electric soldering | 1.50 |
| | 5130A | 1 pr. | Forceps small | .30 |
| | 287 | 2 lb. | Solder | 1.50 |
| | 286 | 1 lb. | Solder flux | .35 |
| | | | Total | $ 30.49 |

C. **Chemicals (All in Glass Containers):**

| | | |
|---|---|---|
| 1 lb. | Acid, acetic CP glacial | $ .61 |
| | Alcohol, methyl | 1.25 |
| | Alum, Potassium | .25 |
| | Ammonium Chloride | .25 |
| | Ammonium dichromate | 1.11 |
| | Copper turning fine | .45 |
| 1 lb. | Iron turning fine | .40 |
| 1 lb. | Lead turning fine | .90 |
| 1 lb. | Tin turning | 2.20 |
| 1 lb. | Zinc sheet—turning | .40 |
| 1 lb. | Ammonium Hydroxide, CP | .55 |
| 1 lb. | Acid, boric, powd. | .25 |
| 1 lb. | Acid, Carbolic USP | .49 |
| 1 lb. | Calcium carbonate chips | .20 |
| 1 lb. | Wood charcoal, lump | .25 |
| 1 lb. | Copper sulphate | .27 |
| 1 lb. | Fehling solution A | .60 |
| 1 lb. | Fehling solution B | .65 |
| 1 lb. | Acid hydrochloric CP | .60 |
| 4 oz. | Iodine crystals, CP | 1.46 |
| 1 lb. | Manganese dioxide powd. | .25 |
| 2 lb. | Mercury metal, tech. | 6.90 |
| 1 lb. | Potassium chlorate, powd. | .45 |

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| | | 4 oz. | Potassium permanganate | $ .23 |
| | | 1 lb. | Sodium Bicarbonate | .20 |
| | | 1 lb. | Sodium chloride | .20 |
| | | 1 lb. | Sodium hydroxide CP pellets | .70 |
| | | 1 lb. | Starch, corn | .25 |
| | | 4 oz. | Camphor gum | .60 |
| | | 1 lb. | Glycerine USP | .75 |
| | | | Total | $ 23.63 |

D. **General Supplies:**

| | | | | |
|---|---|---|---|---|
| 22120 | 3591 | 12 | Candles | $ .28 |
| 95300 | 5862 | 2 | Cement, Duco Household | .60 |
| 25140 | 5882 | 1 lb. spl. | Wire, annunciator, No. 20 | .90 |
| 63805A | 4947A | 1 bag | Corks, assortment | .75 |
| 69700 | 5050 | 1 pkg. | Filter paper, E & D 11 cm | .23 |
| | | 1 vial | Litmus test paper, red | .10 |
| | | 1 vial | Litmus test paper, blue | .10 |
| 95790 | 5810 | 5x5 lb. | Clay, modeling | 7.50 |
| 78785A | 5505B | 3x1 lb. | Rubber stoppers, asst. | 3.00 |
| | | | Total | $ 14.06 |

E. **Extra Desirable Supplies:**

| | | | | |
|---|---|---|---|---|
| | 6877 | 1 | Celestial globe | $ 5.00 |
| 10860 | 1749 | 1 | Engine, large, model upright | 38.50 |
| 10830 | 1775 | 1 | Engine, steam, lecture model | 10.00 |
| 94676B | 8361 | 1 | Insect box, glass top | 5.50 |
| 98002 | 7969 | 1 | Microscope, complete with case, compound | 112.00 |
| 94634A | 9958 | 2 | Pans, sorting | 2.50 |
| 94720D | 8347 | 15 | Boxes, nesting storage | 6.75 |
| 98440 | 3968 | 1 | Projector, tri-purpose | 70.00 |
| 78350B | 3596A | 1 | Screen for above | 33.00 |
| | | | Total | $283.25 |

## ELEMENTARY SCIENCE

### RECAPITULATION

| | |
|---|---|
| Essential Required Equipment | $256.47 |
| Tools | 30.49 |
| Chemicals | 23.63 |
| General Supplies | 14.06 |
| Extra Desirable Supplies | 283.25 |
| GRAND TOTAL | $607.90 |

# MATHEMATICS

### A. The Arithmetic in Grades One to Six Inclusive

The arithmetic in the first and second school years is in most schools incidental and informal in the sense that (1) pupils do not study textbooks, (2) no special time in the school day is set aside for the study of this subject, and (3) the content is restricted to the arithmetic needed in the work and play of the children. Occasions for teaching number ideas are frequent where primary teachers are conscious of the value and necessity for such training, and these teachers use such occasions for constant growth in understanding of number concepts as part of the social experience of the pupils.

A competent teacher will have constantly in mind a set of specific arithmetic goals. If the normal activities of children do not require that all the objectives be attained incidentally, then the teacher will see to it that the ones in danger of being omitted are taught in a formal way.

In some schools the incidental method is used in the third, as well as in the first and second, grade. The general practice is for teachers to use a textbook in each grade after the second. The emphasis in textbooks for grades three through six is on whole numbers, common fractions, and decimals. As in the early grades, many teachers provide practice on these essentials as a part of social activities. In recent years the problem material has been drawn extensively from ordinary experiences of citizens. Following is a sample list of activities that children might initiate or enjoy doing as part of the experience of learning numbers: (1) measuring the number of glasses of milk in a quart, (2) determining amounts to avoid wasting food, (3) counting materials in the room for which pupils assume care, (4) counting change when buying lunches, (5) playing store, (6) counting money earned selling old newspapers and magazines, (7) earning money as workers in vegetable gardens or as newsboys, (8) computing cost of school parties, and (9) finding the cost of books or materials selected and purchased by pupils for the classroom.

It would be incorrect to conclude from the preceding that our teachers now look upon arithmetic as a mere tool subject. On the contrary, we realize that arithmetic has a mathematical as well as a social aim. Arithmetic is still taught in most schools as a system of concepts and principles, but with much more attention to the development of meanings and less emphasis on abstract and unmotivated drill.

### B. The Mathematics of Grades Seven and Eight

It is in grades seven and eight that our mathematics teachers have made the most far-reaching changes during the last quarter of a century. In an earlier day the work of these grades was devoted solely to arithmetic. This has been almost universally replaced by **general mathematics.** General mathematics is a basic exploratory course in which the simple and significant principles of arithmetic, algebra, intuitive geometry, statistics, and numerical trigonometry are taught so as to emphasize their natural and numerous interrelations. General mathematics is a direct outcome of our struggle with the problem of mass education, in that originally this organization of subject matter was proposed to provide an alternative course for ninth year pupils who could not do the algebra and who did not find in the traditional courses the mathematics needed in the common affairs of citizenship. Somewhat later teachers utilized general mathematics to strengthen the work in grades seven and eight. In the early years of this experiment there was naturally considerable confusion as to a desirable content. Fortunately, there is now fairly general agreement regarding the specific things that a pupil should master in these two grades, provided he has adequate ability. The Second Report of the Commission on Post-War Plans* suggests that the requirements for effective citizenship have moved upward and are already much higher than mere control of the four fundamental processes of arithmetic. Competence in mathematics is believed to be almost as crucial as literacy in communication.

### C. The Mathematics of Grade Nine

The teacher of mathematics in grade nine tries to come to grips with the dual responsibility that has rested in the American secondary school since the turn of the century: (1) for giving good training to future leaders, and (2) for providing a general education appropriate for the major fraction of the high school population.

The situation seems to demand a double track in mathematics from the beginning of the ninth grade through the twelfth grade. The problem is especially acute at the beginning of the ninth grade. Approximately one-fourth of the pupils of the ninth grade are ready for a systematic study of algebra. They are in general the pupils who are destined for leadership in science, mathematics, and the other fields of learning. The remainder have not completely mastered the specific mathematical ideas and principles taught in the seventh and eighth grades. Therefore, many school systems offer two courses in the ninth grade: (1) general mathematics, and (2) a beginning course in algebra. Textbooks in general mathematics generally (1) provide materials to review the basic ideas introduced in grades seven and eight, (2) give more emphasis to laboratory or "workshop" techniques, (3) include simple problems from the field of aviation, (4) attempt to meet the mathematical needs of business and industry, (5) provide for a consistent program of reviewing and drill in the essentials of arithmetic, (6) include problem material that is realistic, (7) provide for individual pupil differences, and (8) utilize techniques for teaching pupils how to read.

During the past twenty-five years there has been very substantial improvement in the teaching of algebra in the United States. The following incomplete list of changes illustrates the trends: (1) reduction in the amount of manipulation of symbolism (nests

*The Mathematics Teacher, May, 1945. "This report is in agreement and follows the report of the Policy Committee of the National Council of Teachers of Mathematics that was approved by the Board of Directors in February, 1945."

of parentheses, complex fractions, involved cases of factoring, difficult cases of simultaneous equations); (2) introduction of a unit of from four to six weeks' duration on the trigonometry of the right angle; (3) emphasis on the notion of dependence or the functional relation; (4) teaching with great care the meaning of a formula; (5) applying graphic techniques widely; (6) using the newer testing procedures for instructional purposes; (7) introduction of symbolism gradually and through a variety of geometric and other illustrations; (8) discarding the definitional approach and managing materials so that definitions as well as principles, processes, and concepts grow out of numerous and simple mathematical experiences; (9) making better provision for individual ability and interest differences by providing problems of graded difficulty; (10) using a more meaningful program of "drill" based on the fact that a pupil learns more quickly and remembers longer the things that he understands fully; (11) using a few simple, interesting, and practical applications to motivate each new principle and topic; (12) striving to improve the problem material by selecting functional applications (aviation, the school shop, general science); (13) making use of the bulletin board and other visual aids tc enrich the subject; (14) utilizing laboratory or investigational techniques wherever pos sible and seeking to give the mathematics classroom the furniture, equipment, and appearanee of a workroom; (15) recognizing that poor reading ability severely limits achievement in problem solving in the case of many pupils; (16) recognizing that it is far better to teach a few concepts well than to teach many concepts superficially; and (17) attempting to restrict first-year algebra to those pupils who have the ability and interest to study it, and to provide a course with sufficient rigor and continuity to prepare the student for subsequent courses.

### D. Mathematics in Grades Ten, Eleven, and Twelve

The trend at the present time is in the direction of providing two types of courses in the tenth, eleventh, and twelfth years: (1) the traditional sequential courses: a year of plane geometry in the tenth school year, a second year of algebra in the eleventh year, and a half year of solid geometry in the twelfth year with the other half devoted to trigonometry; and (2) a variety of new courses, as, for example, general mathematics, shop mathematics, statistics, consumer mathematics, social mathematics, and arithmetic review. In general all mathematics courses in these grades are elective, although in many schools one or more years of the traditional courses are required of pupils who are planning to study science and mathematics in colleges or universities.

There is at present an effort to reserve the traditional sequential courses for pupils who desire to take them and have the ability to do them successfully. The main objective of these courses is to develop mathematical ability, and therefore the trend is to organize the work of each year into a few large units built around fundamental principles. There is provision for simple applications from industry, physical science, aviation, and business.

There are many pupils who arrive at the eleventh or twelfth grade without having taken any mathematics beyond the eighth grade. For such pupils some high schools provide a course in mathematics that will make them as competent as possible in a relatively short period of time. Usually this is a general mathematics course that is very close in content and organization to, but containing more extensive materials than, the one described for the ninth school year.

## MATHEMATICS EQUIPMENT

In a large measure, the success of our courses in mathematics has depended on the degree to which the classroom takes on the physical appearance, spirit and attitude of a well-organized laboratory in which developments of new principles, the assignment, supervised study, recitation, and the testing program all find their place and are economically interrelated. It is not enough that desirable facilities be provided; they must be arranged so as to present a unified, attractive picture. Providing for mathematics an adequate equipment and a setting that is convenient and appropriate is receiving increasing attention in our schools.

Good work can be done with homemade instruments and models. For example, pupils can make a simple slide rule from a piece of cardboard and a sheet of logarithmic graph paper. With this, he can learn the principles applied when a slide rule is operated.

An instrument for measuring angles and a model transit can be built. A hypsometer is easily constructed and is quite useful in finding the height of buildings and trees. These and many other instruments can be constructed by the pupils, either in class, at home, or in the school shops. If field trips are impossible, the instruments may be set up in the classroom, and by a liberal use of the imagination, the width of rivers and height of trees can be determined.

Finally, it is suggested that whenever possible the traditional nailed-to-the-floor desks be replaced by flat-top work tables preferably in two sizes, say one group 30 inches high and another 27½ inches, with comfortable chairs to match. Flexible furniture contributes not only to informality, but also to a variety of procedure and the assignment of differential tasks. Many schools are now equipped with such furniture. Bulletin boards, plane and squared black boards, and cases for the storage of materials and books are essential.

We shall classify mathematical equipment for use in grades seven through twelve as (1) the pupil's individual equipment, (2) the classroom equipment, and (3) the equipment in the mathematics laboratory.

## MATHEMATICS SUPPLIES AND EQUIPMENT

### (Grades 7 — 12)

### Pupil's Individual Equipment

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 323 | | 50 pkg. | Plain Drawing Paper, size 9 x 12" (24 sheets to pkg.) | $ 15.00 |
| 321 | | 50 pkg. | Cross Section paper (40 sheets to pkg.) | 12.50 |
| 231 | 3330B | 20 | Protractors, Bristol Board, 14" diameter | 10.00 |
| 163 | | 100 | Rulers, 12" long, graduated both inches and centimeters | 15.00 |
| 244 | | 50 | Student Slide Rules | 60.00 |
| 250A | | 50 | Slide Rule Manuals | 12.50 |
| 67 | 3270 | 100 | Compasses and pencils | 25.00 |
| 330 | | 20 | Drawing Boards size 17 x 22" | 40.00 |

### CLASSROOM EQUIPMENT

| | | | | |
|---|---|---|---|---|
| 329 | | 5 | Blackboard Drawing Set | 22.50 |
| 335 | | 5 | Blackboard Dividers 18" | 12.50 |
| 325 | 27730 | 10 | Celluloid triangles 30° x 60°—10" | 7.50 |
| 326 | 27740 | 10 | Celluloid triangles 45° 10" | 10.00 |
| 340 | | 1 | Steel Straight Edge 4' | 15.00 |
| 345 | | 10 | Pencil Sharpeners | 50.00 |
| 273 | 27090 | 10 | Scissors 8" long | 15.00 |
| 350 | | 20 pkg. | Colored Crayon | 5.00 |
| 5616 | 95250 | 6 rolls | Gummed Tape | 2.10 |
| 355 | | 2 | Flexible Steel Tapes 100' | 20.00 |
| 360 | | 1 | Carpenter's Rule 6' long | 1.00 |

### LABORATORY — MATHEMATHICS EQUIPMENT

| | | | | |
|---|---|---|---|---|
| 593 | | 1 | Dissectible Cone | 9.75 |
| 591 | 2920 | 1 | Geometrical Curves, Solids and Surfaces | 3.85 |
| 365 | | 1 | Spherical Blackboard | 15.00 |
| 252 | | 1 | Demonstration Slide Rule, 4' long | 8.50 |
| 253 | | 1 | Slide Rule Polyphase, 10" | 17.00 |
| 254 | | 1 | Slide Rule Log-Log Duplex | 18.50 |
| 255 | | 1 | Slide Rule Polyphase, 20" | 23.50 |
| 370 | | 1 | Pantograph, 41" long | 9.50 |
| 375 | | 1 | Plane Table | 250.00 |
| 3535A | | 1 | Sextant | 200.00 |
| 385 | | 1 | Transit | 385.00 |
| 390 | | 1 | Level | 50.00 |
| 395 | | 1 | Leveling Rod | 25.00 |
| 400 | | 2 sets | Steel Marking Pins | 10.00 |
| 405 | | 1 | Hypsometer | 15.50 |
| 410 | | 1 | Angle Mirror | 14.50 |
| 415 | | 2 | Parallel Rules 12" | 3.50 |
| 420 | | 1 | Proportional Divider 10" | 35.00 |
| 234 | | 2 sets | Full Circle Protractors 6, 8, & 10 | 54.00 |
| 1585 | | 1 | Sine Cosine Demonstration Board | 12.50 |
| 1586 | | 1 | Tangent Demonstration Board | 14.00 |
| 1587 | | 1 | Surveying Board | 16.00 |
| | | | Total | $1541.20 |

# GENERAL SCIENCE

## GRADES 7 THROUGH 9

## EQUIPMENT, APPARATUS, TOOLS, AND SUPPLIES FOR THE TEACHING OF GENERAL SCIENCE

As a common practice, this subject is offered either over a period of three years in a junior high school or as a one-year offering in the ninth grade of a four-year high school. General science is the most nearly universal of the science courses studied by pupils in the public schools of the United States.

General science, as the name implies, is a course designed to give pupils an opportunity to become acquainted with the important scientific generalizations as these are related to content, methods, and attitudes. As the course outline indicates, the course involves a study of many areas, each of which, at a later stage, represents a specialty. Thus the study tends to orient the pupil to the whole of science and at the same time provides a basis for pupils to consider the making of plans for further studies in the sciences.

The instruction is characteristically a study of experimental demonstrations performed by the teacher, often with the assistance of pupils. Textbooks provide additional information and visual aids are used as opportunities for more extensive observations. Many teachers encourage their pupils to plan and develop projects which call for library study, experimentation, and the preparation of reports. Due to the assignment of classes to general types of classrooms and to the use of teachers who are relatively uninformed in the areas covered by general science, much instruction may be done by textbook reading and class discussion.

The topics in the outline which follows are **listed alphabetically.** The development of topics in the classroom will be in some other sequence, but such a large variety of patterns prevail that it is impossible to present one common pattern. Some schools allocate selected topics to each of the three grades of the junior high school. Some schools relate the basic science to such functional areas as transportation, communication, health, conservation, and the like. Still other schools arrange a cyclic pattern in which certain related topics are developed so as to build up from year to year, for example, air, weather, aviation. Then too, some schools follow a core development in which science finds a place along with subject matter from other disciplines. Whatever be the pattern, the topics in the outline are common content of general science and as such are indicative of necessary equipment and apparatus. The degree of detail included for any one topic will depend upon the time, the facilities available, and the preparation of the teacher.

# GENERAL SCIENCE

## OUTLINE OF COURSE CONTENT*

I. Introduction
- Common materials and forces
- Properties and states of matter
- Classification of the sciences
- Characteristics of a scientist

II. Air (atmosphere)
- Extent and composition
- Weight and buoyancy
- Oxidation, including burning — Conditions necessary; control and prevention

III. Animals
- Kinds and classification
- Distribution
- Structure
- Behavior

*Topics are listed alphabetically. See preceding general statement.

IV. Astronomy
- The sun
- The planets, including the earth and its moon — Seasons; day and night; phases of the moon
- Stars and constellations

V. Communication
- Telegraph
- Telephone
- Radio

VI. Conservation
- Meaning
- Importance
- Methods

VII. Electricity
- Static — Separation of charges; lightning; uses
- Currents — Generation; transformation; control; uses

VIII. Energy
- Sources
- Transformations
- Relation to work

IX. Food
- Classification and uses
- Processing
- Preservation

X. Heat
- Sources
- Movement
- Expansion and contraction
- Control, including insulation

XI. The human body
- Anatomy
- Physiology
- Behavior
- Reproduction and inheritance

XII. Light
- Sources
- Movement
- Color formation
- Optics — Care of the eyes; photography; instruments

XIII. Machines
- Kinds — Simple; complex
- Uses

XIV. Magnetism
- Nature
- The compass
- Electromagnets

XV. Plants
- Kinds and classification
- Growth, including gardening
- Food production
- Plant propagation

XVI. Rocks, minerals, fossils
- Formation
- Classification
- Uses

XVII. Shelter
- Clothing
- Housing

XVIII. Soil
- Formation
- Maintenance of fertility
- Erosion control

XIX. Sound
- Production
- Transmission
- Recording
- Music

XX. Transportation
- Land
- Water
- Air

XXI. Water
- Sources
- Purification
- Uses

XXII. Weather
- Factors
- Prediction
- Relation to man

## APPARATUS AND SUPPLIES

The apparatus and supplies listed here will care for a school having 200 pupils in the seventh, eighth and ninth grades. Where the school to be supplied is larger appropriate increases in quantities will have to be made.

### 1. Science Hardware

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 1070 | 4242 | 2 | Table clamp, with wooden jaws | $ 7.50 |
| 1110E | 4227 | 2 | Rods, round support, 19 mm | 2.50 |
| 1150B | 4268 | 2 | Clamps, right angle | 3.50 |
| 1130B | 4230 | 1 | Rod, round support, 150 mm | 2.25 |
| 1380C | 4257 | 12 | Hood collars, with lock screws | 10.80 |
| 1390C | 4302 | 1 | Rectangular table platform | 2.25 |
| 1320 | 828 | 1 | Clamp, pendulum, metal | 1.50 |
| 1300 | 4325A | 1 | Clamp, motor stick, 2 way form | 1.95 |
| 26870 | 209 | 1 | Plumb bob | .65 |
| 73855 | 5212 | 1 | Glass tubing cutter | 1.25 |
| 27260 | 304 | 1 | Chest of 20 tools | 25.00 |
| | | | Total | $59.15 |

### 2. Demonstration List

| | | | | |
|---|---|---|---|---|
| 5320 | 1420 | 1 | Air pump—lever type | $ 43.00 |
| 5780 | 1514 | 1 | Weight of air globe | 5.00 |
| 5800 | 1509 | 1 | Madgeburg hemisphere | 6.60 |
| 6050 | 1102 | 1 | Lift pump model | 1.85 |
| 6060 | 1104 | 1 | Force pump model | 1.85 |
| 4750 | 1090 | 1 | Hydraulic press model | 6.00 |
| 9600 | 1601 | 1 | Thermometer, simple air | .35 |
| 6200 | 1206 | 1 | Torricellian tube outfit | 1.25 |
| 75450G | 1142 | 1 | Hydrometer jar 12 x 2" | .75 |
| 4940 | 1137 | 1 | Set of 10 density specimens | .75 |
| 4640 | 1004 | 1 | Communicating vessels | 7.50 |
| 4740 | 1050 | 1 | Faucet, demonstration | 3.00 |
| 10210 | 1661 | 1 | Ball and ring | 1.75 |
| 80190 | 1260 | 1 | Thermometer, 3 scale | 1.45 |
| 10410 | 1653 | 1 | Milvay 6 rod conductors | 1.75 |

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 98006 | 7969A | 1 | Microscope, compound, in case | $116.50 |
| 10490 | 1727 | 1 | Convection of air apparatus | 2.35 |
| 10530 | 1720 | 1 | Hot water tank model | 5.75 |
| 10540 | 1733 | 1 | Radiometer, 4 blades | 5.00 |
| 10620 | 1665 | 1 | Franklin pulse glass | 1.25 |
| 10830 | 1775 | 1 | Lecture model of steam engine | 8.00 |
| 10850 | 1781 | 1 | Turbine, working model | 9.35 |
| 10820 | 1073 | 1 | Hero's engine on stand | 4.50 |
| 10860 | 1749 | 1 | Engine, large model | 38.50 |
| 9650 | 1625 | 1 | Apparatus A, steam generator spun copper | 5.00 |
| 10250 | 1275A | 1 | Thermostat, double contact | 3.25 |
| 10740 | 1725A | 1 | Fire syringe with tender | 6.50 |
| 74630 | 1290 | 1 | Hygrometer sling | 5.50 |
| 7310 | 1723 | 1 | Dew point apparatus | 1.50 |
| 5070 | 1122 | 1 | Demonstration hydrometer, wood | .45 |
| 5080 | 1128 | 1 | Hydrometer, for heavy liquids | .70 |
| 5090 | 1126 | 1 | Hydrometer, for light liquids | .70 |
| 21150 | 3680 | 1 | Illuminator — Arc 110 AC | 22.50 |
| 22550 | 3524 | 1 | Mirror, concave-convex | .70 |
| 22650 | 3498 | 1 | Solid glass refraction cube | 2.25 |
| 22720 | 3480 | 1 | Prism, flat equilateral | .70 |
| 22750C | 3468 | 1 | Prism, 4", equilateral | 1.35 |
| 22870 | 3440 | 1 | Lenses, set of 6 demonstration | 3.15 |
| 76195C | 8034 | 1 | Reading glass 3" | 1.50 |
| 22440 | 3528 | 1 | Multiple image kaleidoscope | 1.50 |
| 24816 | 7018 | 1 | Globe, world | 10.00 |
| 24850 | 7070 | 1 | Washington School Collection | 5.75 |
| 66750 | 2606K | 1 | AC-DC Source of current 11 volts DC output | 20.00 |
| 66680A | 2301 | 1 | Storage battery demonstration | 3.75 |
| 15505 | 2732 | 1 | Student portable galvanometer | 12.00 |
| 13855 | 2200 | 1 | Cell, student demonstration | 1.20 |
| 14580B | 2924 | 1 | Bell, 2" electric | 1.15 |
| 14605 | 2970 | 1 | Push button | .20 |
| 16700 | 2363A | 1 | Brownlee electrolysis apparatus | 2.75 |
| 16910 | 2354 | 1 | Electroplating outfit, copper | 2.50 |
| 16610 | 1853 | 1 | Electromagnet, lifting | 6.00 |
| 92357 | 7051 | 1 | Set of Johnson Physiology charts | 12.50 |
| 91446 | 9429 | 1 | Heart, model of | 11.00 |
| 91424 | 9432 | 1 | Ear, model of | 25.00 |
| 91404 | 9446 | 1 | Head, model of | 10.00 |
| 96400 | 9400 | 1 | Light screen | .85 |
| 90228X | 8486 | 1 | Micro-slides, set, blood, etc. set of 10 | 3.50 |
| 89748 | 8485 | 1 | Micro preparations, whole mounts Insects—10 | 10.00 |
| 88804 | 8484 | 1 | General Science micro-slides set | 7.50 |
| 86490 | 8492 | 1 | Life History of Tapeworm Riker mounts | 3.00 |
| 86506 | 8492 | 1 | Life History of Hookworm Riker mounts | 3.00 |
| | | | Total | $484.95 |

### 3. General List

| | | | | |
|---|---|---|---|---|
| 40420 | 4041D | 2 | Harvard trip balances double beam | $32.00 |
| 42500 | 4194A | 2 | Universal hook weights | 15.00 |
| 40802 | 4079 | 10 | Balances, spring, 2000 gram | 13.50 |
| 76145B | 153 | 10 | Meter sticks | 4.50 |
| 7810 | 745 | 18 | Lever holders | 7.20 |
| 79905C | 5572 | 6 | Supports, iron, with rings | 11.10 |
| 50270 | 4763 | 6 | Bunsen burners | 9.00 |
| 56680 | 4918 | 6 | Clamps, test tubes | .72 |
| 56600 | 4900 | 6 | Clamps, burette | 2.40 |
| 81050B | 5207 | 6 | Wire gauze, asbestos center, 5 x 5" | .90 |
| 80585A | 5726 | 2 | Pneumatic trough | 2.20 |
| 80640E | 5620 | 72 | Test tubes, 6 x ¾" | 2.22 |
| 45520 | 4603 | 24 | Bottles, wide mouth, 8 oz. (per doz.) | 1.80 |
| 73740 | 5218 | 48 | Plates, glass, 4 x 4" | 3.36 |
| 79270 | 5865A | 6 | Splints, wood, pkg | 4.50 |
| 44300 | 4516P | 12 | Beakers, Pyrex, 100ml | 2.40 |
| 44300 | 4516P | 24 | Beakers, Pyrex, 250 ml | 4.08 |

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 44300 | 4516P | 12 | Beakers, Pyrex, 600 ml | $ 3.48 |
| 79625B | 5227 | 12 | Rods, stirring, 6" | .45 |
| 70400 | 5100P | 6 | Flasks, Florence, Pyrex, 250 ml | 1.44 |
| 70400 | 5100P | 6 | Flasks, Florence, Pyrex, 500 ml | 1.74 |
| 71510A | 5150P | 12 | Thistle tube, Pyrex | 2.04 |
| 63550C | 4941 | 6 | Condensers, 200 mm | 6.00 |
| 10500 | 5812 | 6 | Lamp, chimney | 1.80 |
| 80795B | 5603 | 6 | Test tube racks | 6.60 |
| 5680 | 1536 | 12 | Balloons, rubber | .65 |
| 65238 | 5008 | 6 | Pans, granite, 2 qts | 2.40 |
| 80060A | 5670 | 6 | Thermometers C & F 100-220 F | 9.60 |
| 76200 | 8052 | 6 | Magnifier, tripod | 5.40 |
| 71200C | 5143P | 12 | Funnels, glass 65 mm short stem | 4.08 |
| 73280 | 4623 | 3 | Gas evaporating bottles, student's | 2.55 |
| 70750 | 5106P | 6 | Flasks, Erlenmeyer, Pyrex, 250 ml | 1.38 |
| 63400D | 1882 | 6 | Compass, 1" | 4.50 |
| 11410 | 1820 | 6 | Wire stirrups | 1.50 |
| 11430 | 1817 | 6 | Magnet boards | 9.00 |
| 11440 | H5218 | 6 | Plates, glass, 4 x 4" | 1.80 |
| 11800 | 1927 | 2 | Friction rod of wax | .50 |
| 11810 | 1929 | 2 | Friction rod of ebonite | .80 |
| 11820 | 1926 | 2 | Friction rod of glass | 1.20 |
| 11850 | 1935 | 2 | Silk pad | 1.30 |
| 11860 | 1939 | 2 | Cat's fur | 2.50 |
| 11880 | 1937 | 2 | Flannel pad | .60 |
| 11960 | 1957 | 2 | Pith balls, electroscope | 2.50 |
| 18980 | 2450 | 2 | St. Louis motors | 9.50 |
| 18990 | 2452 | 2 | Electromagnet field coil | 2.50 |
| 19000 | 2359C | 2 | Armatures | 2.50 |
| 25205 | 5891 | 1 spool | Fuse wire, No. 1, (4 oz.) | 2.00 |
| 14780 | 2992 | 1 | Switch, d.p.s.t. | .55 |
| 8860 | 813 | 2 | Inclined plane board, simple form | 5.00 |
| 9800 | 818 | 2 | Incline plane car | 3.00 |
| 8420 | 752 | 1 | Wheel and axle | 2.25 |
| 8170 | 756 | 12 | Pulley, single | 4.80 |
| 8175 | 758 | 12 | Pulley, double | 6.00 |
| | | | Total | $231.29 |

### 4. Chemicals for General Science

| | | | |
|---|---|---|---|
| 1 lb. | Acid, sulphuric, CP | $ | .45 |
| 1 lb. | Acid, nitric, CP | | .55 |
| 1 lb. | Acid, hydrochloride, CP | | .52 |
| 1 lb. | Ammonium hydroxide, CP | | .45 |
| 1 lb. | Agar, nutrient | | 7.00 |
| 1 lb. | Egg albumen | | .61 |
| 1 gal. | Alcohol, methyl | | .60 |
| 1 oz. | Beef extract | | 1.00 |
| 1 lb. | Wood, charcoal | | .25 |
| 1 lb. | Chloroform, USP | | .70 |
| 1 lb. | Cupric oxide, CP wire form | | 1.78 |
| 5 lb. | Cupric sulphate, tech. | | 1.30 |
| 1 lb. | Dextrose | | .46 |
| 1 lb. | Ferric chloride, tech. | | .60 |
| 1 lb. | Glycerine | | .55 |
| 1 lb. | Hydrogen peroxide, 3% | | .36 |
| 12 vials | Litmus test paper, red | | 1.20 |
| 12 vials | Litmus test paper, blue | | 1.20 |
| 1 lb. | Fehling solution A | | .90 |
| 1 lb. | Fehling solution B | | .75 |
| 1 btl. | Lime water tablets | | .75 |
| 1 lb. | Manganese chloride, tech., powd. | | .60 |
| 1 lb. | Marble chips | | .30 |
| 4 oz. | Magnesium ribbon | | .75 |
| 1 lb. | Potassium chlorate, tech. powd. | | .60 |
| 1 oz. | Phenolphthalein | | .45 |
| 4 oz. | Phosphorous, red | | .45 |

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| | | 2 lb. | Mercury metal | $10.00 |
| | | 4 oz. | Potassium permanganate | .87 |
| | | 1 lb. | Sodium carbonate | .35 |
| | | 1 lb. | Sodium hydroxide, CP pellets | .65 |
| | | 6 lb. | Sulfur roll | .70 |
| | | 5 lb. | Zinc mossy | .70 |
| | | 4 oz. | Cobalt chloride, CP | 1.45 |
| | | 4 oz. | Iodine solution in potassium iodide | .45 |
| | | 4 vials | Rennet tablets | 1.00 |
| | | 1 pt. | Oil, linseed | .75 |
| | | 12 oz. | Powder, bleaching | .20 |
| | 5205 | 5 lb. | Rubber stoppers, Asst. 2-7 (1 & 2 hole) | 6.00 |
| | 5516 | 20 ft. | Rubber tubing, asst. $\frac{3}{16}$", $\frac{1}{4}$" | 2.50 |
| | 5235 | 5 lb. | Glass tubing, asst., 5, 6, 7, 8, 9 mm | 3.50 |
| | 5239 | 1 lb. | Glass tubing, capillary, small | 1.35 |
| | | | Total | $ 55.60 |

**5. Desirable Equipment**

| | | | | |
|---|---|---|---|---|
| 18930 | 2484 | 1 | Dynamo and motor set | $ 6.50 |
| 18050 | 2628 | 1 | Telegraph key and sounder | 4.75 |
| 17880 | 2399 | 1 | Primary & secondary coil | 5.50 |
| 65420 | 8290A | 1 | Dissecting set in leather case | 1.50 |
| 94116A | 8346A | 1 | Terrarium, all glass large | 15.00 |
| 36415 | 8325C | 1 | Aquaria, 10 gal | 10.50 |
| 1078K | LHB10 | 1 | Set, Lantern slides of Digestive Organs & Secretion | 6.00 |
| 1034K | LPB30 | 1 | Set, 30 slides showing protoplasm, water relations of plants, transpiration, carbon relations, nitrogen relations and nitrogen cycle, food reserves and growth processes in plants | 15.00 |
| 43010 | 1215 | 1 | Mercurial barometer, hardwood back | 27.50 |
| 9310 | 944 | 1 | Siren disc & color disc combined | 3.00 |
| 9140 | 907 | 1 | Rotator, high speed | 11.75 |
| 9230 | 917 | 1 | Centrifugal hoop apparatus | 1.75 |
| | | | Total | $108.75 |

## SECONDARY SCHOOL GENERAL SCIENCE

## RECAPITULATION

| | |
|---|---|
| Science Hardware | $ 59.15 |
| Demonstration Equipment | 484.95 |
| General Equipment | 231.29 |
| Chemicals | 55.60 |
| Desirable Equipment | 108.75 |
| GRAND TOTAL | $939.74 |

## SECONDARY SCHOOL BIOLOGY

## INTRODUCTION

Prior to 1900, the biology taught in secondary schools of the United States was presented in separate courses of botany, zoology and physiology. These courses obviously were patterned after corresponding offerings at the college level. The period from 1870-1900 was marked by adherence to a belief in the virtues of formal discipline, and botany and zoology courses of the secondary school were replete with double laboratory periods devoted to individual work, and were characterized by careful attention to the minutiae of structure. Meanwhile, the physiology course had become something of a vehicle for temperance instruction.

With the turn of the century, a number of far-reaching educational changes came into being. In the background of educational thought was realization that the supposed

virtues of formal discipline were evanescent, and that the secondary school population was gradually but surely ceasing to be a select few, and was becoming an unselected group within certain age limits. On quite another front, the horizons of biology were being extended rapidly, with great expansions in the sub-sciences of genetics, physiology, ecology, and economic biology. In addition, the first secondary school biology courses made their appearance, although, to be sure, they were merely a combination of one term of botany and one term of zoology. In colleges the proponents of traditional "type" courses in botany and zoology were assembling their forces and preparing to do verbal battle with those who preferred the "principles" form of organization, a debate which was duly joined in secondary schools as well.

It was clearly a time of changes, and during the first three decades of the new century, the high school course in general biology crystallized as a more or less definite entity. General science appeared upon the scene about 1915, and after its acceptance as a part of the science sequence, biology came to be looked upon as a tenth grade subject. In fact, the combination of general science in the ninth grade and biology in the tenth became a common linkage, and today these two courses are often taught in the same classroom-laboratory and by the same teacher. Meanwhile, the unit organization of the biology course, with little or no recognition of pre-existing artificial divisions between botany and zoology, achieved general favor, the double laboratory period began to disappear, and tenth grade biology was commonly scheduled as a course that met during five single periods of each week.

A basic philosophic change in thinking about secondary school biology was also in progress. During the nineteenth century, when high school populations were highly selected, more than a little thought was given to the biology course as a proving ground for the training of future biologists. Perhaps this or similar thought still lingers in certain quarters, but the general attitude toward the tenth grade biology course has changed; today general biology is more likely to be regarded as an important part of the educational experience which will enable one to understand the environment, his community, and the functional aspects of science in such settings.

Freely granting that exceptions exist, the modern tenth grade biology course is a general course, which is commonly taught by the demonstration-discussion method or some variation thereof, and which is intended to emphasize the aspects of biology that are functional in the common experiences of everyday life. Its subject matter is drawn largely from botany and zoology, but in addition from human anatomy and physiology, hygiene, psychology, historical geology and cultural anthropology.

In approaching recommendations concerning equipment needed for instruction in tenth grade biology, a course of average pattern has been assumed, and a brief outline of this course is presented here. Then a selection of desirable demonstrations, based upon practice as represented in standard text books and work books, has been made, and with the latter as a basis, a list of necessary equipment items has been compiled.

Admittedly, some of the items in the equipment list could be constructed in the classroom-laboratory, or procured by collection in the field, but such procedures are deemed to be advisable only when they make contribution to the general educational experience. Undoubtedly, there are many occasions when such contributions will be evident. For this reason, various tools and other items have been added to the equipment list, not because they are needed for the demonstrations here proposed, but because they may prove to be invaluable in the preparation of certain teaching aids for which the need is specific.

# SECONDARY SCHOOL BIOLOGY

## Outline of Demonstration and Laboratory Content

I. Introduction
- Use and care of the microscope
  - Demonstration of the compound microscope.
- Field trip
  - Collection and preservation of local plants and animals.

II. The changing environment
- The atmosphere
  - Preparation of oxygen, hydrogen, nitrogen and carbon dioxide.
- Water
  - Effects of moisture on seedlings

- Temperature
  - Effects on sprouting seeds and bacteria colonies
- Light
  - Influence upon growing plants
- Soils
  - Different types of soils
- Plants and animals
  - Demonstrations of simple plant and animal cells.

III. The adaptations of organisms
- Thallus plants
  - Observe algae
  - Grow and observe yeasts, molds, and bacteria
- Bryophytes and Pteridophytes
  - Collect and observe structures of mosses and ferns
- Seed plants
  - Sprout seeds and observe structures: stems, leaves, roots and flowers: monocots vs. dicots
- Invertebrates
  - Observe protozoa, hydra, planaria, earthworm, crayfish and insect
  - Dissect earthworm and crayfish
  - Observe cross sections (micro) of hydra, planaria and earthworm
- Vertebrates
  - Study fish, frog, reptiles, birds and mammals
- Special adaptations; phototropism; geotropism; maze experiment; special senses
  - Set growing plants near window, or in box with single opening
  - Plant seeds upside down in glass jar, observe roots and stems
  - Place insect or spider in box, light one end, observe
  - Construct maze; use chick, rat, cat, or mouse

IV. Nutrition
- Animal metabolism
  - Food tests
  - Digestion of foods
  - Digestive systems
  - Circulatory and respiratory systems
  - Oxidation; release of heat energy
- Plant metabolism
  - Circulation in plants
  - Streaming of protoplasm in Elodea or geranium
  - Photosynthesis
  - Capillarity
  - Osmosis

V. Reproduction and heredity
- The nature of reproduction
  - Study of pollen and grafting
  - Eggs of earthworm, crayfish, frog, etc.
  - Development of chick embryo
- Reproduction in plants
  - Examine growing root tip
  - Examine spores of mushroom, mold, ferns, etc.
  - Conjugation of Spirogyra
  - Structure and functions of flowers and seeds
- Reproduction in animals
  - Division of Amoeba and Paramecium
- Variation
- Mendel's Law
  - Grow hybrid corn
  - Drosophila crossing

VI. Biological production
- Field trips, to observe production (no special apparatus required)

VII. Biological control
- Balance of nature
  - Balanced aquaria and terraria
- Saving the soil
  - Soil tests
  - Study legumes
  - Soil capillarity, porosity, tenacity, water run-off
- Weed control
  - Weed identification field trips
- Control of insect and rodent pests
- Control of disease

# BIOLOGY MATERIALS

The following list of materials is recommended for a class of 40 pupils (or less). Necessarily, a suitable room should be available, and its fixtures should include a growing shelf, adequate desks and tables, and drawers or lockers for storage.

## I. Introduction

| Chapco Cat. No. | Welch Cat. No. | Description | Total Price |
|---|---|---|---|
| | 7970 | A. Use and care of the microscope | |
| | | A1. 20 microscopes, 10x oculars, 10x43 objectives, fine and coarse adjustment (In average practice, microscopes are not purchased out of any one annual appropriation, but are accumulated through a period of years. To conform with good practice, one microscope should be available for each pair of pupils) | $2730.00 |
| | | B. Field trip: Collection and preservation of plants and animals. | |
| 94110 | 8327B | A. 3 terraria, 1 gallon, rectangular, clear glass | 19.50 |
| 36415 | 8325A | 2 aquaria, 6 gallon, clear glass | 17.00 |
| 94858 | 8326 | 1 insect cage, 12x12x18, screen sides | 11.00 |
| 94862 | 8327D | 1 observation ant nest, 3 chambers 10x10 | 5.00 |
| 36215 | 8327 | 2 animal cages, collapsible, 12x20x15 | 24.00 |
| 45720 | 9773 | 48 bottles, 8 oz., wide mouth, with corks | 4.80 |
| 94582 | 8338A | 5 collecting nets | 10.00 |
| 94588 | 8336 | 1 ooze collecting net | 5.50 |
| 65870 | 9356 | 2 insect drying boards | 5.70 |
| 75634-B | 5301 | 24 jars, 1 qt., screw lids | 5.00 |
| 95660 | 8332 | 20 pkg. insect pins, assorted sizes | 14.00 |
| 94502 | 8320 | 2 vasculums, 5x7x15 | 8.50 |
| 92397 | 6941 | 1 Smallwood chart, plants and animals, on tripod | 45.00 |
| | | Total | $2905.00 |

## II. The changing environment

| | | | |
|---|---|---|---|
| | | A. The atmosphere | |
| 50205 | 4757 | A1. 5 Bunsen burners | $ 3.75 |
| 79905 | 5572 | 6 support irons, 3 rings, 5x7 base | 8.10 |
| 80640E | 5620 | 144 test tubes, 6 inches | 5.76 |
| 55600 | 4900 | 6 burette clamps, 6 inches | 2.40 |
| 73765 | 5235 | 10 lb. glass tubing, 7 mm. | 5.50 |
| 78830B | 5515 | 50 ft. rubber tubing, 3/16 in. | 6.00 |
| | | 5 lb. potassium chlorate, technical powder | .60 |
| | | 1 lb. manganese dioxide, technical powder | .50 |
| | | 1 lb. zinc, mossy | .45 |
| | | 6 lbs. hydrochloric acid, CP | 1.85 |
| | | 1 lb. calcium carbonate, precipitate | .27 |
| | | 4 oz. yellow phosphorus | .57 |
| 22140 | 3595 | 12 candles, 6 inches | 6.00 |
| | | B. Effects of moisture upon sprouting seeds | |
| 96520D | 9345 | A. 12 flower pots, 4 inches | .95 |
| 96520F | 9345 | 12 flower pots, 6 inches | 2.00 |
| | | C. Effects of temperature | |
| 94636B | 9957C | A. 1 doz. germinating plates | 6.48 |
| | | D. Plant and animal cells | |
| 76725 | 8006 | A. 20 substage lamps | 80.00 |
| 76470X | 8023FX | 1 microscope projector, including microscope with substage condenser | 271.00 |
| 76805 | 8118 | 2 gross micro slides, 3x1, plain | 6.00 |
| 76838F | 8126 | 2 oz. micro. cover glass ¾x¾ | 6.00 |
| 78080 | 5431 | 48 pipettes, straight | 1.60 |
| | | Total | $ 415.78 |

III The adaptations of organisms

| Chapco Cat. No. | Welch Cat. No. | Description | Total Price |
|---|---|---|---|
| | | A. Thallus plants | |
| | | A1 Microscopes and other material previously listed | |
| 64270A | 8386P | 24 Petri dishes, 100x15 | $ 9.60 |
| 65140A | 5000 | 24 crystallization dishes, 100x50 mm | 12.00 |
| 96034 | 5298 | 1 pressure cooker, 10 qt. | 20.00 |
| | 5024 | 1 sterilizing oven, 2 shelves, 12x12x12 | 8.75 |
| 80795B | 5603 | 2 test tube racks, double deck, 24 tube | 2.20 |
| 81050A | 5207 | 6 wire gauzes, 4x4 | .72 |
| | | 1 lb. agar-agar | 1.55 |
| | | 4 oz. beef extract | 1.00 |
| | | 1 lb. dextrose | .35 |
| | | 4 oz. peptone | .95 |
| | | B. Bryophytes and Pteridophytes | |
| | | A. Microscopes and other materials previously listed | |
| 92710 | 6939 | 1 set plant charts, on tripod | 27.50 |
| | | C. Seed Plants | |
| 88746 | 8492 | A. Microscopes and other materials previously listed | |
| | | 1 demonstration set seed plants, 50 types | 11.50 |
| 88814 | 8484C | 20 micro. slides, sections of root, stem and leaf | 12.00 |
| | | D. Invertebrates | |
| | | A. Microscopes and other materials previously listed | |
| 75634C | 5301 | 24 preserving jars, 2 qt., with lids | 12.00 |
| | | 5 lbs. formalin, USP, 40% | 7.00 |
| 75600C | 1166A | 10 battery jars, 1 gallon clear glass | 11.50 |
| 76825A | 8122 | 12 hanging drop micro slides | 1.80 |
| 88730 | 6938 | 1 set animal life history charts | 25.00 |
| 88874 | 8488-92 | 10 cross section Hydra (micro) | 6.00 |
| 88908 | 8488-151 | 10 cross section Planaria (micro) | 6.00 |
| 89024 | 8488-205 | 10 cross section Earthworm (micro) | 6.00 |
| 88834 | 8488-55 | 10 whole mounts of protozoa (micro) | 6.00 |
| 65420 | 8290A | 20 student dissecting sets, in cases | 30.00 |
| 76200 | 8052 | 20 tripod magnifiers | 18.00 |
| | | 20 wax-lined dissecting trays | 20.00 |
| | | D. Vertebrates | |
| | | A. Microscopes and other materials previously listed | |
| | | E. Special adaptations | |
| | | A. Materials previously listed | |
| | | Total | $ 257.42 |

IV. Nutrition

| | | | |
|---|---|---|---|
| | | A. Animal Metabolism | |
| | | A1. Food tests | |
| | | 1 lb. ammonium hydroxide, tech. | $ 1.25 |
| | | 5 lb. carbon tetrachloride | 1.70 |
| | | 1 lb. Fehling solution A | .90 |
| | | 1 lb. Fehling solution B | .90 |
| | | 4 oz. iodine crystals | 1.10 |
| | | 4 oz. potassium iodide | .51 |
| | | 1 lb. corn starch | .25 |
| | | B. Digestion of foods | |
| | | 1 lb. diastase, malt | 2.10 |
| | | 4 oz. pepsin | 1.04 |
| | | 1 lb. sodium chloride | .25 |
| | | 9 lb. acid, sulphuric, CP | 2.10 |
| | | C. Digestive systems study | |
| | | Materials previously listed | |
| | | D. Respiratory and circulatory systems | |
| | | Materials previously listed | |

| Chapco Cat. No. | Welch Cat. No. | Description | Total Price |
|---|---|---|---|
| | | E. Oxidation—release of heat energy | |
| 80070A | 5680 | 6 Thermometers, C&F, -10-110° | $ 9.00 |
| | | B. Plant metabolism | |
| | | A. Circulation in plants; streaming of protoplasm in Elodea or geranium<br>Microscopes and projector, slides, etc., previously listed | |
| | | B. Photosynthesis | |
| | 9410 | 1 simple photosynthesis apparatus | 2.50 |
| 3800 | 519 | 1 set of 4 capillary tubes, mounted | 2.75 |
| 3900 | 538 | C. Osmosis<br>2 Lyon's osmosis membranes | 2.50 |
| | | Total | $ 28.85 |
| | V. | Reproduction and heredity | |
| | | A. Nature of reproduction | |
| | | A. Grafting | |
| | | 1 lb. grafting wax | $ .75 |
| 96732 | 9124 | 6 grafting chisels, 12 in. | 15.00 |
| 96740 | 9118 | 6 grafting knives | 4.50 |
| | | 1 lb. raffia | .50 |
| | | B. Study of pollen<br>Microscopes etc., previously listed | |
| | | C. Eggs of earthworm, crayfish, frog, etc.<br>Secure locally, use scopes etc. | |
| | | D. Development of chick embryo | |
| 96052 | 8352 | 1 electric egg incubator, small | 18.00 |
| | | B. Reproduction in plants | |
| | | A. Examine growing root tips, spores of mushroom, molds, ferns, conjugation of Spirogyra<br>Materials previously listed | |
| | | B. Structure and function of the flower | |
| 91124 | 8484-341A | 1 slide of lily ovule | 1.00 |
| | | C. Reproduction in animals | |
| | | A. Dividing Paramecia and Amoeba | |
| 88834 | 8488-37 | 1 slide showing conjugation | 1.00 |
| 88836 | 8488-36 | 1 slide showing fission | 1.00 |
| | | D. Variation | |
| 91590 | 8492 | 1 set of mitosis models set of spindles | 25.00 |
| 92970 | 8492 | 1 monohybrid inheritance—four o'clock | 2.75 |
| 92991 | 8492 | 1 dihybrid pea inheritance demonstration | 7.50 |
| | | E. Mendel's Laws | |
| | | A. Grow hybrid corn—albino type<br>1 set of albino corn seed | 1.00 |
| | | B. Drosophila crossing<br>1 culture of Drosophila (secure locally) | |
| | | Total | $ 79.00 |
| | VI. | Biological production (no special equipment) | |
| | VII. | Biological control | |
| | | A. Balance in nature | |
| | | 1 Students' balanced aquarium | |

| Chapco Cat. No. | Welch Cat. No. | Description | Total Price |
|---|---|---|---|
| | | B. Saving the soil | |
| 96162 | 9728 | 1 Soil testing set complete | $ 5.00 |
| | | A. Study of legumes | |
| | | Use microscopes, charts, etc. previously listed | |
| | | B. Soil capillarity, porosity, tenacity, water run off | |
| 96242 | 9629 | 1 Soil auger with extension for samples | 5.20 |
| 96172 | 9639 | 12 Soil sample cans, 16 oz. | 1.50 |
| 96202X | 5812 | 1 set of 6 soil tubes, capillarity, 24x2" | 7.50 |
| 96234 | 9526 | 1 Soil-evaporimeters, 2x5 in. | 3.20 |
| 96204 | 5812 | 12 Argand lamp chimneys | 2.50 |
| | | C. Weed Control | |
| | | A. Weed identification field trips etc. | |
| 88709 | 8492 | 1 Set of twenty common weeds | 8.50 |
| 88715 | 8492 | 1 Set of twenty common grasses | 8.50 |
| | | D. Control of Insect and rodent pests | |
| | | A. Use of text books and literature U. S. Dept. of Agriculture | |
| | | E. Control of Diseases | |
| 92934 | 7010 | 1 Set of 12 charts mounted on tripod of bacteria of communicable diseases | 66.75 |
| | | Total | $108.65 |
| | | VIII. Tools and slide-making materials | |
| | | A. Tools (secure locally if possible) | |
| 27270C | 5 | 1 small bench vise, 6 in. | $ 6.00 |
| 26780 | 197 | 1 pr. side cutting pliers | 1.25 |
| 27030 | 267 | 1 screw driver | .70 |
| 26010C | 57A | 1 wood chisel | 1.00 |
| 26020 | 57 | 1 cold chisel | 1.00 |
| | 263 | 1 hand saw | 2.50 |
| 26090X | 105 | 1 steel saw, 3 blades | 2.00 |
| 26130 | 84 | 1 set drill and bits, breast type | 5.00 |
| 69600 | 93 | 3 files, flat | 1.35 |
| 26320 | 94 | 1 wood rasp | .75 |
| | | B. Slide-making materials | |
| | | Various items previously listed | |
| 76882B | 8140 | 6 slide boxes, wood | 2.40 |
| | | 5 lbs. balsam | 2.50 |
| | | 5 lbs. xylol | 2.50 |
| 76910 | 8395 | 12 staining jars | 7.20 |
| | | 1 oz. gentian violet, dry | .55 |
| | | 1 oz. eosin, dry | .75 |
| | | 1 oz. magenta, red | .75 |
| | | 1 oz. methylene blue | .80 |
| | | 4 oz. picric acid, pure cryst. | .38 |
| | | 4 oz. phenol, USP, cryst. | .30 |
| | 8259 | 5 sectioning razors | 5.00 |
| | | Total | $ 44.68 |

## SECONDARY SCHOOL BIOLOGY

## RECAPITULATION

| | |
|---|---|
| Introduction | $2905.00 |
| The Changing Environment | 415.78 |
| The Adaptations of Organisms | 257.42 |
| Nutrition | 28.85 |
| Reproduction and Heredity | 79.00 |
| Biological Production | |
| Biological Control | 108.65 |
| Tools, etc. | 44.68 |
| Grand Total | $3839.38 |

# SECONDARY SCHOOL PHYSICS

## TEACHING OF PHYSICS

### A. Aims and Purposes

Fundamentally, the course in physics is a course in problem solving. The subject matter is such that it lends itself very readily to problems related to an understanding of the physical environment. The solution of these problems requires scientific thinking. Physics offers much opportunity for presenting stimulating problems which contribute to effective learning. Without being directly aware of it, a student may learn to reason, become aware of the cause and effect relationship, and appreciate the work of science and scientists.

The habitual use of the scientific approach to the solution of problems in physics tends to instill in students attitudes of open-mindedness, suspended judgment, and tentative conclusion. It is but a step beyond to apply the scientific method of thinking to problems other than those of physical science.

### B. Laboratory Teaching

The student learns best when he is an active participant in the lesson. The laboratory is the place where all students have an opportunity to handle and examine apparatus, an experience not provided in the classroom. Further, in the laboratory the student may demonstrate to his own satisfaction the truth of the principles he has learned in the classroom. Here he may be presented with an original problem, the answer to which he may determine by personal application of the scientific method. Thus the student, faced with a problem, is required to draw up a plan of procedure, select the necessary apparatus, assemble it and proceed to solve the problem. Observations are made, data is collected and tabulated, a hypothesis is formulated and tested, and finally, a conclusion is stated. This is the ideal in laboratory procedure, but it cannot be used equally well with all students.

More generally, a sheet of directions or a laboratory manual outlines the procedure to be followed in solving a given problem. Apparatus is set out and groups of students carefully follow the directions until a conclusion is reached. The teacher acts in the capacity of guide or consultant, not directly answering questions posed by the young investigators, but rather indicating ways and means by which the solution may ultimately be reached.

Although this method relieves the students of much original thinking, it does provide the set of directions necessary for a large number of our pupils. Moreover, in following the directions and in tabulating the data, the student soon learns to appreciate the importance of precision and accurately in making the observations upon which the conclusion will depend.

### C. Laboratory Equipment

The success with which the laboratory lesson is conducted depends partially upon the adequacy of the supply of materials and the conditions of the materials in use. In any particular school, the former is at least in part determined by the amount of money available for the purchase of supplies, whereas the latter depends upon the energy and skill of the teacher in making repairs.

In many schools the teacher or a laboratory assistant organizes a group of students who under his direction carry out the repair and building of apparatus needed in the laboratory. In this way members of the group learn many skills as well as subject matter. Moreover, there results a sizable saving in the cost of setting up and maintaining a laboratory. A shop equipped with the usual hand tools and raw materials should be provided for the building and maintenance of apparatus.

### D. Descriptions of Good Practices

In introducing a lesson in physics, care should be taken to present the topic of the lesson in the form of a challenging problem. For example, in teaching the principle of flotation, the teacher might begin by exhibiting a picture of a model of a battleship. In the discussion that follows it is brought out that a battleship is built almost wholly of iron and steel, that it is therefore very heavy, and that some of the larger ones weigh as much as 50,000 tons. The teacher then exhibits a flatiron, indicating that it, too, is made of iron, and then asks the question, "Why will a 50,000 ton battleship float, but a two pound flatiron sink?" In considering this problem various explanations will be offered

by the students. Very likely one explanation will be the belief that a ship floats because it is hollow, whereas the flatiron sinks because it is solid. That this answer is unsatisfactory can readily be shown by the fact that one hollow piece of iron may sink while another hollow piece may float. A connection will then be drawn between the weight of the object and the weight of the water it displaces. Evidently, buoyancy has something to do with the weight of water an object can displace. Attention now is directed back to the battleship. Discussion will bring out that a ship, because of its great volume, is able to displace a large weight of water. The problem now resolves itself into a determination of what the relationship is between a floating body and the weight of the displaced water.

A student is invited up to the demonstration table to aid the teacher in selecting the necessary apparatus and in the solution of the problem. It will soon be brought out that in order to float, a body must be capable of at least displacing a weight of liquid equal to its own weight. The lesson closes with the caution that the conclusion still needs to be tested with other objects before it can be accepted. Thus a problem has been presented which may be solved during a student laboratory period.

In the laboratory everyone has the opportunity to determine whether or not a body displaces its own weight of the medium in which it floats. The student finds at his table not only a block of wood, but also a piece of cork, a piece of paraffin, and, perhaps, a weighted test tube. For each of these he determines the weight in air and then the weight of the water displaced by it. Results can be checked against another medium, such as alcohol, carbon tetrachloride, or salt water. Data is tabulated, the conclusion is drawn, and the report is prepared for submission.

When the class reconvenes, questions that may have arisen in preparing the report are taken up, discrepancies are discussed, and the need for accuracy in observation is stressed. If any doubt remains about the validity of the conclusion, opportunity for further testing is provided. If all are satisfied, the teacher may proceed with a few additional demonstrations, such as (a) a flat piece of tin foil will sink, but when shaped like a boat it will float, (b) solid iron will float on mercury, (c) soap bubbles filled with illuminating gas or a toy balloon inflated with hydrogen wil float in air. The topic closes with a discussion of some practical applications of the principle of flotation.

## OUTLINE OF COURSE CONTENT

I Introduction
- Units of measurement—Metric system; English system
  - *Metric units of length, volume and weight
  - English units
  - Lab: measurement of length and volume
- Density
  - Density of a regular and an irregular body
  - Lab: density

II. Mechanics of liquids
- Liquid pressures are proportional to depth and density
  - Upward, downward and sidewise pressures are equal
  - Lab: relation between pressure and depth
- Pressure is independent of shape—Liquids seek their levels
- Pressure applied to liquids—Pascal's Law
  - Hydraulic press
- Buoyancy—Archimedes' Principle
  - Submerged bodies
  - Floating bodies
  - Lab: Archimedes' Principle—Sinking bodies, floating bodies
- Specific gravity—Solids heavier than water; solids lighter than water; liquids
  - Loss in weight by displacement of water
  - Sinker method
  - Lab: bodies heavier than water only
  - Bottle method and hydrometer
  - Lab: liquids heavier and lighter than water

III. Mechanics of gases
- Air has weight
  - Weigh air

*All classroom demonstrations and laboratory experiments are thus indented rather than being listed separately.

Air exerts pressure
- Collapse can by extracting air
- Magdeburg hemispheres

Barometers—Mercury, aneroid; weather depends on air pressure
- Prepare mercury barometer
- Weather maps

Other applications of air pressure—Dirigibles
- Balloons, lift pumps, and siphons

Compressed air—Boyle's Law; applications
- Effect of compressing air
- Lab: Boyle's Law
- Force pump, bicycle pump, atomizer, caisson, Cartesian diver

Bernoulli's Principle
- Curved balls
- Venturi tube, carburetor
- Airplane wing
- Atomizer
- Lab: air pressure and Bernoulli's Principle

IV. Mechanics of solids

Properties of matter—Stresses of various kinds; elasticity
- Tension, compression, bending, twisting and shear
- Lab: Hooke's Law

Molecular motion—Gases; liquids; solids
- Porous cup demonstration
- Mixture of $NH_3$ and HCl
- Copper sulfate and water
- Camphor

Molecular forces
- Lab: molecular forces—cohesion, adhesion; surface tension; capillary action

Concurrent forces—Composition of forces; resolution of forces
- Determine resultant and equilibrant
- Lab: parallelogram of forces
- Resolve weight on inclined plane into component
- Lab: resolution of force

Parallel forces—Principle of moments, equilibrium
- Meter stick set up
- Lab: moments in a lever

Center of gravity—Point where all the weight may be considered concentrated; stability, stable equilibrium, unstable equilibrium, neutral equilibrium
- Determine center of gravity of regular and irregular objects
- Cone on base
- Stand board on end
- Billiard ball

Motion—Velocity; acceleration; laws of motion, inertia, momentum, action-reaction
- Inclined acceleration board
- Bodies fall at same rate
- Inertia ball
- Horizontally and vertically dropped ball reach ground at same time
- Read spring balances

Centrifugal and centripetal forces
- Twirl weight on string, or cup of water, overhead

Work, power, energy—Work is force x distance; power is the rate at which work is done—horse power, potential, kinetic
- Tow a car over table with spring balance
- Determine horse power of student running upstairs
- Determine horse power of electric motor
- Determine potential energy of a raised weight
- Determine kinetic energy of falling steel ball

Machines—Law of machines; lever; pulley; inclined plane, wedge; screw; wheel and axle; gears
- Lever set-up (1st, 2nd, and 3rd types)
- Up-pull and down-pull on pulley set-up
- Lab: pulley systems
- Inclined plane set-up
- Lab: inclined plane
- Jackscrew
- Wheel and axle—water wheels
- Gear chains

Friction
Bearings, lubricants
Compare towing weights over table and in frictionless car

Heat
Nature of heat—Kinetic energy
Demonstrate moving molecules with mercury and glass bead tube, bunsen burner
Expansion due to heat—Solids; liquids—peculiar expansion of water, thermometers (Centigrade and Fahrenheit); gases—Kelvin or Absolute Scale, Charles' Law
Lab: expansion of solids, liquids, gases
Unequal expansion
Calibrate thermometer
Lab: thermometer
Transmission of heat—Conduction—solids, liquids and gases, applications; convection—liquids and gases, applications; radiation —applications
Heat transmission in metals
Ice in bottom of test tube
Air thermometer in water on which ether burns
Convection currents
Bright and black body radiation
Thermos bottle
Lab: transmission of heat
Change of state—Heat units; measuring specific heat; fusion—pressure lowers freezing point, impurities lower freezing point, heat of fusion, heat absorbed in solution; vaporization and condensation—boiling point varies with pressure, heat of vaporization, evaporation a cooling effect; humidity—relative humidity.
Calorimeter demonstration
Lab: specific heat of a metal
Various metals melt paraffin
Paraffin contracts; ice expands
Weighted wire cuts through ice
Freezing point of salt water
Method of mixtures
Lab: cooling curve
Water mixed with salts to demonstrate heat absorption
Boiling under reduced pressure
Evaporation of ether, alcohol, water
Determine humidity
Lab: disappearance of heat during evaporation and solution
Heat engines
Demonstrate various models

I. Sound
Origin of sound—Sound is caused by a rapidly vibrating body of matter
Cause of sound
Transmission of sound—Sound requires elastic media; sound is transmitted in compressional waves
Absence of sound in vacuum
Types of waves
Velocity of sound in air
Reflection of sound—Reflecting surfaces produce echoes
Musical sounds—Loudness depends upon amplitude; pitch depends on frequency; quality depends on overtones and fundamental
Demonstrate loudness
Demonstrate pitch
Demonstrate quality—fundamental and overtones in a string forced to vibrate
Resonance and interference—Forced vibrations; sympathetic vibrations; resonance; beats
Tuning fork struck and stem pressed on table
One fork sets another of equal frequency vibrating at a distance
Tuning fork over resonant air column
Lab: frequency of tuning forks by resonance
Mounted tuning forks with adjustable riders
Musical instruments—Musical scale; string instruments; wind instruments
Pitch in string instruments
Pitch in wind instruments
Recordings—Phonograph; records
How records may be made

VII. Light

Transmission and measurements—Candlepower; foot candles
- Inverse square law
- Lab: measurement of candle power

Reflection—Diffused reflection; regular reflection—law of reflection; images in a mirror; curved mirrors
- Demonstrate difference between diffused and regular reflection
- Angle of incidence equals angle of reflection
- Lab: constructing image in mirror
- Convex and concave mirrors

Refraction—Law of refraction—index of refraction, prism, critical angle and total reflection; lenses—converging and diverging, image constructions, applications
- Bending of light rays on entering media of different density
- Lab: tracing path of ray of light through rectangular glass prism (or triangular prism)
- Total reflection
- Effect of convex and concave lenses on light rays
- Lab: study of images formed by convex and concave lenses

Color—Dispersion of white light—color of light depends on wave length; color of opaque objects depends on selective reflection; color of transparent objects depends on selective transmission; color of mixed pigments depends on subtractive process
- Pass white light through triangular prism
- Exhibit electromagnetic spectrum
- Examine colored pictures under monochromatic light
- Pass white light through colored screens
- Mix blue and yellow paints

Spectroscope
- Analyze sodium flame

Polarized light
- Effect of polarized light on samples of transparent materials

VIII. Magnetism

Nature of magnetism—Magnetic materials—kinds of magnets; polarity; temporary and permanent magnets; magnetic fields; theory of magnetism
- Magnetic and non-magnetic substances
- Like poles repel, unlike attract
- Differences between temporary and permanent magnets
- Lab: study magnetic fields
- Making a magnet

Terrestrial magnetism
- Earth's magnetic field

IX. Static electricity

Nature of static electricity—Electrification of two kinds; conductors and insulators; charging by contact and by induction; electron theory—radio tube, photoelectric tube
- Like charges repel, unlike charges attract
- Examples of conductors and insulators
- Electroscopes (pith ball and gold leaf)
- Lab: static electricity
- Discharge of electroscope by hot wire
- Photo tube and relay

Effects of static electricity—Charges concentrate on points—point discharge; charges reside on outside of conductor; condenser effect—radio condenser, lightning
- Use static machine to generate high voltage
- Exhibit condensers

X. Current electricity

Voltaic cells—Defects
- Zinc-copper-acid cell with galvanometer
- Polarization and local action
- Lab: Voltaic cell

Dry Cell
- Zinc, carbon, salammoniac and electric bell
- Lab: construction of dry cell
- Dry cells cut lengthwise

Ohm's Law—Amperes, volts, ohms; current varies directly as voltage and inversely as the resistance; laws of resistance

Effect of varying length, diameter, temperature and material of wire
Series and parallel circuits—Essential characteristics of each kind of circuit.
Demonstrate different circuits
Effect on brightness of lamps when wired in series and parallel
Lab: parallel and series circuits
Effects of the electric current—Magnetic effect—magnetic field about current bearing conductor, electromagnet, right hand rule, strength depends on ampere turns, applications; chemical effect—electrolysis, storage cell, electroplating; heating effect—electric current causes heat, applications
Iron filings on current bearing conductor
Effect on compass needles
Lab: Oersted effect (optional)
Iron core and wire—electromagnet
Lab: electromagnetism and the electric bell
Lab: principle of the electric motor
Electrolysis of water
Lab: lead storage cell
Demonstrate lead storage cell
Lab: electroplating
Demonstrate electrotype
In series heat is greatest in highest resistance, in parallel greatest in lowest resistance
Measuring instruments—Moving coil galvanometer; ammeter, voltmeter—meaning of fall of potential in an electric circuit; watt-hour meter—cost of electrical energy, units
Exhibit instruments
Suspend fine wire coil between poles of horseshoe magnet
Lab: measuring resistance by ammeter-voltmeter method
Fall of potential in series and parallel cirucits
Lab: cost of electrical appliances
Electromagnetic induction—Faraday's Principle; electric generators—Lenz's Law, back E. M. F. in motor; induction coil; transformer; telephone transmitter and receiver
Coil made to cut magnetic field
Lab: Faraday's Principle
Demonstrate magnets, student generator
Disconnect electric motor from 110 V circuit and press socket prongs against steel wool
Induce current in secondary of dissectable coil
Induce current in step up and step down transformer
Demonstrate telephone circuit
Alternating current power—Impedance; capacitance
Demonstrate effect of condenser and choke coil in A. C. circuit

XI. Radiations

Cathode rays—Discharge through vacua
Demonstrate tube discharges
X-rays
Exhibit and demonstrate X-ray tube
Radio — Receiver
Resonance in a radio circuit (Note: see Static Electricity)
Radio-activity
Particles emitted by radioactive materials
Atomic energy

## APPARATUS AND SUPPLIES

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 153 | 76145B | 1 | Meter Stick, graduated in metric and English | $ .50 |
| 139 | 2800 | 1 | Liter Measure, made of aluminum | 1.70 |
| 129 | 2760 | 1 | Liter Block, dissectible | 5.40 |
| 4041 | 40430 | 1 | Balance, platform, Harvard Trip Scale, capacity 2000 grams | 13.00 |
| 4158 | 42482F | 1 | Weights, set brass metric, 1 gram to 1000 grams in block | 9.00 |
| 4079 | 40802 | 1 | Balance. spring, metric scale 2000 grams in 5 gram division, English scale 72 ounces in ½ ounce divisions | 1.40 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 149 | 2780 | 1 | Metric Chart shows Relationship of Metric and English units size 28 x 44" | $ 3.00 |
| 148A | 2810 | 1 | Liquid measures, with lip and handle, set of four, one pint to one gallon | 2.00 |
| 153A | 76145A | 12 | Half meter stick | 4.20 |
| 5256 | 64860G | 12 | Cylindrical Graduate, graduated up and down, capacity 500 cc | 21.12 |
| 1148 | 4790 | 12 | Can, overflow, aluminum, 13 x 7.5 cm | 9.60 |
| 1146 | 4800 | 12 | Catch Bucket, with handle, aluminum, 7.5 x 5 cm | 7.80 |
| 1154 | 4810 | 12 | Wooden block, water proof, not loaded 7.5 x 7.5 x 3.4 cm | 4.80 |
| 1156 | 4890 | 12 | Cylinder, aluminum, with hook, 7.5 cm high and 2.5 on diameter | 7.20 |
| 4079 | 40802 | 12 | Balance, spring, 2000 grams and 72 ounce capacity | 16.80 |
| 1032 | 4450 | 1 | Gauge, liquid pressure | 2.25 |
| 1012 | 4560 & 75600B | 1 | Pressure apparatus, glass cylinder with disc, complete with support and battery jar | 3.50 |
| 1004 | 4640 | 2 | Constant level tubes, set of five tubes of different shapes complete with support | 17.50 |
| 1023 | 4662 | 1 | Pascal's Vase apparatus complete with three vases, dial, reservoir, and support | 26.50 |
| 1046 | 4770 | 1 | Hydraulic Press Model, made of glass with visible valves | 2.85 |
| 4516P | 44300 | 1 | Beaker, Pyrex glass, capacity 250 cc | .17 |
| 4949 | 63830 | 1 | Cork Flat 2½" diameter | .16 |
| | | 1 x 1 lb. | Paraffin, solid | .25 |
| 1160 | 4860 | 1 | Sinker, lead, with hook, weight 175 grams | .30 |
| 4516P | 44300 | 12 | Beakers, Pyrex glass 400 ml | 2.88 |
| 1160 | 4860 | 12 | Sinkers, lead | 3.60 |
| 1136 | 48520C | 1 | Bottle, specific gravity, adjusted 50 cc | 1.90 |
| 1130 | 75390 | 1 | Hydrometer, for light and heavy liquids | 2.00 |
| | | 1 x 1 pt. | Alcohol, Ethyl Denatured | .50 |
| | | 1 x 1 lb. | Carbon Tetrachloride Pure | .60 |
| 1538 | | 1 | Balloon, rubber | .20 |
| 1424 | 5250 | 1 | Air Pump for vacuum or pressure, simple form | 6.00 |
| 5514 | 78870C | 3 ft. | Tubing, pressure rubber, ¼" | .48 |
| 1509 | | 1 | Discs, Madgeburg Pressure 12.5 cm Diameter | 5.50 |
| 1206 | 6200 | 1 | Barometer Tube with Mercury Cup and Pipette | 1.25 |
| | | 1 x 1 lb. | Mercury CP | 5.50 |
| 1239 | 43110 | 1 | Barometer, Aneroid, Metric and English Scales, Five inch Dial | 12.50 |
| 1305 | 7180 | 1 | Maps, weather, envelope of 100 | 1.00 |
| 1102 | 6050 | 1 | Pump, glass model lift | 1.85 |
| 1104 | 6060 | 1 | Pump, glass model force | 1.85 |
| 1070 | 79150 | 1 | Siphon, glass, plain | .40 |
| 5516 | 78840C | 6 ft. | Tubing, rubber, ¼" diameter | .84 |
| 1080 | 6505 | 1 | Boyle's Law Apparatus, adjustable tubes | 13.50 |
| 1029 | | 1 | Demonstration Manometer 20" High — Tubes 1" in diameter mounted on iron base | 9.00 |
| 1042 | 4720 | 1 | Cartesian Diver complete | 1.20 |
| 4704 | 78760 | 1 | Atomizer bulb, capacity 50 ml | .50 |
| 1683 | 10750 | 1 | Mechanical Equivalent of heat tube | .50 |
| 1721 | | 1 | Venturi tube | 2.00 |
| 732 | | 2 | Balls, ping pong | .50 |
| 573 | 4370 | 1 | Torsion Apparatus complete with four metal rods | 37.50 |
| 567 | 4300 | 1 | Wire testing machine for vertical or horizontal positions complete with spring balance | 17.50 |
| 569 | 4210 | 1 | Hookes Law Apparatus, complete with spring and weight holder | 2.00 |
| 537 | 3760 | 1 | Diffusion apparatus with porous cup tube and stopper | .95 |
| 4516P | 44300 | 1 | Beaker, Pyrex, capacity 250 ml | .17 |
| | | 1 x 1 lb. | Ammonium Hydroxide CP | .75 |
| | | 1 x 1 lb. | Hydrochloric Acid CP | .85 |
| 5150P | 71520 | 1 | Tube, Pyrex, thistle | .17 |
| | | 1 x 1 lb. | Copper Sulphate Crystal Tech | .30 |
| | | 1 x 4 oz. | Balls, camphor | .60 |
| 511 | 3960 | 1 | Surface film frames, set of four | 1.45 |
| 501 | 3790 | 1 | Adhesion disc glass 7.5 cm diam | .60 |
| 525 | 3800 | 1 | Tubes, Capillary, set of seven, with support | 1.25 |
| 738 | 7901 | 1 | Force Board complete with 3 balances | 3.75 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 321 | | 1 pkg. | Graph paper | $ .15 |
| 779 | 8260 | 1 | Ball pulley cord | 1.25 |
| 813 | 8860 | 1 | Plane, inclined, with pulley | 2.75 |
| 818 | 8900 | 1 | Hall's Car | 1.50 |
| 4180 | 42580 | 1 | Weights, set, metric slotted 10 to 500 grams | 4.50 |
| 738 | 7901 | 12 | Composition of Force Board complete with spring balances | 45.00 |
| 4086 | 40860 | 2 | Balances, laboratory dial scale 0 to 15 kg. in 100 gram division | 7.50 |
| 4194 | 42502 | 1 set | Weights, Metric Hook, 10 g to 1000 g | 5.00 |
| 153 | 76145B | 12 | Meter stick | 5.40 |
| 4194 | 42502 | 12 | Weights, Metric, Hook type, 10 g to 1000 g | 60.00 |
| 859 | | 1 | Center of Gravity Set, set of six devices | 7.85 |
| 853 | 7690 | 1 | Double Cone and Inclined Plane | 2.00 |
| 977 | 8810 | 1 | Board, wood, Friction block | .65 |
| 725 | 8580 | 1 | Ball, wood, 2" | .20 |
| 731 | 8585 | 1 | Ball Lignum Vitae 1½" diameter | .40 |
| 817A | 8780 | 1 | Acceleration board complete with steel ball and Lycopodium powder | 7.75 |
| 825 | 3410 | 1 | Metronome, for periods between ⅓ and 1½ seconds | 7.50 |
| 1534 | 5820 | 1 | Guinea and feather tube complete with tripod | 12.50 |
| 545 | 8635 | 1 | Ball, inertia, cast iron, 75 mm Diameter | 1.45 |
| 877 | 8140 | 1 | Second Law of Motion Apparatus, cast iron base with trigger rod | 3.00 |
| 907 | 9140 | 1 | Rotator, hand form, with standard chuck | 12.50 |
| 917 | 9230 | 1 | Hoops, centrifugal, 23 cm diameter | 1.75 |
| 921 | 9220 | 1 | Globe, rotating, 15 cm diameter | 4.50 |
| 823 | 38755 | 1 | Watch, stop, 1/5 second divisions, registers up to 30 minutes | 17.85 |
| 1067 | 8090 | 1 | Brake-Horse-Power Apparatus complete with two spring balances | 22.50 |
| 291 | 64100 | 1 | Speed indicator 4½", dial 1¼" in diameter | 1.75 |
| 717 | 8570 | 1 | Ball, iron, 1" diameter | .35 |
| | | 1 x 1 lb. | Paraffin solid | .20 |
| 747 | | 1 | Lever Apparatus, compound form with weights | 6.50 |
| 756 | 8170 | 1 | Pulley, single | .40 |
| 758 | 8175 | 1 | Pulley, double | .60 |
| 4204 | 1000C | 1 | Tripod base for 13 mm rod | 1.65 |
| 4226 | 1100B | 1 | Support rod 40 cm long | .65 |
| 4226 | 1100D | 1 | Support rod 80 cm long | .95 |
| 4268 | 1140B | 1 | Clamp, right angle, with "V" opening | 1.25 |
| 756 | 8170 | 24 | Pulley, single | 9.60 |
| 758 | 8175 | 24 | Pulley, double | 12.00 |
| 4204 | 1000C | 12 | Tripod bases for 13 mm rod | 19.80 |
| 4226 | 1100B | 12 | Support rods 40 cm long | 11.40 |
| 4268 | 1140B | 12 | Clamps, right angle, "V" openings | 15.00 |
| 813 | 8860 | 12 | Plane, inclined, with pulley | 33.00 |
| 818 | 8900 | 12 | Halls carriages | 18.00 |
| 781 | 8240 | 12 | Cords, pulley | 5.40 |
| 805A | | 1 | Jack Screw simple form, range 2 cm | .85 |
| 752 | 8421 | 1 | Wheel and axle | 2.25 |
| 1100 | 8010 | 1 | Wheel, model water | 11.50 |
| 733 | 8615 | 2 | Balls, steel, ¾" diameter | .20 |
| 1724 | 9755 | 1 | Tube, molecular vibration | 2.75 |
| 4752A | | 1 | Bunsen burner with tubing | 1.04 |
| 1661 | 10210 | 1 | Ball and ring | 1.75 |
| 1631 | 10260 | 1 | Linear expansion apparatus lever form | 7.25 |
| 1663 | 10230 | 1 | Compound bar | .75 |
| 1275A | 10250 | 1 | Thermostat Model, adjustable from 20 to +45 degree C | 3.25 |
| 1605 | 10240 | 1 | Thermometer, Bi-Metallic, in plastic case—range 50 to +130 degree F | 3.50 |
| 1672 | | 1 | Bulb, expansion and jacket | 2.75 |
| 5570 | 79900B | 1 | Support stand, 5 x 7" base | .65 |
| 1621 | 9640 | 12 | Thermometer, ungraduated | 12.00 |
| 1674A | 9690 | 1 | Charles, Law Tube, with Mercury index, mounted on meter stick | 1.50 |
| 1609 | 9760 | 1 | Air Thermometer Apparatus, simple form—mounted on tripod | 6.00 |
| 1653 | 10410 | 1 | Conductometer | 1.75. |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 5620 | 80640E | 12 | Test tubes 6 x ¾", soft glass | $ .37 |
| 4918 | 56680 | 1 | Clamp, test tube, wire form | .12 |
| 1727 | 10490 | 1 | Convection of Gases Apparatus complete with lamp chimneys | 2.50 |
| 1729 | 10480 | 1 | Convection of liquids apparatus, rectangular glass shaped tube, size 15 x 20 cm | 1.85 |
| 1720 | 10530 | 1 | Tank, hot water model, one liter capacity | 5.75 |
| 1729A | 10528 | 1 | Heater, hot water model, made of glass | 2.25 |
| 1733 | 10540 | 1 | Radiometer, single vane | 5.20 |
| 1617 | 10560 | 1 | Leslie's cube | 6.00 |
| 1615 | 10550 | 1 | Leslie's Thermometer | 4.50 |
| 1689 | 9880 | 1 | Calorimeter, double walled, with stirrer | 3.00 |
| 4525 | 44440 | 1 | Beaker, copper, 250 ml | 1.15 |
| 5680 | 80070A | 1 | Thermometer C & F 12" | 1.50 |
| 1623 | 10140 | 1 | Specific Heat Apparatus, complete with 5 metal balls | 3.75 |
| 1670 | 10650 | 1 | Ice bomb | 1.00 |
| 5898 | 25290 | 1 Spl. | Iron Wire No. 18 | .15 |
| | | 1x1 lb. | Sodium Chloride pure | .30 |
| 5680 | 80070A | 12 | Thermometer C & F 12" long | 18.00 |
| | | 2x1 lb. | Napthalene Flakes | .80 |
| | | 1x1 lb. | Ammonium Chloride White | .35 |
| | | 1x1 lb. | Sodium Nitrate Pure | .35 |
| 5100P | 70400 | 1 | Flask, Pyrex, Florence, 250 ml with rubber stopper | .30 |
| 5866A | 29415A | 1 | Sponge | .25 |
| 5298 | 96034 | 1 | Pressure Cooker | 17.80 |
| 1625 | 9650 | 1 | Hypsometer, copper, with tripod | 5.00 |
| 1629 | 9680 | 1 | Steam trap, glass | .50 |
| 5517 | 78845D | 3 ft. | Tubing 5/16" heavy wall | .75 |
| | | 1x1 lb. | Ether pure | .70 |
| | | 1x1 pt. | Alcohol Ethyl Denatured | .40 |
| 9530 | | 1 | Distilling and Condensing Apparatus | 6.00 |
| 5750 | 80890D | 1 | Watch glass 3" | .07 |
| 1280 | 74610 | 1 | Hygrometer, wet and dry, bulb type | 6.00 |
| 1723 | 7310 | 1 | Dew point apparatus, simple form | 1.50 |
| | | 1x1 lb. | Sodium Thiosulphate pure | .35 |
| | | 1x1 lb. | Sal Ammoniac | .30 |
| 3213 | 20000 | 1 | Tuning fork, alloy, 256 VPS No. 3 | 1.75 |
| 4516P | 44300 | 1 | Beaker, Pyrex, glass, 600 ml cap | .29 |
| 1510 | 5950 | 1 | Bell in Vacuo-Jar 2 liter | 6.00 |
| 1426 | 5300 | 1 | Air Pump Plate, 27 cm diameter | 8.50 |
| 3340 | 20820 | 1 | Spring, spiral, two meters long | 2.25 |
| 701 | 8540 | 1 | Collision Ball Apparatus consists of 7 balls and grooved base | 3.00 |
| 3332 | 20420 | 1 | Galton's Whistle | 8.85 |
| 3383 | 20410 | 1 | Sensitive Flame, burner type | 3.00 |
| 937 | 9330 | 1 | Savarts Toothed Wheel,4 Brass Wheels 7.5 cm diameter | 4.50 |
| 949 | 9320 | 1 | Disc, siren, 25 cm diameter aluminum | 1.70 |
| 3246 | 20230 | 1 set (2) | Tuning forks mounted on resonators, with rubber hammer | 15.00 |
| 3308 | | 12 | Resonance Apparatus with Reservoir Tube 25 x 27 cm with Millimeter Scale | 66.00 |
| 3213 | 20000 | 12 | Tuning Forks, 256 VPS No. 3 | 21.00 |
| 3227 | 20000 | 12 | Tuning Forks, 512 VPS No. 10 | 21.00 |
| 3272 | 20510 | 1 | Organ Pipe, metal, with sliding piston—shows effect of open and closed tubes | 7.50 |
| 3538 | 21220 | 1 | Inverse Square Frame, 22.5 cm long—Distance Ratios 1; 2; 3 and Area Ratios 1, 4, and 9 | 3.50 |
| 3577 | 21270 | 12 | Photometer, Bunsen form with Photometer Box | 60.00 |
| 3510 | 22470 | 1 | Mirror, plane—4 x 15 cm | .15 |
| 3675 | 21100 | 1 | Optical Disc—Stevens Form, with etched metal disc | 27.50 |
| 3680 | 21151 | 1 | Mazda Source of Light, 110 volt, 50 watt | 19.25 |
| 3512 | 22520 | 12 | Mirror 10 x 15 cm, plate glass | 6.60 |
| M3512 | 22480 | 12 | Mirror 10 x 10 cm, glass | 1.80 |
| 3514 | 22530 | 24 | Mirror Supports, metal | 6.00 |
| 163 | | 12 | Ruler, 12 inches metric and English | 1.25 |
| 225 | 3300B | 12 | Protractor, brass 4½" diameter | 2.50 |
| 3510 | 22470 | 12 | Mirror, plane 4 x 15 cm | 1.80 |
| 3518 | 22560 | 1 | Mirror, concave and convex, 10 cm diameter with frame and handle | 4.75 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 3494 | 22640 | 12 | Refraction plate 7 x 7 cm x 9 cm | $ 7.20 |
| 3480 | 22720 | 12 | Prism equilateral 7.5 cm, face 9 mm thick | 7.80 |
| 3600 | 21860 | 12 | Optical bench with lens holding screen holder, screen, object and marker | 16.20 |
| 3616 | 22030 | 12 | Candle holder, one candle | 2.40 |
| 3591 | 22120 | 144 | Candles 12's | 3.36 |
| 3400 | 22900B | 12 | Convex lens 10 cm focus, 38 mm diameter | 5.40 |
| 3424 | 22920A | 12 | Concave lens 10 cm focus, 38 mm diameter | 7.80 |
| 9431 | 91418 | 1 | Eye, model, separable into 5 parts | 18.00 |
| 3484 | 22760 | 1 | Prism, equilateral 25 x 100 mm mounted on a stand | 5.50 |
| 3556 | 23530G | 1 set(7) | Colored plates 10 cm square 1 each, red, orange, yellow, green, blue, indigo and violet | 1.40 |
| 4752A | | 1 | Bunsen burner | .65 |
| 3720 | 23240 | 1 | Monochromatic flame attachment | 1.25 |
| | | 1 lb. | Sodium Chloride | .25 |
| 3703 | 23595 | 1 | Polaroid experimental kit for projection work,—includes a set of discs and transparent samples | 40.00 |
| 1801 | 11000 | 1 | Lodestone | .30 |
| 1809 | 11010A | 1 | Magnet, bar, polished steel, 15 x 1.9 x 0.7cm | .45 |
| 1823 | 11100B | 1 | Magnet, horseshoe, 10 cm | .40 |
| 2023 | 12340 | 1 | Suspension stand for holding magnets | 1.45 |
| 1813 | 11020 | 1 set | Bar magnets, 15 x 1 9 x 0 7 cm | 1.20 |
| 1820 | 11410 | 1 | Stirrup, 9 cm between hooks | .25 |
| 1848 | 11490B | 1 lb. | Iron filings in sifter jar | .35 |
| M1803 | 11130 | 1 | Bar, soft iron, 9.5 x 2 x 0.6 cm | .15 |
| 1887 | 63400B | 12 | Compasses, small, 15 mm | 3.60 |
| 1809 | 11010A | 24 | Magnets, bar, size 15 x 1 9 x 0.7 cm | 10.80 |
| 1823 | 11100B | 24 | Magnet, horseshoe, 10 cm | 9.60 |
| 1848 | 11490B | 12 | Iron filings, in sifter jar | 4.20 |
| M1803 | 11130 | 12 | Bar, soft iron, 9 5 x 2 x 0 6 cm | 1.80 |
| 1841 | 11600 | 1 | Glass tube with iron filings | .65 |
| 1843 | 11420 | 1 set | Magnets, floating, set of 6 | .35 |
| 1845 | 11580 | 1 | Permalloy rod | 8.00 |
| 1875 | 63480 | 1 | Needle, dipping, mounted | 3.75 |
| 1929 | 11810 | 1 | Rod, hard rubber, 25 x 1 3 cm | .35 |
| 1925 | 11820 | 1 | Rod, glass, 25 x 1.2 cm | .45 |
| 1935 | 11850 | 1 | Pad, silk, 30 x 30 cm | .65 |
| 1945 | 11940 | 1 pkg.(6) | Pith balls with silk threads | .60 |
| 1957 | 11960 | 1 | Pith ball electroscope | 1.25 |
| 1963A | 12060 | 1 | Electroscope, metal case | 2.25 |
| 1929 | 11810 | 24 | Rods, rubber, 25 x 1.3 cm | 8.40 |
| 1925 | 11820 | 24 | Rods, glass, 25 x 1.2 cm | 10.80 |
| 1935 | 11850 | 12 | Pads, silk, 30 x 30 cm | 7.80 |
| 1820 | 11410 | 12 | Stirrups 9 cm between hooks | 3.00 |
| 2023 | 12340 | 12 | Suspension stands | 17.40 |
| 1963A | 12060 | 12 | Electroscopes, metal case | 27.00 |
| 1912 | 12510 | 1 | Wimshurst Static Machine, 12" plates | 42.50 |
| 1989 | 12270 | 1 | Leyden jar, removable coatings | 5.25 |
| 1951 | 11910 | 1 | Electrophorus, 15 x 15 cm | 1.65 |
| 2200 | 13855 | 1 | Student cell, consists of zinc and copper elements and jar | 1.20 |
| | | 1 lb. | Acid, sulphuric, cp | .85 |
| 2732 | 15505 | 1 | Galvanometer, portable | 12.00 |
| | | 1x4 oz. | Mercury CP | 2.00 |
| 2206A | 13936 | 12 | Amalgamated zinc strips, 25 x 125 mm | 1.80 |
| 2200 | 13855 | 12 | Students cells, zinc and copper element with jar | 14.40 |
| 2238 | 66515 | 12 | Dry cells standard | 6.00 |
| 2208 | 13885 | 1 | Carbon element, 6 x 125 mm | .15 |
| | | 1 lb. | Ammonium Chloride (Sal Ammoniac) Pure | .30 |
| 2922 | 14580A | 1 | Bell, electric, 2½" gong | .55 |
| 2264 | 13790 | 1 | Battery, Sampson, No. 2 | 4.35 |
| 3031A | | 1 | Voltmeter D.C. 0 to 15 Volts, 3" Scale | 12.50 |
| 3031J | | 1 | Ammeter D.C. 0 to 10 Amps., 3" Scale | 12.50 |
| 2754B | | 1 | Resistance Box 99.9 ohms | 16.75 |
| 2425A | 17040 | 1 | Test board for Volt and Ammeter Connection | 6.00 |
| 2428 | 14960 | 1 | Socket, miniature | .12 |
| 2432 | 15070A | 1 | Lamp miniature 2.5 V | .20 |
| 2238 | 66515 | 1 | Dry cell, 1.5 volts | .50 |
| 5888A | 25160 | 1x4 oz. | Copper wire No. 30 D.C.C | .85 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 5888A | 25160 | 1x4 oz. | Copper wire No. 22 D.C.C. | $ .55 |
| 5898 | 25290 | 1x4 oz. | Iron wire No. 26 | .16 |
| 5890 | 25210 | 1x1 oz. | German silver wire No. 30 | .45 |
| 2422 | 15240 | 1 | Lamp board wired for parallel or series circuit. | 5.00 |
| 2347 | 16480 | 1 | Amperes Rule Apparatus consists of heavy copper wire on a block | 1.75 |
| 2990 | 14760 | 1 | Switch, S. P. S. T. | .30 |
| 2307B | 66670C | 1 | Battery, storage, 6 volt 100 amperes hours | 17.65 |
| 2922 | 14580A | 12 | Bell, electric, 2½" gong | 6.60 |
| 1855 | 16600 | 1 | Electromagnet, distance between poles 4 cm | 3.25 |
| 2628 | 18050 | 1 | Telegraph set complete | 7.65 |
| 2450 | 18980 | 1 | St. Louis Motor | 5.25 |
| 2452 | 18990 | 1 | Electromagnet attachment for St. Louis motor | 1.25 |
| 2366 | 16790 | 1 | Electrolysis Apparatus, Hoffman type. | 10.25 |
| 2370 | 16780 | 1 | Support for Electrolysis Apparatus | 6.50 |
| 2299 | 14070 | 1 | Battery, storage, demonstration | 2.75 |
| 2428 | 14960 | 12 | Sockets, miniature | 1.44 |
| 2430 | 15070B | 12 | Lamps, miniature, 1.5 V | 2.40 |
| 2325 | 66720 | 1 | Hydrometer battery testing | 1.00 |
| 2354 | 16910 | 12 | Copper plating outfits complete | 30.00 |
| 5885 | 25120 | 1x4 oz. | Nichrome wire bare No. 30 | 3.10 |
| 5886 | 25150 | 1x4 oz. | Copper wire bare No. 30 | .65 |
| 2732A | 66910 | 1 | Student Galvanometer, ammeter and voltmeter | 18.00 |
| 1829 | 11120 | 1 | Magnet, horseshoe, 14 cm | .75 |
| 3031J | | 6 | D. C. Ammeter, 10 amps, 3" scale. | 75.00 |
| 3031C | | 6 | D. C. Voltmeter, 3" scale, 150 and 7.5 volts | 78.00 |
| 3100 | 16405 | 1 | Kilowatt hour dial demonstration | 5.50 |
| 3081A | | 1 | A. C Voltmeter, 150/15 Volts, 3" scale | 12.50 |
| 3081J | | 1 | A. C. Ammeter, 20 Amps, 3" scale | 12.50 |
| 1829 | 11120 | 24 | Magnets, horseshoe, 14 cm | 18.00 |
| 2732 | 15505 | 12 | Galvanometers, student | 144.00 |
| 2408 | 18880 | 1 | Dynamo electric machine—Miller Cowan with slip rings | 26.50 |
| 2399 | 17880 | 1 | Induction coil, primary, secondary | 5.50 |
| 2392A | 67150 | 1 | Coil, Commercial Induction, 1" spark. | 11.50 |
| 2600 | 18530 | 1 | Dissectible Transformer, model for demonstration. | 16.50 |
| 2630 | 18090 | 1 | Telephone receiver, demonstration form. | 2.50 |
| 2634 | 18110 | 1 | Telephone transmitter, demonstration form | 2.50 |
| 2635A | | 1 | Coil, Telephone induction | 3.50 |
| 2601A | | 1 | Choke Coil Apparatus with transformer and lamp | 13.50 |
| 2153 | 12760 | 1 set (6) | Tubes, Geissler, 15 cm long | 9.00 |
| 2145 | 12860 | 1 | Deflection of Cathode Ray Tube | 15.00 |
| 2126 | | 1 | X-Ray Tube, 10 cm bulb | 32.50 |
| 2133 | 13470 | 1 | Fluoroscope, 5 x 7" screen | 18.25 |
| 2391A | | 1 | Induction coil 3" spark | 42.50 |
| 5542 | 13430 | 1 | Spinthariscope | 5.85 |
| | | | Total | $2207.01 |

## RECAPITULATION

Total cost of apparatus and supplies ..... $2207.01

# SECONDARY SCHOOL CHEMISTRY

## THE TEACHING OF CHEMISTRY

### A. Aims and Purposes

Chemistry courses today are undergoing modification as a part of the continuing effort to adjust our curriculum to meet the implications of a changing concept of secondary education. We are still in a period of transition from the traditional college-preparatory aims to those aims generally summed up in the philosophy of "education to meet all the needs of all the Youth." The chemistry teacher cannot ignore the need of some of his students for instruction directed toward the beginning of specialized training, nor, on the other hand, can he ignore the need of all his students for that kind of instruction in science which contributes most toward attainment of the aims of general

education. Students with widely divergent interests, academic aptitudes, and aims are thrown together in the same class to be taught "chemistry." The chemistry teacher who is really concerned about the education of boys and girls is therefore forced to weigh carefully just what subject matter and activities go into the course—and why.

### B. Types of Rooms

There are well defined types of rooms in which chemistry instruction is carried on. There may be a separate lecture room in which the class meets certain days of the week and a laboratory in which the experimental work is carried on. Some high schools are equipped with combination laboratory-and-recitation rooms. The combination classroom-laboratory conserves space, and in addition has the important educational advantage of making it possible for the class to engage in experimental activities at any time, in order to integrate the laboratory work with the problems of study. Laboratory work thus serves as an important step in working out the answers to problems; it is not restricted to certain days according to a fixed, administrative schedule.

### C. Laboratory Equipment

It is highly desirable that laboratory work in chemistry be carried out by individuals or by groups of two. Students need a locker fitted out with the glassware and other general equipment required for doing the standard experiments. Students are charged with caring for and preserving their own equipment. The general hardware—Bunsen burners, ringstands, tongs, etc.—is provided in a general locker, which is open to use by several classes. A reserve of equipment and supplies is kept in a stockroom or in storage cabinets. Chemicals may be kept in the stockroom and issued as needed either by the teacher or by an assistant—possibly one of the students; or the most often used chemicals may be made generally available on a reagent shelf. The list of equipment, apparatus and supplies given later in this report contains the materials deemed necessary for a course in chemistry. This list might be thought of as representing good practice; it is not as complete a list as would be found in the best-equipped high schools, but, on the other hand, it is superior to the inadequate materials with which a good many of our high schools struggle along.

### D. Descriptions of Good Practices

Good practice in the teaching of chemistry succeeds in placing boys and girls in "problem situations" and in directing them in the use of the scientific method of problem solving. Through such practice students are taught the values of laboratory procedures in finding the answers to questions and of maintaining scientific attitudes while seeking such answers. This method of instruction emphasizes understandings, rather than memorizations, of basic concepts of chemistry. It eliminates as completely as possible the "cook-book" type of laboratory work, which consists only of routine checking of factual information already available in the textbook. When placed in situations where their work is of a more original nature, students begin to appreciate the value of systematic records. There is a well-defined trend toward reducing the number of "cook-book" experiments in chemistry to the end that emphasis may be placed on the following types of laboratory work: (1) experiments essential to the development of basic skills and techniques; (2) experiments which familiarize the student with important chemical materials and processes through first-hand experience; (3) experiments which require the application of basic laboratory procedures and of chemical principles to the solution of a specific problem; and (4) experiments which involve the solving of an original problem of the student's own devising.

Insofar as general class work is concerned, good practice in the teaching of chemistry consists of skillfully integrating a great variety of activities into a developmental or problem solving approach to the answers to real, worthwhile questions. Among the activities frequently employed, besides the laboratory work already mentioned, are the following: teacher demonstrations; student demonstrations and reports; exhibits and displays; field trips; audio-visual aids; library reference work; committee projects; and a wide variety of testing and evaluational activities.

The outline of subject matter that follows will give an idea of the coverage of a representative chemistry course. However, such an outline cannot reveal the kinds of teaching procedures that go along with it; and although the practice of teaching chemistry topic by topic according to outline unfortunately still persists, chemistry teachers are increasingly conducting their course in the manner and spirit of the scientific method.

Chemistry is generally given as a one-year course during either the eleventh or twelfth year. While many schools retain the older schedule of three class periods (usually 45 minutes long) and two double laboratory periods per week, probably more have moved to five 50-60 minute periods per week with no particular days set aside for laboratory work.

There are at least two rather well-defined methods of presenting the work in chemistry. Probably the larger number of chemistry teachers are inclined to follow the subject-matter outline rather closely and consider the applications of this subject matter as outgrowths or extensions of its study. They definitely attempt to relate chemistry to the life of the individual, to his home and community, and to national and international problems. The thinking of this group of teachers leads them to believe that a knowledge and understanding of the basic facts, principles, laws, and generalizations of chemistry are a prerequisite to a recognition and understanding of their application.

A smaller but growing number of chemistry teachers (as well as teachers in other science fields) try to develop the course by setting up and examining into the numerous life problems of the individual, his home, his community, his nation, and his world, insofar as they involve or require a knowledge of chemistry for their solutions. The thought here is that this method of approach more nearly approximates the true scientific method of learning, and that a deeper insight into the nature and content of chemistry will thereby result.

In any event, teachers of high school chemistry are largely agreed that the chemistry outlined in the first five units to follow is a basic requirement. These five units usually constitute about one semester's work. From this point on, the sequence and nature of the chemistry course may vary widely according to the needs and interests of the students. For example, one teacher may include metallurgy in preference to the organic unit; another may prefer to include both the metallurgy and organic units at the expense of much detailed chemistry of sulfur, nitrogen, and the halogens. Teachers usually have freedom to set up their own pattern.

The following outline presents a unit organization of high school chemistry, together with the associated experiments that may be done.

## OUTLINE OF COURSE CONTENT

I. Introduction
- Preliminary laboratory work
- Measurement
- Historical background of chemistry
- The role of chemistry in modern life
  - *Preliminary: Bunsen burner, manipulating glass, laboratory techniques, measurement

II. The chemical nature of matter
- The physical states of matter
- The identification of matter—Physical properties; chemical properties
- The classification of matter—Elements; compounds—law of definite proportions, analysis and synthesis; mixtures—solutions as mixtures, air as a mixture
- The changes that matter undergoes—Physical change; chemical change—types and simple word equations, factors that induce and regulate chemical change
- Two key elements in chemistry—Oxygen—the chemistry** of oxygen, burning, spontaneous combustion, dust explosions; Lavoisier's work; hydrogen—the chemistry of hydrogen, hydrogenation; oxidation and reduction; the composition of water—analysis by electrolysis, synthesis by reduction of cupric oxide, synthesis in an eudiometer, law of combining volumes; hydrogen peroxide and the law of multiple proportions
  - Physical and chemical change*
  - Mixtures and compounds
  - Burning; heating metals in air
  - Oxygen
  - Hydrogen
  - Reduction by hydrogen
  - Other sources of hydrogen
  - Electrolysis of water (demonstration)
  - Conservation of matter

III. The structure of matter
- The molecular theory of matter—Evidence for molecules; nature of molecules; gas laws and the behavior of gases

*All classroom demonstrations and laboratory experiments are indented thus rather than being listed separately.
**Wherever the expression "the chemistry of" appears in this outline, it is meant to include such topics as historical background, occurrence, preparation, physical and chemical properties, and uses or applications of the substance under consideration.

The atomic theory of matter—Evidence for atoms; the nature of atoms; atomic weights, gram-molecular weights and gram-molecular volumes
The composition of atoms—Review of researches into atomic composition —electrical discharges through gases, radio-activity, X-rays and Moseley's work on atomic numbers; sub-atomic particles—the electron, the proton, the neutron, others
The structure of atoms—Orbits and electrons; the nucleus; use of atomic weights and atomic numbers in "diagramming" atoms
Applications of atomic structure —Outer-orbit electrons and chemical activity —equations; valence, ionic valence and covalence—equations; isotopes; crystal structure and ionic space lattices; oxidation-reduction reactions
Nucleonics—Explanation of radioactivity; transmutation of the elements; nuclear fission and "atomic" energy; electronics—brief introduction
Molecular weight of oxygen; per cent of oxygen in $KClO_3$
Combining weight and valence of magnesium

IV. Solutions and colloids
True solutions—Nature of; preparation of solutions of desired concentration —percentage composition of solutions, molar solutions, factors affecting solubility; effect of solutes on freezing and boiling points of solvent
Separating solutions into solute and solvent—Distillation, fractional distillation; crystallization
Near-solutions or colloids—Nature of matter in colloidal stage of subdivision; types of colloidal dispersions and their preparation; properties of matter in colloidal condition; applications of colloids
Solutions and suspensions
Crystals and crystallization
Determination of water of crystallization
Distillation
Fractional distillation
Colloids

V. Ions in solution; electrolytes
Background of theory of ions in solution—Lowering of freezing points; conductivity of solutions; Arrhenius theory, speed of reactions between dry and dissolved electrolytes
Reactions explained by ionic behavior—equilibrium reactions and equations; end reactions and equations; mass action
Electrolysis of solutions—Ionic explanation of electrolysis. water, hydrochloric acid; electroplating; chemical cells; storage battery
Acids and bases explained by ionic behavior—Acids and the hydronium ion; bases and the hydroxyl ion; strengths of acids and bases—pH values, normal solutions; neutralization reactions and equations; hydrolysis reactions and equations
Electrolytes—General characteristics of acids and bases; general methods of preparing acids, bases, and salts—equations; nomenclature of acids, bases, and salts
Properties of acids and bases
Preparation of acids and bases
Neutralization
Conductivity (demonstration)
Double displacement reactions
Hydrolysis
Electroplating and refining of copper
Per cent of acetic acid in vinegar
Per cent of ammonia in household ammonia water
The chemical cell
The storage battery
Preparation of salts
Calculated yield and experimental yield
Titration; normal solutions

VI. The halogens as a chemical family
The periodic table and the classification of the elements
Chlorine as a member of the halogen family—Chemistry of chlorine; hydrogen chloride and hydrochloric acid
Others members of the halogen family—Chemistry of the halogens; family relationships among the halogens; bleaching
Chlorine
Hydrogen chloride and hydrochloric acid
Bromine
Iodine

VII. The nitrogen family

Nitrogen—The chemistry of nitrogen; nitrogen fixation; other gases composing the atmosphere

Important nitrogen compounds—Ammonia—chemistry of ammonia, refrigeration; nitric acid—chemistry of nitric acid, explosives; other nitrogen compounds—nitrous acid, oxides of nitrogen

Other members of the nitrogen family—Phosphorus—chemistry of phosphorus, acids of phosphorus; arsenic; antimony; bismuth

The nitrogen family as related to soils and fertilizers—The nature of soil; maintaining soil fertility—acidity of soil, fertilizers, nitrogen cycle; insecticides

Composition of the air
Ammonia
Nitric acid; nitrates
Oxides of nitrogen
Phosphorus and its compounds

VIII. Sulfur

The chemistry of sulfur the element
The oxides of sulfur
The acids of sulfur—Sulfites and their uses; sulfates and their uses; alums
The sulfides—Sulfides as ores of metals; carbon disulfide; hydrogen disulfide

Sulfur
Hydrogen sulfide
Sulfur dioxide
Sulfuric acid

IX. Some base forming elements

The sodium family—Chemistry of sodium; chemistry of potassium; important compounds—sodium hydroxide, sodium carbonate, Solvay process

Calcium and magnesium—Natural occurrence; caves and caverns; lime products and their applications; the chemistry of hard water and water softeners

Minerals—Silicates; silicate industries—cement, glass, ceramics

Compounds of calcium
Hard water
Baking powders

X. Metals and metallurgy

Principles of metallurgy—Concentration of the ore; smelting; electrolytic separation; activity series of the metals; refining the metal

Iron and its varieties—The chemistry of making pig iron; the chemistry of making steel; heat treatment of steel

Copper

Aluminum and magnesium —Alumino-thermics

Other common metals

Some uncommon metals

Alloys—Nature of alloys; alloy steels; nonferrous alloys

Protection and preservation of metals—Ionic-electronic explanation of corrosion; methods of protection

Recovery of metals from ores
Activity series of the metals
Oxidation and reduction of iron ions
The thermit reaction (demonstration)
Alloys and amalgams (demonstration)

XI. Carbon and organic chemistry

Chemistry of carbon the element
The oxides of carbon

Relationship of carbon to fuels and flames—Fuels as energy sources, calorific values of fuels; petroleum and its future—gasoline manufacture, other petroleum products; natural and manufactured gases

Hydrocarbons—Homologous series; chains and rings; saturated and unsaturated compounds; substitution and addition products; structural formulas in organic chemistry

Important classes of hydrocarbon derivatives—Alcohols; aldehydes and ketones; ethers; organic acids; esters; soap making

Plastics and synthetics—Rubber, a natural plastic; synthetic rubber; plastics

Carbohydrates—Sugars; starches; cellulose and its uses

Foods and nutrition—The classes of foods; vitamins; alkaloids

Natural and manufactured fibres and textiles

Drugs and medicinals
- Carbon
- Destructive distillation
- Carbon dioxide
- Organic acids, alcohols, and esters
- Soap making
- Carbohydrates
- Fermentation; alcohols
- Methane and acetylene
- Molecular models of organic molecules (demonstration)

XII. Applied or consumer chemistry
- Qualitative analysis—Identification of the salts of important acids; analysis for Group I of the metals
- Household chemistry —Fire and burning; fire prevention; fire extinguishers; silverware polishes; cleansing agents
- Consumer chemistry—Meanings of labels on bottles and packages; comparison of consumer products: vinegar, antifreezes, baking powders
- Dyes, stains, textiles
- Paints, varnishes, and lacquers
- Cosmetics
  - Analysis of baking powders
  - Identification of anions
  - Borax bead and cobalt nitrate tests
  - Flame tests
  - Analysis for Group I metals
  - Proteins and fats
  - Identification of textile fibres
  - Dyeing
  - Removal of spots and stains
  - Paints
  - Composition of milk
  - Photography

## CHEMISTRY

### 1. Demonstration Apparatus

#### a. Essential

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 56305 | 4854 | 1 | Chart of periodic system, Hubbard | $ 7.50 |
| 56307 | 4853 | 1 | Chart of the metals | 2.75 |
| 3650 | 4860 | 1 | Brownian movement apparatus | 4.50 |
| 63750 | 2369A | 1 | Conductivity cell | 1.75 |
| 80590 | 5731 | 1 | Pneumatic trough, glass—12 x 6½ x 6½" | 6.00 |
| 75450H | 1142 | 12 | Hydrometer jar, 15 x 2" | 10.80 |
| 80710L | 5629P | 12 | Ignition tubes, Pyrex, 200 x 25 mm | 2.76 |
| 75450G | 1142 | 6 | Hydrometer jars 12 x 2" | 4.44 |
| | | | Total | $ 40.50 |

#### b. Desirable But Not Essential

| | | | | |
|---|---|---|---|---|
| 56308 | 4851 | 1 | Chart of electrochemical series | $ 2.00 |
| 2760 | 129 | 1 | Liter block, dissectible | 4.50 |
| 16810 | 2366 | 1 | Hoffman's electrolysis apparatus | 9.85 |
| 16810 | 2370 | 1 | Support for electrolysis apparatus | 6.50 |
| 65030B | 4995 | 1 | Dessicator, Schiebler type 150 mm | 5.00 |
| 65060 | 4999C | 1 | Dessicator, plate 150 mm | 1.80 |
| 40220 | 4000B | 1 | Analytical balance, 200 gram cap | 82.50 |
| 40215C | 4096 | 1 | Set of weights for above 1 mg to 100 gm class S | 28.50 |
| 23310 | 3693 | 1 | Spectroscope, grating type, table model | 35.00 |
| | 635 | 1 set | Molecular models for organic chem. study | 35.00 |
| | | | Total | $210.65 |

## 2. General Desk Equipment

This equipment is usually kept in a separate drawer which is available for use by all classes; it is usually not issued to individual working units. The quantities indicated are based on twelve working units (individual students or groups of 2 or 3 students) and one unit for the instructor's desk. In addition, a reasonable allowance is included for breakage and replacements during the year. (Items starred * are to be shared by two working groups.)

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 50280 | 4763 | 16 | Bunsen burners, Tirril | $ 24.00 |
| 80490B | 5703 | 16 | Tongs, crucible, brass | 5.60 |
| 48420 | 4652 | 10* | Reagent bottles, hydrochloric acid conc. 4 oz | 6.00 |
| 48420 | 4652 | 10* | Reagent bottles, hydrochloric acid dil. 4 oz | 6.00 |
| 48420 | 4652 | 10* | Reagent bottles, nitric acid, conc. 4 oz | 6.00 |
| 48420 | 4652 | 10* | Reagent bottles, nitric acid, dil. 4 oz | 6.00 |
| 48420 | 4652 | 10* | Reagent bottles, sulfuric acid, conc. 4 oz | 6.00 |
| 48420 | 4652 | 10* | Reagent bottles, sulfuric acid, dil. 4 oz | 6.00 |
| 48420 | 4652 | 10* | Reagent bottles, ammonium hydroxide 4 oz | 6.00 |
| 48420 | 4652 | 10* | Reagent bottles, sodium hydroxide, 4 oz. | 6.00 |
| 45610 | 4608A | 48 | Bottles, g.s., narrow mouth, mushroom stopper, 16 oz | 22.00 |
| 80760 | 5609 | 16 | Test tube racks metal 32 tubes double | 16.00 |
| 79905B | 5572 | 16 | Ring stand supports, complete with 3 rings | 21.60 |
| 49710 | 4727B | 16 | Clamps, (burette clamps) | 23.20 |
| 81050B | 5207 | 16 | Wire gauze, 5 x 5" | 2.40 |
| 80580A | 5726 | 13 | Pneumatic trough 10 x 7 x 4½" | 13.00 |
| 40450 | 4030 | 6* | Triple-beam balance, 111 gram cap | 117.00 |
| 70130 | 5063 | 13 | Filter pump aspirators metal | 21.45 |
| 79240 | 4993 | 16 | Deflagrating spoons, stainless steel | 4.00 |
| 69620B | 89 | 16 | Files, triangular, 5" | 3.52 |
| 64680C | 5407C | 16 | Mortar and pestle, Coors No. 0 | 16.00 |
| 36555 | 5906 | 16 | Asbestos mats, 5 x 5" | .48 |
| 80540B | 5711 | 16 | Pipestem triangles, 2" | 1.98 |
| 49250B | 4675C | 16 | Test tube brushes med. | 1.47 |
| 56680 | 4918 | 16 | Clamps, test tube, Stoddard's | 1.73 |
| 50350A | 4767 | 16 | Wing tops, for Bunsen burners | 2.40 |
| 44600 | 4560 | 16 | Blowpipes, 8" | 6.40 |
| | | | Total | $352.23 |

## 3. Individual Locker Apparatus

This list should allow sufficient materials for twelve working units, and if each unit is composed of two or three students it will be sufficient for a class of 24 or 36 students. It is flexible enough to handle any class from 12 to 36 students. The school need only multiply this listing by the number of classes and it will be assured of having correct materials. Students generally keep this apparatus in locker drawers and are often charged for breakage and replacements. Estimated quantities of these materials needed for replacement are included in section 4 of this listing.

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 44300 | 4516P | 12 | Beakers, Pyrex, 100 cc | $ 2.40 |
| 44300 | 4516P | 12 | Beakers, Pyrex, 250 cc | 2.04 |
| 44300 | 4516P | 12 | Beakers, Pyrex, 400 cc | 2.88 |
| 64310 | 4972C | 12 | Crucibles, Coors, size No. 0 | 2.40 |
| 64315 | 4972CC | 12 | Crucible covers, No. 0 | .96 |
| 64830C | 5258 | 12 | Cylinders, graduated, 25 ml. Blue line | 7.92 |
| 70750 | 5106P | 12 | Flasks, Erlenmeyer, Pyrex, 250 ml | 2.76 |
| 69700 | 5050 | 12 pkg. | Filter paper, 11 cm diameter | 2.76 |
| 71260 | 5140 | 12 | Funnels, 65 mm short stem | 3.96 |
| 71150 | 5150P | 12 | Funnels, thistle tube, Pyrex | 2.04 |
| 73740 | 5218 | 48 | Glass plates, 3 x 3" | 2.88 |
| 77960H | | 12 vials | Litmus paper, red (per doz.) | 1.00 |
| 77960F | | 12 vials | Litmus paper, blue (per doz.) | 1.00 |
| 80890D | 5750 | 12 | Watch glasses, 3" | .78 |

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 65210 | 5004C | 12 | Dish, evaporating, Coors, size 00A | $ 2.88 |
| 70400 | 5100P | 12 | Flask, Florence, flat bottom, Pyrex, 250 ml | 2.88 |
| | | | Total | $ 41.54 |

## 4. General and Reserve Apparatus and Equipment

This apparatus is usually kept in a general supply room and is issued on a loan basis or for breakage replacement by the teacher or a laboratory assistant. Items from section 3 above which are duplicated in this list are for the purpose of providing a reserve supply of individual apparatus to care for breakage.

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 70250 | 5775 | 1 | First aid kit large | $ 7.25 |
| 66370B | 5557A | 1 | Distilling apparatus, Stokes Gas fired ½ gal./hr | 35.00 |
| 70220 | 5091 | 1 | Fire extinguisher 1 gal. size | 14.00 |
| 70830 | 5108P | 6 | Filtering flask, Pyrex, 250 ml | 4.74 |
| 45520 | 4603 | 60 | Wide mouth bottles, 8 oz | 4.50 |
| 73730 | 5215 | 12 | Glass plates, cobalt blue, 2 x 2" | 1.56 |
| 71180 | 5130 | 12 | Forceps steel—5" straight | 1.80 |
| 79270 | 5865A | 12 | Wood splints | 9.00 |
| 64700A | 5407 | 1 | Mortar and pestle 185 mm | 3.18 |
| 36380 | 4503A | 1 | Laboratory coat (size 40) full length | 4.75 |
| 78198B | 8246 | 12 | Bead wire, platinum, in handle—26 B and S gauge | 7.20 |
| 44300 | 4516P | 12 | Beakers, Pyrex, 100 ml | 2.40 |
| 44300 | 4516P | 12 | Beakers, Pyrex, 250 ml | 2.04 |
| 44300 | 4516P | 12 | Beakers, Pyrex, 400 ml | 2.88 |
| 44300 | 4516P | 6 | Beakers, Pyrex, 1000 ml | 3.36 |
| 49370B | 4708 | 12* | Burette, 50 cc, with stopcock, Exax | 21.00 |
| 22130 | 3589 | 12 | Paraffin candles | .45 |
| 63550C | 4941 | 6* | Condenser, Liebig, 400 mm glass | 6.00 |
| 63900B | 4954B | 2 | Cork borers (set of 8) | 3.30 |
| 63805B | 4947 | 2 pkg. | Corks, assorted 3-16 | 2.60 |
| 64830E | 5258 | 6* | Cylinders, graduated, Exax, 100 cc | 4.98 |
| 64830F | 5256 | 1 | Cylinder, graduated, Exax, 500 cc | 1.76 |
| 73460B | 4790 | 12 | Calcium chloride tube, 6" | 6.00 |
| 69700 | 5050 | 12 pkg. | Filter paper, 11 cm | 2.76 |
| 71150 | 5150P | 12 | Funnel, thistle tube, Pyrex | 2.04 |
| 70750 | 5106P | 12 | Flasks, Erlenmeyer, Pyrex, 250 ml | 2.76 |
| 70750 | 5106P | 12 | Flasks, Erlenmeyer, Pyrex, 500 ml | 3.36 |
| 71260 | 5140 | 12 | Funnels, glass, 65 mm short stem | 3.96 |
| 73765 | 5235 | 5 lb. | Glass tubing, 6 mm | 3.00 |
| 73765 | 5235 | 2 lb. | Glass tubing, 4 mm | 1.90 |
| 75810 | 5314 | 6 | Labels, Dennison, No. 261 | .90 |
| 65260B | 5010 | 12 | Lead dishes 3" | 2.16 |
| 76200 | 8052 | 6* | Magnifiers, tripod | 6.00 |
| 78010K | 5435A | 6 | Pipettes, 25 ml transfer Blue line | 3.30 |
| 78010F | 5435A | 6 | Pipettes, 10 ml transfer Blue line | 2.64 |
| 78730B | 5491P | 6* | Retorts, Pyrex, 250 ml glass stoppered | 10.44 |
| 78780B | 5505 | 1 lb. | Rubber stoppers, 1 hole, No. 1 (58 per lb.) | 1.20 |
| 78780B | 5505 | 1 lb. | Rubber stoppers, 1 hole, 3" (52 per lb.) | 1.20 |
| 78780B | 5505 | 1 lb. | Rubber stoppers, 1 hole, No. 3 (39 per lb.) | 1.20 |
| 78780B | 5505 | 1 lb. | Rubber stoppers, 1 hole, No. 4 (33 per lb.) | 1.20 |
| 78780B | 5505 | 1 lb. | Rubber stoppers, 1 hole, No. 5 (29 per lb.) | 1.20 |
| 78780B | 5505 | 2 lb. | Rubber stoppers, 1 hole, No. 6 (22 per lb.) | 2.40 |
| 78780B | 5505 | 2 lb. | Rubber stoppers, 1 hole, No. 7 (15 per lb.) | 2.40 |
| 78780C | 5505 | 1 lb. | Rubber stoppers, 2 hole, No. 3 (39 per lb.) | 1.20 |
| 78780C | 5505 | 1 lb. | Rubber stoppers, 2 hole, No. 4 (33 per lb.) | 1.20 |
| 78780C | 5505 | 1 lb. | Rubber stoppers, 2 hole, No. 5 (29 per lb.) | 1.20 |
| 78780C | 5505 | 2 lb. | Rubber stoppers, 2 hole, No. 6 (22 per lb.) | 2.40 |
| 78780C | 5505 | 2 lb. | Rubber stoppers, 2 hole, No. 7 (15 per lb.) | 2.40 |
| 78780C | 5505 | 1 lb. | Rubber stoppers, 2 hole, No. 8 (11 per lb.) | 1.20 |
| 78830B | 5515 | 50 ft. | Rubber tubing, 3/16" I.D. | 3.00 |
| 78830E | 5515 | 50 ft. | Rubber tubing, 3/8" I.D. | 4.50 |
| 80650F | 5628P | 48 | Test tubes, Pyrex, 150 x 18 mm | 2.16 |
| 80710L | 5629P | 24 | Test tube, ignition, Pyrex, 200 x 25 mm | 5.52 |
| 56700A | 4914 | 24 | Clamps, screw, Hoffman | 7.20 |
| 77960H | | 24 vials | Litmus paper, red | 2.00 |

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 77960F | | 24 vials | Litmus paper, blue | 2.00 |
| 77960U | | 12 vials | Tumeric test paper | 1.20 |
| 77960S | | 12 vials | Starch-potassium iodide test paper | 1.20 |
| 80060A | 5670 | 12 | Thermometer, -10 to 110° | 13.80 |
| 80890D | 5750 | 24 | Watch glasses, 3" | 1.56 |
| 25920 | 5938 | 2 sq. ft. | Zinc metal sheets, 1/32" | 1.40 |
| 73765 | 5235 | 2 lb. | Glass rod, 6 mm | 2.00 |
| 78830C | 5517 | 10 ft. | Rubber tubing, thick wall for high vacuum ¼" | 2.20 |
| 80640E | 5620 | 2 | Gross test tubes, ordinary glass, 6 x ¾" | 7.50 |
| 70400 | 5100P | 12 | Flask, Florence, flat bottom, Pyrex 250 cc | 2.88 |
| 70400 | 5100P | 12 | Flask Florence, flat bottom, Pyrex, 500 cc | 3.48 |
| 70400 | 5100P | 2 | Flask, Florence, flat bottom, Pyrex 1000 cc | .88 |
| 73460B | 4790 | 6 | Calcium chloride tubes, U-shaped 6" | 1.80 |
| 50620A | 4759 | 1 | Burner, high temperature | 2.35 |
| 64310 | 4972C | 12 | Crucible, Coors, size No. 0 | 2.40 |
| 64315 | 4972CC | 12 | Crucible, covers, size No. 0. | .96 |
| 64830D | 5258 | 12 | Cylinders, graduated, 25 ml | 7.92 |
| 65210 | 5004C | 12 | Dish, evaporating, Coors, size 00A | 2.88 |
| 71330 | 5149C | 1 | Funnel, Buchner, No. 4 | 4.80 |
| | | | Total | $301.16 |

## 5. Additional Desirable Apparatus

This apparatus is generally of use to several of the sciences and hence may be available to the chemistry teacher from other parts of the science department.

| Chapco Cat. No. | Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 43010 | 1215 | 1 | Mercurial barometer | $ 27.50 |
| 66750 | 2606K | 1 | AC-DC power pack (or other source of DC power) | 20.00 |
| 78401 | 1410B | 1 | Vacuum pump, motor-driven | 65.00 |
| 98002 | 7969 | 1 | Microscope, complete with case, compound | 112.00 |
| 21151 | 3680 | 1 | Illuminator, 110-volt, AC | 19.25 |
| 74630 | 1281 | 1 | Hygrometer with revolving humidity table | 5.50 |
| 66515 | 2238 | 12 | Dry cells, 1.5 volt | 6.00 |
| 14540B | 2978A | 12 | Set of connectors | 3.00 |
| 73840 | 102 | 1 | Glass cutter | .60 |
| 75780B | 5310 | 2 | Jars, stoneware, 2 gal. | 5.00 |
| 26570B | 111 | 1 | Hammer, claw | 1.65 |
| 26780 | 197 | 1 | Side cutting pliers | 1.25 |
| 27030 | 268 | 1 | Screwdriver, four-in-one | 1.00 |
| 27090B | 273 | 1 | Paper-cutting shears | 1.55 |
| 27100 | 275 | 1 | Metal-cutting shears | 1.50 |
| 27310 | 315 | 1 | Stillson's pipe wrench | 1.85 |
| 27120 | 281 | 1 | Soldering outfit | 1.00 |
| 5080 | 1128 | 1 | Hydrometer for heavy liquids | .75 |
| 5090 | 1126 | 1 | Hydrometer for light liquids | .75 |
| 6505 | 1080 | 1 | Boyle's law apparatus | 11.00 |
| 9755 | 1724 | 1 | Molecular demonstration apparatus | 2.75 |
| 77105 | 5354 | 1 | Babcock milk tester, 4 bottles | 13.50 |
| | | | Total | $300.40 |
| | | | Grand Total (except chemicals) | $1246.48 |

## CHEMICALS

Based on 12 working units of 1, 2 or 3 students each, for one year.

| | | | | | |
|---|---|---|---|---|---|
| 1 lb. | Acid, acetic, 36% | $ .46 | 1 gal. | Alcohol, ethyl, denatured | $1.50 |
| 4 oz. | Acid, acetic, glacial USP | .20 | 1 pt. | Alcohol, methyl | .30 |
| 4 oz. | Acid, citric CP | .20 | 4 oz. | Alizarine paste | .60 |
| 4 oz. | Acid, Formic, 90% pure | .30 | 1 oz. | Alpha naphthol | .20 |
| 12 lb. | Acid, hydrochloric CP | 3.12 | 1 lb. | Alum ammonium | .24 |
| 4 oz. | Acid, hydrofluoric tech. | .39 | 1 lb. | Aluminum potassium sulfate | .60 |
| 7 lb. | Acid, nitric CP | 2.10 | 4 oz. | Aluminum foil | .60 |
| 4 oz. | Acid, Oxalic, cryst. CP | .52 | 1 lb. | Aluminum sheet | 1.17 |
| 4 oz. | Acid, Salicylic, CP | .30 | 1 lb. | Aluminum sulfate, tech | .25 |
| 9 lb. | Acid, sulphuric, CP | 2.00 | 1 lb. | Ammonium carbonate, USP | .38 |
| 4 oz. | Acid, tannic, tech | .40 | 1 lb. | Ammonium chloride, CP | .52 |
| 4 oz. | Acid, tartaric | .40 | 8 oz. | Ammonium ferric citrate (green) | .52 |
| 4 oz. | Alcohol, amyl | .26 | | | |

| | | |
|---|---|---|
| 8 oz. | Ammonium dichromate | $ .88 |
| 8 lb. | Ammonium hydroxide CP | 2.64 |
| 4 oz. | Ammonium nitrate, cryst. CP | .40 |
| 4 oz. | Ammonium oxalate, CP | .49 |
| 4 oz. | Ammonium molybdate AR | .75 |
| 4 oz. | Ammonium sulfate CP | .36 |
| 1 lb. | Ammonium sulfate, dark | .38 |
| 4 oz. | Antimony lumps | .30 |
| 4 oz. | Arsenic trioxide | .20 |
| 1 lb. | Barium chloride, cryst. CP | .61 |
| 4 oz. | Barium hydroxide, CP | .43 |
| 4 oz. | Barium nitrate CP | .49 |
| 4 oz. | Bismuth metal | .75 |
| 1 lb. | Bleaching powd. | .25 |
| 1 lb. | Bone black | .36 |
| 1 lb. | Borax, pure | .25 |
| 4 oz. | Boric acid, CP | .40 |
| 4 oz. | Brass sheet | .25 |
| 1 oz. | Calcium metal turnings | .60 |
| 4 oz. | Cadmium chloride CP | .92 |
| 1 lb. | Calcium carbide | .29 |
| 1 oz. | Cadmium nitrate, CP | .39 |
| 5 lb. | Calcium carbonate Marble chips | .60 |
| 1 lb. | Calcium chloride gran. 8 mesh pure | .44 |
| 1 lb. | Calcium fluoride | .26 |
| 4 oz. | Calcium nitrate, CP | .46 |
| 2 lb. | Calcium oxide (good quality lime) | .40 |
| 2 lb. | Calcium, hydroxide, hydrated lime | .40 |
| 4 oz. | Calcium phosphate, mono pure | .18 |
| 1 lb. | Calcium sulfate (Plaster of Paris) | .20 |
| 1 oz. | Camphor gum | .30 |
| 2 lb. | Carbon disulphide | .74 |
| 2 lb. | Carbon tetrachloride | .66 |
| 4 oz. | Casein powd. | .30 |
| 1 lb. | Chalk precipitated | .27 |
| 12 | Charcoal sticks | .50 |
| 1 lb. | Charcoal wood, powd | .20 |
| 1 lb. | Chloroform, USP | .59 |
| 4 oz. | Chromium sulfate, CP | .65 |
| 4 oz. | Cobalt nitrate, cryst. CP | 1.52 |
| 4 oz. | Copper chloride, cryst. pure | .21 |
| 4 oz. | Copper foil, thin | .26 |
| 1 lb. | Copper turnings | .60 |
| 4 oz. | Copper nitrate, cryst. pure | .27 |
| 4 oz. | Copper oxide, powd., CP | .72 |
| 4 oz. | Copper oxide, wire form, CP | .75 |
| 2 lb. | Copper sulfate, cryst., CP | 1.22 |
| 1 oz. | Cotton, absorbent | .15 |
| 1 pt. | Cotton seed oil | .50 |
| 4 oz. | Dextrin | .25 |
| 1 oz. | Gallein, red powd. | .50 |
| 1 oz. | Fuchsine red, acid, powds | .35 |
| 1 oz. | Methyl violet | .30 |
| 1 oz. | Malachite, green | .40 |
| 1 oz. | Congo red | .25 |
| 1 oz. | Eosine | .45 |
| 1 lb. | Formalin | .36 |
| 1 oz. | Fluorescein | .50 |
| 4 oz. | Gelatine, gran. | .40 |
| 1 lb. | Glucose | .35 |
| 1 lb. | Gypsum | .20 |
| 4 oz. | Hydrochinone | .40 |
| 1 lb. | Hydrogen peroxide | .25 |
| 1 oz. | Iodine resublimed | .38 |
| 4 oz. | Iron chloride, ferric, CP | .38 |
| 1 lb. | Iron filings, fine clean | .29 |
| 1 lb. | Iron filings, coarse | .25 |
| 4 oz. | Iron oxide ferric, powd | $ .25 |
| 1 lb. | Iron sulfide, ores, lumps | .40 |
| 1 lb. | Iron sulfate, ous, CP | .81 |
| 1 lb. | Lead acetate | .40 |
| 1 lb. | Lead foil | .45 |
| 1 lb. | Lead nitrate, CP | .81 |
| 4 oz. | Lead oxide (litharge) | .20 |
| 4 oz. | Lithium nitrate, pure | .25 |
| 4 oz. | Logwood chips | .20 |
| 1 oz. | Magnesium powd. | .30 |
| 1 oz. | Magnesium ribbon | .40 |
| 1 lb. | Magnesium sulfate USP | .20 |
| 4 oz. | Manganese chloride | .30 |
| 2 lb. | Manganese dioxide tech. | 1.12 |
| 4 oz. | Manganese sulfate, tech. | .22 |
| 1 lb. | Mercury | 3.67 |
| 1 oz. | Mercuric nitrate CP | .62 |
| 1 oz. | Methyl orange, dry | .45 |
| 8 oz. | Mercuric oxide, red | 2.14 |
| 1 oz. | Mercurous nitrate, CP | .65 |
| 4 oz. | Nickel chloride, pure | .21 |
| 1 lb. | Corn starch | .25 |
| 1 lb. | Potato starch | .31 |
| 1 lb. | Paraffin | .20 |
| 1 qt. | Oil, petroleum, No. 30 | .55 |
| 1 oz. | Phenolphthalein, USP | .20 |
| 1 oz. | Phosphorus, red | .22 |
| 1 oz. | Phosphorus, yellow | .42 |
| 4 oz. | Photographic developer | .99 |
| 8 oz. | Potassium and aluminum sulfate, alum | .20 |
| 4 oz. | Potassium acid tartrate | .30 |
| 1 lb. | Potassium bromide | .55 |
| 1 lb. | Potassium chlorate, cryst. CP | 1.00 |
| 4 oz. | Potassium chloride | .20 |
| 2 lb. | Potassium and sodium tartrate (Rochelle salt) | .60 |
| 4 oz. | Potassium chromate | .20 |
| 4 oz. | Potassium and chromium sulfate (chrome alum) | .20 |
| 1 lb. | Potassium dichromate | .38 |
| 1 lb. | Potassium ferricyanide | 1.21 |
| 4 oz. | Potassium ferrocyanide | .20 |
| 2 lb. | Potassium hydroxide CP pellets | 1.84 |
| 4 oz. | Potassium iodide, CP | 1.11 |
| 1 lb. | Potassium nitrate, cryst. CP | .75 |
| 4 oz. | Potassium permanganate, CP | .56 |
| 4 oz. | Potassium sulfate, CP | .60 |
| 4 oz. | Potassium sulfocyanate, pure | .45 |
| 4 oz. | Rose metal | .94 |
| 1 oz. | Pyrogald, cryst. | .33 |
| 8 oz. | Silver nitrate, CP | 4.20 |
| 4 oz. | Sodium metal | .35 |
| 8 oz. | Sodium acetate | .40 |
| 4 oz. | Sodium benzoate | .25 |
| 4 oz. | Sodium aluminum sulfate (sodium alum) | .20 |
| 4 oz. | Sodium bicarbonate, baking soda | .20 |
| ½ lb. | Sodium bisulfite, tech | .28 |
| ½ lb. | Sodium bromide USP | .21 |
| 1 lb. | Sodium carbonate, cryst., washing soda | .20 |
| 1 lb. | Sodium carbonate, pure, dry | .23 |
| 5 lb. | Sodium chloride, salt, fine | .60 |
| 4 oz. | Sodium chromate, powd. | .20 |
| 2 lb. | Sodium hydroxide, CP pellets | 1.48 |
| 4 oz. | Sodium iodide, USP | 1.02 |
| 1 lb. | Sodium nitrate, CP | .68 |
| ¼ lb. | Sodium nitrite | .35 |
| ½ lb. | Sodium peroxide, powd. | .55 |
| 1 lb. | Sodium phosphate, CP | .91 |

| | | |
|---|---|---|
| 4 oz. | Sodium phosphate (monosodium) CP | $ .46 |
| 4 oz. | Sodium phosphate, dibasic CP | .36 |
| 1 lb. | Sodium silicate soln | .21 |
| 1 lb. | Sodium sulfate, cryst | .40 |
| 1 lb. | Sodium sulfite, pure, dry | .26 |
| 1 lb. | Sodium thiosulfate (hypo) | .25 |
| 1 lb. | Sodium tetraborate (borax) | .25 |
| 1 oz. | Strontium nitrate CP | .31 |
| 1 lb. | Strontium chloride, CP | .61 |
| 1 lb. | Sulfur roll | .25 |
| 1 lb. | Sulfur flowers | .25 |
| 8 oz. | Tin, granulated | $1.06 |
| ½ lb. | Tin, thick, foil | .75 |
| ½ lb. | Tin sticks | 1.04 |
| 1 lb. | Woods metal | .82 |
| 4 oz. | Tin oxide | .33 |
| 1 oz. | Wool, glass, fine Bohemian | .30 |
| 1 lb. | Wool, steel | .50 |
| ½ lb. | Zinc sheet | .30 |
| ½ lb. | Zinc granulated | .55 |
| 4 oz. | Zinc dust | .20 |
| 4 oz. | Zinc nitrate, CP | .48 |

| Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|
| | 1 lb. | Zinc sulfate | $ .30 |
| 5209 | 1 sq. ft. | Copper gauze, 80 mesh, | 1.75 |
| 5916 | 1 sq. ft. | Copper sheet No. 24 | .80 |
| 5886 | 1 spool | Wire, copper, (4 oz.), No. 16 | .44 |
| 5886 | 1 spool | Wire, copper, (4 oz.), No. 18 | .45 |
| 5886 | 1 spool | Wire, copper, (4 oz.), No. 22 | .57 |
| 5886 | 1 spool | Wire, copper, (4 oz.), No. 30 | .75 |
| | 2 lb. | Lead shot, No. 10 | .70 |
| 5885 | 1 spool | Nichrome wire, (4 oz.), No. 22 | 1.35 |
| | | Total | $107.64 |

## RECAPITULATION

| | |
|---|---|
| Demonstration Apparatus | |
| Essential | $ 40.50 |
| Desirable but not essential | 210.65 |
| General Desk Equipment | 352.23 |
| Individual Locker Apparatus | 41.54 |
| General and Reserve Apparatus and Equipment | 301.16 |
| Additional Desirable Apparatus | 300.40 |
| Chemicals | 107.64 |
| GRAND TOTAL | $1354.12 |

# SECONDARY SCHOOL PHYSICAL SCIENCE

Recent years have witnessed well-defined efforts on the part of those interested in science education to broaden the scope of high-school science instruction to the end that it may become more functional in the everyday life of the student. These efforts have produced several types of physical science courses to be offered in addition to the usual courses in chemistry and physics at the eleventh or twelfth grade level. Included have been courses in Senior Science, Consumer Science, Fused Physical Science (combining the principles and methods of chemistry and physics only), and Generalized Physical Science (combining the principles and methods of all the physical sciences).

Where these courses have been offered, it has usually been to the non-college preparatory students. However, there is a growing belief that courses in physical science may be more suitable than the more traditional courses in chemistry and physics for all students—non-college and college-bound alike—whose major interests, abilities, and probable future field of specialization are outside the realm of science. Colleges and accrediting agencies are showing an increasing disposition to recognize such courses.

The chief aim of the course in generalized physical science is to draw on the contents and methods of the physical sciences for the purpose of helping young people gain competency in using science in solving adjustment problems within certain broad areas of human experience. It is important to note that the aim is not to present a certain body of organized science, but rather to utilize science, when and as needed, in working out the solutions to real problems arising out of the experiences of daily living—the provision of the essentials of existence, such as food, air, water, and energy; the maintenance of health; the securing of greater comfort, convenience, and safety; the development of wiser consumership and increased economy; and the promotion of more effective conservation.

Attainment of the aims of generalized physical science is sought through (a) methods directed toward developing understanding of facts, concepts, and principles; (b) methods directed toward promoting growth in habits of reflective thinking or scientific problem-solving, in scientific attitudes, and in appreciations. The outline in the latter part of this section is reasonably representative of present practice. No attempt is made here to indicate present practice in the other types of physical science courses.

The keynote to a satisfactory room for the teaching of physical science is "flexibility." Ideally, the various activities that go on in the course are integrated into a pattern of procedures approximating the scientific method of solving problems. Once a problem has been introduced and explored tentatively through discussion and reading, a wide variety of investigational activities may be initiated, such as preparing, giving, and observing demonstrations; conducting individual experiments; examining exhibits and displays; consulting reference materials and observing films and slides. In a course conducted in this manner, there are no set days for lectures, demonstrations, laboratory work, or quizzes.

Implications of good practices in the teaching of generalized physical science have been included in the foregoing paragraphs. Ideally, the problems accepted for study in the course should arise from a consideration of the problems of human adjustment to whose solution physical science can make a real and functional contribution. Actually, it is often necessary for the teacher to have a more or less detailed "blueprint" of many vital and worthwhile problems in reserve, into which he can lead the class and motivate the pupils in seeking their solutions. In any case, solutions to the problems should be worked out by a developmental method as suggested above. One further example will be described somewhat in detail.

Suppose the class has been working in the unit area of "Light," and having delved into the problem, "How do we see?" has learned that one essential factor in the seeing process is light itself. The big question then arises, "How can we provide adequate and proper illumination?" How this large problem can be broken down into smaller problems and how these, in turn, can be solved by procedures approximating the scientific method are indicated as follows:

I. How much light is needed or recommended for the doing of various tasks?
   Consult text or other reference.

II. What are some effects on one's health of working under inadequate illumination?
   Consult text or other reference.

III. How can we measure the amount of illumination?
   Study such types of foot-candle meters as may be available; a photoelectric meter is desirable.

IV. What factors determine the amount of illumination a surface receives?
   Effect of distance checked with foot-candle meter; law of inverse squares developed. Study visibility of eye charts at fixed distance using lamps of different wattage. Bunsen photometer determinations of candle powers of lamps.

V. What difference does the kind of light used have on vision?
   Use of polaroid to control glare. View colored scene or strips of paper in various colors of light.

VI. What methods of illumination are commonly used?
   Consult text.

VII. How do we produce or obtain light for illumination?
   Non-luminous and luminous gas flames. Display of various kinds of incandescent electric lamps.

VIII. How do various electrical sources of light compare in cost and efficiency?
   Experimental study of commercial efficiency of electric lamps. Computations of cost of operating electric lamps.

IX. Applying the findings.
   Is my home adequately and properly illuminated?
   Is our school adequately and properly illuminated?

It follows that the physical science course is best taught in a room that provides all the facilities needed for carrying on demonstrations and individual experiments of a wide

variety, as well as facilities for the usual classroom procedures. It is important that the physical science course be conducted in a location affording ready access to both the chemistry and physics supplies and equipment.

The physical science course requires materials and apparatus similar to that used in teaching physics and chemistry; consequently no separate listing of equipment for the physical science course is included in this report.

The following brief outline will indicate the topics usually covered in the generalized physical science course:

I. Fire, fuels and heat
II. Power and machines
III. The solar system and the stars
IV. Weather
V. The crust of the earth
VI. Materials used in construction
VII. Light and other radiations
VIII. Sound

## THE COLLEGE

### INTRODUCTORY STATEMENT

**The universities and colleges of the United States provide extensive opportunities for for education beyond the secondary level.** Numerous types of higher educational institutions exist within the country. While a considerable degree of uniqueness exists in individual institutions, they may in general be grouped in certain broad categories.

**The four year liberal arts college** provides a program leading to the baccalaureate degree. This college provides a broad program of general education, plus opportunity for specialization in one of the conventional academic fields. As a rule, each student selects, not later than at the end of the second year, a field of specialization ("major") to which he devotes most of the remaining two years. Besides this "major" he may pursue a "minor" in some related subject and may round out his course with "electives," the selection of which is somewhat loosely supervised by faculty advisors with a view to providing well-rounded interests in the main fields of intellectual enterprise. The program of the liberal arts college may for the individual be either terminal or preparatory for the professional or graduate school. The college may be either an independent institution or one of the colleges of a university.

**The professional or technical school** furnishes a program directed toward providing competence in the various professions and technical pursuits. The necessary preliminary training for entrance into these schools and the length of the program provided vary in accord with the demands of the different professions. A core of work in general education is associated with the professional program, either as a part of the pre-professional program or as a related phase of the total professional program. The professional or technical school may exist independently or as one of an associated group of schools of a university. In the latter case, much of the supporting work in general education and the professional field may be provided by one or more of the associated colleges.

**The graduate school** offers programs leading to the master's degree, requiring ordinarily not less than one year of study beyond the baccalaureate degree, and to the doctor's degree, requiring ordinarily not less than three years of study beyond the baccalaureate degree. The program of the graduate school may involve intensive specialization in any one of the academic or professional fields. The graduate school appears as a part of a university.

**The junior college** is an institution providing up to two years of study beyond the secondary school. The program may be the first two years of a college program or a terminal program of general education or sub-professional or semi-technical education. Many are tax-supported, being essentially tuition-free extensions of the regular public schools.

**The extension program** which is associated with many universities attempts to provide organized educational opportunity for other than regular full time students. The organization of such programs ranges from regular university courses offered at regional centers to special programs adapted to meet the needs of special groups. The content of

study may vary from highly technical fields for advanced professional groups to very generalized programs for non-specialized groups. The extension movement represents an attempt to bring the resources of the university to the citizen.

The individual states maintain one or more tax-supported, degree-granting colleges or universities and also grant charters to privately controlled institutions of higher learning. In practice, the individual institutions possess a large degree of autonomy in educational policy and administration. All such institutions operate on a non-profit basis under the direction of their respective lay boards of trustees, who serve without compensation.

Many of the privately controlled institutions have accumulated large endowments. In 1939-40 endowment earnings provided 23.4% of the income of institutions under private control and only 2.3% of the total income of the publicly controlled institutions.[1]

Privately controlled institutions charge higher student fees than the publicly controlled institutions, which derive a large part of their income from tax sources. In 1939-40, 52.9% of the total educational and general income of the privately controlled institutions was derived from student fees,[2] whereas only 18.6% of the income of public institutions was derived from this source. The relatively low fees charged by public institutions and the rather generous scholarships available at both private and public institutions have materially assisted in making higher education available to able students with limited financial resources.

The total science offering in the colleges is designed to serve three major purposes, namely: (1) to provide appropriate content in general education, (2) to provide essential supporting content and technical skills for the professional and technical programs, and (3) to provide the beginning of specialization, which may be continued in graduate study and research in some specific field of science.

The beginning courses in each of the sciences usually serve all three of the previously stated purposes. However, some schools have developed special survey courses in broad fields of science to provide for the general education need. Also where occasion has demanded, many of the beginning courses have been adapted to meet the needs of professional programs.

The more advanced courses are designed to serve the last two purposes stated above. This program provides for the education of potential research workers. Associated with these educational programs is the program in both pure and applied research. The major part of the basic research in science has been carried on in the college and universities.

There are many variations of the conventional pattern of higher education outlined in the foregoing paragraphs. Educational experimentation and adaptation has been continuous at this level. There has been extensive experimentation with the reorganization of the program of general education during recent years. This reorganization has affected the program of science education.

Outlines have been prepared for established undergraduate courses in the sciences. These outlines have been grouped into the conventionally recognized fields of science. Many additional courses appear in the science offerings of the colleges of the United States. These have not been indicated here because (1) they are highly specialized offerings serving a small per cent of students, and/or (2) there is no standard body of content. The apparatus and supply lists have been developed to provide for each group of courses outlined for each of the major fields of science.

## LIST OF REPRESENTATIVE SCIENCE COURSES

### OFFERED IN THE UNDERGRADUATE COLLEGE

Following is the list of courses for which outlines and apparatus lists have been prepared:

**ASTRONOMY**

General Astronomy
Practical Astronomy
Celestial Mechanics

[1] U. S. Office of Education, Federal Security Agency, Statistics of Higher Education, 1939-40 and 1941-42 (Biennial Surveys of Education in the United States, 1938-40 and 1941-42) Washington, D. C., 1944, Vol. II, Chapter IV, p. 23.
[2] Ibid.

**BACTERIOLOGY**

General Bacteriology
Medical Bacteriology

**BOTANY**

General Botany
Field Botany
Plant Physiology
Plant Pathology
Plant Anatomy
Morphology of Thallophytes and Bryophytes
Morphology of Pteridophytes and Spermatophytes
Plant Ecology
Plant Cytology
Plant Microtechnique (laboratory)

**CHEMISTRY**

General Chemistry
Qualitative Analysis
Quantitative Analysis
for majors
for non-majors
Organic Chemistry
for majors
for non-majors
Physical Chemistry
for majors
for non-majors
Biochemistry

**GEOLOGY**

General Geology
Historical Geology
Mineralogy
Elementary Petrography
Map Interpretation
Economic Geology
Field Geology
Structural Geology
Sedimentation
Paleontology
Micropaleontology
Stratigraphy

**MATHEMATICS**

Plane Trigonometry
College Algebra
Plane Analytic Geometry
Differential Calculus
Integral Calculus
Differential Equations

**PHYSICS**

General Physics
Intermediate Physics:
Mechanics
Heat
Electricity and Magnetism
Optics
Modern Physics

**ZOOLOGY**

General Zoology
Invertebrate Zoology I
Invertebrate Zoology II
Invertebrate Zoology III
Field Zoology
Comparative Vertebrate Anatomy
Vertebrate Embryology
Histological Technique
Elementary Genetics
Parasitology
Animal Ecology

## COLLEGE ASTRONOMY

The astronomy courses listed here are offered to undergraduate students in the colleges of the United States.

| COURSES OFFERED | USUAL CREDIT HOURS* |
|---|---|
| General Astronomy | 6 - 8 |
| Practical Astronomy | 3 - 6 |
| Celestial Mechanics | 3 - 6 |

*One credit (or semester) hour is usually granted for a course which requires two hours of student preparation and one hour of recitation per week, or a three-hour laboratory period per week, or the equivalent, for a period of eighteen weeks. Thus a course which meets for three one-hour recitations and one three-hour laboratory and assumes six hours of individual student preparation would be considered a four semester hour course.

## GENERAL ASTRONOMY

This is a 6 to 8 semester hour course. The emphasis is on a non-mathematical course, since a great deal of valuable astronomical knowledge may be acquired with only an elementary background of mathematics and physics.

The time schedule of the course should be interrupted or modified at any time to take advantage of popular interest in any current events the sky affords, such as naked-eye sunspots, aurorae, comets, meteor showers, and novae. Concentration on sky work should be at seasons most favorable to the locality.

The course will naturally be made flexible to utilize to the full the available apparatus, e.g., if a transit telescope is available, solar and star transits may be observed

### OUTLINE OF COURSE CONTENT

I. Introduction

General background of course—Cultural value of astronomy
Discussion of constellations

II. The earth

Rotation and proofs
Definition of astronomical terms
Diurnal motion—Appearance of sky at different latitudes
The ecliptic and the zodiac
Size and shape of earth—Law of gravity
Atmosphere—Refraction, twilight, aurorae
Revolution of earth—Proofs; form of orbit
The seasons as a consequence of revolution
Our calendar and its development
Time—Moving index and reference lines; sidereal—determination; apparent solar, mean solar; standard—date line
Precession of the equinoxes

III. The moon

Explanation of phases and relation to rising and setting time
Distance—Determination; geocentric parallax
Orbit of moon—Monthly and yearly variations in position

Rotation of moon—Surface conditions and features
Tides—Past and future of earth-moon system; rockets
Lunar eclipses—Frequency and phenomena
Solar eclipses—Frequency and phenomena
Eclipse seasons and saros

IV. Telescopes
Refractors and reflectors
Great observatories of the world

V. The planets
General characteristics of solar system
Motions of planets with respect to stars—Ptolemaic, Tychonic and Copernican systems; Kepler's Laws; Newton
Aspects of inferior planet—Mercury; surface conditions
Venus—Surface and transits
Earth (reviewed)—Aspects of superior planet
Mars—Surface, rotation, satellites
Asteroids—Eros campaign 1931 for solar parallax
Jupiter—Surface conditions, satellites; Roemer and the velocity of light
Saturn—Ring system and satellites
Uranus, Neptune, Pluto

VI. Other members of solar system
Comets—General characteristics; spectacular vs. periodic comets; Halley's Comet
Meteors and meteor showers
Meteorites and meteor craters
Zodiacal light—Theories of origin of solar system

VII. The sun
Distance, size and volume
Surface—Sunspots and terrestrial effects
Chromosphere and corona—Coronagraph
Analysis of light—Spectroscopes
Spectrum of sun—Doppler Effect; spectrohelioscope
Structure of atom and meaning of lines
Sun's radiation—Source of solar energy; Bethe's Theory

VIII. The stars
Star catalogues, charts, and their purposes
Stellar parallaxes—Parsec and light year; photographic parallaxes; the nearest stars
Proper motions—Apex of sun's way
Radial velocities and stellar spectroscopes—Measuring engines
Magnitudes—Apparent, photographic and visual
Absolute magnitudes—Number of stars
Stellar spectra—Spectral sequence
Variable stars—General characteristics; regular variables—Cepheids, period luminosity law; long period variables—amateur observers; semi-regular variables—novae
Binary stars, general—Visual doubles; masses of binaries; multiple stars; possible discovery of other planets; spectroscopic binaries; velocity curves; eclipsing binaries
Stellar characteristics and atmospheres—Mass-luminosity law; range in physical properties of stars

IX. The galaxy
Structure from star counts—Absorption of light
Rotation of the galaxy—Cosmic year
Diffuse nebulae—Bright and dark
Planetary nebulae—Galactic clusters
Globular clusters as outlines of the stellar system

X. Extragalactic nebulae
Numbers and distribution
Resolution of nebulae—Classification
The local group—Characteristics of its members
Supernovae
Velocity distance relationship
Recession of the nebulae—Expanding universe

### LABORATORY EXPERIMENTS

Plot star maps—Sky work on constellations
Exercises with celestial globe
The ecliptic on the globe
Perpetual day—Work with season's apparatus—Graph of ecliptic
Graph for converting sundial to standard time for student's location
Observe position of moon among stars on six dates
Graph of moon's path
Study of moon with telescope
Planetary phenomena for coming year from cheap, available almanac
Apparent path of Mars over two years
Construction of model for planetary orbit
Curtate orbits of several planets and asteroids
Verification of Kepler's Laws from ephemeris data
Curve of sunspots from data of two centuries
Study of solar spectrum with available apparatus—Line plotting from existing tables
Exercise involving use of all available catalogues
Determination of apex from catalogue data
Study of line widths on plates or prints
Light curves of different types plotted
Binary orbit plotted
Observation of minimum of Algol
Sky work—Study of remaining half of sky
Telescopic examination of clusters and nebulae

## PRACTICAL ASTRONOMY

This is a 3 to 6 semester hour course.

### OUTLINE OF COURSE CONTENT

I. Coordinate systems
   - Terrestrial latitude and longitude
   - Horizon system
   - Equator system
   - Ecliptic system
   - Orientation on celestial sphere
   - The astronomical triangle

II. Time and its conversion
   - Solar time—Apparent, mean, standard
   - Sidereal time
   - Interrelationships
   - Comparison of timepieces

III. Tools, instrumental and otherwise
   - Verniers
   - Microscopes and micrometers
   - Screws and their testing
   - Computing machines
   - Tabular aids
   - Star catalogues—Precession and mutation; reduction to apparent place
   - Differencing and interpolation
   - Method of least squares
   - Measures of precision—Probable error

IV. The equatorial telescope
   - Adjustment of polar axis
   - Field of view and magnifying power
   - Filar position micrometer—Value of one revolution of screw; diameter of planet, angular and linear; measurement of double stars

V. Time determination by the transit telescope
   - Errors and constants
   - The level
   - Wire intervals
   - The time equation
   - Error of sidereal clock from time sets
   - Relative personal equation

VI. The sextant or octant
- Observation of altitudes
- Corrections to observations
- Lines of position

VII. Spherical trigonometry
- Right spherical triangle—Napier's Rules
- Fundamental formulae of the general triangle
- Formulae for transformation of coordinates—Modern tabular aids
- Application to astronomical problems

VIII. Celestial photography
- Plates and filters
- Dome techniques—Focus, exposure, guiding
- Dark-room techniques
- Measurement of photographs

IX. Position of a celestial body from photographic plate
- Comparison stars and catalogue positions
- Plate constants
- Method of dependences
- Precision

The year course would include a selection from the problems listed below as "Fundamental Problems" and "Special Problems." Usage differs in different institutions.

Fundamental problems (solved visually)
- Form and dimensions of earth—Diurnal parallax
- Longitude by radio and time sets
- Latitude by zenith telescope
- Star positions by meridian circle
- Lunar occultations—Usefulness and formulae; graphical prediction; observation; reduction by Innes method

Special problems (solved by photography)
- Time by the zenith tube
- Radial velocities
- Proper motions
- Stellar magnitudes—Yellow, blue, red
- Annual parallax

## CELESTIAL MECHANICS

This is a 3 to 6 semester hour course. The subject is best taught to students who have a good working knowledge of integral calculus and who have had some experience with theoretical mechanics.

In general the first course is held to theory, with numerous short examples for illustrations. Actual computations of orbits and ephemerides are usually done as post graduate work, although the special cases of visual and spectrographic binaries are sometimes worked as exercises in this course.

### OUTLINE OF COURSE CONTENT

I. Laws of motion
- Newton's laws of motion
- General equations of motions and accelerations of particles in space
- The areal velocity

II. The centers of mass and of gravity of bodies having regular figures.

III. Mechanics of orbital motion
- Central forces and the law of areas
- The reduction of order in a system of simultaneous differential equations.
- The Vis Viva integral
- The general equation of an orbit
- Newton's law of universal gravitation

IV. The attractions of bodies and the potential function as developed with
- Thin spherical or ellipsoidal shells and the attracted particles within, in, or outside the shell
- Spherical and oblate spheroidal solids upon an exterior particle

V. The two body problem
- General equations of motion
- Motion of center of mass in space
- Equations of relative motion in space
- Motions in the plane
- Integrations for reduction of order
- Finding the elements of the orbit in terms of the constants of integration
- The cases of parabolic and elliptic motion

VI. The determination of orbits
- Preparation of the observations
- The method of Gauss
- The method of La Place
- The Leuschner of abbreviation of the Harzer method

VII. The general properties in a system of n bodies

VIII. Multi-body problems
- The conditions encountered on the three body problem and the restricted types of treatment which are possible
- Special astronomical cases which may be solved

## COLLEGE ASTRONOMY

### APPARATUS LIST

The following items are recommended for a course in college astronomy:

| Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|
| 3728 | 1 | Refracting telescope of six inch aperture mounted equatorially on a substantial base. It will have polar axis adjustable in altitude to the latitude of the location, a one or two inch finder, driving clock and gears computed to give sidereal time motion, and will be provided with a small visual spectroscope. The objective lens to have approximate focal length of 75". The power is to be from 60-300 magnifications, with at least four changes of magnification. This instrument to be of highest quality of workmanship and design, boxed for shipment with special compartment for detachable pieces. | $10,000.00 |
| 3535 | 1 | Marine sextant, best grade | 500.00 |
| 6878A | 2 | Star charts, large | 10.00 |
| 3955 | 1 | Lantern slide projector | 76.55 |
| LA100 | 100 | Selected astronomical slides, 100 in unit | 61.50 |
| 3596B | 1 | Screen for projector | 40.00 |
| | | Total | $10,688.05 |

## COLLEGE BACTERIOLOGY

The Bacteriology courses listed here are offered to undergraduate students in the colleges of the United States.

| Courses Offered | Usual Credit Hours |
|---|---|
| General Bacteriology | 3 - 5 |
| Medical Bacteriology | 4 - 6 |

These courses include class recitations, lecture, student laboratory exercises and individual study.

# GENERAL BACTERIOLOGY

This course comprises lectures and laboratory instruction in the fundamental principles of bacteriology and their applications, as based upon study of representative types of bacteria and allied micro-organisms. It is an introduction to bacteriology.

## OUTLINE OF COURSE CONTENT

I. History and development of bacteriology
II. Methods of study of bacteria
III. Morphology and cell structure of bacteria
IV. Growth and chemical composition of bacteria
V. Effect of physical agents on bacteria
VI. Effect of chemical agents on bacteria
VII. Bacterial enzymes and respiration
VIII. Autotrophic and heterotrophic respiration
IX. Nitrogen fixation and nutritive requirements
X. Comparative physiology and phylogeny of bacteria
XI. Bacterial variation
XII. Classification of bacteria
XIII. Parasitism and relation of bacteria to disease
XIV. Bacterial virulence and host resistance
XV. Transmission of infection
XVI. Bacteriology of water and sewage
XVII. Bacteriology of milk and food
XVIII. Immunity—Antigens; antibodies
XIX. Cellular immunity and the immune state

## LABORATORY EXPERIMENTS

Preparation of nutrient media, including broth, sugar broth and agar

Bacterial morphology including examination in the living state, the simple stain and the spore stain

Demonstration of capsules; the acid-fast stain; the gram stain

The study of representative species of bacteria with regard to colonial morphology, microscopic morphology, stain reactions, the fermentation of dextrose, lactose and sucrose

The hydrolysis of starch

Nitrate reduction

Hydrogen sulfide formation, indol formation and reaction in litmus milk culture

Bacterial species, including Staphylococcus aureus, Staphylococcus albus, Staphylococcus citreus, Sarcine lutea, Bacterium coli, Bacterium aerogenes, Salmonella suipestifer, Proteus vulgaris, Bacterium prodigiosum, Pseudomonas pyocyaneus, Bacillus subtilis, and Bacillus magotherium

Morpholy of higher fungi, including one species of yeast and three species of molds

The effect of ultra violet light on bacteria

The differentiation of Bacterium coli and Bacterium aerogenes on the basis of the production of indol, the methyl red test, the Voges-Proskauer and the citrate test

The bacterio-static effect of dyes using methyl violet and mercurochrome

The effect of increased osmotic pressure on the bacterial morphology

The pathogenicity of bacteria, in which pneumococcus injected in the mouse and anthrax bacillus in the guinea pig are demonstrated

The bacteriological examination of water (A.P.H.A. Standard method)

Types of bacteria in air, soil, throat and skin

Bacterial examination of milk, including total bacterial count, differential count, the physiological types of bacteria; the methylene blue reduction test; the direct microscopic count of bacteria (the Breed method)

The agglutination reaction, including micro agglutination and H and O agglutination

# MEDICAL BACTERIOLOGY

A lecture and laboratory course in the study of pathogenic bacteria and immunology. The course is designed to introduce the beginning student in bacteriology to the principles of culturing bacteria, disinfection, virulence of bacteria, the mechanisms of disease production and immunology. This is followed by laboratory work with the common pathogenic species.

### OUTLINE OF COURSE CONTENT

I. History and morphology of bacteria
II. Disinfectants
III. Bacterial physiology
IV. Classification of bacteria
V. Bacterial variation
VI. Relation of bacteria to disease
VII. Bacterial virulence
VIII. Bacteriology of water and milk
IX. Host resistance
X. Transmission of disease
XI. Antigens and the chemical basis of specificity
XII. Antibodies
XIII. The antigen-antibody reaction
XIV. Antigenic analysis and the antigenic structure of bacteria
XV. Applied immunology
XVI. Anaphylaxis and allergy
XVII. Allergy in bacterial infections
XVIII. Bacteria of the respiratory tract—Streptococcus; pneumococcus; meningococcus and related species; hemophilus; corynebacterium diphtheriae
XIX. Mycobacterium tuberculosis
XX. Intestinal bacteria
XXI. Bacteriology of wounds
XXII. Anaerobic bacteria
XXIII. Bacteria of venereal disease

## MEDICAL BACTERIOLOGY

### LABORATORY EXPERIMENTS

Culture of representative bacterial species for studies of colonial and microscopic morphology
Effects of the disinfectants phenol and alcohol on spore-forming and non-spore-forming bacteria
Effect of heat on bacteria; normal flora of human respiratory and intestinal tracts and skin
Bacteriological examination of water
Techniques of animal inoculation; intraperitoneal inoculation of pneumococci in the mouse
Titration of diphtheria toxin by intradermal inoculation of rabbits
Inoculation of guinea pig with suspension of tubercle bacilli
Precipitin test
H and O agglutination test
Hemolysis
Wassermann test
Phagocytic test
Demonstrations of anaphylaxis
Tuberculin tests on infected guinea pig
Study of colonial and microscopic morphology of bacteria of the respiratory tract
Bile solubility tests of pneumococci; "Quellung" tests with pneumococci
Identification of bacterial species in an unknown mixture of respiratory pathogens
Examination of mice infected with human influenza virus and with mouse pneumonitis virus
Stains of elementary bodies of the latter
Autopsy of tuberculous guinea pig
Study of enteric bacteria on differential mediums
Identification of species in an unknown mixture of enteric pathogens
Cultures of obligate anaerobes
Identification of species in an unknown mixture of bacteria that might be found in wounds
Study of smears of suspected cases of gonorrhea
Culture of the gonococcus
Dark field microscopy

# GENERAL AND MEDICAL BACTERIOLOGY

## STUDENT APPARATUS

**(Class of 20 Students)**

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 8318 | | 20 pkg. | Blotting paper, 19 x 24 inches | $ 35.00 |
| 8216 | 65570 | 20 | Forceps, dissecting | 10.00 |
| 8272 | 65760A | 20 | Scissors, dissecting | 30.00 |
| 8246 | 78198A | 20 | Needles, inoculating, platinum wire fused into glass handle | 10.00 |
| 8351 | 76865 | 20 books | Lens Paper, 50 sheets | 3.00 |
| 7976 | | 20 | Microscopes with 16 and 4 MM dry objectives and 1.8 mm oil immersion objective, 5 and 10X eyepieces, Abbe Condenser, in case | 4240.00 |
| 8006 | 76720 | 20 | Microscope lamps | 100.00 |
| 8118 | 76805 | 20 box | Microscope slides, 3 x 1 inch, 72 to box | 15.00 |
| 8124 | 76830E | 20 box | Microscope cover glass No. 1, 18 MM, ½ oz. boxes | 35.00 |
| | | 20 x 1 oz. | Mineral Oil for immersion | 9.00 |
| 5427 | 77965C | 20 | Pencils, wax, blue | 4.00 |
| 8140 | 76880 | 20 | Slide boxes, holds 25 slides | 4.00 |
| 8284 | 57600 | 20 | Syringes, Hypodermic, 1.0 cc with 2 needles | 50.00 |
| 5809E | 24650 | 20 yds. | Towelling | 7.00 |
| | | | Total | $4552.00 |

## TOTAL LOCKER EQUIPMENT FOR 20 STUDENTS

| | | | | |
|---|---|---|---|---|
| 4516P | 44300 | 40 | Beakers Pyrex glass 250 ML capacity | $ 8.40 |
| 5629 | 80610C | 144 | Tubes, Bacteriological, 4 x ½" | 3.50 |
| 8372 | | 10 | Bottles with glass cap and dropper, 60 ML | 6.50 |
| 4752 | | 20 | Bunsen burners | 15.00 |
| 5106P | 70750 | 10 | Flasks Pyrex glass 500 CC | 2.80 |
| 5106P | 70750 | 10 | Flasks Pyrex glass 1000 CC | 4.30 |
| 5140 | 71260 | 20 | Funnels 15 CM | 16.00 |
| 5140 | 71260 | 20 | Funnels 10 CM | 10.00 |
| 5629 | 80610C | 36 | Glass Tubes 6 x ¾" | 1.35 |
| 5235 | 73765 | 5 lb. | Glass Tubing, asst. | 3.00 |
| 5256 | 64860B | 10 | Graduates Cylindrical 500 CC | 17.60 |
| 5256 | 64860B | 10 | Graduates Cylindrical 100 CC | 8.80 |
| 8060 | 76175 | 20 | Magnifiers Doublet, 14X | 70.00 |
| 5431 | 78080 | 72 | Medicine droppers | 2.40 |
| 8386P | 65270A | 2400 | Petri Dishes, Pyrex 100 x 15 MM | 912.00 |
| 8387 | | 20 | Petri Dish racks | 150.00 |
| 4948 | 63805A | 2 pkg. | Corks 0 to 11 asst., 144 to pkg | 1.90 |
| 4921 | 56740C | 10 | Pinchcocks | 1.50 |
| 5436A | 78040A | 200 | Pipettes 10 CC | 110.00 |
| 5436A | 78040A | 300 | Pipettes 1 CC | 132.00 |
| 5438A | 78090B | 20 | Pipette boxes | 60.00 |
| 5505 | 78780 | 5 lb. | Rubber stoppers, asst. | 6.25 |
| 5517 | 78845B | 50 ft. | Tubing, rubber, ¼" | 10.00 |
| 5516 | 78840A | 50 ft. | Tubing, rubber, 3/16" | 7.50 |
| 5572 | 79905A | 20 | Ring stand 3 ring | 30.00 |
| 8122 | 76825A | 48 | Slides with spherical depression | 55.20 |
| 8398 | | 20 | Pan, staining | 40.00 |
| 8396 | 76915 | 20 | Dishes, staining | 11.00 |
| 5227 | 79625 | 36 | Rods, stirring, 8 x 3/16" | 1.50 |
| 5603A | | 20 | Test Tube Support, wood | 20.00 |
| 5608 | 80761 | 20 | Test Tube Support, wire | 30.00 |
| 5720 | 80560A | 20 | Tripods 5" | 10.00 |
| 5670 | 80060A | 30 | Thermometers 110 degree centigrade | 34.50 |
| | | | **Total** | **$1793.00** |

## GENERAL EQUIPMENT

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 7080 | | 1 | Autoclave Steam Sterilizer | $260.00 |
| 4030 | 40450 | 1 | Balance Triple Beam | 21.50 |
| 8379 | | 1 set | Slides, Bacteriological, set of 30 | 17.50 |
| 8331B | 57400A | 1 | Centrifuge Electric | 65.00 |
| 8353B | 57400B | 1 | Incubator Electric | 83.00 |
| 5032B | | 1 | Oven electric automatic | 95.00 |
| 3930A | 78345A | 1 | Screen, aluminum 6 x 6 ft | 17.50 |
| 8356 | 79505 | 1 | Sterilizer, steam | 15.00 |
| 5550 | | 1 | Sterilizer, electric | 55.00 |
| | | | Total | $631.50 |

## CHEMICALS

| | | | | | |
|---|---|---|---|---|---|
| 1x1 lb. | Acid Hydrochloric CP | $ .70 | 1x4 oz. | Alcohol, amyl, CP | $ .65 |
| 1x4 oz. | Acid Tannic CP | .90 | 1x1 lb. | Acetone, CP | .60 |
| 12 tubes | Agar Culture Nutrient | 3.00 | 1x100 g. | Dimethyl-alpha-naphthyl amine | 4.25 |
| 1x1 lb. | Aluminum Potassium Sulphate CP | .70 | 1x4 oz. | Sulfanilic acid, CP | 1.35 |
| 1x1 gal. | Alcohol, methyl | 1.75 | 1x1 oz. | Methyl, red | 1.17 |
| 1x4 oz. | Agar Agar Powder | 1.25 | 1 pkg. | Brome-cresol purple | 1.50 |
| 1x8 oz. | Bacto-Beef | 3.00 | 1x4 oz. | Phenolphthalein, CP | .95 |
| 1x1 lb. | Bacto Gelatin | 3.00 | 1 pkg. | Brom-thymol Blue | 1.86 |
| 1x2 oz. | Beef Extract | .65 | 1x25 gms. | Nigrosin | 1.25 |
| 1x4 oz. | Canada Balsam in Xylol | 2.25 | 1x25 gms. | Safranin | 1.80 |
| 1x1 lb. | Cotton Non-absorbent | .65 | 1x1 lb. | Ammonium oxalate, CP | 1.10 |
| 2x1 lb. | Chloroform CP | 1.50 | 1x1 lb. | Mercuric Chloride, CP | 4.41 |
| 1x1 lb. | Dextrose CP | .75 | 1x4 oz. | Acid, chromic, CP | .85 |
| 1x10 gram | Fuchsin Basic Stain | .85 | *1x1 lb. | Lead Acetate (for Lead semi-solid agar), CP | .60 |
| 1x4 oz. | Grams staining solution | 1.50 | *1x1 lb. | Sodium sulfite (for Endo agar), CP | .51 |
| 1x10 gram | Gentian Violet | .85 | *1x1 lb. | Ferrous sulfate (for Bismuth sulfite agar), CP | .81 |
| 2x1 lb. | Glycerine pure | 1.00 | *1x25 gm. | Brilliant green (for Bismuth sulfite agar) also for SS Agar | 1.80 |
| 1x4 oz. | Leffers Staining Solution | 1.50 | *1x25 gm. | Bismuth sulfite (for Bismuth sulfite agar) | 2.00 |
| 1x4 oz. | Lugol's Iodine solution | 1.25 | *1x25 gm. | Eosin (for EMB Agar) | 1.80 |
| 1x4 oz. | Mercuric chloride CP | 1.50 | *1x25 gm. | Methylene Blue (for EMB or Eosin - Methylene - blue Agar) | 1.80 |
| 1x4 oz. | Nutrient Broth | 2.50 | *1x4 oz. | Sodium citrate (for SS or or Salmonell - Shigella Agar), CP | .60 |
| 1x4 oz. | Peptone Bacteriological | 1.50 | *1x25 gm. | Neutral red (for SS or Salmonell - Shigella Agar) CP | 1.80 |
| 1x4 oz. | Silver Nitrate CP | 3.00 | | Total | $106.19 |
| 1x1 lb. | Sodium Chloride CP | .60 | | | |
| 1 liter | Sodium Hydroxide solution, normal | 1.75 | | | |
| 1x1 gal. | Water Distilled | 1.00 | | | |
| 1x1 lb. | Xylol CP | .60 | | | |
| 1x1 lb. | Lactose, CP | .74 | | | |
| 1x1 lb. | Sucrose, CP | .85 | | | |
| 1x25 gm. | Mannite (Mannital) CP | .50 | | | |
| 1x25 gm. | Para-dimethyl-amino-benzaldehyde | 1.15 | | | |
| 1x25 gm. | Tetramethyl-para-phenylene diamine | 30.00 | | | |

*It is suggested that these special media be furnished in dehydrated form.

## RECAPITULATION

| | |
|---|---|
| Student Apparatus | $4552.00 |
| Locker Equipment | 1793.00 |
| General Equipment | 631.50 |
| Chemicals | 106.19 |
| TOTAL | $7082.69 |

# COLLEGE BOTANY

The botany courses listed here are offered to undergraduate students in the colleges of the United States.

| COURSES OFFERED | USUAL CREDIT HOURS |
|---|---|
| General Botany | 4 - 8 |
| Field Botany | 4 |
| Plant Physiology | 3 - 4 |
| Plant Pathology | 3 - 4 |
| Plant Anatomy | 3 - 4 |
| Morphology of Thallophytes and Bryophytes | 4 |
| Morphology of Pteridophytes and Spermatophytes | 4 |
| Plant Ecology | 4 - 8 |
| Plant Cytology | 3 - 4 |
| Plant Microtechnique (laboratory) | 3 - 4 |

These courses include class recitation, lecture, student laboratory exercises, and individual study. They frequently incorporate field study.

## GENERAL BOTANY

### OUTLINE OF COURSE CONTENT

Introduction
- Plant science
- The parts of plants
- Learning the names of plants
- Seasonal aspects of plants
- Local plant communities
- Points of view in the interpretation of plant behavior

II. Cells as biological units

III. Leaves
- The tissue system of leaves
- Environment and leaf development
- Hereditary differences in leaves

IV. Related chemistry

V. The food of plants
- Food manufacture—The synthesis of sugar—photosynthesis; factors influencing the rate of photosynthesis; synthesis of starches; synthesis of fats and proteins
- Uses of food in plants—Respiration; plant development; substances made from foods

VI. Some biological relations of green plants
- Interrelations of parts of a plant

VII. Physical processes involved in the movement of materials in plants
- Plant behavior related to osmosis
- The loss of water vapor from plants; transpiration—Transpiration affects plant development and distribution

VIII. Stems
- Forms and external features of stems
- General regions and processes in stems
- Tissues and processes in stems

IX. Roots
- Development and structures
- Processes and soil relations

X. Flowers, fruits, and seeds
- Sexual reproduction in flowering plants
- Growth, dormancy, and germination of seeds
- Vegetative multiplication of flowering plants

XI. Origin of plants used by man
- Heredity in plants
- Cross-fertilization and hybrid segregation
- Mutations
- Types of variation and diversity of organisms

XII. Non-green plants
- The biology of bacteria
- Bacteria of the soil
- The fungi

XIII. Plant diseases

XIV. Under-water environments

XV. The algae

XVI. Mosses and liverworts

XVII. Ferns, club mosses and equisetums

XVIII. The seed plants

XIX. Some families of flowering plants

XX. Plants of the past

XXI. The vegetation of North America

## FIELD BOTANY (Local Flora)

### Outline of Course Content

This is a laboratory, field and lecture course primarily designed to train students to identify the more common algae, mosses, liverworts, ferns and seed plants, found in the local region. Identification keys are selected which will cover the local area. Field characteristics and identification in the field are emphasized as well as use of manuals and keys. Field trips are taken whenever possible. A collection of properly identified, pressed herbarium specimens may be required.

## PLANT PHYSIOLOGY

### OUTLINE OF COURSE CONTENT

I. Properties of solutions

II. Interfacial phenomena

III. Colloidal systems

IV. The properties of sols and gels

V. Plant cells

VI. Diffusion

VII. Osmosis and osmotic pressure—Water relations of plants
- Imbibition
- Permeability
- The osmotic quantities of plant cells
- The loss of water from plants
- The stomatal mechanism
- Factors affecting transpiration
- The movement of water through the plant
- Soils and soil water relations
- Absorption of water
- The internal water relations of plants

VIII. The chlorophylls and the carotinoids

IX. Photosynthesis
- Factors affecting photosynthesis
- Carbohydrate metabolism
- Fat metabolism
- Absorption of mineral salts
- Utilization of mineral salts
- Nitrogen metabolism
- Digestion
- Translocation of solutes

X. Respiration
   Anaerobic respiration
   Mechanism of respiration

XI. Growth, assimilation, and accumulation
   Growth hormones
   Factors affecting growth
   Growth correlations
   Germination and dormancy
   Growth periodicity

XII. Plant movements

## PLANT PATHOLOGY

### OUTLINE OF COURSE CONTENT

I. The science of plant pathology
II. Interrelationships with other sciences
III. Symptoms, signs and classification of plant diseases
IV. Methods of investigating plant diseases
V. Plant diseases as related to environment
VI. General plant disease control
VII. Fungicides
VIII. Disease-free seed and plants
IX. Quarantines
X. Rotations to prevent plant diseases
XI. Disease resistance in plants
XII. Insects in relation to plant diseases
XIII. Storage, transportation and market problems

### LABORATORY EXPERIMENTS

Introduction to laboratory techniques
Diseases caused by slime molds
Diseases caused by bacteria
Diseases caused by fungi—Phycomycetes
Diseases caused by fungi—Ascomycetes
Diseases caused by fungi—Basidiomycetes
Diseases caused by fungi—Imperfecti
Diseases caused by parasitic seed plants
Diseases caused by nematodes
Virus diseases
Non-parasitic diseases

## PLANT ANATOMY

This is a first course in plant anatomy and therefore is a general course. It has been planned especially as a service course for agronomists, entomologists, foresters, horticulturists, pharmacists, and others who feel a need for a knowledge of the fundamentals of plant structure. The acquisition of facts by direct observation of plant material is followed by informal class discussions. Very little time is given to strictly formal lectures.

### OUTLINE OF COURSE CONTENT AND LABORATORY WORK

I. Introduction (one lesson)
   To make the students aware of some of the problems in plant anatomy
   To show that the terms used in plant anatomy must be critically examined to see that they are logical and in agreement with the facts observed

II. Tissue differentiation in the embryo (two lessons)
   To show how the organs of a plant originate and enlarge, beginning with the fertilized egg (Special attention is given to the origin and development of the root primary meristems)

III. The root (nine lessons)
- Primary structure of the root
  - To acquaint the student with the location and names of the primary root tissues
- Ontogeny of the root
  - To give a "moving picture" of the time of origin as well as the time and direction of differentiation and maturation of primary root tissues and to see how roots grow in length
- Secondary tissues of roots
  - To acquaint the student with the means and results accompanying the increase of roots in diameter
- Origin of secondary roots and root hairs
  - To present the facts concerning the time, place, and sequence of events accompanying the origin and growth of secondary roots and root hairs

IV. The hypocotyl (two lessons)
- To impress upon the student the fact that the hypocotyl is an organ of the plant possessing a manner of growth, and frequently a tissue organization, peculiar to it alone

V. The leaf (six lessons)
- Tissues of the mature leaf
  - To help the student obtain a three-dimensional "feeling" for each tissue of the leaf and for the leaf as a whole
  - To illustrate the effect of environmental differences upon the structure of the leaf
  - To illustrate the effect of heritable differences upon the structure of the leaf
- Ontogeny of leaf tissues
  - To give a "moving picture" of the events involved in the origin, differentiation, and maturation of the tissues of a dicot leaf
- Stomates
  - To show that differences in stomatal structure (the term stomate as used here includes the cells surrounding the opening) are due to differences in the origin and subsequent division and growth of the cells involved

VI. The stem (six lessons)
- Ontogeny of the stem
  - To give a "moving picture" of the early growth of the stem by acquainting the student with the place of origin as well as the time and direction of differentiation and maturation of the primary tissues
- Secondary tissues of stems
  - To give a "moving picture" of the later growth of the stem by acquainting the student with the place of origin as well as the time and direction of differentiation and maturation of the secondary tissues
- Vascular bundle types
  - To give an insight into some heritable variations in stems, calling attention to the fact that the same type of variation may occur in closely related plants as well as those not closely related and in plants growing in the same habitat as well as those growing in decidedly different habitats
- Stelar types
  - To point out the relationships that exist between vascular bundle types and stelar types

VII. The cell
- Cell types
  - To show some of the variations that occur in cells and to aid the student in obtaining a conception of the origin, growth, distribution, and identification of some of the more common cell types
- Wood identification (if time permits)
  - To show that many cell types may be recognized macroscopically or with a low-power hand lens and that the grouping and arrangement of these cell types is a constant characteristic of the wood of each genus of trees

## MORPHOLOGY OF THALLOPHYTES AND BRYOPHYTES

### OUTLINE OF COURSE CONTENT AND LABORATORY WORK

I. Introduction
- Meaning and scope of morphology
- Kinds—Comparative; experimental
- Relation to other botanical subjects
- Applications to human welfare
- Place in botanical history

II. Divisions of plant kingdoms dealt with
Thallophytes—General characteristics
Bryophytes—General characteristics

III. Filterable viruses
Possible lowest forms of life
Some characteristics—Living plants showing infection; slides showing infected tissue

IV. Bacteria (Schizophytes)
General discussion of characteristics
Slides showing typical forms—Rods (Bacilli); spheres (Cocci); spirals (Spirillum)
Living cultures of various types to examine
Slides—Spores; sheath; flagella; involution forms; nuclear (?) granules
Nitrogen fixing forms—Living soybean plants with nodules—students examine the living bacteria (bacteriods), fix, stain, and further study; azotobacter—students isolate from soil by means of mannite medium, fix, stain, and study
Nitrite and nitrate formers—Obtain energy from oxidation of inorganic compounds
Sulfur bacteria—Beggiatoa; Thiothrix—spores; purple bacteria; source of energy in above three is $H_2S$
Iron bacteria—Chlamydothrix; Spirophyllum, etc.
Micrococcus silenicus—Oxidizea silenium
Certain soil bacteria—Capable of utilizing free $H_2$
Forms F-J may live upon inorganic substances—May give some idea as to type of first organisms existing on the earth's surface
Myxobacteriaceae—Chondromyces apiculatus

V. Blue green algae
General discussion—No highly organized nucleus (microscope and lantern slides to show this); chlorophyll not in chloroplasts; no sex; reproduction; extremes of habitats; some may be partially saprophytic; phycocyanin; gelatinous sheaths
Forms used—Gleocapsa; Chrococcus; Oscillatoria; Merismopedia; Microcystis; Hypothrix (calcium deposits); Pleurocapsa (calcium deposits); Nostoc; Anabaena (dissected from Azolla); Rivularia; Scytonema and Tolypothrix (false branching); Stigonema (true branching)

VI. Green algae (Chlorophyceae)
Volvocales—Discussion of cell forms, colonies, reproduction, origin of plants and animals; Eudorina; Volvox; Euglena—living material, saprophytic form; Peridnium; Chlamydomonas—living material
Chlorocoacales—Structure and life cycles; Tetraspora; Scenedesmus; Pediastrum; Hydrodictyon
Ulothricales—Asexual, simple to complex sexual reproduction; alternation of generations; Pleurococcus; Ulothrix; Draparnaldia; Chaetophora; Coleochaeta; Ulva—alternation of generations
Siphonocladiales—Life cycles; Cladophora—alternation of generations; Pithophora—experimental saprophytic form developed
Siphonales—Life histories; Botrydium; Bryopsis; Vaucheria
Oedogoniales—Life cycle, monoecious and dioecious; Oedogonium
Zygnemales—Life cycles; reduction division; Spirogyra; Zygnema
Desmidiales—Life cycles; Closterium; Cosmarium
Diatomae—Sexual and asexual reproduction; rejuvenation; several species
Charales—Structure and life cycle;—Chara; Nitella

VII. Brown algae (Phaeophyceae)
General characteristics, distribution, habitats, etc.
Species studied in detail—Ectocarpus—asexual and sexual life cycles; Fucus—observation of fertilization in living material, structure, life cycle; Laminaria—diploid and haploid forms; Dictyota—diploid and haploid individuals of life cycle; Padina, Macrocystis, Nereocystis, Sargassum, Pylaillea, Postelsia, etc., as further representatives

VIII. Red algae (Rhodophyceae)
General characteristics, distribution and habitats
Species studied in detail—Batrachospermum—adult and juvenile (Chantransia) forms, life cycle; Lemanea; Polysiphonea—diploid and haploid individuals; Galaxoria, Porphyra, etc., as further representatives

IX. Slime fungi (Myxophyta)
Acrasieae—Dyctostelium, life history
Myximycetae—Structure of plasmodium and fruiting parts, fusion of nuclei, etc.; Fuligo; Lycogola; Stemonitis, Trichia, etc

X. True fungi (Mycophyta)
- Phycomycetes—General characteristics
  - Plasmodiophora brassicae—life cycle illustrated by living material;
  - Spongospora subterranea;
  - Rhizopus, life cycle with living material, plus and minus strains;
  - Albugo candida—life cycle;
  - Saprolegnia—life cycle with living material
- Ascomycetes—General characteristics
  - Yeast—students stain for spores; primitive ascus (?);
  - Exoascus deformans—binucleate cells, life cycle, asci not in clusters forming fruit bodies;
  - Microsphaera—asexual and sexual reproduction;
  - Penicillium—asexual and sexual reproduction;
  - Aspergillus—asexual and sexual reproduction;
  - Claviceps (Ergot)—asexual and sexual reproduction;
  - Peziza, Morchella, etc.;
  - Cordyceps;
  - Lichens—general discussion; Placodium elegans—primitive form, soredia, shows algal and fungal relationship;
  - Collema pulposum—sexual reproduction, nostoc easily dissected out;
  - Physcia—characteristics of apothecium;
  - Peltigera—foliose form; Usnea barbata—fruticose form; Lecanora—crustose form; Parmellia, Pykia, Umbillicaria, Endocarpon, Cladonia, Rochella, etc., as further representatives
- Basidiomycetes—General characteristics, binucleate condition;
  - Corn smut—life history;
  - Puccinia—alternate hosts, sexual and asexual reproduction;
  - Agaricus—characteristics of fleshy fungi;
  - Lycoperdons;
  - Lichens—Cora, tropical; Clavaria mucida, a primitive type (?) of this region

XI. Bryophyta
- Liverworts
  - Ricciaceae—Riccia and Ricciacarpes, primitive type, structure, land and water forms, etc.;
  - Marchantiaceae—Marchantia, structure, life cycle, relationship of fruiting to length of day, etc.; Conccephalum; Lunularia—sexual and vegetative reproduction; Reboulia; Frimbriaria;
  - Jungermanaceae—thallose: Pellia; Aneura; Metzgeria; Pallavacinia; foliose: Porella; Frullania; Lejeunia; Cephalozia;
  - Anthoceraceae—Notothylas, structure and life cycle;
  - Anthoceros, life cycle, presence of chlorenchyma, stomata, columella, indeterminate growth, spores ripening at various times in same sporophyte, etc., in the sporophyte
- Mosses
  - General discussion of structure, life history, importance in nature, etc.;
  - Antithetic alternation of generations;
  - Methods of reproduction, propagation, etc.;
  - Forms studied:
  - Polytrichum—life history as a general type;
  - Catharinea—life history as a general type;
  - Sphagnum—life history, protonema, structure, etc.;
  - Funaria—sporophyte with some chlorenchyma, stomata, etc.;
  - Splachnum—apophysis containing well developed chlorenchyma, stomata, etc.;
  - Georgia (Tetraphis) pellucida—peristome with four teeth, gemmae, etc.;
  - Aulacomnium palustre—broad bodies and fine antheridia;
  - Leptobryum pyreforme—brown buds on rhizoids, monecitous, etc.;
  - Webera—brown buds, zygomorphy in sporophyte, etc.;
  - Leucobryum glaucum—secondary protonema;
  - Climacium americanum—reproduction of gametophyte by means of runners, etc.;
  - Fontinalis—dying away of old parts resulting in the cutting off of branches, which become established as new individuals, water form, etc.;
  - Schistostega—luminous protonema;
  - Forms showing green buds on leaves;
  - Bryoziphium—fine for archegonia, rarely fruits, rare, etc.;
  - Pogonatum—persistent protonema, etc.;
  - Discelium—rare, greatly reduced gametophyte, persistent protonema, etc.;
  - Buxbaumia—rare, extreme hypophysis, zygomorphy, etc.;
  - Gymnostomium curvirostre—fossilization (recent), etc.;
  - Bryum—Marschall's work, development of diploid protonema from sporophytic tissue, etc.

## MORPHOLOGY OF THE PTERIDOPHYTES AND SPERMATOPHYTES

A study of the comparative structures and life histories of the ferns, gymnosperms, and angiosperms, giving particular attention to the structure and development of seed plants. Representatives from each of the following groups are studied and compared and appropriate generalizations made.

### OUTLINE OF COURSE CONTENT AND LABORATORY WORK

I. Sub-kingdom: Pteridophytes, homosporous and heterosporous
- Phylum X: Ptenophyta—fern plants
  - Class 35: Phyllopteridae
    - eusporangiate ferns
    - leptosporangiate ferns
  - Class 36: Isoeteae—quillworts
  - Class 37: Hydropteridae—water ferns
- Phylum XI: Calamaphyta—calamite plants
  - Class 38: Sphenophylleae—wedge-leaf calamites; fossil
  - Class 39: Equisiteae—horsetails
  - Class 40: Calamarieae—calamites; fossil
- Phylum XII: Lepidophyta—scab-leaf plants; club mosses
  - Class 41a: Acrotheceae—Devonian fossil plants with terminal sporangia; example Rhynia
  - Class 41: Lycopodieae—lycopods
  - Class 42: Selaginelleae—selaginellas; fossil and living

II. Sub-kingdom: Gymnosperms
- Phylum XIII: Cycadophyta*
  - Class 43: Pteridospermae—seed ferns; fossil
  - Class 44: Cycadeae—cycads; fossil and living
  - Class 45: Cordaiteae—cordiates; fossil
  - Class 46: Ginkgoeae—ginkgo
- Phylum XIV: Strobilophyta—strobilus plants
  - Class 47: Coniferae
  - Class 48: Gneteae—joint firs; example Ephedra

III. Sub-kingdom: Angiosperms
- Phylum XV: Anthophyta
  - Class 49: Monocotylae—monocots
  - Class 50: Dicotylae—dicots

IV. Procedure
- Study of the external form of the plant or plant part during its growth
- Use:
  - Fresh material from greenhouse and out-of-doors
  - Dry and preserved specimens
  - Lantern slides and pictures
- Study of the internal structure, using:
  - Dissection of fresh material
  - Microscopic slides
  - Published illustrations
- Discussion and summarization of the life history in presence of the plant materials

*For convenience the fossil groups are studied together, in connection with the work on the Cycads. At this time it is desirable to show the steps in the development of the seed.

## PLANT ECOLOGY

Patterns of vegetation, local, regional, and continental; the historic, climatic, soil, and factors that limit the various plant communities. Lectures, discussions, and laboratory work on tundra, boreal forest, hemlock-hardwood, and deciduous forest. The forest, grassland and desert vegetation of Western North America. Lectures, reference reading and laboratory work. Field study of regional plant communities, several extended trips.

**Lecture—Discussion**

1. Ecological point of view compared and contrasted with taxonomic and physiological viewpoints; inductive vs. deductive reasoning; synecology and autecology.
2. Development of the ecological point of view; historical notes.
3. Ecological classification—nomenclature and examples from field observations at Buckeye Lake and Olentangy flood plain.

4. Nomenclature and terminology continued; the processes of vegetation.
5. Factors effecting Vegetation of the region: Historical.
6. Successional Relationships and plant communities of a picked region.
7. History of the Vegetation of the local state: Lantern slides.
8. Paleoecological Methods and interpretations: fossil pollen.
9. Present day factors: classification.
10-11. Light.
12-13. Temperature.
14-15. Precipitation: Rain, snow, sleet, hail, dew.
16. Wind, composition of atmosphere, etc.
17. Edaphic factors.
18. Biotic factors.
19. The Tundra Formation.* Lecture and lantern slides.
20. Tundra continued.
21. The Boreal Forest Formation.* Lecture and lantern slides.
22. Boreal Forest continued.
23. The Hemlock—White Pine—Hardwood Formation.* Lecture and lantern slides.
24. Hemlock—Hardwood continued.
25. Hemlock—Hardwood concluded.
26. The Deciduous Forest Formation.* Lecture and lantern slides.
27. Deciduous Forest continued.
28. Deciduous Forest concluded.
29. The Tall-grass Prairie Formation.* Lecture and lantern slides.
30. Tall-grass Prairie concluded.
31. Final examination.

*The various formations are discussed with regard to: location and extent, seasonal aspect, floristic composition, plant association, successional relationships, major climatic phenomena, soils, topography, factors favoring, factors limiting and regional examples, if any.

## PLANT CYTOLOGY

### OUTLINE OF COURSE CONTENT

I. The mature somatic cell
   - Structure and differentiations of the wall
   - Structure and differentiations of cytoplasm—Plastids; Mitochondria; Ergastics—crystals, starch and aleurone grains, etc.
   - Structure and differentiations of the nucleus—Nucleoli; polynucleate cells; nucleoplasmic ratio; non-spherical nuclei

II. The non-dividing meristematic cell
   - Comparison with the mature cell

III. The dividing meristematic cell (mitosis): its phases
   - In sporophytes
   - In gametophytes (pollen tubes)

IV. The dividing sporogenous cell (meiosis): its phases
   - Microsporogenesis
   - Megasporogenesis (including development of embryo sac)

V. Fertilization

VI. Departures from the usual division process
   - Amitosis
   - Failure of completion—Colchicine, heat, etc., causing doubling in mitosis, non-reduction in meiosis
   - Gene-controlled asynapsis
   - Interspecific hybrids
   - Apomixis, parthenogenesis, etc.

## PLANT MICROTECHNIQUE

### OUTLINE FOR LABORATORY STUDY

I. Introduction
II. Collecting and subdividing plant materials for processing
III. Killing, fixing and storing plant tissues

IV. Dehydration for embedding
V. Infiltration and embedding in paraffin
VI. Microtome sectioning of material in paraffin
VII. Staining paraffin sections
VIII. Infiltration and staining material embedded in celloidin
IX. Sectioning and staining material embedded in celloidin
X. Sectioning unembedded tissues
The steam method for wood
The freezing method
XI. The preparation of whole mounts
XII. Smear methods for chromosomes
XIII. Vegetative organs of vascular plants
XIV. Reproductive organs of vascular plants
XV. Bacteria, fungi and algae
XVI. Mosses and liverworts
XVII. The microscope, construction, use and care
XVIII. The preparation of drawings of plant tissues
Use of the camera lucida
Measurement of microscopic structures
XIX. Photomicrography

# GENERAL BOTANY

## STUDENT APPARATUS

**(for 20 students)**

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 4516P | 44300 | 6 | Beakers Pyrex Glass 400 ML | $ 1.44 |
| 4616P | 44300 | 6 | Beakers Pyrex Glass 250 ML | 1.02 |
| 4503A | 36385 | 1 | Coat, Laboratory White Drill | 4.75 |
| 8321 | 94040 | 1 | Collecting Trowel | .45 |
| 8320 | 94502 | 1 | Collecting Case 5 x 6 x 16" | 4.25 |
| 8251 | 65830B | 10 | Dissecting Pans, Wax lined | 12.50 |
| 8290C | | 20 | Dissecting set, Botany | 140.00 |
| 5143P | 71220 | 6 | Funnels, Pyrex glass 75 mm | 2.28 |
| 5219 | 5775A | 6 | Glass Plates, 10 x 10" | 2.70 |
| 9957C | | 6 | Germinating Plates, unglazed porcelain 10" diam. | 3.30 |
| 8317A | | 20 | Herbariums, 11 x 14" Complete with mounting sheets | 30.00 |
| 8351 | 76865 | 4 pkg. | Lens paper, 50 sheets | .60 |
| 8052 | 76200 | 10 | Magnifiers, Tripod 10X | 10.00 |
| 7976 | | 20 | Microscope with 5 and 10X eyepiece and 16 and 4 MM Dry Objective and 1.8 MM Oil Objective. Magnification 50X to 970X in Hardwood Case | 4240.00 |
| 8006 | 76720 | 20 | Microscope Lamp, substage—2 way | 80.00 |
| 8118A | 76800 | 144 | Microscope Slides 3" x 1" | 2.00 |
| 8132 | 76835A | 1 oz. | Microscope cover glasses 18 mm round | 4.00 |
| 540 | | 1 | Osmosis Apparatus, simple form | .60 |
| 9400 | 96400 | 1 | Photosynthesis Light Screen | .75 |
| 5431 | 78080 | 20 | Pipettes, Medicine Droppers | .67 |
| 5628P | 80650A | 20 | Test Tubes, Pyrex Glass—150 x 18 mm | .90 |
| | | | Total | $4542.21 |

## GENERAL APPARATUS

**One Set For the Entire Class**

| | | | | |
|---|---|---|---|---|
| 5063 | 70130 | 1 | Aspirator, Water 3/8" I. P. Thread | $ 1.65 |
| 1166A | 75600A | 6 | Battery Jars, White Glass 6 x 8" | 6.90 |
| 1456 | 75640C | 6 | Bell Jar, Straight Form, Knob top, capacity 8 Liter | 42.00 |
| 4603 | 45520 | 48 | Bottles, Wide Mouth, 8 oz. | 3.60 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 3962 | 78270A | 1 | Baloptican, Combined Opaque Slide Projector | $159.60 |
| 1536 | 5860 | 12 | Rubber Balloons, 5 cm diam. | .65 |
| 4716 | | 4 | Burette, Glass Stopcock, 50ML | 6.00 |
| 4050 | 1872 | 1 | Balance, Triple Beam Weights to 1610 Grams without auxiliary weights | 15.00 |
| 4752A | | 20 | Burners, Bunsen with Gas and Air adjustment | 15.00 |
| 3750 | 23150 | 1 | Binoculars prism type, magnification 8 diameters (if possible provide 1 set to each pair of students) | 85.00 |
| 5239 | | 10 lb. | Capillary Glass Tubing for osmosis I. D. 2½ MM O. D. 7 MM | 11.00 |
| 4954D | | 1 | Cork Borers, set of 12 with individual handles | 4.00 |
| 9115 | 92995 | 1 | Chart, Grafting Model 20 x 36" | 5.00 |
| 4854 | 56305 | 1 | Chart of the Atoms, 42 x 58" | 7.50 |
| 6939 | | 1 set | Charts, Botany, set of 30 charts complete with chart-head and tripod support | 27.50 |
| 2202 | 66600A | 3 | Cups, porcelain 40 x 90MM | .90 |
| 5809 | 24550 | 10 yds. | Cheesecloth | 1.60 |
| 4900 | 56600 | 4 | Clamps, burette adjustable | 1.60 |
| 8390 | 65150A | 3 | Dishes, Moist Chamber 200 mm Diam. 70 mm High | 10.05 |
| 5106P | 70750 | 6 | Flasks Pyrex, Erlenmeyer 500 ML | 1.68 |
| 9345 | 96520 | 12 | Flower Pots—4" earthenware | .72 |
| 9345 | 96520 | 12 | Flower Pots—6" earthenware | 2.04 |
| 9345 | 96520 | 12 | Flower Pots—8" earthenware | 4.08 |
| 5050 | 69700 | 2 | Filter Paper 12.5 cm | .50 |
| 5155 | 71460A | 2 | Funnel—separatory 250 ML, Globe shape | 4.40 |
| 8302 | 94508 | 1 | Flower or Plant Press | 3.25 |
| 8324 | 96516 | 2 | Germinating Box 15" long—8" high | 9.00 |
| 5235 | 73765 | 4 lb. | Glass Tubing 6 mm diam. soft glass | 2.40 |
| LB02 | | 1 set | Lantern Slides—100 selected slides on Botany | 48.00 |
| 1494 | 3890 | 3 | Membranes, Animal for osmosis | 1.05 |
| 8023F | 76470B | 1 | Microprojector Model B, for 110 volts A. C | 189.00 |
| 7603 | | 1 | Microtome Clinical improved form, with knife and freezing attachment | 223.50 |
| 1805 | 11230 | 1 | Micrometer Eyepiece Glass Disc 21.3 MM in diameter ruled to 0.1 MM divisions | 4.00 |
| 8109 | | 1 | Micrometer Stage 75 x 25 MM ruled to 1/100th of inch | 14.50 |
| 9427 | 91570 | 1 | Model of typical Monocotyledon Stem. Cross and longitudinal sections of a Corn Stem, in colors | 20.00 |
| 9428 | 91574 | 1 | Model of typical netted Vein leaf. Cross section of Leaf blade and oblique section of the petiole, in colors | 20.00 |
| 5015 | | 1 | Oven drying 6" high 8" wide 6" deep double wall | 15.00 |
| 8386P | 65270A | 40 | Petri Dishes, Pyrex 100 x 15 | 15.20 |
| 9160A | | 1 | Pruner, Tree, Henry's | 4.50 |
| 1426 | 5300 | 1 | Pump Plate—27 cm in diameter | 8.50 |
| 5516 | 78840A | 12 ft. | Rubber tubing ¼" inside diam., light wall | 1.56 |
| 5505A | | 1 lb. | Rubber Stoppers, asst. | 1.25 |
| 5517 | 78845B | 12 ft. | Rubber tubing ¼" diam., heavy wall | 2.40 |
| 9155 | 96714 | 1 | Shears, Pruning | 1.25 |
| 1264 | | 1 | Soil Thermometer | 4.00 |
| 5572 | 79905A | 3 | Support with 3 rings 1 ea. 3, 4, and 5" diam | 4.05 |
| 3936A | | 1 | Screen white opaque 7 x 7 ft. on Spring roller | 16.00 |
| 5286 | 76930 | 1 | Slide Warmer—electric 24½" long, 6⅛" wide, adjustable between 40 and 60 Degrees C | 50.00 |
| 5670 | 80060A | 10 | Thermometers, 220 deg. C | 16.00 |
| 8346B | | 1 | Terrarium 20" long—12" wide 18½" high | 25.00 |
| 1701 | 10580A | 4 | Vacuum Bottle quart size | 6.00 |
| | | | Total | $1123.38 |

## BOTANY MATERIAL

1 Four great plant groups. The Thallophytes, Bryophytes, Pteridophytes, and Sphermatophytes mounted on an opal glass plate in a sealed museum jar.... $ 7.50

1 Moss Collection. 5 common Mosses, labeled and mounted on glass plate in sealed museum jar ..... $ 6.00

| | | |
|---|---|---|
| 1 | Moss life history. Mounted on glass plate in sealed museum jar | $ 6.00 |
| 1 | Fern life history in sealed museum jar | 6.00 |
| 1 | Pine life history completely labeled—arranged in Riker mount | 7.50 |
| 1 | Algae collection of Blue Green Algae — Green Algae, Brown Algae and Red Algae, mounted on glass plate in sealed museum jar | 8.50 |
| 10 | Wheat Rust life history, mounted on a plaque | 10.00 |
| 1 | Plant disease collection, showing 20 specimens of important plants each infected with a different destructive disease in Riker mount | $ 6.00 |
| 1 | Lichen collection, nine kinds illustrating 3 types, neatly arranged in Riker mount | 4.00 |
| 1 | Carnivorous plant collection including venus flytrap, sun dew, pitcher plant and bladderwort in sealed museum jar | 6.50 |
| 1 | Useless and harmful grasses, a collection of 20 floral heads of useless or harmful grasses in glass topped display jar | 6.00 |
| 10 sets | Microscope slides, set of 100 on botany, in leatherette covered case | 400.00 |
| | Total | $474.00 |

## CHEMICALS

| | | |
|---|---|---|
| 1x1 lb. | Acid acetic glacial cp | $ .70 |
| 1x1 lb. | Acid hydrochloric cp | .75 |
| 1x1 oz. | Acid indole butyric | 3.00 |
| 1x4 oz. | Acid pyrogallic cp | 1.35 |
| 1x1 lb. | Acid sulphuric cp | .90 |
| 1x1 gal. | Alcohol ethyl 95% denatured | 1.75 |
| 1x1 gal. | Alcohol methyl wood alcohol | 1.75 |
| 1x5 lb. | Calcium Carbonate marble chips | .60 |
| 1x5 lb. | Calcium Chloride granular for drying tubes, pure | 2.00 |
| 1x1 lb. | Chloroform cp | .80 |
| 1x1 oz. | Cobalt Chloride Crystal cp | .60 |
| 1x1 lb. | Copper Sulphate crystal cp | .65 |
| 1x1 lb. | Cotton absorbent | 1.00 |
| 1x1 lb. | Cotton non absorbent | .80 |
| 1x10 gram | Eosin yellow | .90 |
| 1x1 lb. | Ether anhyd cp | .85 |
| 1x1 lb. | Ether petrolic cp | .60 |
| 5x1 gal. | Formaldehyde pure | 10.00 |
| 2x4 oz. | Gelatin sheet | $ 1.50 |
| 1x1 lb. | Glucose pure granular | .25 |
| 1x4 oz. | Iodine solution | .30 |
| 1x1 lb. | Lanolin wool fat | .75 |
| 1x1 lb. | Lead nitrate cp | .82 |
| 1x4 oz. | Levulose fructose | 2.50 |
| 1x1 gal. | Lime water | 1.25 |
| 6 vials | Red and blue litmus paper | .90 |
| 1x1 lb. | Mercury metal cp | 5.50 |
| 1x4 oz. | Mercuric chloride cp | 1.80 |
| 1x10 gram | Methylene blue stain | .85 |
| 1x1 oz. | Peppermint oil usp | 2.00 |
| 1x1 oz. | Phloroglucinol | 2.00 |
| 1x1 lb. | Potassum hydroxide pellets cp | .95 |
| 1x4 oz. | Potassium permanganate cp | .75 |
| 1x1 lb. | Soluble starch cp | 1.60 |
| 1x1 lb. | Sucrose cane sugar | .25 |
| 1x5 lb. | Xylene cp | 2.00 |
| | Total | $54.97 |

## ADDITIONAL MATERIAL REQUIRED FOR FIELD BOTANY (Local Flora)

### STUDENT APPARATUS

**(for 20 students)**

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 8061B | 76160B | 20 | Magnifiers, Coddington type, 10X, focus 1" | $120.00 |

### GENERAL APPARATUS

**(for class of 20 students)**

| | | | | |
|---|---|---|---|---|
| 8302 | 94508 | 4 | Plant Presses, with straps, 12 x 16" | $ 13.00 |
| 8302A | 94510 | 100 | Felt Paper Driers, 11 x 16" | 4.50 |
| 8317B | | 1000 | Herbarium Mounting Paper Sheets, 7¾ x 9¾" | 15.00 |
| | | | Total | $32.50 |

# ADDITIONAL EQUIPMENT REQUIRED FOR PLANT PATHOLOGY

## FOR THE ENTIRE CLASS

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 5299 | | 1 | Autoclave horizontal type, Range 40 to 140 deg. C. 24 x 20 x 12" Electrically heated | $425.00 |
| 4000E | 40220 | 1 | Balance Analytical, 200 gram capacity sensitivity 0.1 mg in mahogany case 17 x 16 x 9" | 100.00 |
| 4096 | | 1 | Balance Weights, Glass S, 0 to 100 gm, Gold plated, Complete set in velvet lined mahogany box with ivory tipped forceps and 3 riders | 45.00 |
| 8370 | | 1 | Centrifuge size 1, Type C | 148.00 |
| 8376C | | 1 | Centrifuge Head for above 4 place | 9.00 |
| 8370P | | 8 | Centrifuge Tube 15 ml Pyrex | 5.44 |
| 4995 | 65030B | 6 | Dessicators, Knob Cover 6" diameter | 30.00 |
| 8375 | | 1 | Electrophometer | 150.00 |
| 103 | | 6 | Glass Cutters | 3.60 |
| 5279 | 74109A | 1 | Hot Plate, Electric 6" diam. 3 heat switch 600, 300, 150 watts | 10.50 |
| 8353B | B | 1 | Incubator electric 15" high 12" Wide 11" deep, Double doors, Electric Thermoregulator for constant temp. 37.5 deg. C. | 85.00 |
| 8022 | 98612 | 6 | Microscopes, dissecting, with 25 mm doublet lens | 36.00 |
| 5032B | | 1 | Oven, constant temperature, double wall 10 x 10½ x 12" inside dimensions, temperature control sensitive to ½ Deg. C. plus or minus | 95.00 |
| 1410B | | 1 | Pump, Vacuum and pressure guaranteed vacuum, .02 mm—15 lb. per square inch pressure | 65.00 |
| 2751 | 67680 | 1 | Rheostat, slide wire 170 ohms resistance | 11.50 |
| 1320 | 7290 | 1 | Thermograph, recording thermometer, in gray enamel, metal case 25 x 16 x 12.5 cm | 100.00 |
| 1322 | | 1 | Thermograph Chart for above 0 to 100 deg. F | 4.00 |
| 5554 | 66170A | 1 | Water distilling Apparatus, Automatic electric, 1 gal. per hr. | 125.00 |
| 5554B | 66245A | 1 | Water Storage tank for distilled water 10 gal. | 37.50 |
| 5759D | | 1 | Water Bath, electrically heated 14 x 14 x 15" four sets of concentric rings | 62.00 |
| | | | Total | $1547.54 |

## CULTURE MEDIA

| | | | | | |
|---|---|---|---|---|---|
| 1x4 oz. | Brain Heart Infusion | $ 3.25 | 1x4 oz. | Brain Veal Agar | $ 3.25 |
| 1x4 oz. | Heart Infusion Broth | 3.25 | 1x4 oz. | North Gelatin Agar | 2.75 |
| 1x4 oz. | Dextrose Infusion Broth | 2.75 | 1x4 oz. | Potato Infusion Agar | 2.25 |
| 1x4 oz. | Veal Infusion Medium | 3.25 | 1x4 oz. | Liver Infusion Agar | 3.25 |
| 1x4 oz. | Egg Meat Medium | 2.15 | 1x4 oz. | Entamoeba Medium | 3.25 |
| 1x4 oz. | Heart Infusion Agar | 3.25 | 1x4 oz. | Stock Culture Agar | 3.25 |
| 1x4 oz. | Blood Agar Base | 3.25 | 1x4 oz. | Legumin Trypagar | 3.25 |
| 1x4 oz. | Dextrose Heart Agar | 3.25 | 1x4 oz. | Testicular Agar | 3.25 |
| 1x4 oz. | Cystine Heart Agar | 3.25 | 1x4 oz. | Brain Liver Heart | 3.25 |
| 1x4 oz. | Bordet Gengou Agar Base | 2.25 | 1x4 oz. | Liver Veal Agar | 2.75 |
| | | | | Total | $60.40 |

## BIOLOGY MATERIAL

Plant organs depicting disease due to the following groups:

| | | | |
|---|---|---|---|
| 1 | Bacteria cultures, living | $ 6.00 | |
| 1 | Slime molds, collection of five named specimens in Riker mount | 4.50 | |
| 1 | Edible mushrooms, five specimens named and mounted in museum jar | 7.00 | |
| 1 | Phycomycetes, three common named specimens mounted in a museum jar | 6.00 | |
| 1 | Ascomycetes, six common named specimens mounted in a museum jar | $6.00 | |
| 1 | Basidiomycetes examples of five forms greatly differing in structure, museum mount | 6.50 | |
| | Total | $36.00 | |

## ADDITIONAL MATERIAL FOR THE MORPHOLOGY OF THALLOPHYTES & BRYOPHYTES

### FOR EACH STUDENT

| | | |
|---|---|---|
| 1 | Binocular microscope, stereoscopic | $193.00 |
| | Total | $193.00 |

### PRESERVED BIOLOGY MATERIAL FOR THE ENTIRE CLASS

One unit of 20 of each of the following:

| | | | |
|---|---|---|---|
| Gloecapsa | $ 1.50 | Albugo | $ 1.50 |
| Nostoc | 1.50 | Erysiphe Pwd Mildew | 1.50 |
| Oscillatoria | 1.50 | Puccinia, wheat rust—teliospores | 1.50 |
| Volvox | 1.50 | Puccinia, wheat rust—alcidia | 1.50 |
| Euglena | 1.50 | Puccinia, wheat rust—uredospores | 1.50 |
| Ulothrix | 1.50 | Marchantia—antheridia | 1.50 |
| Cladophora | 1.50 | Marchantia—archegonia | 1.50 |
| Vaucheria—Fruiting | 1.50 | Marchantia—thallus—cupules | 1.50 |
| Diatoms, mixed | 1.50 | Polytrichum archegonia | 1.50 |
| Fucus—fruiting | 1.50 | Polytrichum antheridia | 1.50 |
| Polysiphonia—carpospores | 1.50 | Rhizophus, sporangia and zygotes | 1.50 |
| Polysiphonia—tretraspores | 1.50 | Saprolegnia fruiting | 1.50 |
| Polysiphonia—antheridia | 1.50 | | |
| Plasmodium (club root) | 1.50 | Total | $39.00 |

## ADDITIONAL MATERIALS REQUIRED FOR GENERAL MORPHOLOGY OF THE PTERIDOPHYTES AND SPERMATOPHYTES

### FOR ENTIRE CLASS

### BIOLOGICAL MATERIAL

| | | |
|---|---|---|
| 1 | Fern Allies Collection, arranged in Riker mount | $ 3.50 |
| 1 | Common Fern, Fruiting fronds of ten specimens named and mounted in Riker Mount | 4.50 |
| 25 | Water Ferns, Salvinia | 1.50 |
| 25 | Horsetails (equisetum) Strobili | 1.50 |
| 25 | Horsetails (equisetum) with Sterile and fertile shoots | 3.00 |
| 25 | Lycopodium Strobili | 1.50 |
| 25 | Selaginella Strobili | 1.50 |

Angiosperms:

| | | |
|---|---|---|
| 1 | Comparative germination. Several stages illustrated by Corn and Pea germination in museum jar | $10.00 |
| 1 | Typical monocot and dicot flowers. Excellent comparative preparation three specimens from each group named and mounted in museum jar | 8.50 |
| | Total | $35.50 |

## ADDITIONAL EQUIPMENT FOR PLANT ANATOMY

| | | |
|---|---|---|
| 1 | Apeco Photocopy for preparation of Photomicrographs | $100.00 |
| 1 set | Botany Slides, microscopic, set of 50 selected for plant anatomy | 22.50 |
| 3 | Camera lucida in leatherette wood covered case | $90.00 |
| | Total | $212.50 |

## ADDITIONAL MATERIAL FIELD & LABORATORY EQUIPMENT FOR PLANT ECOLOGY

**Demonstrations:**

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 3125 | | 1 | Recording Pyrheliometer with 100 Microampere meter, 10 junction type—sensitivity 1.5 millivolts per centimeter square | $550.00 |
| 1304 | | 1 | Standard Weather Bureau Rain Gauge 20 cm in diameter 60 cm high | 25.00 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 1292 | 74640 | 1 | Hygrothermograph—recording with charts for weekly records. Range plus 10° to 110° F. temperature—0% to 100% for humidity, Length 12½" Height 9¼" Depth 5¾" | $200.00 |
| 1330 | | 1 | Atomometer with mercury trap | 8.00 |
| 1274 | 7260 | 1 | Minimum Maximum Thermometer Six's self registering | 10.00 |
| 1267 | | 1 | Maximum Thermometer, Weather Bureau pattern 20 to 120° F. in 1° div. | 10.00 |
| 1269 | | 1 | Minimum Thermometer, Weather Bureau type-p —20° to +120° F. in 1° division | 10.00 |
| 1290 | 74600 | 1 | Sling Psychrometer, wet and dry bulb thermometer mounted on metal plate which is free to swing | 10.00 |
| 1295 | | 1 | Aspirating Psychrometer complete with aspirator bulb and two thermometers | 15.00 |
| 3586A | 21240 | 1 | Light Meter, direct reading graduated in foot candles | 17.50 |
| 2749 | 67660 | 1 | Potentiometer, student form, two ranges 0 to 16 millivolts and 0 to 1.6 volts. In polished box with cover | 80.00 |
| 3590 | | 1 | Illuminometer, outdoor control with 3 cell weather-proof light collector | 175.00 |
| | | | Total | $1110.50 |
| | | | **Class or Student Use:** | |
| 6890 | | 1 set of | 100 Topographic maps assorted | $ 15.00 |
| 3944 | 95458 | 20 sets | Colored pencils—12 colors | 20.00 |
| 6975 | | 1 set of 9 | Base Maps: World, Continents, Northern Hemisphere, various sections of North America. On spring rollers in case | 100.00 |
| 8036 | 76195D | 20 | Hand Lenses, 4" diameter | 50.00 |
| 9629 | 96242 | 1 | Soil Auger, length 40 inches, diam. 1½" | 5.00 |
| 296 | 64070 | 1 | Hand Counter, registers to 9,999 | 7.50 |
| 823 | 38755 | 1 | Stop-watch, 1/5th second divisions | 20.00 |
| 4954F | 63870 | 1 | Cork Boring Machine with 8 borers | 25.00 |
| 9575 | | 1 | David Peat Sampler | 75.00 |
| 127 | 26680 | 1 | Hand level, 12" long, wood block type | 2.00 |
| 174A | 3250 | 1 | Tape Measure, linen—66 ft. in ½" div. | 5.00 |
| 9729 | | 5 | Soil Testing Outfit, with screw cap tube | 1.00 |
| 8320 | 94502 | 5 | Vasculum Metal, 5 x 6 x 16 with shoulder straps | 22.50 |
| 8302 | 94502 | 5 | Plant Press 12 x 16" | 15.00 |
| | | | Total | $363.00 |

## ADDITIONAL EQUIPMENT FOR PLANT CYTOLOGY

### STUDENT EQUIPMENT

#### ONE FOR EACH STUDENT

| | | | | |
|---|---|---|---|---|
| 8008 | | 1 | Mechanical stage—reads to 1/10th MM—takes slides up to 25 x 75 mm | $ 50.00 |
| 8010B | | 1 | Binocular microscope—stereoscopic | 193.00 |
| | | | Total | $243.00 |

### BIOLOGY MATERIALS

| | | | | |
|---|---|---|---|---|
| 8484 | | 12 | Prepared slides showing the mitosis in onion root tips No. 350 | $12.00 |
| | | | Total | $12.00 |

## ADDITIONAL EQUIPMENT REQUIRED FOR PLANT MICRO TECHNIQUE

**For a Class of 20 Students**

| | | | | |
|---|---|---|---|---|
| 8372 | | 20 | Balsam Bottles, with Glass Dropper and Glass Cap, capacity 60 ml | $ 15.00 |
| 4516P | 44300 | 40 | Beakers, Pyrex Glass, 150 ml | 7.20 |
| 8372 | | 120 | Bottles, for Celloiden, 60 ml with glass dropper | 90.00 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 4608 | 45600 | 140 | Bottles, with glass stoppers, 500 ml capacity | $ 84.00 |
| 5256 | 64860B | 20 | Cylinders, Graduated cap 100 ml x 1 ml double scale | 17.60 |
| 8396 | 76915 | 120 | Coplin Jars, Tall Form Capacity 10 slides | 72.00 |
| 8259 | | 20 | Knives, Gillette, with replaceable blades | 20.00 |
| 5334P | 49930 | 20 | Lamps Alcohol, pyrex glass 8 oz. capacity | 18.00 |
| 8116AB | | 20 | Microtome Knives, Blade 90 mm long with 82 mm cutting edge, complete with handle | 300.00 |
| 5435A | 78010A | 20 | Pipette, Volumetric 5 ml Exax Blue line | 7.80 |
| 8144 | 76870 | 20 | Slide Box Leatherette, to hold 100 Slides | 30.00 |
| 8391 | 65340A | 120 | Stender Dishes, low form 48 mm diam. 34 mm high | 42.00 |
| 8391X | | 120 | Stender Dishes, Tall form | 78.00 |
| 4611 | | 200 | Vials with Plastic Screw Caps, 26 mm Diam. 95 mm High | 20.00 |
| 5752 | 80895A | 240 | Watch Glasses, Syracuse Type 65 mm diam | 29.00 |
| | | | Total | $830.60 |

## GENERAL APPARATUS

**For the Class of 20 Students**

| | | | | |
|---|---|---|---|---|
| 5063 | 70130 | 1 | Aspirator Water, will produce a vacuum of 28.5" | $ 1.65 |
| 4030 | 40450 | 1 | Balance Triple Beam, Stainless Steel, capacity 111 grams —smallest division 1/100 gram, no auxiliary weights required | 21.50 |
| 8113 | | 2 | Camera Lucida, in leatherette covered wood case | 60.00 |
| 44-11 | | 1 | Camera, photomicrographic, Type K, 3¼ x 4¼ Double Plate Holder Shutter and observation eyepiece | 125.00 |
| 4995 | 65030B | 2 | Dessicator, glass, 6" diam. Knob Top, cover ground air tight | 10.00 |
| 8115N | | 1 | Microtome, Sliding-Automatic Feed, accommodates objects measuring up to 35 x 32 mm | 275.00 |
| 8115Q | | 1 | Microtome Knife, for use with above | 30.00 |
| 8116 | 77050 | 1 | Microtome Freezing attachment, for use with sliding microtome | 22.00 |
| 8118 | 76805 | 1 | Rotary Microtome, Minot with 120 mm plain knife | 248.00 |
| 5032B | | 1 | Electric Oven 60 degrees C., Double Wall 17 x 11 x 14" | 95.00 |
| 5286 | 76930 | 1 | Electric Slide Warmer to about 50 degrees C. 24½" long 6⅜" wide | 50.00 |
| | | | Total | $938.15 |

## STAINS

| | | | | | |
|---|---|---|---|---|---|
| 1x10 gram | Aniline Blue | $ .75 | 1x10 gram | Neutral Red | $ .75 |
| 1x10 gram | Bismarck Brown | .75 | 1x10 gram | Orange G | .75 |
| 1x10 gram | Carmine | .50 | 1x10 gram | Phyloxine | 1.00 |
| 1x10 gram | Fast Green | 2.00 | 1x10 gram | Rose Bengal | 1.50 |
| 1x10 gram | Fuchsin Acid | .75 | 1x25 gram | Safranin A | 1.50 |
| 1x10 gram | Fuchsin Basic | .75 | 1x25 gram | Safranin Y | 2.00 |
| 1x10 gram | Gentian Violet | .75 | 1x10 gram | Sudan III | .75 |
| 2x10 gram | Haematoxylin light | 5.00 | | | |
| 1x10 gram | Janus Green | 1.00 | | Total | $20.50 |

## REAGENTS

| | | | | | |
|---|---|---|---|---|---|
| 2x5 lb. | Acetone cp | $ 5.40 | 1x1 lb. | Collodion cotton pyroxilin | $12.00 |
| 3x5 gal. | Alcohol denatured 95% | 21.00 | 2x5 lb. | Ether cp anhydrous | 6.80 |
| 3x2 gal. | Alcohol denatured absolute | 9.00 | 1x1 lb. | Ferric ammonium sulphate cp | .64 |
| 1x4 oz. | Carbolic acid cp | .47 | 1x4 oz. | Ferric chloride cp | .40 |
| 1x1 oz. | Chromic acid cp | 1.50 | 2x1 gal. | Formaldehyde pure | 4.50 |
| 1x5 lb. | Chloroform cp | 3.60 | 2x5 lb. | Glacial acetic acid cp | 4.00 |
| 1x1 lb. | Canada balsam in xylol | 7.00 | 2x5 lb. | Glacial cp | 5.90 |
| 1x1 lb. | Clove oil | 3.00 | 1x1 lb. | Gelatin sheets | 1.50 |
| 1x1 lb. | Cedarwood oil for immersion | .50 | 1x1 lb. | Gum arabic yellow | .75 |
| 1x4 oz. | Chloral hydrate | .50 | 1x1 lb. | Hydrogen peroxide cp | .50 |
| | | | 1x1 lb. | Hydrofluoric acid cp | 1.30 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1x4 | oz. | Lithium carbonate cp | $ 1.00 | 2x1 | liter | Propionic acid | $ 7.00 |
| 2x1 | lb. | Methyl salicylate | 1.40 | 1x1 | lb. | Sodium Bicarbonate cp | .48 |
| 2x1 | lb. | Nitric acid cp | 1.70 | 1x9 | lb. | Sulphuric acid cp | 2.40 |
| 6x1 | lb. | Paraffin for imbedding | 3.00 | 1x1 | lb. | Turpentine Venice | 2.00 |
| 1x1 | oz. | Picric acid cp | .38 | 4x5 | lb. | Xylene cp | 9.20 |
| 1x1 | oz. | Potassium iodide cp | .48 | | | | |
| | | | | | | Total | $119.30 |

## BIOLOGY MATERIALS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Bacterial cultures, living, per culture | $ 6.00 | 25 | Mosses, polytrichum sporophyte | $ 1.50 |
| 25 | Fungi, mushrooms | 1.50 | 25 | Polytrichum antheridia | 1.50 |
| 25 | Algae, spirogyra | 1.50 | 25 | Liverworts, marchantia sporophyte | 1.50 |
| | | | 25 | Marchantia antheridia | 1.50 |

## REPRODUCTIVE ORGANS FROM

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 25 | Pine staminate cones | $ 1.50 | 25 | Oak staminate flowers | $ 1.50 |
| 25 | Pine pistillate cones 1, 2 and 3 years mixed | 1.50 | 25 | Strawberry flowers | 1.50 |
| 25 | Oak pistillate flowers | 1.50 | 25 | Dandelion tap root | 1.50 |
| | | | 25 | Bean root showing nodules | 1.50 |

# COLLEGE BOTANY

## RECAPITULATION

### GENERAL BOTANY

| | |
|---|---|
| Student Apparatus | $4542.21 |
| General Apparatus for the class | 1123.38 |
| Botany material | 474.00 |
| Chemicals | 54.97 |
| Grand total for General Botany | $6194.56 |

### FIELD BOTANY

| | |
|---|---|
| Student Appartus | $ 120.00 |
| General Apparatus | 32.50 |
| Grand total for Field Botany | $ 152.50 |

### PLANT PATHOLOGY

**(Additional Material Required)**

| | |
|---|---|
| General Apparatus for the Class | $1547.54 |
| Culture Media | 60.40 |
| Biology Material | 36.00 |
| Grand total for additional material for Plant Pathology | $1643.94 |

### MORPHOLOGY OF THALLOPHYTES AND BRYOPHYTES

| | |
|---|---|
| Student Apparatus | $ 193.00 |
| Biology Material (for entire class) | 39.00 |
| Grand total for additional material required for Morphology of Thallophytes and Bryophytes | $ 232.00 |

### GENERAL MORPHOLOGY OF THE PTERIDOPHYTES AND SPERMATOPHYTES

**(Additional Material Required)**

| | |
|---|---|
| Biological Materials | $ 35.50 |
| Total | $ 35.50 |

### PLANT ANATOMY

**(Additional Material Required)**

| | |
|---|---|
| General Apparatus (for the entire class) | $ 212.50 |
| Total | $ 212.50 |

### PLANT ECOLOGY

**(Additional material field and laboratory equipment)**

| | |
|---|---|
| Demonstration | $1110.50 |
| Class or Student Use | 363.00 |
| Grand total for Plant Ecology | $1473.50 |

### PLANT CYTOLOGY

**(Additional Material Required)**

| | |
|---|---|
| Student Apparatus | $ 243.00 |
| Biology Material | 12.00 |
| Grand total for additional material required for Plant Cytology | $ 255.00 |

### PLANT MICROTECHNIQUE

**(Additional Material Required)**

| | |
|---|---|
| Student Apparatus | $ 830.60 |
| General Apparatus for the Class | 938.15 |
| Stains | 20.50 |
| Reagents | 119.30 |
| Biology Materials, preserved | 25.50 |
| Grand total of additional material for Plant Microtechnique | $1934.05 |
| GRAND TOTAL OF ALL MATERIALS | $12,133.55 |

## COLLEGE CHEMISTRY

The chemistry courses listed below are offered to undergraduate students in the colleges of the United States. Many additional courses are also provided, depending upon the special interests of the staff, the physical equipment of the institution, and the departments for which special services are provided.

| COURSES OFFERED | USUAL CREDIT HOURS |
|---|---|
| General Chemistry | 8 to 10 |
| Qualitative Analysis | 4 to 5 |
| Quantitative Analysis | |
| for majors | 8 to 10 |
| for non-majors | 4 to 5 |
| Organic Chemistry | |
| for majors | 8 to 10 |
| for non-majors | 4 to 5 |
| Physical Chemistry | |
| for majors | 8 to 10 |
| for non-majors | 4 to 5 |
| Biochemistry | 5 |

The chemistry major usually takes some special courses in addition to the courses listed above.

## GENERAL CHEMISTRY

The following list of topics represents the material generally presented in the first year of college chemistry, together with appropriate experiments to accompany the lecture material.

By proper selection and deletion, the material of this course can be combined with selected appropriate material from qualitative analysis to provide the year of general and qualitative analysis for the non-major students.

## OUTLINE OF COURSE CONTENT

I. Introduction
   Purpose of studying chemistry
   A brief history of science
   Relation of chemistry to other sciences

II. The Metric System—Measurements of length, mass and volume; measurements of temperature; density and specific gravity

III. Matter and its varieties—Elements, compounds; law of definite proportions; analysis and synthesis; mixtures

IV. The changes that matter undergoes—Chemical and physical changes

V. The make-up of matter—Atoms and atomic theory; molecules

VI. Atomic structure—Dalton's Theory; particles of matter—protons, neutrons, electrons; complex structure of matter, atomic diagrams

VII. Energy—Transformation; law of conservation of energy; measurements—caloric, calorimeter

VIII. Oxygen—Historical; occurrence; the chemistry of oxygen

IX. The factors influencing the speed of a reaction—Temperature, concentration, catalyst

X. The gas laws—Boyle's and Charles' Laws; standard conditions; Dalton's law of partial pressures; Gay-Lussac

XI. Graham's law of diffusion—Rates of diffusion of gases

XII. The kinetic molecular theory—Avogadro's Law

XIII. Hydrogen—Historical; occurrence; the chemistry of hydrogen; exothermic and endothermic reactions

XIV. Water and hydrogen peroxide—Historical; occurrence; purification of water; law of definite proportions; law of multiple proportions

XV. Molecular and atomic weights—Relative atomic weights; accurate determinations of atomic weights; isotopes; molecular weights—Avogadro's Number

XVI. Problems—Combining weights

XVII. Valence—Electronic definition of valence

XVIII. Equivalent weights of elements

XIX. States of matter—Gases, liquids and solids; relationships between various physical states of matter; allotropic forms—ozone and its chemistry

XX. Solutions—Solute and solvent; three varieties of solutions; concentrations of solutions

XXI. Ionization—Faraday's Laws; ionization theory of Arrhenius; Debye-Huckel theory of complete dissociation; acids, bases and salts; ionic and molecular equations

XXII. Electrolysis and ionization—Ionic explanation of electrolysis

XXIII. Electrochemistry—The electromotive series; various cells; electroplating, electroforming; electrometallurgy

XXIV. Equations—Equations involving no change in valence; equations involving a change in valence

XXV. Chlorine—Historical; occurrence; the chemistry of chlorine

XXVI. Hydrogen chloride and hydrochloric acid

XXVII. Sodium—Historical; occurrence; chemistry of sodium; sodium hydroxide

XXVIII. Acids, bases, salts—pH; Bronsted Theory

XXIX. The periodic table—Lothar, Meyer and Mendeleff; applications and uses

XXX. Radioactivity—Disintegration of radium; artificial transmutation of the elements

XXXI. Rates of reactions—Equilibrium

XXXII. The halogens—Relationship of properties to the position of the halogens in the periodic table; the chemistry of each of the halogens and their salts; the oxygen compounds of the halogens

XXXIII. Sulfur and group 6 of the periodic table—Historical; occurrence; the chemistry of sulfur; selenium and tellurium

XXXIV. The atmosphere—The gases of the atmosphere

XXXV. Nitrogen and group 5 of the periodic table—Chemistry of nitrogen, ammonia, the acids of the nitrogen and their salts; phosphorus, arsenic, antimony and bismuth; comparison of each member of the family as to physical and chemical properties

XXXVI. Silicates and borates—Occurrence; important uses; ceramics, including glass, pottery, etc.; clays

XXXVII. Colloids—Particle size; general properties of colloids; applications of colloidal systems

XXXVIII. The chemistry of carbon and its compounds

XXXIX. Organic chemistry—Definition and history; homologous series; position and functional isomerism

XL. The alkane series of hydrocarbons—Chemistry of the alkanes; derivatives of the alkanes

XLI. The alkene series of hydrocarbons—Chemistry of the alkenes

XLII. Refining of petroleum—Fractional distillation; synthetic petroleum; rubber and synthetic rubber; plastics

XLIII. The alcohols and ethers—Chemistry of alcohols and ethers

XLIV. Organic acids, fats and oils, proteins

XLV. Carbohydrates—Sugars; starch; cellulose

XLVI. The aromatic hydrocarbons from coal tar—Benzene series; products derived from coal tar; drugs, plastics, miscellaneous

XLVII. The metals and metallurgy—Position of the metals in the periodic table; physical and chemical properties of the metals; occurrence of the metals in nature

XLVIII. Metallurgy—Concentration by washing, flotation; roasting of—hydroxides, carbonates, sulfides; reduction with carbon, aluminum, of sulfide ores, electrolysis; refining by electrolysis, distillation

XLIX. Metallurgy of some of the common metals—Sodium, magnesium, aluminum, zinc, lead, tin, copper, iron

L. Alloys—Types of alloys; phase diagram; structure of alloys; some common alloys

LI. Compounds of the metals—Chemical properties of the chlorides. nitrates, sulfides, etc.; physical properties; commercial uses

LII. Qualitative analysis
Separation of the metals into 5 cation groups—chemical equilibrium, the mass law; ionization constants, solubility products; complex ions; amphoteric compounds; oxidation and reduction; hydrolysis
Separation and identification of the anions

LIII. Review—Types of chemical reactions; chemical equations; chemical problems; atomic structure; types of chemical bonds

## LABORATORY EXPERIMENTS

It is not to be expected that any one student will complete every one of the experiments listed below. Selection of the number and type of the experiments will depend upon the type and length of course planned.

Chemical arithmetic—Errors, significant figures, approximations, units
The manipulation of glass tubing
Measurement—the Metric System
Properties of matter—Chemical and physical change
Elements, compounds—Separations from mixtures
Study of a mixture
Chemical change
Accurate weighing and determination of densities
Atomic structure
Sources of oxygen
Catalysis
Preparation of oxygen—Combustion; formation of acids and bases
Weight of a liter of oxygen—Law of definite proportions
Methods of preparing hydrogen
Preparation and properties of hydrogen
Hydrogen as a reducing agent
Weight of a metal to displace a gram-atomic weight of hydrogen—Equivalent weights
Some properties of water-solutions
Hydrogen peroxide
Molecular weights of gases
Solubility—Supersaturated solutions
Hydrates—Efflorescence and deliquescence
Formula of a hydrate—Law of definite proportions

Double decomposition or metathesis
Normal solutions—Equivalent weights
Normal solutions—Acidimetry; titration of solutions
Preparation and properties of chlorine
Hydrogen chloride—Hydrochloric acid
Uses and properties of the oxygen compounds of chlorine
Ionization and chemical action
Electrolysis of a salt solution
Hydrolysis—pH of solutions
The per cent of oxygen in the air
Ammonia—Preparation; properties
Reduction properties of nitric acid
Nitrous oxide
Sulfur—Combination with metals; hydrogen sulfide
Hydrogen sulfide—Properties and uses
Sulfuric acid
Phosphorus
Arsenic, antimony and bismuth
Carbon and its compounds (acetic acid; alcohols; ethers; petroleum; carbohydrates; esters; saponification)
Identification of common acid radicals—Review
Properties of metals and non-metals
Properties of alloys
Metallurgy—General metallurgical principles
Electrochemistry—Cells and batteries
Properties of sodium and its compounds
Hydroxides of the metals
Some potassium compounds—Properties
Ammonium compounds
Tests for potassium, sodium, ammonium salts
Copper compounds
Silver—Photography
Magnesium, calcium, strontium, and borium compounds
Building materials, plasters, mortar, cements
Hard water, testing, softening, and clarification
Zinc, cadmium, and mercury compounds
Aluminum and its compounds
Tin and lead
Chromium and manganese
Iron—Ferric and ferrous compounds
Cobalt and nickel
Systematic identification of metallic ions

## QUALITATIVE ANALYSIS

This is primarily a laboratory course accompanied by appropriate lectures and recitations on the theory. For the shorter course in qualitative analysis, an appropriate selection from the following list can be made to fit the special needs.

### OUTLINE OF COURSE CONTENT

I. Introduction—Definitions; separations; identifications
II. Solutions
III. Solutions of electrolytes
IV. Chemical equilibrium
V. Application of chemical equilibrium—Ionization of weak electrolytic; solubility product constant; water constant
VI. Amphoteric compounds
VII. Complex compounds—Coordination theory; instability constant
VIII. The sulfides—Their precipitation and solution
IX. Oxidation and reduction—Chemical equations
X. Hydrolysis and buffers—pH of solutions; hydrolysis constant
XI. Discussions of group separations

### LABORATORY EXPERIMENTS

Preliminary laboratory work
Preliminary experiments on cation groups
An unknown on the determination of cation groups (first four groups only)

Preliminary experiments on Group I
An unknown on Group I (sample in solution)
Preliminary experiments on Copper Subgroup
An unknown on the Copper Subgroup (sample in solution)
An unknown containing Group I and the Copper Subgroup (sample in solution)
Preliminary experiments on Tin Subgroup
An unknown on the Tin Subgroup (sample in solution)
An unknown on Group II (sample in solution)
Preliminary experiments on Group III
An unknown on Group III (sample in solution) (phosphates and oxalates absent)
*An unknown on Group III (sample in solution) (phosphates and oxalates may be present)
*An unknown on Groups II and III (sample in solution) (phosphates and oxalates may be present)
Preliminary experiments on Group IV
An unknown on Group IV (sample in solution)
Preliminary experiments on Group V
An unknown on Group V (sample in solution)
*A general unknown on the cation groups (sample in solution)
*A general unknown on cations (solid, soluble in water or in dilute acids)
An unknown metal or alloy
Preliminary experiments on anions
Two general unknowns on anions (solids), issued at the same time. The cations are $Na^+$, $K^+$ and $NH_4^+$, and need not be reported.
Two general unknowns (solids), issued at the same time. Report cations and anions.
*$PO_4^{---}$ and $C_2O_4^{--}$, if present, should be included in report.

## QUANTITATIVE ANALYSIS

This outline represents typical experiments and theory for a year of elementary quantitative analysis. The number of experiments chosen will depend upon the amount of time allotted for the laboratory; this list allows of a wide range of selection.

### OUTLINE OF COURSE CONTENT

I. Theory and use of balance

II. Volumetric analysis
- General principles
- Equivalent weight—Normality of solutions; calculations
- Primary standards

III. Neutralizations
- Hydrogen ion concentration and pH
- Indicators, buffers, pH curves
- Titration of weak and strong acids vs. weak and strong bases
- Titration of polybasic acids
- Titration of solutions of hydrolyzed salts
- Mixtures of carbonate and bicarbonate
- Mixtures of carbonate and hydroxide
- Calculations on above topics

IV. Oxidation—Reduction
- Equivalent weight of redox substances
- Balancing redox equations
- Electrochemical theory of oxidation
- Nernst equation, standard oxidation potentials, equilibrium constants
- Use of permanganate, dichromate and cerate solutions

V. Iodimetry and iodometry
- Theory and practice

VI. Volumetric methods
- Those involving precipitation or complex formation
- Theory and practice

VII. Gravimetric analysis
- Errors of weighing
- Special types of balance
- Operations of gravimetric analysis
- Calculations—Use of factors
- Solubility products principle
- Purity of precipitates

VIII. Theory of electroanalysis

IX. Theory of colorimetric analysis

## LABORATORY EXPERIMENTS

*Preparation of acid and base solutions of approximately known strength
*Standardization of acid and base solutions
*Titration of solid acid
*Titration of soda ash
*Preparation and standardization of permanganate solution
Determination of iron in iron ore
*Preparation of standard dichromate solution
*Determination of iron in iron ore
Preparation and standardization of cerate solution
*Determination of calcium in limestone (by permanganate for shorter course; by cerate for longer course)
Preparation and standardization of sodium thiosulfate and iodine solutions
*Determination of copper in copper ore or copper salt, or of antimony in stibnite
Determination of arsenic in arsenious oxide
Titration of bleaching powder
Choice of—*Volhard method for silver; Mohr method for chloride; Cyanide by silver nitrate titration; Fajans adsorption indicator method for halide
Calibration of set of weights
*Determination of chloride as AgCl
*Determination of sulfate as $BaSO_4$
*Determinaton of silica in an insoluble silicate
*Determination of iron as ferric oxide
Analysis of limestone for silica and insoluble $R_2O_3$, calcium oxide, and magnesium oxide
*Determination of magnesium as $Mg_2P_2O_7$
Analysis of monel metal for Cu and Ni
Analysis of brass for Sn, Pb, Cu, and Zn
Use of visual and photoelectric colorimeters
*Determination of manganese in steel by the periodate method
Determination of molybdenum in steel by the thiocyanate method
Determination of iron and copper in water

*Items starred are considered essential for the one semester course provided for the non-majors.

## ORGANIC CHEMISTRY

The essential difference between the course for majors in chemistry and that for non-majors is the time and the emphasis on the various topics. The first fifteen topics are more general and a selection from them will permit of a suitable shorter course. The topics beginning with XVI are more specific and theoretical and are designed for the course for majors.

## OUTLINE OF COURSE CONTENT

I. Introduction
- Definition and history of organic chemistry
- Scope of organic chemistry—Regulation of living processes; foods; clothing; fuels; drugs; war materials; plastics, rubbers, etc.; miscellaneous
- Relationship to inorganic chemistry—Properties of compounds; types of reactions; valence

II. Classification in organic chemistry
- Structure—Isomerism, structural, tautomerism, optical (asymmetric molecules with asymmetric C. S, N atoms; also without asymmetric atoms—allenes, spirans, etc.); cistrans isomers
- Functional groups
- Valence and types of bonds—Polar valence, covalence, coordinate covalence; thermochemistry and bond energy

III. Methane and its derivatives
- Substitution—Halogenation; chlorination; bromination
- Tetrahedral structure
- Oxygen derivatives of methane

IV. Saturated hydrocarbons
Paraffins—Homologous series; general formulas; structure and isomerism; Geneva nomenclature; reactions of paraffins
Petroleum—Source of paraffins and cycloparaffins; origin and history; fractional distillation; constitution; utilization of fractions—gasoline, cracking process
Cycloparaffins—"Strain" theory; reactions of cycloparaffins

V. Unsaturated hydrocarbons
Olefins—Formulas and nomenclature; methods of preparation; reactions; uses—ripening of fruit, anesthetics, manufacture of antifreeze, mustard gas, alcohol, ether
Acetylenic hydrocarbons—Formulas and nomenclature; methods of preparation; reactions; uses—lighting, welding, manufacture of acetic acid, Lewisite, plastics, synthetic rubber
Diolefins—Nomenclature; reactions; natural rubber; synthetic rubber; naturally occurring polyolefins

VI. Aromatic hydrocarbons—Coal tar; nomenclature and structure; reactions of nucleus; reactions of side-chain; uses—drugs, dyes, explosives, DDT

VII. Alcohols
Simple alcohols—Nomenclature and classification; preparation—wood distillation, fermentation, hydration of olefins; reactions; uses
Glycols—Preparation; uses—antifreeze, explosives
Glycerol—Preparation from fat; uses—preservative, explosives, drugs
Naturally occurring alcohols

VIII. Ethers—Preparation; uses—solvents, anesthetics

IX. Aldehydes and ketones—Nomenclature; preparation; reactions; uses—insecticides, fumigants, manufacture of drugs, plastics, synthetic rubber; naturally occurring aldehydes and ketones

X. Acids and their derivatives
Acids—Occurrence and nomenclature; preparation—fermentation, from fats and oils
Acid salts
Acid chlorides
Acid anhydrides
Acid amides
Acid esters — Occurrence and uses; fats and oils — soaps, detergents, oleomargarine, drying oils, metabolism of fats; waxes
Dibasic acids
Hydroxy acids—Occurrence in milk, fruits
Unsaturated acids—Geometrical isomerism; resins, plastics
Carbonic acid—Phosgene; urea—quantitative estimation, uses

XI. Optical isomerism—Forms of lactic acid; polarized light; polarimeter; asymmetric carbons; resolution of racemates

XII. Carbohydrates
Monosaccharides—Glucose or corn sugar; fructose or fruit sugar
Disaccharides—Sucrose or cane sugar; maltose or malt sugar; lactose or milk sugar
Polysaccharides—Starch—structure and occurrence, commercial utilization, metabolism of starch; cellulose—structure and occurrence, rayon, cellulose acetate, cellulose nitrate

XIII. Amines—Structure and nomenclature; preparation; reactions; uses—dyes, drugs, vitamins

XIV. Amino acids and proteins
Amino acids—Structure and occurrence; "essential" amino acids; hormones
Proteins—Structure; tests for proteins; coagulation and precipitation; metabolism of proteins; virus proteins

XV. Natural products
Alkaloids—Nicotine; caffeine
Essential oils
Natural pigments—Chlorophyll; carotenes
Vitamins
Plant growth substances

The following more specific topics necessary for chemistry majors are included at appropriate times in the course. These topics are more theoretical in character.

XVI. Organometallic compounds—Includes discussion of Grignard reaction in some detail; also Li, Zn, Na, etc., compounds

XVII. Active methylene condensations—Discussion of Claissen, Dieckmann, aldol condensations, alkalization of active methylenes, Perkin reaction, Michael reaction, etc.

XVIII. Ring formation and polymers—Ease of formation, stability of alicylicic rings of various sizes, Baeyer Strain theory, ring formation vs. polymer formation, condensation and addition types of polymers, etc.

XIX. Aromatic hydrocarbons—Polycyclic aromatic compounds—naphthalene and anthracene chemistry; quinones

XX. Heterocyclic chemistry—Furanes, thiophene, pyrrole, pyridine, etc.

XXI. Dyes—Common types

XXII. Medicinals

XXIII. Nitro compounds, amines, etc.

XXIV. Sulfur compounds—Mercaptans, etc.

XXV. Phenols and various derivatives

## LABORATORY EXPERIMENTS

For the year course, the number of laboratory experiments will be dependent greatly on the time allowed. For a one-semester brief course, about 15-20 of the experiments listed should be chosen. For two-thirds of a year, about 30-34 of the experiments would be selected. List B includes preparations to be used for the chemistry major course.

Preparation of absolute alcohol
Melting points, determination of, identification of an unknown by melting points
Purification by recrystallization
Fractional distillation, boiling points
Extraction
The amylenes or gasoline (qualitative tests)
Reactions of hydrocarbons
Ethylene dibromide, butyl bromide, or alkyl halides
Properties of alcohols
Tertiary amyl alcohol
Ethyl acetate
Malonic ester
n—Caproic acid
Acetyl chloride
n—Butyl acetoacetic ester
Diethyl ether
Reactions of aldehydes and ketones (with unknown)
2—Heptanone
Methyl salicylate (aspirin)
Acetamide
Methylamine hydrochloride
Succinic anhydride
Cyclopentanone
Bromobenzene
Nitrobenzene
Aniline
Acetanilide
p—Bromoacetanilide
p—Nitroaniline
Methyl orange
Chloro- and cyanobenzene
Benzyl alcohol and benzoic acid
Cinnamic acid and coumarin
Malachite green
Sugars
Polysaccharides
Reactions of proteins

**List B**

o—Benzoylbenzoic acid
Anthraquinone
o—Chlorotoluene
Triphenyl carbinol
Benzophenone oxime and Beckmann Rearrangement
Ethyl *n*—butyl aceto acetate
Methyl *n*—amyl ketone
4—Methyl—$\Delta^4$—tetrahydrophthalic anhydride
4—Cyano—4 phenylpimelonitrile
Polymerization
Characterization of amines
Quinoline
Sulfanilamide

## PHYSICAL CHEMISTRY
### for Chemistry Majors

### OUTLINE OF COURSE CONTENT

I. Introduction—Scientific method; field of physical chemistry; atomic and molecular weights; law of combining weights; Avogadro's Number; sources of chemical information (literature); treatment of laboratory data

II. Gases—Gas laws; molar gas constant, gas density and molecular weights; critical constants; kinetic theory of gases; kinetic equation and deductions

III. Solids—Crystallography; X-rays and crystal structure; X-ray analysis

IV. Physical properties and molecular constitution—Molar volume; molar refraction; specific and molar rotation; absorption of light; Sugden's Parachor; electron diffraction; dipole moments

V. Thermodynamics—First law of thermodynamics; reversible processes; isothermal and adiabatic expansion; heat capacity; Joule-Thomson Effect; second law of thermodynamics; entropy; free energy and work content; spontaneous changes; Carnot cycle; Gibbs-Helmholtz equation

VI. Thermochemistry—Thermochemical equations; laws of thermochemistry; heats of formation and combustion; influence of temperature on heat of reaction

VII. Liquids—General properties; vapor pressure; Clausius-Clapeyron equation; heats of vaporization; surface tension; viscosity; equations of state

VIII. Solutions—Composition of solutions; gases in gases; ideal solutions; gases in liquids; composition diagrams of binary systems; fractional distillation; partially miscible liquid systems; heat of solution

IX. Solutions of non-volatile solutes—Raoult's Law; boiling point elevation; freezing point depression; osmotic pressure; free energy of dilution; Van't Hoff "i"; Arrhenius' Theory

X. Colloids—Preparation of colloids; optical behavior; sedimentation equilibrium; electrical behavior; stability of colloids; adsorption; Donnan equilibrium

XI. Chemical equilibria—Law of mass action; equilibrium constants; free energy changes in chemical reactions (equilibrium box); activity and fugacity; influence of temperature on chemical equilibrium; the principle of LeChatelier

XII. Heterogeneous equilibria and the phase rule—Heterogeneous systems; phase rule; phase diagrams (water, sulfur, ferric chloride and water, alloys); cooling curves: solid solutions; three component systems

XIII. Electrical conductance—Electrical units; specific and equivalent conductance; Faraday's Laws; migration of ions—transference numbers; ionic conductances—Kohlrausch's Law; conductance titrations; electroanalysis; irreversible electrode phenomena

XIV. Electromotive force—Galvanic cells; standard cells; reference electrodes; measurement of electromotive force; temperature coefficient of galvanic cells; electrochemical conventions; standard electrode potentials; equilibrium constant and electromotive force; concentration cells; the hydrogen electrode; potentiometric titrations; junction potentials; activity from electromotive force; storage cells

XV. Ionic equilibria—Ionization of weak electrolytes; common ion effect; ionization of water; heat of ionization; proton theory of acids; hydrolysis; buffer action; theory of indicators; solubility product; interionic attraction; Debye Huckel Theory; theories of conductance

XVI. Chemical thermodynamics—Free energies of formation; influence of temperature on free energy; calculation of activity; partial molal quantities; third law of thermodynamics; thermodynamic calculation of equilibrium constant

XVII. Chemical kinetics—Reaction orders; mathematical analysis of reactions; determination of reaction order; influence of temperature on reaction velocity; kinetic theory of gases; activation energies; catalysis

XVIII. Quantum theory—Laws of radiation; quantum theory; spectroscopy; photoelectric effect; Compton Effect; Raman Effect; energy of dissociation

XIX. Photochemistry—Types of spectra; laws of photochemistry; photochemical kinetics; photography

XX. Nuclear structure—Radioactivity; radio-elements and the periodic table; the packing effect; transmutation; artificial radioactivity; nuclear reactions; nuclear fission and intra-atomic energy

XXI. Atomic structure—Properties of cathode rays; properties of electrons; X-rays and atomic numbers; mass spectra and isotopes; deuterium

XXII. Molecular structure—Valence; electron theory of valence; electrostatic attractions; calculation of activation energies

## LABORATORY EXPERIMENTS

Molecular weight by vapor density (Victor Meyer or Dumas method)
Gas density (by direct weighing method)
Molecular weight of gases (by effusion method)
Vapor pressure of liquids (Ramsey-Young method)
Surface tension of liquids by DuNouy tensiometer, capillary rise method
Molar volume of liquids (using pycnometer and vapor thermostat)
Viscosity of liquids (Ostwald viscometer)
Freezing point depression—Vacuum flask method; Beckmann freezing tube method
Distillation of binary mixtures (refractive index method of analysis)
Steam distillation (determination of molecular weight)
Partial miscibility (two component system)
Heat of neutralization (calorimetric method)
Heat of solution (calorimetric method—electrical)
Distribution of a solute between immiscible solvents
Solubility as a function of temperature
Transition temperature (thermometric method)
Three component systems (mutual solubility)
Cooling curves and freezing point diagrams for two component metallic systems (thermocouple)
Equilibrium constant for organic (liquid) reaction
Transference numbers in cupric sulfate solution (including electroanalysis of solutions)
Electrical conductance of strong and weak electrolytes (Wheatstone Bridge)
Solubility of sparingly soluble salt (by conductance measurements)
Conductance titrations (acids and bases)
Single electrode potentials and standard electrode potentials (potentiometer)
Hydrogen ion activity and pH—Using hydrogen electrode, *quinhydrone electrode, *glass electrode

Potentiometric titration (oxidation-reduction)
Equilibrium constant and free energy from E.M.F. measurements and direct titration method
*Activity of electrolytes and $E^{\circ}$ (by extrapolation to zero concentration)
E.M.F. as a function of temperature (Gibbs-Helmholtz equation)
Chemical kinetics—Hydrolysis of acetal (dilatometric method)
Catalysis—Decomposition of hydrogen peroxide (including effect of temperature)
Density of solutions—Partial molal volume
*Spectrometry (qualitative identification and absorption spectra)
*Refractive index of liquids (also see experiment number 9)
Preparations and properties of colloids
*Adsorption of a solute from solution

*Optional

## PHYSICAL CHEMISTRY
### for Non-majors

### OUTLINE OF COURSE CONTENT

I. Gases—Gas laws; molar gas constant, gas density and molecular weights; critical constants; kinetic theory of gases; kinetic equation and deductions

II. Liquids—General properties; vapor pressure; heats of vaporization; surface tension; viscosity

III. Solutions—Composition of solutions; gases in gases; ideal solutions; gases in liquids; composition diagrams for binary systems; fractional distillation; partially miscible liquid systems; heat of solution

IV. Solutions of non-volatile solutes—Raoult's Law; boiling point elevation; freezing point depression; osmotic pressure; Arrhenius' Theory

V. Chemical equilibria—Law of mass action; equilibrium constants; free energy changes in chemical reactions (equilibrium box); influence of temperature on chemical equilibrium; the principle of LeChatelier

VI. Heterogeneous equilibria and the phase rule—Heterogeneous systems; cooling curves; solid solutions

VII. Conductance—Electrical units; specific and equivalent conductance; Faraday's Laws; conductance titrations; eletroanalysis

VIII. E. M. F.—Galvanic cells; standard cells; measurement of electromotive force; equilibrium constants; hydrogen electrode; potentiometric titration

IX. Kinetics—Rates; reactions; catalysis; influence of temperature on velocity

X. Colloids—Properties; applications of colloidal systems

### LABORATORY EXPERIMENTS

Calibration of thermometers
Determination of the vapor pressure of acetic acid—Dumas method
Surface tension by torsion balance method
Determination of viscosity (capillary viscosimeter)
Heats of neutralization
Partial miscibility—Phenol and water
Molecular weight of sugar by lowering of freezing point
Distribution of solute between immiscible solvents
Clock reactions
Chemical equilibrium
Colorimetric measurement of pH
Transference number by moving boundary method
Adsorption
Colloidal state

# ELEMENTARY BIOCHEMISTRY

## OUTLINE OF COURSE CONTENT

I. Introduction
II. Carbohydrates
III. Fats
IV. Proteins
V. Enzymes
VI. Salivary digestion; gastric digestion and gastric analysis
VII. Pancreatic digestion; intestinal digestion
VIII. Bile
IX. Blood
X. Tissues
XI. Metabolism

## LABORATORY EXPERIMENTS

Carbohydrates
Fats, including $I_2$ and saponification
Proteins
Digestion and (quantitative) gastric analysis
Bile
Blood (qualitative only)
Tissues (isolation of various tissue components)
Urine analysis—Two complete quantitative urine analyses, following qualitative work

## LECTURE DEMONSTRATION APPARATUS

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 5-705 | S18805 | 1 only | Atomic Chart, Hubbard, Wall size, latest version | $ 7.50 |
| 7-965 | S23685 | 6 only | Crucibles, porcelain Coors size 2 55 ml | 2.40 |
| 9-240 | S28745 | 3 only | Drying tubes, U form, tubulated Calcium Chloride 150 mm | 1.50 |
| 9-475 | S29125 | 1 only | Hoffman electrolysis apparatus | 19.00 |
| 9-956 | S33555 | 1 only | Filter pump, Hydro aspirator | 1.50 |
| 10-197 | S34695X | 1 only | Flask, vacuum, Lab. 1 pint, Pyrex | 10.00 |
| 10-420 | S35745 | 2 only | Funnels separatory 60 ml | 4.00 |
| 11-191 | S39055 | 1 only | Gas generator, Kipp, improved form 1 L size | 20.00 |
| 12-821 | S61815X | 2 sets | Models, organic structure | 54.00 |
| 14-365 | S75245 | 2 only | Spatulas, flexible Stainless Steel 100 mm | 1.80 |
| 15-195 | S82135 | 1 only | Tongs Crucible, Brass, riveted | .50 |
| 15-312B | S82565 | 1 only | Trough, pneumatic, glass size B | 4.00 |
| 3-035 | S39535 | 4 only | Bottles, Gas Washing, 250 ml | 13.20 |
| 8-540 | S24635X | 6 only | Cylinders, Wide form, Heavy Ring Neck, 300 mm high, 100 mm dia. | 30.00 |
| | | 1 only | Balance, Demonstration 1 kg-30 mg | 46.75 |
| 8-145 (Size D) | S24005D | 12 only | Crucibles, Clay, melting high form | 1.80 |
| 14-210 | S73865 | 2 only | Sand bath—Shallow form 8" | 1.20 |
| 2-300 | S4285 | 1 set | Weights, Balance Class C 1 gm to 1000 gm | 12.50 |
| | | | Total | $231.65 |

## MATERIALS FOR PREPARATION OF EQUIPMENT

**Glass Tubing, Pyrex, Standard Wall**

| | | | | |
|---|---|---|---|---|
| 11-365 | S40125 | 2 lb. | 7 mm o.d. | $ 1.40 |
| 11-365 | S40125 | ½ lb. | 11 mm o.d. | .35 |
| 11-365 | S40125 | 2 lb. | 15 mm o.d. | 1.40 |
| 11-365 | S40125 | 2 lb. | 19 mm o.d. | 1.40 |
| 11-365 | S40125 | 2 lb. | 25 mm o.d. | 1.40 |

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 11-365 | S40125 | 4 lb. | 41 mm o.d. | $ 3.20 |
| 14-157 | S73505 | 20 ft. | Rubber Tubing, hand made, black pure gum, Med. Wall 3/16 x 3/64 | 2.60 |
| 14-175 | S73555 | 10 ft. | Rubber Tubing, hand made, black pure gum, vacuum, 1/4 x 3/16" | 3.30 |
| 14-155-5 | S73515 | 20 ft. | Rubber Tubing, pure gum, black, 3/16 x 1/16" | 4.80 |
| 14-130 | S73305 | 1 lb. | Assorted Solid rubber stoppers | 1.50 |
| 7-785 | S23055 | 100 | Assorted corks, XXX quality, regular length | 1.90 |
| 15-545 | S85135 | 4 oz. | Wire, Copper, soft, bare, B & S No. 20 | .50 |
| 5-772 | A113 | 24 only | Clamps, round jaw, burette | 18.00 |
| | | | Total | $41.75 |

## GENERAL CHEMICAL APPARATUS FOR ALL COURSES

| | | | | |
|---|---|---|---|---|
| 9-022 | S27465 | 1 only | Distilling Apparatus Barnstead 10 gal | $460.00 |
| 9-023 | S27565 | 1 only | Low water cutoff 10 gal. 1 hr | 99.00 |
| 3-140 | S8545 | 48 only | Bottles, Reagent, flint glass, raised lettering 16 oz., Blank | 31.60 |
| 3-140 | S8545 | 12 only | Acetic Acid | 7.90 |
| 3-140 | S8545 | 12 only | Ethyl Alcohol | 7.90 |
| 3-140 | S8545 | 12 only | Ammonium Hydroxide | 7.90 |
| 3-140 | S8545 | 12 only | Ammonium Hydroxide, dilute | 7.90 |
| 3-140 | S8545 | 12 only | Ammonium oxalate | 7.90 |
| 3-140 | S8545 | 12 only | Barium Chloride | 7.90 |
| 3-145 | S8545 | 12 only | Calcium Chloride (Engraved Name) | 18.00 |
| 3-140 | S8545 | 12 only | Ether | 7.90 |
| 3-140 | S8545 | 12 only | Hydrochloric Acid, Conc. | 7.90 |
| 3-140 | S8545 | 12 only | Hydrochloric Acid, Dil. | 7.90 |
| 3-140 | S8545 | 12 only | Nitric Acid, Conc. | 7.90 |
| 3-140 | S8545 | 12 only | Nitric Acid, Dil. | 7.90 |
| 3-140 | S8545 | 12 only | Potassium dichromate | 7.90 |
| 3-140 | S8545 | 12 only | Silver Nitrate (Amber) | 7.90 |
| 3-140 | S8545 | 12 only | Sodium Carbonate | 7.90 |
| 3-140 | S8545 | 12 only | Sulfuric Acid, Conc. | 7.90 |
| 3-140 | S8545 | 12 only | Sulfuric Acid, Dil. | 7.90 |
| 3-140 | S | 12 only | Sodium hydroxide | 7.90 |
| 3-140 | S | 12 only | Potassium hydroxide | 7.90 |
| 14-639 | S77365 | 1 only | Plug-easer | 30.00 |
| 2-716 | S12555 | 1 only | National Blow Torch Hand model (Gas-air, gas-oxygen-gas Air lg Tips) | 9.00 |
| 2-470 | S30915 | 1 only | Storage Battery—Heavy Duty Lead | 19.27 |
| 11-464A (7" dia.) | S41005-7 | 2 only | Hot plates—round—3 heat 110V 60C AC | 25.00 |
| 11-403 | S40395 | 2 only | Safety Goggles Clear glass, Chem. Workers | 3.30 |
| 14-292 | | 1 only | Safety Shields (glass) | 25.00 |
| 14-098-5 | S40305-10 | 2 only | Pairs Rubber Glove, Heavy Duty, Synthetic | 8.00 |
| 10-022 | S33785 | 1 only | First Aid Cabinet, Complete | 23.50 |
| | | 1 only | Projection Lantern Standard, Blower, opaques and slide | 159.60 |
| 10-012 | | 3 only | Fire extinguishers, liquid $CO_2$ | 72.00 |
| 7-880 | S23245 | 2 only | Cork rollers | 7.00 |
| | | 1 only | Tool set, Laboratory Complete | 65.00 |
| 6-665 | S19795 | 100 yds. | Cheese Cloth, single weight | 15.00 |
| 12-075 | S44605 | 1 gro. | Matches, Safety | 1.50 |
| | | 1 cs. | Soap Castile | 7.00 |
| 11-855 (#219) | S44105 | 1 doz. boxes | Labels, Plain 19 x 38 | 1.30 |
| 11-875 | S44155 | 12 only | Label Books, printed chemical | 14.50 |
| 11-313A | | 1 only | Glass Cutter, Hot wire up to 7½" dia., for 110 volt 50-60 cycle AC | 27.50 |
| 11-314 | | 1 only | Pkg. extra wires | .25 |
| 13-874-70B | | 1 only | Screen, projector, metal case type 45" x 60" | 16.70 |
| | | 1 only | Soldering iron 12" | 5.00 |
| | | 2 lbs. | Solder, wire form | 2.00 |
| | | | Extra bulb for projector above 500 Watt 110V | 2.50 |
| | | | Total | $1308.45 |

# GENERAL CHEMISTRY EQUIPMENT NECESSARY FOR 20 STUDENTS

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 1-440 | S1185 | 24 only | Asbestos Mats 4" x 4" x 1/16" | $ .60 |
| 2-035 & 2-300 | S3215-4285 | 2 only | Harvard Trip Scales (with weights 1-1000 g), Sens. 0.1, Cap. 2000 g | 70.00 |
| 2-140 | S3475 | 20 only | Balances—Hand (Horn Pan Type) | 75.00 |
| 2-275 | S4275 | 20 sets | Balance Weights—10 mg—50 gm | 115.00 |
| 2-383-5 | A175 | 1 only | Barometer, mercurial | 25.25 |
| 3-573 | S9985 | 24 only | Test Tube Brushes | 4.08 |
| 3-960 | S12265 | 20 only | Bunsen Burners | 36.00 |
| 5-772 | A113 | 20 only | Clamps, rustproof, small, Burette | 15.00 |
| 5-774 | | 20 only | Clamps, rustproof, large, Burette | 19.00 |
| 7-785 | S23055 | 500 | Corks, assorted sizes | 8.50 |
| 7-845 | S23175 | 1 set | Cork borers 6 in set | 2.00 |
| 7-865 | S23205 | 1 only | Cork borer sharpener | 2.50 |
| 8-050 | S23835 | 20 only | Crucibles, iron, diameter 20cc | 3.80 |
| 7-955 | S23665 | 48 only | Crucibles, porcelain No. 00 Coors | 9.60 |
| 8-690 | S25505 | 48 only | Dishes, Coors porcelain, evap. 8cm | 12.48 |
| | | 30 only | Electrodes, carbon, dia. 4.5 mm | 2.00 |
| 9-725 | S32235 | 48 only | Files, triangular 6" | 13.92 |
| 10-280 | S35155 | 24 prs. | Forceps, iron 5" | 3.84 |
| 15-590 | S85335 | 36 only | Gauze, iron wire, asbestos center 5 x 5 | 7.20 |
| 5-841 | S19565 | 24 only | Test tube clamps | 2.88 |
| 12-015 | S44385 | 10 only | Magnets, horseshoes 3" | 11.00 |
| 12-055 | S44465 | 10 only | Magnifiers, Tripod | 10.00 |
| 12-096 | S44685 | 12 only | Meter sticks, grad. in in. on reverse side | 7.80 |
| 12-962 (Size 00) | S62235C | 24 only | Mortars 8 cm, Coors porc., with 10 cm pestle | 13.44 |
| 9-795 | S32915 | 48 only | Pks. paper, filter, qualitative 12.5 cm | 13.44 |
| 9-795 | S32915 | 24 only | Pks. paper, filter qualitative 20 cm | 13.20 |
| T-46 | S65255 | 24 only | Vials, paper litmus, blue | 2.88 |
| T-52 | S65255 | 24 only | Vials, paper litmus, red | 2.88 |
| 5-850B | S19495 | 24 only | Pinchcocks | 5.04 |
| 13-765 | S70115 | 6 ft. | Platinum wire No. 24 (Approximately 8 grams) | 32.00 |
| 14-770 | S79005 | 20 only | Test tube racks | 22.00 |
| 14-415 | S75935 | 24 only | Sponges, grass | 21.60 |
| 8-575 | S24855 | 24 only | Spoons, deflagrating iron ½" | 4.80 |
| 14-430 | S75215 | 24 only | Spoons, Coors porcelain, spatula end, 123 mm | 9.60 |
| 14-725 | S78835 | 20 only | Filter stands—2 funnel | 32.00 |
| 14-680 | S78365 | 24 only | Iron stands, with 2 rings | 41.28 |
| 14-135 & 14-140 | S73305-15-25 | 6 lb. | Assorted rubber stoppers No. 0-6, 1 and 2 hole | 9.00 |
| 14-985 | S80005 | 24 only | Thermometers Chemical —5° to +250° | 50.40 |
| 15-280 | S82415-1½ | 24 only | Triangles, pipestem, for No. 00, crucible size A | 4.80 |
| 15-300 | S82505 | 24 only | Tripods, iron ring 5" O.D. | 18.00 |
| 14-157 | S73505 | 100 ft. | Rubber tubing, for Bunsen burners, ¼ x 1/16 | 16.00 |
| 14-157 | S73505 | 50 ft. | Rubber tubing, soft 3/16 x 3/64 | 6.50 |
| | S30635 | 4 only | Voltmeters, Student type, single range, specify range | 84.00 |
| 3-995 | S13005 | 24 only | Wing tops for Bunsen burners 13 mm | 5.76 |
| 2-540 | S4675 | 60 only | Beakers 100 ml. Pyrex | 12.00 |
| 2-540 | S4675 | 60 only | Beakers 150 ml. Pyrex | 10.80 |
| 2-540 | S4675 | 60 only | Beakers 250 ml. Pyrex | 10.20 |
| 2-540 | S4675 | 42 only | Beakers 400 ml. Pyrex | 10.08 |
| 2-540 | S4675 | 36 only | Beakers 600 ml. Pyrex | 10.44 |
| 2-890 | S8295 | 8 doz. | Bottles, widemouth 8 oz | 8.64 |
| 2-890 | S8295 | 4 doz. | Bottles, widemouth 16 oz | 5.76 |
| 3-699 | S10635 | 24 only | Burettes, 50 ml. with Stopcock | 46.32 |
| 10-040 | S34105 | 33 only | Flasks, Erlenmeyer 250 ml. Pyrex | 7.59 |
| 10-035 | S33825 | 30 only | Flasks, Florence 125 ml. Pyrex | 6.00 |
| 10-035 | S33825 | 36 only | Flasks, Florence 50 ml. Pyrex | 6.48 |
| 10-199 | S34815 | 4 only | Flasks, Volumetric 100 ml. Exax | 2.20 |
| 10-320 | S35305 | 24 only | Funnels 60° 6.5 cm | 8.88 |
| 10-320 | S35305 | 24 only | Funnels 60° 9 cm | 10.80 |
| 11-410 | S40455 | 24 only | Graduates, tall, 30 ml | 17.52 |

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 11-410 | S40455 | 24 only | Graduates, short, 125 ml | $ 24.24 |
| 13-649 | S69515 | 24 only | Pipettes, 10 ml | 10.56 |
| 13-720 | S69945 | 96 only | Glass Plates 3 x 3 | 7.68 |
| 13-735 | S69975 | 24 only | Plates, Cobalt, glass 3 x 3 | 3.12 |
| 11-377 | S40085 | 4 lb. | Rods, glass, 8 mm, Pyrex | 2.80 |
| 9-215 | S28815 | 24 only | Tubes, Calcium Chloride, 100 mm | 4.80 |
| 14-955 | S79515 | 36 only | Tubes, Test hard glass 150 x 16 mm | 1.80 |
| 14-915 | S79505 | 36 only | Tubes, Test soft 8 x 1 in | 3.00 |
| 14-915 | S79505 | 36 doz. | Tubes, Test soft 6 x ¾ in | 20.16 |
| 10-457 | S35895 | 2 doz. | Tubes, Thistle 30 cm stem 6 mm dia., Pyrex | 4.08 |
| 9-235 | S28735 | 24 only | Tubes, U, dia. 7/16", height 4" | 5.52 |
| 11-365 | S40125 | 3 lbs. | Tubing, hard glass, 15 mm dia. Pyrex | 2.10 |
| 11-350 | S40135 | 15 lbs. | Tubing, soft glass, med. walls O.D. 7 mm | 9.00 |
| 2-610 | S83605 | 48 only | Watch glasses 3" dia | 3.60 |
| 15-311 | | 20 only | Troughs, pneumatic seamless—enameled 12¼" | 25.00 |
| | | | Total | $1167.24 |

## ALSO

| | | |
|---|---|---|
| 5 lbs. | Developer suitable for plate or film order above | $ 5.00 |
| 10 lbs. | Acid fix for same | 5.00 |
| 1 only | Arc support, spectograph | 30.00 |
| 12 doz. | Carbon Graphite Rods ¼" x 6" | 84.24 |
| 1 only | Safe-light, red | 4.00 |
| 2 only. | Trays, Enameled Steel, 10 x 12 | 1.80 |
| | Total | $130.04 |

## AND THIS

| | | |
|---|---|---|
| 1 only | Grating Spectrograph, Vertical racking film holder, for first order spectograms app. 25 cm in length, between 2350 and 7000 Angstroms, grating, camera, apparatus masks complete | $450.00 |
| 20 bxs. | Photographic film (Panchromatic) for use with above Spectrograph | 28.00 |
| Total Equipment and Supplies | | $1775.28 |

## OR THIS

| | | |
|---|---|---|
| 1 only | Spectrometer, Student Model, with adjustable prism table, 15 cm collimator | $250.00 |
| 1 only | Prism for above 22.5 mm high x 45 mm long | 25.00 |
| 1 only | Comparison prism for above | 10.00 |
| 1 only | Prism clamp for above | 5.00 |
| 1 only | Camera attachment for above | 125.00 |
| 20 bxs. | Photographic Plates—Spectrographic 12 plates per box 6½ x 9 cm | 40.00 |
| | | $455.00 |
| Total Equipment and Supplies | | $1752.28 |

# CHEMICALS

## FOR GENERAL CHEMISTRY FOR 20 STUDENTS FOR ONE YEAR

| | | |
|---|---|---|
| 2 lbs. | Acid, acetic, 36%, U.S.P. | $ .72 |
| ½ lb. | Acid, hydrofluosilicic, C.P., in Ceresine bottle | 1.60 |
| 24 lbs. | Acid, hydrochloric, Sp. gr. 1.19, C.P. | 7.60 |
| 28 lbs. | Acid, nitric, sp. gr. 1.42 ACS, C.P. | 9.80 |
| ½ lb. | Acid, perchloric, 60% solution, sp. gr. 1.54 ACS, C.P. | 1.30 |
| 36 lbs. | Acid, sulfuric, sp. gr. 1.84 C.P. | 10.00 |
| ½ lb. | Acid, tartaric, crystals, C.P., ACS | 1.40 |
| 2 lbs. | Agar-agar, white | 9.00 |
| 2 lbs. | Aluminum metal, sheet, No. 20 B & S gauge | 2.64 |

| | | |
|---|---|---|
| 2 lbs. | Aluminum metal, rod | $ 2.60 |
| ½ lb. | Aluminum chloride, C.P., anhydrous, sublimed | 1.80 |
| 2 lbs. | Aluminum sulfate, C.P. crystals | 1.80 |
| 2 lbs. | Ammonium carbonate, C.P., ACS | 1.60 |
| 2 lbs. | Ammonium chloride, C.P., ACS | 1.04 |
| 16 lbs. | Ammonium hydroxide, sp. gr. 0.90, C.P., ACS | 5.40 |
| ½ lb. | Ammonium molybdate, crystals, C.P. | 1.50 |
| ½ lb. | Ammonium nitrate, crystals, C.P., ACS | .80 |
| ½ lb. | Ammonium oxalate, large crystal, C.P., ACS | 1.20 |
| ½ lb. | Ammonium sulfate, C.P., ACS | .70 |
| ½ lb. | Antimony metal, powder | .80 |
| ½ lb. | Antimony trichloride, crystals, C.P. | 1.90 |
| ½ lb. | Arsenic trioxide, C.P., ACS | 2.10 |
| 2 oz. | Babbitt metal | .80 |
| 2 lb. | Barium Chloride, C.P., ACS | 1.20 |
| ½ lb. | Barium nitrate, crystals, C.P., ACS | .90 |
| 2 lb. | Bauxite, Powd. | .50 |
| 2 oz. | Bell metal | 1.00 |
| 2 oz. | Bismuth metal, granular, C.P. | .90 |
| ½ lb. | Bismuth trichloride, C.P. | 3.60 |
| ½ lb. | Bromine, C.P., ACS | 2.00 |
| ½ lb. | Cadmium nitrate, C.P., crystals | 1.80 |
| 10 lbs. | Calcium carbonate, marble chips | 1.70 |
| ½ lb. | Calcium magnesium carbonate (dolomite) | 1.00 |
| 2 lbs. | Calcium chloride, anhydrous, lump reagent, special ACS | 2.10 |
| ½ lb. | Calcium fluoride, C.P. powder | 1.60 |
| ½ lb. | Calcium nitrate, C.P. | .90 |
| 4 lbs. | Calcium oxide, (quick lime) Techn. Powd. | 1.00 |
| 2 lbs. | Calcium phosphate, crude (bone ash) | .50 |
| 2 lbs. | Calcium sulfate, (Native gypsum) | .66 |
| 4 lbs. | Calcium sulfate, calcined (Plaster of Paris) | 1.32 |
| 2 lbs. | Carbon disulfide, C.P. ACS | 1.20 |
| 2 lbs. | Charcoal, animal, powder | .80 |
| 2 lbs. | Charcoal, wood, powder | .70 |
| 2 lbs. | Chromic anhydride C.P. ACS (chromium trioxide) | 3.60 |
| ½ lb. | Chromium nitrate, C.P., Granular | 1.20 |
| ½ lb. | Cobalt nitrate, C.P. | 2.20 |
| 2 lbs. | Copper metal, foil, .008 inch thick, electrolytic | 1.98 |
| 4 lbs. | Copper metal, turnings, light | 3.40 |
| 2 Spools | ¼ lb. copper wire, B & S No. 24 | .80 |
| ½ lb. | Cupric chloride, crystals, C.P. | 1.00 |
| ½ lb. | Cupric nitrate, C.P. ACS | 1.20 |
| ½ lb. | Cupric oxide, powder, C.P., ACS | 1.40 |
| 4 lbs. | Cupric sulfate, crystals, C.P., ACS | 2.40 |
| 2 lbs. | Ether, ethyl, C.P., ACS | 1.70 |
| ½ lb. | Ferrous ammonium sulfate, C.P. | .80 |
| 2 lbs. | Glucose, anhydrous, C.P. | 1.30 |
| 2 lbs. | Glycerin, white, U.S.P., C.P. | 1.44 |
| 2 lbs. | Hydrogen peroxide 3%, 10-volume, U.S.P. | .60 |
| ½ lb. | Iodine, C.P., resublimed, ACS | 2.90 |
| 2 lbs. | Iron filings, coarse | .80 |
| 200 gms. | Iron nails, small | 4.00 |
| 2 Spools | Iron wire, for standardizing, 1 oz. ea. | .80 |
| 2 lbs. | Iron carbonate, ferrous pwd., N.F. | 1.60 |
| ½ lb. | Iron chloride, ferric, C.P., lumps, ACS | .70 |
| 2 lbs. | Iron oxide, ferric, C.P. | 1.54 |
| 2 lbs. | Iron oxide, magnetic, black | 1.00 |
| 2 lbs. | Iron sulfate, ferrous, C.P. fine crystals | 1.60 |
| 4 lbs. | Iron sulfide, ferrous, stick | 1.60 |
| 1 lb. | Lead metal, granular, silver-free | .50 |
| 2 lbs. | Lead nitrate, C.P. crystals, ACS | 1.80 |
| 2 lbs. | Lead dioxide, (peroxide) brown, C.P. Special, powder | 3.00 |
| 2 lbs. | Lead monoxide, litharge, yellow, C.P. | 1.40 |
| 2 lbs. | Lead tetroxide, red lead, C.P. | 1.20 |
| ½ lb. | Magnesium metal, powder | 1.58 |
| 4 oz. | Magnesium metal, ribbon, 1/8 inch wide | 1.70 |
| 2 lbs. | Magnesium carbonate, C.P. | 3.30 |
| 2 lbs. | Magnesium chloride, crystals, C.P., ACS | 2.50 |
| 2 lbs. | Magnesium sulfate, crystals (Epsom Salt) | .30 |
| 2 lbs. | Manganese dioxide C.P. | 2.50 |
| ½ lb. | Manganese nitrate T.P. 50% solution | 1.20 |

| | | |
|---|---|---|
| 2 lbs. | Mercury metal, C.P. | $ 8.22 |
| ½ lb. | Mercuric chloride, C.P. powder ACS | 2.84 |
| ½ lb. | Mercuric nitrate, C.P. | 3.38 |
| 1 lb. | Mercuric oxide, red, C.P. | 4.94 |
| ½ lb. | Mercurous nitrate, C.P. | 3.56 |
| 2 oz. | Methyl orange indicator | 1.00 |
| ½ lb. | Naphthalene, white, resublimed, C.P. | 1.10 |
| ½ lb. | Nickel nitrate, C.P. | 1.30 |
| ½ lb. | Nickel ammonium sulfate, C.P. | 1.06 |
| 2 lbs. | Paraffin, solid, medium, m.p. 52° C | .70 |
| 2 oz. | Pewter metal | .60 |
| 2 oz. | Phenolphthalein, reagent, ACS | .80 |
| ½ lb. | Phosphorus, red, amorphous | .90 |
| ½ lb. | Phosphorus, yellow, sticks, 5/8" | 1.20 |
| 2 lbs. | Potassium aluminum sulphate, C.P., ACS | 1.30 |
| ½ lb. | Potassium bromide, C.P., ACS | .90 |
| 2 lbs. | Potassium carbonate, anhydrous, C.P., ACS | 1.70 |
| 2 lbs. | Potassium chlorate, crystals, C.P., ACS | 2.00 |
| 2 lbs. | Potassium chloride C.P. | 1.36 |
| 2 lbs. | Potassium dichromate, fine gran | 1.60 |
| ½ lb. | Potassium ferricyanide, C.P., ACS | 1.90 |
| ½ lb. | Potassium ferrocyanide, C.P., ACS | 1.00 |
| 2 lbs. | Potassium hydroxide, sticks, C.P., ACS | 1.84 |
| ½ lb. | Potassium iodide, crystals, C.P., ACS | 2.20 |
| 2 lbs. | Potassium nitrate crystals, C.P., ACS | 1.46 |
| 2 lbs. | Potassium permanganate, C.P. | 2.40 |
| ½ lb. | Potassium sulfate, crystals, C.P., ACS | .80 |
| 2 lbs. | Potassium thiocyanate, C.P. | 3.70 |
| 2 lbs. | Siliceous earth (Kieselguhr), pure, white | .90 |
| ½ lb. | Silver nitrate, reagent, ACS | 7.50 |
| ½ lb. | Sodium metal, C.P., ACS | 1.14 |
| ½ lb. | Sodium ammonium phosphate, C.P. | .90 |
| 2 lbs. | Sodium bicarbonate, powder, C.P., ACS | .90 |
| 2 lbs. | Sodium carbonate, anhydrous, C.P., ACS | 1.14 |
| 10 lbs. | Sodium chloride, crystals, C.P., ACS | 4.60 |
| 2 lbs. | Sodium chloride, rock salt, coarse | .40 |
| 2 lbs. | Sodium dichromate, C.P. | 1.60 |
| 4 lbs. | Sodium hydroxide, reagent, pellets, ACS | 2.80 |
| 2 lbs. | Sodium nitrate, C.P., ACS | 1.60 |
| 2 lbs. | Sodium nitrite, crystals, C.P., ACS | 1.80 |
| ½ lb. | Sodium peroxide, in sealed can, Parr | .80 |
| 2 lbs. | Sodium phosphate, primary (monobasic), C.P. | 1.70 |
| 2 lbs. | Sodium phosphate, secondary (dibasic) crystals, C.P., ACS | 1.20 |
| 2 lbs. | Sodium potassium tartrate, crystals, C.P., ACS | 2.60 |
| 2 lbs. | Sodium sulfate, crystals, C.P. | 1.50 |
| 2 lbs. | Sodium sulfite, anhydrous, C.P., ACS | 1.00 |
| 2 lbs. | Sodium tetraborate, crystals, C.P., ACS | 1.10 |
| 2 lbs. | Sodium thiosulfate, crystals, C.P., ACS | 1.10 |
| 2 oz. | Solder | .60 |
| 2 lbs. | Starch, arrowroot, powdered | .80 |
| 16 ft. | Steel drill rod, (diam. 1/16 inch) | 2.00 |
| 2 oz. | Stereotype metal | .50 |
| ½ lb. | Strontium nitrate, C.P. | 1.20 |
| 2 lbs. | Sucrose, U.S.P. | 1.20 |
| 2 lbs. | Sulfur, U.S.P. (sublimed Flowers of Sulfur) | .60 |
| 2 lbs. | Sulfur, roll, (Brimstone) | .50 |
| 2 lbs. | Tin metal, C.P., granular, 30 mesh | 4.90 |
| ½ lb. | Tin chloride, stannic, anhydrous, fuming C.P | 1.50 |
| ½ lb. | Tin chloride, stannous, crystals, C.P., ACS | 1.20 |
| 2 lbs. | Toluene, C.P. | 1.00 |
| 4 lbs. | Zinc metal, C.P., granular, 20 mesh, ACS | 3.60 |
| 2 lbs. | Zinc metal, sheet, for standardizing, in strips, ½ x 6½ inches | 2.54 |
| ½ lb. | Zinc nitrate, C.P. | 1.00 |
| ½ lb. | Zinc oxide, wet process, C.P | 1.00 |
| ½ lb. | Zinc sulfate, C.P., ACS | .70 |
| 2 lbs. | Wood's metal, sticks | 5.20 |
| | Total | $278.10 |

## QUALITATIVE ANALYSIS SEMIMICRO FOR 20 STUDENTS

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 2-540 | S4675 | 40 only | Beakers Pyrex 50 ml. | $ 7.60 |
| 2-540 | S4675 | 40 only | Beakers Pyrex 100 ml. | 8.00 |
| 2-540 | S4675 | 40 only | Beakers Pyrex 250 ml. | 6.80 |
| 2-982 | | 576 | Bottles, dropping screw top 15 ml | 57.60 |
| 3-340 | | 288 | Bottles 12 ml., screw top | 14.40 |
| 14-065 | S73135 | 120 | Medicine dropper bulbs, 1 ml. capacity | 2.00 |
| 3-960 | S12265 | 20 | Bunsen Burners | 36.00 |
| 4-067 | S11915 | 20 | Micro Burners | 22.00 |
| 4-695 | S46775 | 40 | Porcelain, Casseroles 15 ml. | 24.00 |
| 9-725 | S32235 | 20 | Triangular files 6" | 5.80 |
| 9-805 | S33215 | 20 pkgs. | Filter paper No. 1 4.25 cm | 3.00 |
| 10-040 | S34105 | 24 | Erlenmeyer Flask Pyrex 50 ml | 4.32 |
| 10-040 | S34105 | 24 | Erlenmeyer Flask pyrex 125 ml | 4.56 |
| 10-320 | S35305 | 24 | Funnel, S. Stem 65 mm | 8.88 |
| 10-320 | S35305 | 48 | Funnel, S. Stem 40 mm | 16.80 |
| 11-375 | S40075 | 2 lbs. | Glass Rod 3 mm, soft glass | 1.60 |
| 11-350 | S40135 | 2 lbs. | Glass Tubing 4 mm, soft glass | 1.60 |
| 8-549 | S24675 | 24 | Cylinder, Graduated 10 ml | 13.20 |
| T-52 | S65255 | 24 | Litmus Paper vials red | 2.40 |
| T-46 | S65255 | 24 | Litmus Paper vials blue | 2.40 |
| 13-735 | S69975 | 24 | Cobalt Glass Plate 3" x 3" | 4.08 |
| 13-720 | S69945 | 96 | Glass Plates 3" x 3" | 7.68 |
| | | 20 | Reagent Blocks Trays | 10.00 |
| 14-157 | S73505 | 20 ft. | Rubber Tubing gum 3/16 x 3/64 | 2.60 |
| 14-157 | S73505 | 100 ft. | Rubber Tubing Black 1/4 x 1/16 | 16.00 |
| 14-157 | S73505 | 50 ft. | Rubber Tubing black 3/16 x 3/64 | 6.50 |
| 14-372 | | 24 | Spatulas Nickel Metal | 18.00 |
| | S48620 | 24 | Test Plate 6 holes | 6.96 |
| | S10006 | 24 | Micro Test tube Brush | 3.12 |
| | S19555 | 20 | Test tube holder—Micro | 2.00 |
| | 7530C | 24 | Test tube rack, micro | 13.44 |
| 14-955 | S79515 | 240 | Test Tubes, pyrex 3" | 7.20 |
| 14-955 | S79515 | 120 | Test Tubes, pyrex 125 mm | 4.80 |
| 14-986 | S80005 | 24 | Thermometer −10 to 110° | 36.00 |
| 2-610 | S83605 | 48 | Watch glasses 5 cm | 5.76 |
| | | 20 | Water bath, micro, top only | 30.00 |
| 15-590 | S85335 | 20 | Wire gauze 4 x 4 | 2.00 |
| | | | Total | $419.10 |

## GENERAL QUALITATIVE

| | | | |
|---|---|---|---|
| 4-970 | 5 | Centrifuges, Safety head | $175.00 |
| C-544 | 2 x 1 lb. | Hydrogen Sulfide cubes or similar paraffin—Sulfur Mixture | 2.50 |
| | | Total | $177.50 |

## CHEMICALS FOR 20 STUDENTS IN QUALITATIVE ANALYSIS

| | | | |
|---|---|---|---|
| 2x5 lb. | Acid Acetic Glacial | $4.20 | |
| 5 Gal. | Alcohol, Ethyl 95% den | 8.25 | |
| 10 gm. | Aluminon Reagent | .65 | |
| 1 lb. | Aluminum Nitrate .9$H_2O$ T.P. | 1.10 | |
| 1 lb. | Ammonium Acetate T.P. | 1.00 | |
| 5 lbs. | Ammonium Chloride T.P. | 2.35 | |
| 8 lbs. | Ammonium Hydroxide T.P. | 2.70 | |
| ¼ lb. | Ammonium Molybdate T.P. | .75 | |
| 1 lb. | Ammonium Oxalate T.P. | 1.40 | |
| 1 lb. | Ammonium Sulfide T.P. Light | .55 | |
| 1 lb. | Ammonium Sulfate T.P. | .57 | |
| ¼ lb. | Ammonium Sulfocyanate T.P. | .90 | |
| 1 lb. | Iso-Amyl Alcohol C.P. | 1.30 | |
| ¼ lb. | Antimony penta chloride C.P. | 1.20 | |
| ¼ lb. | Antimony tri chloride T.P. | $ .95 | |
| ¼ lb. | Arsenic trioxide T.P. ACS | 1.05 | |
| ¼ lb. | Barium Acetate T.P. | .78 | |
| 1 lb. | Barium Hydroxide 8$H_2O$ T.P. | .75 | |
| 1 lb. | Barium Nitrate T.P. | 1.10 | |
| ¼ lb. | Bismuth Nitrate 5$H_2O$ T.P. | 1.00 | |
| 1 lb. | Bromine T.P. | 2.00 | |
| 1 lb. | Cadmium Nitrate .4$H_2O$ T.P. | 2.75 | |
| 1 lb. | Calcium Acetate .1$H_2O$ T.P. | 1.60 | |
| 5 lb. | Calcium Oxide Techn. Lumps | 1.00 | |
| 1 lb. | Calcium Nitrate T.P. | .95 | |
| 1 lb. | Calcium sulfate T.P. Ppt | .80 | |
| 2 lbs. | Carbon Tetrachloride Techn | .70 | |
| 1 oz. | Chlorplatinic acid 6$H_2O$ C.P. | 44.00 | |

| | | |
|---|---|---|
| 1 lb. | Chromium nitrate $9H_2O$ T.P. | $1.50 |
| 1 lb. | Cobalt Nitrate $6H_2O$ T.P. | 3.00 |
| 1 lb. | Copper Nitrate $3H_2O$ T.P. | 1.25 |
| 1 oz. | Dimethyl glyoxime T.P. | .75 |
| 2 lbs. | Ether | 1.50 |
| 1 lb. | Ferric Chloride $6H_2O$ T.P. | .60 |
| 1 lb. | Ferrous Ammonium Sulfate $6H_2O$ T.P. | .65 |
| 1 lb. | Ferrous Sulfate $7H_2O$ T.P. | .80 |
| 18 lbs. | Hydrochloric acid conc. T.P. | 5.70 |
| ¼ lb. | Hydrofluoric acid 48% T.P. | .65 |
| 2 lbs. | Hydrogen peroxide 3% U.S.P. | .60 |
| ¼ lb. | Iodine T.P. | 1.45 |
| ¼ lb. | Lanthanum Nitrate $6H_2O$ CP. | 6.50 |
| 1 lb. | Lead Acetate $3H_2O$ T.P. | .65 |
| 1 lb. | Lead Nitrate T.P. | .90 |
| 5 lbs. | Manganese dioxide Native Powd. | 1.50 |
| 2 lbs. | Magnesium Chloride T.P. | 2.50 |
| 1 lb. | Magnesium Nitrate $6H_2O$ T.P. | 1.00 |
| 1 oz. | Uranium Acetate T.P. | .80 |
| 1 lb. | Magnesium Acetate $4H_2O$ T.P. | 1.80 |
| 1 lb. | Manganese nitrate T.P. 50% Solution | 1.30 |
| 1 lb. | Mercurous Chloride U.S.P. | 3.39 |
| 1 lb. | Mercuric Chloride U.S.P. | 2.70 |
| 1 lb. | Mercuric Nitrate $2H_2O$ T.P. | 4.98 |
| 1 lb. | Mercurous Nitrate $H_2O$ T.P. | 5.28 |
| 2 lbs. | Methyl Alcohol T.P. | 1.22 |
| 1 lb. | Nickel Nitrate $6H_2O$ T.P. | 1.50 |
| 21 lbs. | Nitric Acid Conc. T.P. | 7.35 |
| 7 lbs. | Phosphoric Acid 85% U.S.P. | 2.73 |
| ¼ lb. | Potassium Antimoniate C.P. | 2.75 |
| 5 lbs. | Potassium Chloride T.P. | 3.10 |
| 3 lbs. | Potassium Chromate Pure | 1.80 |
| ¼ lb. | Potassium Cyanide T.P. | 1.00 |
| 1 lb. | Potassium Ferricyanide T.P. | 1.25 |
| 1 lb. | Potassium Ferrocyanide $3H_2O$ T.P. | 1.25 |
| 5 lbs. | Potassium Hydroxide U.S.P. Sticks | 3.30 |
| 1 lb. | Potassium Iodide U.S.P. | 1.80 |
| 1 lb. | Potassium Nitrite T.P. | 2.25 |
| 2 lbs. | Potassium Permanganate T.P. | 2.40 |
| 1 lb. | Potassium Sodium Tartrate T.P. | 1.30 |
| 1 lb. | Sodium Acetate T.P. Cryst. | .80 |
| 1 lb. | Sodium Arsenate $7H_2O$ T.P. | $1.25 |
| 1 lb. | Sodium Arsenite T.P. | 1.30 |
| 2 lbs. | Sodium Borate U.S.P. Powd. | 60 |
| 1 lb. | Sodium Bromide U.S.P. | .56 |
| 5 lbs. | Sodium Carbonate Techn. Calc. | 1.35 |
| 5 lbs. | Sodium Chloride Techn. | .75 |
| 1 lb. | Sodium Fluoride Techn. Tinted | .40 |
| ¼ lb. | Sodium Iodide $2H_2O$ U.S.P. | 1.25 |
| 5 lbs. | Sodium Nitrate Refined Gran. | 1.90 |
| 1 lb. | Sodium Nitrite Techn. | .45 |
| 1 lb. | Sodium Diphosphate Techn. | .30 |
| 2 x 1 qt. | Sodium Silicate Solut. | .80 |
| 5 lbs. | Sodium Sulfate $10H_2O$ U.S.P. | 1.75 |
| 2 lbs. | Sodium Sulfide Techn. Cryst. | .70 |
| 2 lbs. | Sodium Sulfite $7H_2O$ Pure Cryst. | .60 |
| 1 lb. | Sodium Tartrate $2H_2O$ Pure | 1.30 |
| 2 lbs. | Sodium Thiosulfate $5H_2O$ Techn. | .40 |
| 1 lb. | Stannic Chloride Techn. Cryst. | 1.60 |
| 1 lb. | Stannous Chloride $2H_2O$ Techn. | .90 |
| ¼ lb. | Strontium Acetate C.P. | 1.25 |
| ¼ lb. | Strontium Nitrate T.P. | .60 |
| 27 lbs. | Sulfuric Acid Conc. T.P. | 7.50 |
| 1 lb. | Zinc Nitrate $6H_2O$ T.P. | 1.00 |
| 1 lb. | Zinc Sulfate $7H_2O$ Techn. Cryst. | .35 |
| 1 lb. | Aluminum Turnings | .84 |
| 5 lbs | Asbestos Powd. | 1.00 |
| 2 lbs. | Calcium Fluoride Native Powd. | .70 |
| 1 lb. | Copper wire bare No. 20 | 1.00 |
| 1 lb. | Copper Oxide T.P. Black Powd. | 2.00 |
| 1 lb. | Dextrose Techn. Powd. | .35 |
| 5 lbs. | Ferrous Sulfide Lumps | 1.50 |
| 2 lbs. | Potassium Carbonate Techn. | .70 |
| 2 bxs. | Iron Tacks | 1.00 |
| 1 lb. | Micro Cosmic Salt T.P. | .85 |
| 1 lb. | Potassium Bisulfate T.P. Cryst. | .80 |
| 1 lb. | Potassium Chlorate N.F. Cryst. | .50 |
| 2 lbs. | Sodium Peroxide T.P. Calorific | 3.00 |
| 1 lb. | Starch Corn U.S.P. | .25 |
| ¼ lb. | Tin foil 1/2000" | .55 |
| ¼ lb. | Tumeric | .30 |
| 5 lbs. | Mossy Zinc Techn. | 2.30 |
| 5 lbs. | Potassium Nitrate U.S.P. | 2.10 |
| | Total | $222.00 |

## GENERAL LABORATORY EQUIPMENT FOR 20 STUDENTS IN QUANTITATIVE ANALYSIS

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 1-931 | S2595 | 5 only | Balances, Analytical, Cap. 200 g, Sensitivity 1/20 mg | $930.00 |
| 2-015 | S3435 | 3 only | Triple Beam Scales, 111 gm Capacity | 64.50 |
| 2-100 | S3365 | 1 only | Balance, Solution 20 kg. Capacity | 83.00 |
| 2-224 | | 5 sets | Weights, Balance 5 mg to 100 g | 112.50 |
| 2-383-5 | A175 | 1 only | Barometer, Mercurial | 25.25 |
| 2-887 | S8475 | 4 only | Bottles, Pyrex 5 gal. capacity | 18.00 |
| 2-470 | S30915 | 1 only | Battery, Storage, 6V | 37.00 |
| 3-005 | S8865 | 20 only | Bottles, Dropping 30 ml. Schuster | 17.60 |
| 3-118 | S8622 | 12 only | Bottles, Reagent, Pyrex, Acetic Acid, 16 oz | 16.42 |
| 3-118 | S8622 | 12 only | Bottles, Reagent, Pyrex, Ammonium Hydroxide, 16 oz. | 16.42 |
| 3-118 | S8622 | 12 only | Bottles, Reagent, Pyrex, Barium Chloride, 16 oz. | 16.42 |
| 3-118 | S8622 | 12 only | Bottles, Reagent, Pyrex, Bromine Water, 16 oz. | 16.42 |
| 3-118 | S8622 | 12 only | Bottles, Reagent, Pyrex, Hydrochloric Acid, Conc., 16 oz. | 16.42 |

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 3-118 | S8622 | 12 only | Bottles, Reagent, Pyrex, Hydrochloric Acid, Dil., 16 oz... | $ 16.42 |
| 3-118 | S8622 | 12 only | Bottles, Reagent, Pyrex, Nitric Acid, Conc., 16 oz | 16.42 |
| 3-118 | S8622 | 12 only | Bottles, Reagent, Pyrex, Nitric Acid, Dil., 16 oz | 16.42 |
| 3-118 | S8622 | 12 only | Bottles, Reagent, Pyrex, Sodium Phosphate, 16 oz | 16.42 |
| 3-118 | S8622 | 12 only | Bottles, Reagent, Pyrex, Sulfuric Acid, Conc., 16 oz | 16.42 |
| 3-118 | S8622 | 12 only | Bottles, Reagent, Pyrex, Sulfuric Acid, Dil., 16 oz | 16.42 |
| 3-118 | S8622 | 12 only | Bottles, Reagent, Pyrex, Ammonium Molybdate, 16 oz | 16.42 |
| 3-118 | S8622 | 12 only | Bottles, Reagent, Pyrex, Ammonium Oxalate, 16 oz | 16.42 |
| 3-118 | S8622 | 12 only | Bottles, Reagent, Pyrex, Blank, 16 oz | 16.42 |
| 7-101 | | 1 only | Colorimeter, photoelectric, complete with cells, filters, 110V, AC, 60 C | 195.00 |
| 7-102 | | 6 only | Absorption Cells for above 23 ml | 3.00 |
| 7-165 | S20485 | 1 only | Colorimeter, Duboscq Type | 180.00 |
| 7-170 | S20505 | 6 only | Colorimeter Cups 50 mm | 48.00 |
| 7-845 | S23175 | 1 set | Cork Borers (9/set) | 3.25 |
| 7-880 | S23245 | 1 only | Cork Press | 3.50 |
| 7-865 | S23205 | 1 only | Cork Borer Sharpeners | 2.50 |
| 9-261 | S29465 | 2 only | Electro Analyzers (2 spindle) 110V AC 60 C | 700.00 |
| | | 4 only | Glass stirrers for above | 4.00 |
| 9-307 | S29632 | 4 only | Electrodes, Platinum, 11 gm. | 320.00 |
| 9-309 | S29672 | 4 only | Electrodes, Platinum, 25 gm. | 280.00 |
| 9-273 | S29675 | 1 only | Mercury Cathode Cell, Melaven | 4.50 |
| 9-313 | S29705 | 1 only | Electrometric Titration Apparatus, Stirrer, 110V AC | 160.00 |
| 9-313-8 | S29735 | 1 only | Platinum electrode for above | 9.50 |
| 9-313-12 | S29725 | 1 only | Tungsten electrode for above | 3.00 |
| 9-313-17 | | 1 only | Calomel electrode for above | 7.50 |
| 9-958 | S33565 | 20 only | Aspirator pumps | 38.00 |
| 13-245A | S64135 | 1 only | Oven, Drying, 115V AC—Inside 12 x 12 x 12½ Range 35°-200°C | 170.00 |
| 8-600 | S25015 | 5 only | Dessicators 10" | 71.75 |
| | | | Total | $3721.23 |

## COLLEGE COURSE IN QUANTITATIVE CHEMICAL ANALYSIS

The following equipment is to be issued as standard desk equipment for 20 students in Quantitative and Technical Analysis.

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 2-540 | S4675 | 20 only | Beakers, 150 ml. Pyrex, low-form | $ 3.60 |
| 2-540 | S4675 | 20 only | Beakers, 250 ml. Pyrex, low-form | 3.40 |
| 2-540 | S4675 | 20 only | Beakers, 400 ml. Pyrex, low-form | 4.80 |
| 2-540 | S4675 | 20 only | Beakers, 600 ml. Pyrex, low-form | 5.80 |
| 2-540 | S4675 | 20 only | Beakers, 1000 ml. Pyrex, low-form | 11.20 |
| 2-609 | A126 | 20 only | Watch Glasses 4 inch | 4.00 |
| 2-610 | S83605 | 20 only | Watch Glasses 75 mm | 1.58 |
| 2-610 | S83605 | 20 only | Watch Glasses 100 mm | 2.00 |
| 2-610 | S83605 | 20 only | Watch Glasses 125 mm | 2.58 |
| 2-620 | A127 | 20 only | Beaker Tong | 35.00 |
| 2-901 | S8255 | 20 only | Bottle, R.S. Round, Flint, 1000 ml | 12.00 |
| 2-907 | S8375X | 20 only | Bottles, G.S. Round, Flint, 500 ml | 14.00 |
| 2-907 | S8375X | 20 only | Bottles, G.S. Round, Flint, 1000 ml | 22.00 |
| 2-917 | S8355 | 20 only | Bottles, G.S. Round, Amber, 250 ml | 10.00 |
| 2-917 | S8355 | 20 only | Bottles, G.S. Round, Amber, 1000 ml | 18.00 |
| 3-393 | S9365X | 20 only | Bottle, Wash, 1 liter | 20.00 |
| 3-415 | S9495 | 20 only | Bottle, Weighing 15 ml., Low Form | 12.00 |
| 3-415 | S9495 | 20 only | Bottle, Weighing 30 ml., Low Form | 14.40 |
| 3-415 | S9495 | 20 only | Bottle, Weighing 60 ml., Low Form | 24.00 |
| 3-699 | S10635 | 20 only | Burettes, 50 ml., Straight, Blue Line Exax | 38.60 |
| 3-960 | S12265 | 20 only | Burners, Universal | 36.00 |
| 3-995 | S12995 | 20 only | Wing Tops, for 11 mm. tube | 3.20 |
| 4-695-3A | S14725 | 20 only | Casseroles 210 ml., Coors 180-3A Porcelain | 20.40 |
| 5-772 | A113 | 20 only | Burette Clamp, Single, Rustproof | 15.00 |
| 7-965 | S23685 | 20 only | Crucibles, Coors 230-0 Porcelain, High Form | 4.00 |
| 7-970 | S23695 | 20 only | Crucible Covers, Coors, 240-0, Porcelain | 1.60 |
| 8-030 | S23915 | 4 only | Crucibles, Platinum, 20 ml. (16 grams) approximately | 280.00 |
| 8-035 | S-23915X | 4 only | Crucible covers, Platinum, for 20 ml. Crucible (4 grams) approximately | 80.00 |

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 8-195 | S24315 | 20 only | Gooch Crucibles, Coors 270-3, Porcelain | $10.60 |
| 8-236 | S24402 | 20 only | Fritted Glass Crucibles, Low Form, Medium, 15 ml. Pyrex | 23.00 |
| 8-285 | S24475 | 20 only | Crucible Holder, Walter | 9.00 |
| 8-549 | S24675 | 20 only | Cylinder, Graduated 10 ml., Blue Line Exax | 11.00 |
| 8-549 | S24675 | 20 only | Cylinder, Graduated 100 ml., Blue Line Exax | 16.60 |
| 8-595 | S25005 | 20 only | Dessicator 150 mm. ins. diam. | 105.00 |
| 8-635 | S25185 | 20 only | Dessicator Plate, Porcelain, 140 mm. 5 holes | 36.00 |
| 9-725 | S32235 | 20 only | Triangular File, length 4" | 4.40 |
| 9-850 | S33155 | 20 pkg. | Whatman #41, 15 cm. Filter Paper, Double Washed, Soft | 47.00 |
| 9-855 | S33175 | 20 pkg. | Whatman #42, 15 cm. Filter Paper, Double Washed, Dense | 47.00 |
| 10-040 | S34105 | 20 only | Flasks, F.B. 250 ml., Erlenmeyer, Pyrex | 4.60 |
| 10-040 | S34105 | 20 only | Flask, F.B. 500 ml., Erlenmeyer, Pyrex | 5.60 |
| 10-090 | S34125 | 20 only | Flasks,Wide Mouth, Erlenmeyer, 250 ml. Pyrex | 4.60 |
| 10-180 | S34365 | 20 only | Flasks, Filter 500 ml. Pyrex | 21.40 |
| 10-204 | S34845 | 20 only | Flask, Volumetric, Blue Line Exax, Standard Tapered Stopper, 250 ml | 19.40 |
| 10-204 | S34845 | 20 only | Flask, Volumetric, Blue Line Exax, Standard Tapered Stopper, 500 ml | 25.80 |
| 10-204 | S34845 | 20 only | Flask, Volumetric, Blue Line Exax, Standard Tapered Stopper, 1000 ml | 30.00 |
| 10-326F | S35345 | 20 only | Funnels, long stem, 75 mm. diam., Pyrex, Fluted | 8.20 |
| 10-435 | S35805 | 20 only | Funnels, Separatory 250 ml., pear shaped | 51.00 |
| 12-960 | S62235-D | 20 only | Mortar and Pestle #1 Coors Porcelain | 14.20 |
| 13-649 | S69515 | 20 only | Transfer Pipette 10 ml. Blue Line Exax | 8.80 |
| 13-649 | S69515 | 20 only | Transfer Pipette 25 ml. Blue Line Exax | 11.00 |
| 13-649 | S69515 | 20 only | Transfer Pipette 50 ml. Blue Line Exax | 14.40 |
| 13-664 | S69565 | 20 only | Pipette, graduated 10 ml., Mohr Measuring | 11.00 |
| 13-700 | S69695 | 20 only | Medicine Dropper | 1.00 |
| 14-050 | S73045 | 20 only | Iron Rings, 4 inch | 8.60 |
| 14-104 | S73225 | 20 only | Policeman, Rubber | 2.00 |
| 14-120 | S40095-150 | 20 only | Glass Rod for Policeman, dia. 3/16" | 1.00 |
| 14-357 | S75290 | 20 only | Scoopula | 5.00 |
| 14-371 | S75285 | 20 only | Spatula, 4 inch blade, Stainless Steel | 26.00 |
| 14-670 | S78305 | 20 only | Ring Stands, Medium Size | 24.00 |
| 14-686 | S78405 | 20 only | Support, Small Size | 45.00 |
| 14-687 | S78435 | 20 only | Universal Clamp | 50.00 |
| 14-688 | A118 | 20 only | Burette Support, with White Porcelain Base and Double Burette Clamp | 130.00 |
| 14-730 | S78855 | 20 only | Funnel Holder, 4 hole | 35.00 |
| 14-955 | S79515 | 20 only | Test Tubes 18 x 150 mm Pyrex, Flared | 1.00 |
| 14-985 | S80005 | 20 only | Thermometer —5 deg. to 360 deg. C | 40.00 |
| 15-193 | S82146 | 20 only | Crucible Tongs, Stainless Steel | 15.00 |
| 15-255 | S82445X | 20 only | Nichrome Triangles, 3 inch | 4.00 |
| 15-270 | S82465 | 20 only | Quartz Triangles, 2 inch | 30.00 |
| 15-300 | S82505 | 20 only | Tripods, 6 inch | 19.00 |
| 15-518A | S-84215X | 20 only | Water Bath, 8 inch with 3 holes and covers, all brass | 130.00 |
| 15-545 | S85135 | 20 only | Copper Wire, 24 gauge, ¼ lb. spools | 10.80 |
| I-63 | S85245X | 1 oz. | Iron Wire, 30 gauge | 8.00 |
| 15-585 | S85315 | 20 only | Wire Gauze 4" x 4", Nickel Chromium | 7.40 |
| | | | Total | $1831.56 |

## QUANTITATIVE CHEMICAL ANALYSIS CHEMICALS FOR A CLASS OF 20 STUDENTS

| | | |
|---|---|---|
| 4 x 1 lb. | Arsenious Acid, TP ACS | $11.00 |
| 1 case | Acid Hydrochloric, conc. TP 10x6 lbs. per case | 12.10 |
| 4 x 1 lb. | Acid Hydrofluoric, TP ACS | 5.20 |
| 1 case | Acid Nitric, TP ACS, 10x7 lbs. per case | 16.70 |
| 4 x 1 lb. | Acid Oxalic, cryst. TP ACS | 3.40 |
| 1 case | Acid Phosphoric, ortho, 85% TP ACS 10x7 lbs. per case | 32.80 |
| 1 case | Acid Sulfuric TP ACS, 10x9 lbs. per case | 15.40 |
| 5 x 5 lb. | Ammonium Chloride, TP ACS | 11.75 |
| 5 x 1 lb. | Ammonium Fluoride, cryst. CP | 20.00 |

| | | |
|---|---|---|
| 1 case | Ammonium Hydroxide, TP ACS, 10x4 lbs. per case | $11.10 |
| 5 x 1 lb. | Ammonium Oxalate TP, ACS | 7.00 |
| 2 x 5 lb. | Ammonium Persulfate, TP ACS | 6.50 |
| 2 x 5 lb. | Ammonium Phosphate, dibasic, TP ACS | 12.00 |
| 2 x 1 lb. | Asbestos, Acid-washed | 10.00 |
| 2 x 5 lb. | Barium Chloride, TP ACS | 5.60 |
| 2 x 1 lb. | Bromine, TP ACS | 4.00 |
| 4 x 1 lb. | Calcium Carbonate, ppt. TP | 4.00 |
| 8 x 1 lb. | Calcium Hypochlorite, tech | 2.80 |
| 4 x 1 lb. | Ceric Ammonium sulfate, cp | 24.00 |
| 4 x 1 lb. | Ceric Sulfate, C.P. Anhydrous | 15.00 |
| 4 x 1 lb. | Copper (ic) Sulfate, cryst. TP ACS | 2.40 |
| 2 x 25 lb. | Calcium Chloride, Tech. indicating 4 mesh | 11.50 |
| 4 x 5 lb. | Ether, Ethyl, anhyd. TP ACS | 15.80 |
| 4 x ¼ lb. | Fluorescein, Alkali Soluble | 11.00 |
| 4 x 5 lb. | Iron (ic) Ammonium Sulfate TP ACS | 13.00 |
| 4 x 5 lb. | Iron (ous) Ammonium Sulfate, TP ACS | 11.80 |
| 4 x 5 lb. | Iron (ous) Sulfate, TP | 15.00 |
| 6 x 1 lb. | Magnesium Chloride, cryst. TP ACS | 7.50 |
| 4 x 5 lb. | Manganese Sulfate, $4H_2O$ ACS | 20.80 |
| 4 x 1 lb. | Mercuric Chloride, cryst. TP ACS | 16.24 |
| 1 x 1 lb. | Methyl Orange, C.P | 4.75 |
| 2 x 4 oz. | Methyl Red, C P | 8.00 |
| 6 x 5 gms | Phenanthroline, ortho, monohydrated | 60.00 |
| 2 x 1 lb. | Phenolphthalein, U.S.P. | 2 80 |
| 4 x 5 lb. | Potassium Bichromate, Fine Cryst. ACS, TP | 14.60 |
| 4 x 5 lb. | Potassium Chromate, TP ACS | 16.40 |
| 4 x 5 lb. | Potassium Cyanide, TP | 53.00 |
| 6 x 1 lb. | Potassium Hydrogen Phthalate, TP ACS | 13.80 |
| 4 x 5 lb. | Potassium Iodide, cryst. TP ACS | 59.00 |
| 4 x 5 lb. | Potassium Permanganate, cryst. TP ACS | 23.00 |
| 6 x 1 lb. | Potassium Thiocyanate, TP | 11.10 |
| 4 x 1 lb. | Silver Nitrate, cryst. TP ACS | 56.00 |
| 4 x 5 lbs. | Sodium Bicarbonate, powd. TP ACS | 8.60 |
| 4 x 5 lbs. | Sodium Carbonate, anhyd. TP ACS | 10.40 |
| 4 x 5 lbs. | Sodium Chloride, TP ACS | 9.20 |
| 4 x 100 g. | Sodium Diethyldithiocarbonate C. P. | 9.00 |
| 2 x 25 lbs. | Sodium Hydroxide, pellets, TP ACS | 23.00 |
| 2 x 5 lbs. | Sodium Molybdate, TP | 26.00 |
| 2 x 5 lbs. | Sodium Oxalate, TP | 17.00 |
| 4 x 1 lb. | Sodium Periodate, C.P. Para | 96.00 |
| 2 x 5 lbs. | Sodium Sulfite, TP | 4.60 |
| 4 x 5 lbs. | Sodium Thiosulfate, TP ACS | 9.60 |
| 4 x 1 lb. | Starch soluble TP | 4.00 |
| 4 x 1 lb. | Sulfur, ppt. (Lac Sulfur) USP | 3.00 |
| 20 tubes | Test Paper, Litmus blue, ACS | 1.40 |
| 20 tubes | Test Paper, Litmus Red, ACS | 1.40 |
| 2 x 5 lbs. | Metallic Tin, 20 mesh TP | 24.00 |
| 2 x 5 lbs. | Tin (ous) Chloride, cryst. TP | 12.50 |
| 2 x 5 lbs. | Urea, TP | 9.00 |
| 2 x 5 lbs. | Zinc Metal, gran. 40 mesh | 8.50 |
| | Total | $955.04 |

## GENERAL LIST OF ORGANIC CHEMISTRY APPARATUS FOR 20 STUDENTS

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 2-033 | S3455 | 2 only | Balances, Triple beam .1 gm-610 gm capacity with weights 1610 gm—complete | $30.00 |
| 7-845 | S23175 | 2 sets | Cork borers, brass—permanent handles, set of 15 borers | 14.00 |
| 7-880 | S23245 | 1 only | Cork press for corks up to 1⅝" | 3.50 |
| 7-865 | S23205 | 1 only | Cork borer sharpener | 2.50 |
| 1-435 | S1175 | 4 only | Asbestos sheets 42 x 48 x 1/16 | 4.80 |
| 3-902 | S12165 | 2 only | Burner, high temperature | 5.50 |
| 7-785 | S23055 | 10 bags | Corks, XXX, Assorted 6-15 | 19.00 |

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 7-890 | S23265 | 2 lbs. | Cotton, Absorbent, unsterilized | $ 2.20 |
| G-23 | S40225 | 2 lbs. | Glass Wool, pyrex dia. 0002-0003" | 5.40 |
| 14-130 | S73305 | 5 lbs. | Rubber stoppers, solid, assorted 00-8 | 7.50 |
| 14-215 | S73875 | 20 only | Sand bath, deep, hemispherical 10" iron | 30.00 |
| 14-415 | S75935 | 20 only | Sponge, grass, unwashed | 12.00 |
| 14-635-5 | | 4 cans | Stop Cock lubricant, acid and alkali proof, providing air tight seals up to 100° C., in 2 oz. cans | 5.00 |
| 15-545 | S85135 | 4 only | Spools of Copper Wire No. 20, (each ¼ lb.) | 1.96 |
| 11-311 | S39835 | 2 lbs. | Glass beads, perforated,4 mm dia. | 6.60 |
| 2-383-5 | A175 | 1 only | Barometer, mercurial | 25.20 |
| 1-107A | S71245 | 1 only | Air pump, pressure or vacuum | 70.00 |
| 11-292 | S39745 | 4 only | Manometers | 80.00 |
| 11-350 | S40135 | 30 lbs. | Glass Tubing 8 mm soft glass | 18.00 |
| 11-350 | S40135 | 30 lbs. | Glass Tubing 13 mm soft glass | 15.00 |
| 13-947 | | 1 only | Refractometer for 110 V AC or DC | 50.00 |
| 11-502 | | 2 only | Steam Safety heaters | 19.00 |
| | | | Total | $427.21 |

## ORGANIC CHEMISTRY DESK APPARATUS FOR 20 STUDENTS

| | | | | |
|---|---|---|---|---|
| 10-060 | S33855 | 24 only | Flask—R.B.L.N. 1 L. | $15.12 |
| 10-065 | S33865 | 24 only | Flask—R.B.S.N. 1 L. | 14.88 |
| 10-065 | S33865 | 24 only | Flask—R.B.S.N. 500 ml. | 10.32 |
| 10-065 | S33865 | 24 only | Flask—R.B.S.N. 200 ml. | 7.68 |
| 10-040 | S34105 | 48 only | Flask, Erlenmeyer 200 cc | 10.08 |
| 10-040 | S34105 | 24 only | Flask, Erlenmeyer 500 cc | 6.72 |
| 10-040 | S34105 | 48 only | Flask, Erlenmeyer 50 cc | 8.64 |
| | | 24 only | Flasks Wurtz 50 cc | 7.00 |
| | | 24 only | Flasks Wurtz 125 cc | 12.00 |
| | | 24 only | Flasks Wurtz 250 cc | 14.40 |
| 10-170 | S34045 | 24 only | Flasks, Claissen 125 cc | 33.84 |
| 2-540 | S4675 | 60 only | Beakers Griffin 50 ml. | 11.40 |
| 2-540 | S4675 | 60 only | Beakers Griffin 150 ml. | 10.80 |
| 2-540 | S4675 | 42 only | Beakers Griffin 400 ml. | 10.08 |
| 2-540 | S4675 | 48 only | Beakers Griffin 600 ml. | 13.92 |
| 2-540 | S4675 | 48 only | Beakers Griffin 800 ml. | 16.80 |
| SS-6180 | S35350 | 24 only | Funnels 2" Short Stem Pyrex | 7.92 |
| C-6180 | S35350 | 24 only | Funnels 4" Short Stem Pyrex | 11.52 |
| 8-549 | S24675 | 24 only | Cylinders, Graduated 10 ml. | 13.20 |
| 8-562 | S24765 | 24 only | Cylinders, Graduated 100 ml., short form | 26.40 |
| 10-405 | S35695 | 24 only | Separatory funnel 250 cc | 63.30 |
| 9-215 | S28815 | 24 only | Calcium Chloride Drying tube, 100 mm | 4.80 |
| 1-025 | S575 | 24 only | Adaptors 105°, lime glass, length 180 mm | 7.68 |
| 14-986 | S80005 | 24 only | Thermometers 5°-250°C—Student Grade | 50.40 |
| 7-715 | S22635 | 48 only | Condensers, Liebig 500 mm resistance glass sealed | 93.60 |
| 7-709 | S22585 | 24 only | Condenser Tube 50 cm, for 25 cm Jacket | 8.40 |
| 11-375 | S40075 | 4 lb. | Glass Rod, 8 mm, soft glass | 2.40 |
| 2-880 | S8235 | 6 doz. | Bottles 4 oz. | 5.04 |
| 2-880 | S8235 | 12 doz. | Bottles 2 oz. | 8.64 |
| 9-956 | S33555 | 24 only | Aspirators | 36.00 |
| 14-915 | S79505 | 12 doz. | Test Tubes, soft glass ¾ x 6" | 6.72 |
| 10-356 | S35555 | 20 only | Funnel, Buchner 4 inch, Size 2A | 51.60 |
| 10-180 | S34365 | 20 only | Flask, Suction 500 ml. | 21.40 |
| 8-690 | S25505 | 20 only | Dishes, Evap. Porc. 3", Size 00A | 4.80 |
| 8-690 | S25505 | 20 only | Dishes, Evap. Porc. 7", Size 7 | 24.00 |
| 2-610 | S83605 | 24 only | Watch glass 6 inch | 4.08 |
| 14-157 | S73505 | 400 ft. | Rubber Tubing 3/16 x 3/64 | 52.00 |
| 5-772 | A113 | 24 only | Burette Clamps | 18.00 |
| 15-195 | S82135 | 20 only | Crucible Tongs, Brass 9" | 11.00 |
| 5-841 | S19565 | 24 only | Test tube holders | 2.88 |
| 15-590 | S85335 | 48 only | Gauze Wire 5 x 5 | 9.60 |
| 3-915 | S11735 | 48 only | Burners, Bunsen | 38.40 |
| 5-733 | A102 | 40 only | Condenser Clamps extension | 32.00 |
| 5-756 | A106 | 80 only | Clamp holders | 28.80 |
| 14-055 | S73055 | 40 only | Iron rings 3" extension | 15.20 |
| 5-847 | A122 | 40 only | Clamps, screw | 20.00 |
| 12-140 | S44885 | 3 only | Melting Point Tubes (Thiele-Dennis) Pyrex | 4.05 |

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 9-801 | S32935 | 50 bxs. | Filter Paper 9 cm Med. Qual | $10.50 |
| 14-365 | S75245 | 20 only | Spatula, Stainless Steel 4" blade | 18.00 |
| 14-670 | S78305 | 40 | Supports, ring stands 24" | 70.00 |
| 7-835 | S23125 | 40 | Cork rings | 36.00 |
| 14-955 | S79515 | 10 doz. | Test tubes, pyrex 150 x 16 | 6.00 |
| 14-915 | S79505 | 20 doz. | Test tubes, soft glass 3" | 6.80 |
| 13-664 | S69565 | 24 only | Pipettes 10 ml, graduated 1/10 ml | 13.20 |
| 2-610 | S83610 | 24 only | Watch glasses 75 mm | 1.80 |
| 3-995 | S12995 | 20 only | Wing tops for burners, brass, 11 mm | 3.20 |
| 7-965 | S23685 | 20 only | Crucibles, porcelain, tall form 30 ml | 6.40 |
| 9-725 | S32235 | 20 only | Files, triangular 6" slender | 5.80 |
| 12-960 | S62235D | 20 only | Mortar and Pestle, Porcelain 100 mm | 14.20 |
| T-46 | S65255 | 24 only | Litmus Paper, vials, blue | 2.88 |
| T-52 | S65255 | 24 only | Litmus Paper, vials, red | 2.88 |
| 13-752 | S70005 | 20 only | Plate, Porous, clay 6" | 6.00 |
| 14-175 | S73555 | 60 ft. | Tubing, Rubber ¼ x ⅛ vacuum or pressure | 19.80 |
| 14-770 | S79005 | 20 only | Test tube supports, wood, 13 place double row | 22.00 |
| | | | Total | $1132.97 |

## ORGANIC CHEMISTRY CHEMICALS FOR 20 STUDENTS FOR ONE YEAR

| | | |
|---|---|---|
| 200 g. | Acetaldehyde, B.P. 20-22°C | $ 1.40 |
| 200 g. | Acetamide, M.P. 79-80°C | 1.15 |
| 200 g. | Acetanilide, M.P. 113-114°C | .65 |
| 2 kg. | Acetic Anhydride, 99-100% | 7.80 |
| 30 lbs. | Acetic Acid, Glacial T.P. | 12.60 |
| 10 lbs. | Acetone, U.S.P. | 3.60 |
| 1 kg. | Acetyl Chloride (Pract.) | 5.00 |
| 1 kg. | Adipic Acid, M.P. 151-153 C.P. | 1.80 |
| ¼ lb. | Allyl Alcohol B.P. 95.5-97°C C.P. | .65 |
| ½ lb. | Aluminum Sulfate (reagent) | .90 |
| 2 lbs. | Aluminum Chloride, Anhydrous Tech. | 1.60 |
| 3 kg. | Aniline (pract.) B.P. 77-79°C—15 mm | 2.35 |
| 1 kg. | Anthracene M.P. 213 C.P. | 45.00 |
| ¼ lb. | Ammonium Chloride (reagent) | .35 |
| ¼ lb. | Ammonium Molybdate C.P. | .75 |
| ¼ lb. | Ammonium Sulfate, C.P. | .35 |
| 1 kg. | n-Amyl Alcohol, B.P. 135-137 Pract. | 1.65 |
| ¼ lb. | Barium Chloride, reagent | .40 |
| ½ lb. | Barium hydroxide T.P. | .80 |
| 3 kg. | Benzaldehyde (pract.) | 6.60 |
| 6 kg. | Benzene (pract.) B.P. 79-81 | 1.80 |
| 200 gm. | Benzoic Acid, M.P. 120-121° | .85 |
| 100 gm. | Benzyl Alcohol, B.P. 92-94°C @ 8 m.m. | .60 |
| 100 gm. | Benzyl Chloride, B.P. 75-77°C @ 22 m.m. | .60 |
| ½ lb. | Bran | .50 |
| 6 lbs. | Bromine, Tech. | 6.66 |
| 1 kg. | Bromobenzene B.P. 154-155° | 3.50 |
| 200 gm. | Benzene sulfonyl chloride, M.P. 13-14°C | 1.05 |
| 1 kg. | Benzophenone M.P. 47-48 | 5.00 |
| 1 kg. | Benzoyl Chloride M.P.—0.5 | 1.95 |
| 6 kg. | n-Butyl Alcohol B.P. 116-118°C | 11.10 |
| 1 kg. | tert. Butyl Alcohol M.P. 23-25°C | 1.10 |
| 4 kg. | n-Butyl Bromide B.P. 100-101°C | 44.00 |
| 500 gm. | n-Butyraldehyde B.P. 72-74°C | 1.00 |
| ¼ lb. | Calcium Acetate reagent | .60 |
| 1 lb. | Calcium Carbide | .35 |
| 16 lbs. | Calcium Chloride, Anhydrous, tech. 4 mesh | 6.40 |
| ¼ lb. | Calcium formate, reagent | .90 |
| ¼ lb. | Calcium oxide, reagent | .45 |
| ¼ lb. | Camphor Powd. U.S.P. | .40 |
| 1 lb. | Carbon Tetrachloride, reagent | .60 |
| ¼ lb. | Casein Pure Soluble | .35 |
| 4 lbs. | Chlorinated Lime (app. 35% Active $Cl_2$) | 1.40 |

| | | |
|---|---|---|
| 4 lbs. | Chloroform, reagent | $ 3.00 |
| 2 oz. | Citral Pure | 1.50 |
| ¼ lb. | Citronellal Pure | 2.50 |
| ¼ lb. | Copper Metal, Dust, Electrolytic | .90 |
| ¼ lb. | Cupric oxide Techn. Black Powd. | .30 |
| 10 lbs. | Cupric sulfate, reagent | 5.50 |
| 20 gm. | Crystal violet (cert.) | 1.80 |
| 1 kg. | Chlorosulfonic acid (pract.) | 1.75 |
| 500 g. | p-dichloro benzene M.P. 52.5-53 | .60 |
| 3 kg. | Diethyl malonate (malonic ester) B.P. 94-96° @ 18 m.m. | 25.50 |
| 1 kg. | Dimethyl Aniline (free from Mono.) M.P. 1°C | 3.50 |
| 400 g. | Ethyl Benzoate B.P. 100-102°C 20 mm | 2.65 |
| ¼ lb. | Eggwhite—dried powder (albumin) | 1.25 |
| 30 lbs. | Ether, Diethyl (reagent) | 23.70 |
| 1 kg. | Ethyl Acetate, Anhydrous B.P. 76-77 | 1.05 |
| 2 kg. | Ethyl Acetoacetate B.P. 78-79 @ 10 mm | 5.20 |
| 2 x 5 gal. | Ethyl Alcohol, denatured No. 1 | 16.50 |
| 1 kg. | Ethyl Bromide, B.P. 38°-40°C | 4.50 |
| 1 lb. | Potassium Sodium Tartrate, C.P. | 1.30 |
| ¼ lb. | Ferric Chloride, reagent | .35 |
| 2 x 1 lb. | Formaldehyde solution U.S.P. | .90 |
| ½ lb. | Ferrous sulfate (reagent) | .80 |
| ¼ lb. | Fructose Pure Syrupy | 1.40 |
| 1 qt. | Gasoline, white purified with $H_2SO_4$ | 1.00 |
| 10 lbs. | Glycerol, C.P. | 6.60 |
| ¼ lb. | Gelatine, U.S.P. | .40 |
| 500 g. | Glucose (Dextrose) (hydrate) (pract.) | .45 |
| 3 lbs. | Iodine U.S.P. | 9.00 |
| 50 g. | Iodoform (pract.) M.P. 118-119.5 | 1.30 |
| 2 lbs. | Iron Metal nails | .50 |
| 1 lb. | Iron Metal, filings | .40 |
| 1 pt. | Kerosine, White | .30 |
| 500 g. | Hydroxyl Amine hydrochloride M.P. 153-5°C | 4.00 |
| ¼ lb. | Lactose T.P. | .45 |
| 2 lbs. | Lead Acetate, reagent | 1.30 |
| 1 lb. | Magnesium metal turnings, for Grignard | 1.30 |
| ¼ lb. | Maltose C.P. | 2.25 |
| ½ lb. | Mercuric Chloride, reagent | 2.84 |
| 5 lbs. | Methyl Alcohol, reagent | 2.80 |
| ¼ lb. | Methyl Ethyl Ketone B.P. 79-80° T.P. | .50 |
| 2 x ¼ lb. | Methyl Iodide B.P. 41-3°C | 2.60 |
| ½ lb. | Milk, dried | .70 |
| 4 oz. | Millon's Solution | 1.25 |
| 200 gm. | A-Naphthol M.P. 95-6°C | 2.10 |
| 200 gm. | B-Naphthol M.P. 122-123°C | 1.20 |
| 5 lbs. | Nitrobenzene M.P. 5°C | 3.00 |
| 2 lbs. | Norite A—Techn. | 1.00 |
| ¼ lb. | Olive Oil U.S.P. | .50 |
| 100 g. | Paraldehyde, free of aldehyde M.P. 11-12°C | .55 |
| 2 lb. | Paraffin, Medium hard | .70 |
| ¼ lb. | Phenol, recrystallized | .45 |
| 2 x 1 oz. | Phenolphthalein M.P. 260-1°C | .80 |
| 2 x 1 oz. | Phenyl hydrazine M.P. 18-19°C | 1.50 |
| ½ lb. | Phosphorus, Red Amorph. | .90 |
| 4 lbs. | Phosphorus trichloride, tech. | 4.44 |
| 50 gm. | Picric Acid M.P. 121-121.5°C | 2.25 |
| 2 lbs. | Potassium Acetate, reagent | 1.90 |
| ¼ lb. | Potassium Bisulfate, reagent | .40 |
| 5 lbs. | Potassium Bromide, reagent C.P. | 4.00 |
| 1 lb. | Potassium Carbonate, anhydrous T.P. | .85 |
| 4 lbs. | Potassium Cyanide, reagent | 11.00 |
| ¼ lb. | Potassium dichromate T.P. | .40 |
| ¼ lb. | Potassium Ferrocyanide T.P. | .50 |
| 10 lbs. | Potassium Hydroxide, reagent Sticks | 8.10 |
| ¼ lb. | Potassium Iodide, reagent | 1.10 |
| ¼ lb. | Potassium Nitrate, reagent | .40 |
| ¼ lb. | Potassium Permanganate, reagent | .55 |
| 100 gm. | N-propyl Alcohol B.P. 96-98°C | .35 |
| 1 lb. | iso-Propyl Alcohol (98-99%) | .50 |
| 100 gm. | Resorcinol M.P. 109-110°C | 1.05 |
| 2 x ¼ lb. | Salicylic acid M.P. 157-159°C T.P. | 1.26 |

| | | |
|---|---|---|
| 1 qt. | Schiff's Solution | $ 2.00 |
| ½ lb. | Silver Nitrate, reagent | 7.50 |
| 1 lb. | Soda lime 4-8 Mesh, 2% Moist. | .75 |
| 2 lbs. | Sodium Metal, reagent | 2.60 |
| 3 lbs. | Sodium Bisulfite, reagent | 1.65 |
| 10 lbs. | Sodium Chloride U.S.P. | 2.20 |
| 10 lbs. | Sodium Dichromate, tech. | 3.50 |
| 1 lb. | Sodium Carbonate, Anhydrous T.P. | .57 |
| 10 lbs. | Sodium Hydroxide T.P. Sticks | 6.50 |
| 5 lbs. | Sodium Nitrite, U.S.P. | 2.30 |
| ¼ lb. | Sodium Nitro ferricyanide | 1.90 |
| ¼ lb. | Sodium Sulfate, anhyd. | .40 |
| 1 lb. | Starch, U.S.P. Corn | .25 |
| 2 lbs. | Sodium Chlorate, reagent | 2.30 |
| 200 gm. | Succinic Acid, M.P. 189-190° C | 2.10 |
| 1 lb. | Sucrose, reagent | .70 |
| 200 gm. | Sulfanilic acid | 1.20 |
| 4 lbs. | Tin Metal, granular Pure Mossy | 6.80 |
| ¼ lb. | Stannous Chloride, reagent T.P. | 1.20 |
| 2 oz. | Tannic acid, U.S.P. | .75 |
| ½ lb. | Toluene, reagent | .50 |
| 1 kg. | o-Toluidene, (from nitrate) B.P. 83-85, @ 15 mm | 5.00 |
| 2 lbs. | Xylene, reagent | 1.00 |
| ¼ lb. | Zinc Metal, dust T.P. | .35 |
| 2 lbs. | Zinc Chloride, reagent | 1.70 |
| 2 oz. | Vanadium pentoxide, reagent | 2.50 |
| 8 lbs. | Ammonium hydroxide, S.G. .9 | 2.70 |
| 24 lbs. | Hydrochloric Acid, S.G. 1.19, reagent | 7.60 |
| 14 lbs. | Nitric Acid, S.G. 1.4, reagent | 4.90 |
| 72 lbs. | Sulfuric Acid, S.G. 1.84, reagent | 20.00 |
| 20 lbs. | Sodium Hydroxide Tech. Flake | 3.00 |
| | Total | $461.12 |

## GENERAL APPARATUS FOR PHYSICAL CHEMISTRY FOR 20 STUDENTS

**(Not necessary to duplicate for each unit)**

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 1-110A | S71605 | 1 only | Air pump, with motor, doublestage App. .0003 mm Vacuum 110V 60 C A.C., 10 1 capacity | $ 90.00 |
| 2-035 | S3215 | 1 only | Balance, Harvard Trip Scales | 15.00 |
| 2-100 | S3365 | 1 only | Balance, Solution, lg. capacity | 83.00 |
| 2-147 | | 1 only | Balance, gravitometer range 0.9-10.00 S.G. | 125.00 |
| 1-931 | S2595 | 3 only | Balances, Analytical 1/20 mg. sens. 200 g. cap. | 558.00 |
| 2-224 | S4105 | 3 sets | Balance weights, 5 mg-100 g. | 81.00 |
| 2-300 | S4285 | 1 set | Balance weights, Brass lg-500g | 7.00 |
| 2-383-5 | A575 | 1 only | Barometer, Mercurial | 25.25 |
| 7-513 | | 6 only | Bottles, gas washing and absorbing | 43.50 |
| 3-290 | S9335 | 3 only | Bottles, Specific gravity, Sprengel | 9.00 |
| 2-425 | S30845 | 12 only | Battery, Dry Cell 1½ volt, 40 watt hours | 6.00 |
| | S29855 | 2 only | Cells, conductivity, Ostwald | 56.00 |
| 6-662-1 | S19725 | 1 only | Clock, Interval timer, spring mechanism | 11.40 |
| 7-195 | S20655 | 1 only | Colorimeter, Micro, Biological, 20 mm direct reading | 150.00 |
| 7-703 | | 3 only | Condensors, shock proof, 300 mm pyrex | 4.95 |
| 7-835 | S23125 | 12 only | Cork Rings 60 mm | 8.64 |
| 7-835 | S23125 | 12 only | Cork Rings 115 mm | 14.40 |
| 9-343 | S29765 | 2 only | Resistance Boxes, dial pattern, 9,999 ohms | 90.00 |
| 9-344 | | 2 only | Resistance Boxes 4 dial 999.9 ohms | 90.00 |
| 9-346 | S29835 | 1 only | Microphone hummer | 55.00 |
| 9-347 | | 2 only | Buzzer, to convert 3V D.C. to interrupted current | 20.00 |
| 9-352 | S29785 | 2 only | Telephone receivers | 11.00 |
| | | 2 only | Bridges, Slide wire, 50 cm. | 80.00 |
| 9-518 | | 1 only | Rectifier, 110 V AC 60 C to o-6V D.C. | 90.00 |
| 9-522-5 | | 1 only | Meter, Universal, A.C.-D.C. (volt, ohm, milliampmeter) | 24.00 |

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 10-506A | S36525 | 1 only | Furnace, crucible, 110V, A.C. 60C, 1200 watt lg | $ 45.00 |
| 10-507A | S36545 | 1 only | Rheostat for furnace | 21.00 |
| 10-508A | S36565 | 1 only | Extra heating units for furnace | 4.50 |
| 10-566 | S37665 | 1 only | Gas Pressure Regulator for Oxygen | 28.50 |
| 11-253 | | 1 only | Gauge, McLeod, High Vacuum, Columbia Modification | 50.00 |
| 11-286 | S39795 | 2 only | Gauges, Manometer, Mercury, Pressure or vacuum 60 cm | 23.00 |
| 11-350 | S40135 | 15 lb. | Glass Tubing, soft glass, 7 mm | 9.00 |
| 11-365 | S40125 | 12½ lb. | Glass Tubing, pyrex, 7 mm | 8.75 |
| 11-463-5 | S40825 | 2 only | Heaters, Immersion 500 W | 18.50 |
| 11-505-5 | S30070 | 2 only | Sealed glass electrodes 2½" | 13.00 |
| 11-505-7 | S30071 | 2 only | Sealed glass electrodes 2½" High pH | 18.00 |
| 11-505-300 | S30060 | 1 only | Hydrogen-ion meter, portable direct reading | 165.00 |
| 11-505-10 | S30090 | 2 only | Electrode, Sealed, Calomel 2½" | 17.00 |
| 11-506-1 | | 2 only | Potentiometers, Student type | 170.00 |
| 11-506-27A | S30335A | 2 only | Galvanometers, D.C., pointer type | 57.00 |
| 11-506-27E | S30325A | 1 only | Galvanometer, AC-DC-Mirror type | 62.50 |
| 11-506-30 | S30365 | 1 only | Standard Cells, Eppley | 20.00 |
| 11-506-38 | S30385 | 2 only | Standard Cells, Eppley, Students | 24.00 |
| 11-506-40 | S30475 | 2 only | Calomel electrode vessel, Wilson Modification | 24.00 |
| 11-506-46 | | 2 only | Hydrogen electrodes, Modified Hildebrand | 17.00 |
| 11-506-56 | | 1 only | Hydrogen-Calomel electrode assembly | 17.50 |
| 11-506-60 | | 1 only | Calomel Electrode Vessel and Gas channel | 15.00 |
| 11-582 | | 1 set | Hydrometer set, Precision, Spec. Gravity | 31.00 |
| 11-991-5 | S44290 | 2 only | Fluorescent Titration Illuminators 110V A.C. 60C | 30.00 |
| 12-830 | S62075 | 1 only | Molecular Wt. Apparatus, Beckman | 35.00 |
| 12-835 | S62085 | 2 only | Freezing Chamber for Beckman Freezing point Apparatus | 1.80 |
| 12-840 | S62095 | 2 only | Air jackets for Beckman F.P. App | 1.60 |
| 12-900 | S61995 | 2 only | Molecular Weight Determination Apparatus | 60.00 |
| 12-935 | S62055 | 1 only | Mol. Wt. Det'n Apparatus Menzies | 14.50 |
| 13-245A | S64095 | 1 only | Oven, Drying 35°-150.5°C multi-shelf 110V A.C. 60C | 98.50 |
| 13-345 | | 1 only | Paint Sieve with N.B.S. stamp | 16.00 |
| 13-580A | | 2 only | Viscosimeter heaters, 110V | 16.50 |
| 13-616 | S83335 | 2 only | Viscosity Pipettes No. 100 Uncalibrated | 11.00 |
| 13-616 | S83335 | 2 only | Viscosity Pipettes No. 200 Uncalibrated | 11.00 |
| 13-616 | S83335 | 2 only | Viscosity Pipettes No. 300 Uncalibrated | 11.00 |
| 13-616 | S83335 | 2 only | Viscosity Pipettes No. 400 Uncalibrated | 11.00 |
| | S70565 | 1 only | Polarimeter—.1° accuracy—student type | 325.00 |
| | S70755 | 6 only | Polarimeter sample tubes for above 200 mm | 48.00 |
| 13-874-92A | S71600 | 1 only | Pump, midget circulating, 110V A.C. 60C 4-6 gal./min. | 24.00 |
| 13-906 | S71815 | 1 only | Pyrometer, High Resistance, scale calibrated in both millivolts and degrees 1100° C | 93.50 |
| 13-908 | S72035 | 1 only | Thermocouple, for above, 3 ft. 8 gauge, Chromel-Alumel | 3.85 |
| 13-947 | | 1 only | Refractometer, Student type n 1.3-1.9 ± .002 | 50.00 |
| 13-962 | S72305 | 1 only | Refractometer, Abbe | 470.00 |
| 13-991 | | 2 only | Relays, electronic | 50.00 |
| 14-052 | | 6 only | No. 3 Rings, open for supporting leveling bulbs | 12.00 |
| 14-258 | | 1 only | Shaker, 110V A.C. 60 C for Florence & Erlenmeyer flasks | 90.00 |
| 14-502 | | 2 only | Lab motor 110V A.C. 60C 1750 RPM Motor | 35.50 |
| 14-503 | | 2 only | Stirrer, electrically driven, 110V A.C. 60 C Induction type | 23.50 |
| 14-509-5A | | 1 only | Stirring apparatus, portable, lab model | 35.00 |
| 14-646-10 | S76447 | 2 only | Stop watch 1/5 sec., non-magnetic jewel movement | 60.00 |
| 14-670 | S78305 | 24 only | Ring stands, medium | 28.80 |
| 14-815 | | 1 only | Tensiometer—Du Nouy-Student | 75.00 |

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 14-817 | S79335 | 4 only | Surface Tension Apparatus—Cap. tube method | 20.00 |
| 14-986 | S80005 | 6 only | Thermometers, Gen. Lab.—5° to 360°C | 13.80 |
| 15-055 | S81155 | 4 only | Thermometers, Beckman | 140.00 |
| 15-077 | S81425 | 1 only | Thermometer, all metal—10° to 110° | 4.52 |
| 15-077 | S81425 | 1 only | Thermometer, all metal—0°-100° | 4.52 |
| 15-077 | S81425 | 1 only | Thermometer, all metal—0°-150° | 4.52 |
| 15-077 | S81425 | 1 only | Thermometer, all metal—0°-250° | 5.80 |
| 15-155 | S80385 | 1 set | Thermometers, Precision Anschutz | 85.00 |
| 15-179 | S81832 | 1 only | Thermoregulators, Lab. Immersion | 10.00 |
| 15-182-5 | | 1 only | Thermoregulators, Electric adjustable | 22.50 |
| 15-341 | S83035 | 4 only | Vapor density apparatus, Victor Meyer, pyrex | 13.52 |
| 11-160 | S38835 | 4 only | Gas measuring tubes, for above 50 cc | 13.20 |
| 15-444-5, 10, 15, 25, 35 | S84860 | 3 only | Constant Temperature baths, complete with 12" x 12" jar, base, thermostat unit, stirring motor, heater 300 w, thermometer 110°C. | 285.00 |
| 9-958 | S33565B | 20 only | Aspirators | 38.00 |
| | | | Total | $5003.82 |

## PHYSICAL CHEMISTRY

This equipment is standard desk equipment for 20 students.

| | | | | |
|---|---|---|---|---|
| 1-470 | S1235 | 20 lbs. | Asbestos Paper | $ 4.40 |
| 2-540 | S4675 | 40 only | Beakers, 150 ml. | 7.20 |
| 2-540 | S4675 | 40 only | Beakers, 250 ml. | 6.80 |
| 2-540 | S4675 | 42 only | Beakers, 400 ml. | 10.08 |
| 2-540 | S4675 | 48 only | Beakers, 1000 ml. | 26.88 |
| 2-540 | S4675 | 42 only | Beakers, 2000 ml. | 46.20 |
| 2-610 | S83605 | 40 only | Watch glasses, 50 mm. | 2.40 |
| 2-883A | S8245 | 84 only | Bottles, B.S.C., 8 oz. | 8.40 |
| 2-901 | S8255 | 40 only | Bottles, N.M.C.S., 1000 ml. | 24.00 |
| 2-907 | | 40 only | Bottles, N.M.G.S., 1000 ml. | 44.00 |
| 3-415 | S9495 | 40 only | Weighing Bottles, 50 x 40 mm. | 37.20 |
| 3-573 | S9985 | 20 only | Test Tube Brushes | 3.40 |
| 3-699 | S10635 | 48 only | Burettes, 50 ml. | 92.64 |
| 3-900 | S12195 | 20 only | Burners, Fisher | 45.00 |
| 3-962 | | 20 only | Burners | 30.00 |
| 5-772 | A113 | 40 only | Burette Clamps | 30.00 |
| 5-779 | A117 | 20 only | Burette Clamps | 45.00 |
| 5-849 | A124 | 20 only | Pinch Clamps | 6.00 |
| 7-965 | S23685 | 10 doz. | Crucibles No. 00 | 20.40 |
| 9-725 | S32235 | 20 only | Files, triangular 6" | 5.80 |
| 10-035 | S33825 | 20 only | Flasks, Florence, F.B. 500 ml. | 5.80 |
| 10-035 | S33825 | 20 only | Flasks, Florence F.B. 1000 ml. | 8.80 |
| 10-040 | S34105 | 160 only | Flasks, Erlenmeyer, 125 ml. | 30.40 |
| 10-090 | S34125 | 80 only | Flasks, Erlenmeyer, W.M. 250 ml. | 18.40 |
| 10-204 | S34845 | 24 only | Flasks, Volumetric, G.S. 25 ml. | 19.44 |
| 10-204 | S34845 | 20 only | Flasks, Volumetric, G.S. 50 ml. | 17.20 |
| 10-204 | S34845 | 48 only | Flasks, Volumetric, G.S. 100 ml. | 41.28 |
| 10-204 | S34845 | 20 only | Flasks, Volumetric, G.S. 250 ml. | 19.40 |
| 10-204 | S34845 | 20 only | Flasks, Volumetric, G.S. 500 ml. | 25.80 |
| 10-204 | S34845 | 24 only | Flasks, Volumetric, G.S. 1000 ml. | 36.00 |
| 10-326 | S35335 | 20 only | Funnels, long stem, 65 mm. | 6.80 |
| 11-377 | S40075 | 20 only | Glass rods 3 ft., 6 mm. | 3.00 |
| 11-845 | S43945 | 20 only | Crocks, 1 gallon | 30.00 |
| 11-850 | S44105 | 20 only | Boxes of Labels No. 209 | 2.60 |
| 13-664 | S69565 | 20 only | Pipettes, grad. 1 ml. in 1/10 | 8.80 |
| 13-664 | S69565 | 20 only | Pipettes, grad. 2 ml. in 1/10 | 10.00 |
| 13-664 | S69565 | 24 only | Pipettes, grad. 10 ml. in 1/10 | 13.20 |
| 13-649 | S69515 | 20 only | Pipettes, Transfer, 5 ml. | 7.80 |
| 13-649 | S69515 | 20 only | Pipettes, Transfer, 25 ml. | 11.00 |
| 13-649 | S69515 | 20 only | Pipettes, Transfer, 100 ml. | 22.00 |
| 14-157 | S73505 | 60 ft. | Rubber tubing, 3/16" | 7.80 |
| 14-157 | S73505 | 120 ft. | Rubber tubing, 1/4" | 19.20 |
| 14-157 | S73505 | 120 ft. | Rubber tubing, 5/16" | 21.60 |
| 14-417 | S79545A | 20 only | Sponges | 10.00 |
| 14-670 | S78305 | 20 only | Iron Supports, 24" | 30.00 |
| 14-955 | S79515 | 40 only | Test Tubes, 20 x 150 | 2.40 |
| 14-955 | S79515 | 40 only | Test Tubes, 25 x 150 | 3.60 |

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 14-955 | S79515 | 40 only | Test Tubes, 29 x 200 | $ 10.00 |
| 14-955 | S79515 | 40 only | Test Tubes, 32 x 200 | 12.00 |
| 14-955 | S79515 | 40 only | Test Tubes, 38 x 200 | 14.40 |
| 14-985 | S80005 | 20 only | Thermometers —10 to 150 deg. C | 32.00 |
| 15-193 | | 20 only | Crucible Tongs | 15.00 |
| 15-300 | S82505A | 40 only | Tripods 9 x 5" | 30.00 |
| 15-585 | S85315 | 40 only | Wire gauzes 4 x 4" | 14.80 |
| | | | Total | $1056.32 |

## CHEMICALS FOR PHYSICAL CHEMISTRY FOR CLASS OF 20 STUDENTS

| | | |
|---|---|---|
| 1 gal. | Acetone, Tested Purity, ACS | $ 3.00 |
| 10 lbs. | Acid, Acetic, glacial 99.5%, Tested Purity, ACS | 4.20 |
| 1 lb. | Acid, Benzoic, synthetic TP (Tested Purity) ACS | 2.00 |
| 24 lbs. | Acid Hydrochloric, TP (Tested Purity) ACS Sp. Gr. 1.19 | 7.60 |
| 2 lbs. | Acid, Oxalic, crystal, TP (Tested Purity) ACS | 1.70 |
| 18 lbs. | Acid, Sulfuric TP (Tested Purity) ACS Sp. Gr. 1.84 | 5.00 |
| 1 lb. | Agar-Agar, flakes, USP, XI | 4.75 |
| 2 gal. | Alcohol, Ethyl 95% USP | 43.00 |
| 1 gal. | Alcohol, Ethylic, absolute, USP | 24.50 |
| 10 lbs. | Alcohol, Methyl (Acetone free) Absolute TP (Tested Purity) ACS | 5.60 |
| 2 gal. | Benzene TP (Tested Purity) ACS | 5.00 |
| 2 lbs. | Bismuth Metal, gran. C.P. | 6.40 |
| 2 lbs. | Calcium Chloride (for drying) 4 mesh TP (Tested Purity) ACS | 1.70 |
| 1 gal. | Carbon Tetrachloride, TP (Tested Purity) ACS | 5.00 |
| 1 lb. | Charcoal, activated, 6-14 mesh for absorbing | 1.75 |
| 10 lbs. | Chloroform TP (Tested Purity) ACS | 7.00 |
| 4 lbs. | Collodion, USP XII | 2.40 |
| 5 lbs. | Copper (ic) Sulfate, crystal, TP (Tested Purity) ACS | 2.75 |
| 5 lbs. | Ether, Ethylic, anhyd. TP (Tested Purity) ACS | 3.95 |
| 5 lbs. | Ethyl Acetate, C.P. | 2.90 |
| 1 lb. | Formaldehyde Neutral, TP (Tested Purity) | .60 |
| 1 lb. | Gelatin, gran. USP XII | 1.05 |
| ⅛ oz. | Gold chloride, tri (acid) CP | 3.20 |
| 1 lb. | Gum Arabic, sorts, USP XI | .50 |
| 1 lb. | Gum Tragacanth, White powder, USP XII | 2.25 |
| 1 lb. | Iron (ic) Chloride Lump, TP (Tested Purity) ACS | .60 |
| 5 lbs. | Mercury, redistilled, USP, XII | 17.50 |
| ¼ lb. | Phenolphthalein, USP XII Powder | .45 |
| 5 lbs. | Potassium Carbonate, anhyd. TP (Tested Purity) ACS | 4.00 |
| 5 lbs. | Sodium Hydroxide, Pellets, TP (Tested Purity) ACS | 3.25 |
| 8 lbs. | Sodium Sulfate, small cryst. TP (Tested Purity) | 6.00 |
| 8 lbs. | Sodium Sulfate, Anhyd. TP (Tested Purity) ACS | 5.60 |
| 1 oz. | Platinum Chloride 10% | 5.25 |
| 100 g. | Acetal | 2.05 |
| 2 lbs. | Nitrobenzene, C.P. | 1.30 |
| 100 g. | Quinhydrone (M.P.) 169-170°C | .90 |
| ¼ lb. | Silver Nitrate C.P. | 3.75 |
| 1 lb. | Mercurous Chloride, ACS, C.P. | 4.73 |
| | Total | $203.18 |

## BIOCHEMISTRY GENERAL LABORATORY APPARATUS FOR 20 STUDENTS

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 1-915 | S2535 | 4 only | Balance, Special student | $325.00 |
| 2-033 | S3455 | 2 only | Balance, Triple beam 1610 gm cap | 30.00 |
| 2-224 | S4105 | 4 sets | Weights, Class S2 5 mg to 100 g | 108.00 |
| 4-970 | | 4 only | Student safety head Centrifuges | 140.00 |
| 6-257 | | 1 only | Electro hemometer | 75.00 |
| 6-536 | | 4 only | Urinometer sets | 16.00 |
| 6-586 | S6975X | 4 only | Einhorn Saccharimeter sets | 8.80 |

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 7-101 | | 2 only | Colorimeter, photo electric, complete with cells, filters | $390.00 |
| 7-190 | S20565 | 2 only | Colorimeter Biological | 276.00 |
| 11-365 | S40125 | 5 lbs. | Glass Tubing 8 mm Pyrex | 3.50 |
| 11-985 | S70590 | 1 only | Sodium Vapor Lamp | 75.00 |
| 12-304 (FB-4) | S52015 | 2 only | Microscopes 10x (16 mm), 43x (4 mm) objectives and 5x and 10x eyepieces | 233.00 |
| 13-155B | S63345 | 1 only | Kjeldahl Rack, 6 unit | 135.00 |
| 13-245A | S64135*100 | 1 only | Oven, Drying 12 x 12 x 12½ Inside 35°-200°C | 170.00 |
| 13-792 | | 1 only | Polarimeter, Spencer | 125.00 |
| 9-958 | S33565-B | 20 only | Aspirators | 38.00 |
| 5-102A | S16205 | 2 only | Centrifuges, Clinical 15 and 50 ml. head 110V | 130.00 |
| 13-745-5 | S70025-00 | 25 only | Spot plates, white porcelain | 23.00 |
| 21-158 | S48565 | 48 only | Micro pipettes | 156.00 |
| 25-025 | | 1 only | Kern Circle Polarimeter | 450.00 |
| | | | Total | $2907.30 |

## BIOCHEMISTRY DESK EQUIPMENT FOR 20 STUDENTS

The following equipment is to be issued as standard desk equipment for students in Biochemistry. The complete list will suffice for a group of 20 students.

| | | | | |
|---|---|---|---|---|
| 2-540 | S4675 | 60 only | Beakers, 150 ml. | $10.80 |
| 2-540 | S4675 | 60 only | Beakers, 250 ml. | 10.20 |
| 2-540 | S4675 | 84 only | Beakers, 400 ml. | 20.16 |
| 2-540 | S4675 | 72 only | Beakers, 600 ml. | 20.88 |
| 2-610 | S83605 | 40 only | Watch Glasses, 50 mm | 2.40 |
| 2-610 | S83605 | 40 only | Watch Glasses, 100 mm | 4.00 |
| 2-903 | S8305 | 120 only | Bottles, cs. wide mouth, 60 ml. | 18.00 |
| 2-905 | S8375 | 20 only | Bottles, gs. narrow mouth, 60 ml. | 9.40 |
| 2-905 | S8322 | 20 only | Bottles, gs. narrow mouth, 250 ml. | 15.00 |
| 3-335 | S83225D | 20 only | Vials (shell 70 x 21 mm) | 1.00 |
| 3-574 | S9995 | 20 only | Test Tube Brushes | 3.00 |
| 3-699 | S10635 | 24 only | Burettes, 50 ml. | 46.32 |
| 3-962 | | 20 only | Bunsen Burners | 30.00 |
| 3-995 | S12995 | 20 only | Wing Tops 11 mm | 3.20 |
| 5-505 | S17905 | 48 only | Centrifuge Tubes, 15 ml. | 9.60 |
| 5-535 | S18035 | 40 only | Centrifuge Tubes, 50 ml. | 14.40 |
| 5-731 | A100 | 40 only | Extension Clamps, small | 26.00 |
| 5-733 | A102 | 40 only | Extension Clamps, large | 32.00 |
| 5-810 | S19405X | 20 only | Screw Clamps, large 6" | 24.00 |
| 5-840 | S19575 | 20 only | Test Tube Holders, metal | 3.00 |
| 6-481 | S6315 | 72 only | Blood Sugar Tubes | 40.32 |
| 7-703 | | 20 only | Shock-proof condensers, 400 mm jacket, 650 mm. | 35.00 |
| 7-712 | S22595 | 24 only | Condenser tubes, pyrex, 650 mm. | 16.32 |
| 7-890 | S23255 | 20 lbs. | Absorbent Cotton | 22.00 |
| 8-549 | S24675 | 20 only | Cylinders, grad. 10 ml. | 11.00 |
| 8-549 | S24675 | 20 only | Cylinders, grad. 100 ml. | 16.60 |
| 8-690 | S25505 | 40 only | Dishes, porc. No. 000 | 6.80 |
| 8-690 | S25505 | 20 only | Dishes, porc. No. 8 | 31.60 |
| 9-720 | S32225 | 20 only | Files, round, 5" | 5.80 |
| 9-725 | S32235 | 20 only | Files, triang. 5" | 5.00 |
| 9-801 | S32935 | 20 bxs. | Filter paper, 15 cm. | 6.60 |
| 9-820 | S33255 | 20 bxs. | Filter paper, 11 cm. | 11.20 |
| 10-035 | S33825 | 20 only | Flasks, flat bot. 1000 ml. | 8.80 |
| 10-040 | S34105 | 40 only | Flasks, Erlenmeyer, 125 ml. | 7.60 |
| 10-055 | S33845 | 20 only | Flasks, Pyrex, 2000 ml. | 17.60 |
| 10-055 | S33845 | 20 only | Flasks, Pyrex, 3000 ml. | 22.20 |
| 10-060 | S33855 | 20 only | Flasks, round bot. 100 ml. | 4.00 |
| 10-090 | S34125 | 20 only | Flasks, Erlenmeyer, wide mouth 250 ml. | 4.60 |
| 10-098 | S34135 | 24 only | Flasks, Erlenmeyer, g.s. 50 ml. | 24.24 |
| 10-110 | S34405 | 40 only | Flasks, Kjeldahl, 500 ml. | 16.80 |
| 10-140 | S33915 | 20 only | Flasks, round bot. 1000 ml. | 21.40 |
| 10-204 | S34845 | 24 only | Flasks, volumetric, 25 ml. | 19.44 |
| 10-204 | S34845 | 20 only | Flasks, volumetric, 250 ml. | 19.40 |
| 10-204 | S34845 | 20 only | Flasks, volumetric, 1000 ml. | 30.00 |
| 10-320 | S35305 | 40 only | Funnels, short stem 7.5 cm. | 16.00 |
| 10-325 | S35320 | 40 only | Funnels, long stem 7.5 cm. | 17.60 |

| E & A Cat. No. | Sargent Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 10-356 | S35555 | 20 only | Funnels, Buechner No. 3 | $56.40 |
| 10-437 | S35815 | 21 only | Funnels, Separatory, 250 ml. | 82.74 |
| 11-380 | S40095 | 42 only | Glass rods, 3 x 125 mm | 1.68 |
| 11-380 | S40095 | 42 only | Glass rods, 5 x 200 mm | 2.52 |
| 11-522 | | 20 only | Hydrometers, sp. g. 1.000-1.200 | 28.00 |
| 12-519 | S58725 | 2 oz. | Microscope cover glasses, 25 mm | 8.50 |
| 12-550 | S58775 | 72 only | Microscope slides, 75 x 25 mm | .93 |
| 12-960 | S62235D | 20 only | Mortars and Pestles No. 1 | 14.20 |
| 13-080 | S62695X | 20 only | Needles, inoculating, 3" | 26.00 |
| 13-380 | S65775 | 20 only | Glass Marking Pencils, red | 4.80 |
| 13-649 | S69515 | 20 only | Pipettes, transfer, 50 ml. | 14.40 |
| 13-664 | S69565 | 20 only | Pipettes, grad., 1 ml. in 1/100 | 10.00 |
| 13-664 | S69565 | 24 only | Pipettes, grad., 10 ml. in 1/10 | 13.20 |
| 13-700 | S69695 | 20 only | Medicine droppers with bulbs | 1.00 |
| 13-745 | S70025-00 | 20 only | Plates, wh. porc. 12 cavities | 18.40 |
| 14-050 | S73045 | 40 only | Iron Rings, 3" | 16.00 |
| 14-104 | S73225 | 42 only | Rubber Policemen | 4.20 |
| 14-120 | S40095 | 42 only | Glass Rods for above (3-1/16") | 2.10 |
| 14-130 | S73305 | ½ lb. | Rubber Stoppers, solid, No. 2 | .60 |
| 14-130 | S73305 | 3½ lbs. | Rubber Stoppers, solid, No. 5 | 5.25 |
| 14-140 | S73325 | 1 lb. | Rubber Stoppers, 2 hole, No. 6 | 1.50 |
| 14-157 | S73505 | 6 ft. | Rubber Tubing, 3/16 x 3/64" | .78 |
| 14-157 | S73505 | 24 ft. | Rubber Tubing, 1/4 x 1/16" | 3.84 |
| 14-215 | S73875 | 20 only | Sand Baths, 10" | 30.00 |
| 14-372 | | 20 only | Spatulas, metal, double ends 180 mm | 15.00 |
| 14-670 | S78305 | 20 only | Stands, medium | 24.00 |
| 14-740 | S78815 | 20 only | Funnel Holders, 4 hole | 22.00 |
| 14-775 | S79055 | 20 only | Test Tube Racks | 35.00 |
| T-50 | S65255 | 20 only | Vials, litmus paper, neutral | 2.40 |
| T-38 | S65255 | 20 only | Vials, Congo Red Paper | 2.40 |
| 14-924 | S79525X | 144 | Test Tubes, 3⅛ x ⅝" | 9.36 |
| 14-950 | S79655X | 60 only | Test Tubes, grad. at 10 ml. | 24.00 |
| 14-955 | S79515 | 120 only | Test Tubes, 18 x 150 mm Pyrex | 6.00 |
| 15-193 | S82125 | 20 only | Crucible Tongs | 15.00 |
| 15-518 | S84215 | 20 only | Water Baths, 10" | 220.00 |
| 15-585 | S85315 | 40 only | Wire Gauzes, 4 x 4" | 14.80 |
| | | | Total | $1478.28 |

## BIOCHEMICAL LIST OF CHEMICALS FOR A CLASS OF 20 STUDENTS

| | | |
|---|---|---|
| 1 lb. | Acetic Anhydride, TP | $ 1.30 |
| 1 gal. | Acetone, B.P. 56-57 deg. C, TP | 3.00 |
| 10 lbs. | Acid Acetic, glacial, TP | 4.20 |
| 1 lb. | Acid Carbolic, white loose, Cryst. TP | 1.00 |
| 10 lbs. | Acid Citric, gran., TP | 9.00 |
| 50 gm. | Acid Hippuric, C.P. | 1.60 |
| 30 lbs. | Acid Hydrochloric, TP | 9.50 |
| 5 lbs. | Acid Lactic, 85%, TP | 7.25 |
| 35 lbs. | Acid Nitric, TP | 12.25 |
| 1 kg. | Acid Oleic, C.P. (Linolic Acid free) | 14.00 |
| 10 lbs. | Acid Oxalic, crystal, TP | 8.00 |
| 100 g. | Acid Palmitic, crystal, C.P. | 7.50 |
| 1 lb. | Acid Phosphomolybdic, crystal TP | 8.10 |
| 35 lbs. | Acid Phosphoric, Ortho, 85% TP | 21.00 |
| 1 lb. | Acid Phosphotungstic, crystal TP | 7.15 |
| 3 lbs. | Acid Picric, 10% $H_2O$, TP | 5.40 |
| 45 lbs. | Acid Sulfuric, TP | 12.50 |
| 1 lb. | Acid Tannic, lightest, clearly sol. TP | 3.00 |
| 10 lbs. | Acid Tartaric Gran. TP | 16.00 |
| 10 lbs. | Acid Trichloracetic, TP | 51.50 |
| 10 lbs. | Agar-Agar, flakes, U.S.P. | 46.50 |
| 4 gal. | Alcohol, Ethylic, 95% | 86.00 |
| 30 lbs. | Alcohol, Methylic (Acetone free), T.P. | 11.40 |
| 1 oz. | Alizarin Sodium Sulfonate (ind.) | .55 |

| | | |
|---|---|---|
| 1 lb. | Alumine, Absorption, 80-200 mm | $ 2.75 |
| 10 lbs. | Ammonium Chloride, TP | 4.70 |
| 20 lbs. | Ammonium Hydroxide, TP | 6.75 |
| 10 lbs. | Ammonium Molybdate, TP | 18.20 |
| 10 lbs. | Ammonium Oxalate, TP | 13.50 |
| 10 lbs. | Ammonium Sulfate, TP | 5.20 |
| 100 g. | Arabinose (pectin sugar), cryst. C.P. | 13.50 |
| 2 lbs. | Barium Carbonate, ppt. TP, ACS | 2.60 |
| 10 lbs. | Barium Chloride, TP | 5.60 |
| 3 lbs. | Barium Hydroxide, cryst. TP | 2.25 |
| 1 gal. | Benzene, Thiophene free, TP, A.C.S. | 2.50 |
| 100 g. | Benzidine (Paradiaminodiphenyl) C.P. | 2.75 |
| 2 lbs. | Bismuth Subnitrate, TP | 8.00 |
| 24 oz. | Boileezers | 2.40 |
| 1 g. | Bromthymol blue indicator | 1.25 |
| 25 lbs. | Calcium Chloride, cryst. TP | 17.50 |
| 2 lbs. | Calcium Hydroxide, TP | 1.50 |
| 2 gal. | Carbon Tetrachloride, TP | 10.00 |
| 5 lbs. | Casein, Pure, soluble | 4.75 |
| 6 lbs. | Charcoal, Animal, powder | 2.40 |
| 25 lbs. | Chloroform, TP | 12.75 |
| ½ lb. | Cholesterin, C.P. | 7.20 |
| 3 lbs. | Collodion, U.S.P. | 1.80 |
| 2 lbs. | Copper Acetate, neutral, cryst. TP | 3.50 |
| 1 lb. | Copper Carbonate, green, ppt. TP | 2.00 |
| 20 lbs. | Copper (ic) Sulfate, cryst. TP | 11.00 |
| 1 lb. | Dextrin, Alc. ppt. C.P. | 1.75 |
| 10 lbs. | Dextrose, anhyd. TP | 5.90 |
| 250 g. | Dimethylaminoazobenzene, C.P. | 10.00 |
| 500 g. | Dimethylaminobenzaldehyde, p. C.P. | 14.00 |
| 20 lbs. | Ether (Sulfuric), Ethylic, anhy. TP | 15.80 |
| 5 lbs. | Formaldehyde, neutral, TP | 2.75 |
| 1 lb. | Furfural, C.P. | 1.50 |
| 500 g. | Galactose (Lactoglucose), C.P. | 8.50 |
| 10 lbs. | Gum Arabic, sorts, U.S.P. | 4.50 |
| 5 lbs. | Gum Guaiac, lump, N.F. | 3.00 |
| 100 g. | Inulin, white, C.P. | 6.00 |
| 3 lbs. | Iodine, resublimed, TP | 12.60 |
| 5 lbs. | Iron (ic) Ammonium Sulfate, TP. | 3.25 |
| 3 lbs. | Iron (ic) Chloride, TP | 1.80 |
| 2 lbs. | Iron (ous) Sulfate, cryst. TP | 1.60 |
| 10 lbs. | Lactose, powder, TP | 8.00 |
| 3 lbs. | Lead Acetate, normal, TP | 1.95 |
| 1 lb. | d-Levulose, syrup pure | 5.00 |
| 1 lb. | Magnesium Chloride, crystal, TP | 1.25 |
| 5 lbs. | Magnesium Sulfate, crystal, TP | 2.15 |
| 10 lbs. | Maltose (Malt Sugar) C.P. | 80.00 |
| 3 lbs. | Mercuric Chloride, Crystal, TP | 12.18 |
| 1 lb. | Mercuric Potassium Iodide, C.P. | 11.70 |
| 1 g. | Methyl Red, pH Indicator | .35 |
| 1 oz. | Methylene Blue, water sol., USP | .40 |
| 50 g. | Naththol, Alpha, recryst. C.P. | 1.00 |
| 50 g. | Orcinol, C.P. | 5.00 |
| 1 lb. | Pectin (from Apples) dry, powd. | 7.00 |
| 5 lbs. | Pepsin, gran. U.S.P. | 21.25 |
| 1 g. | Phenol Red, U.S.P. | 1.25 |
| ¼ lb. | Phenolphthalein, U.S.P. | .45 |
| ¼ lb. | Phenylhydrazine Hydrochloride, C.P. | 1.75 |
| ¼ lb. | Phenoglucinol (Pheloroglucin), C.P. | 7.15 |
| 1 lb. | Potassium Acetate, TP | .95 |
| 10 lbs. | Potassium Dichromate, lge. cryst. TP | 7.30 |
| 3 lbs. | Potassium Bisulfate, cryst. TP | 2.40 |
| 3 lbs. | Potassium Ferrocyanide, Cryst. TP | 3.75 |
| 25 lbs. | Potassium Hydroxide, pellets, TP | 15.50 |
| 1 lb. | Potassium Iodate, TP | 6.25 |
| 10 lbs. | Potassium Iodide, cryst. TP | 29.50 |
| 1 lb. | Potassium Nitrate, cryst. TP | .73 |
| 6 lbs. | Potassium Oxalate, Neutral, cryst. TP | 7.80 |
| 10 lbs. | Potassium Permanganate, cryst. TP | 11.50 |
| 20 lbs. | Potassium Phosphate, prim., TP | 21.60 |
| 1 lb. | Rennin, 1:30,000, N.F. | 11.50 |

| | | |
|---|---|---|
| 1 lb. | Resorcinol, recrystal., wh., U.S.P. | $ 2.75 |
| 10 lbs. | Saccharose (Sucrose), TP | 6.20 |
| 10 lbs. | Sea Sand | 1.00 |
| 2 lbs. | Silver Nitrate, Cryst. TP | 28.00 |
| 12 oz. | Sodium Metal | 1.35 |
| 3 lbs. | Sodium Acetate, Crystal, TP | 2.40 |
| 1 lb. | Sodium Borate, crystal, TP | .55 |
| 10 lbs. | Sodium Carbonate, anhyd. TP | 5.20 |
| 10 lbs. | Sodium Chloride, crystal, TP | 4.60 |
| 25 lbs. | Sodium Citrate, TP | 17.50 |
| 3 lbs. | Sodium Cyanide, TP | 2.55 |
| 3 lbs. | Sodium Glycerophosphate, cryst. N.F. | 7.80 |
| 5 x 10 lbs. | Sodium Hydroxide, pellets TP | 30.00 |
| 10 lbs. | Sodium Phosphate, dibasic, cryst. TP | 5.50 |
| 10 lbs. | Sodium Potassium Tartrate, TP | 12.50 |
| 1 lb. | Sodium Pyrophosphate, cryst. TP | .75 |
| 1 lb. | Sodium Sulfite, crystal, TP | .50 |
| 10 lbs. | Sodium Thiosulfate, cryst. TP | 4.80 |
| 10 lbs. | Sodium Tungstate (Folin), TP | 49.00 |
| 2 lbs. | Soluble Starch, TP | 2.00 |
| 1 lb. | Sulfur, finely powd. ppt., USP | .75 |
| 20 vials | Test Paper—Starch Iodide | 1.60 |
| 10 g. | Thymolphthalein, CP | .85 |
| 10 lbs. | Tissuemat Flakes, M.P. 52-54 | 5.40 |
| 200 g. | Tolidin, Ortho, C.P. | 5.70 |
| 10 lbs. | Toluene, TP | 4.60 |
| 1 g. | Triketohydrindene Hydrate | 1.60 |
| 1 g. | Tropaeolin, ortho, pH Ind. | .35 |
| 2 lbs. | Urea, TP | 2.00 |
| 2 lbs. | Vanillin, U.S.P. | 13.50 |
| 4 x 25 g. | d-Xylose, C.P. | 6.00 |
| 2 lbs. | Zinc Chloride, dry, gran. TP | 1.70 |
| 1 g. | Brom. Cresol Purple | 1.25 |
| 1 g. | Cresol Red | 1.25 |
| 2 g. | Thymol Blue | 2.50 |
| | Total | $1127.61 |

# COLLEGE CHEMISTRY

## RECAPITULATION

| | | |
|---|---|---|
| Lecture Demonstration Apparatus | | $ 231.65 |
| Materials for Preparation of Equipment | | 41.75 |
| General Equipment for all Courses | | 1308.45 |
| General Chemistry | | |
| Equipment and Supplies | $1803.28 | |
| Chemicals | 278.10 | |
| | | 2081.38 |
| Qualitative Analysis | | |
| Equipment and Supplies | 419.10 | |
| General Supplies | 177.50 | |
| Chemicals | 222.00 | |
| | | 818.60 |
| Quantitative Analysis | | |
| Equipment and Supplies | 3721.23 | |
| Desk Equipment | 1831.56 | |
| Chemicals | 955.04 | |
| | | 6507.83 |
| Organic Chemistry | | |
| General Apparatus | 427.21 | |
| Desk Apparatus | 1132.97 | |
| Chemicals | 461.12 | |
| | | 2021.30 |

| | | |
|---|---|---|
| Physical Chemistry | | |
| General Apparatus | $5003.82 | |
| Desk Equipment | 1056.32 | |
| Chemicals | 203.18 | |
| | | 6263.32 |
| Biochemistry | | |
| General Apparatus | 2907.30 | |
| Desk Equipment | 1478.28 | |
| Chemicals | 1127.61 | |
| | | 5513.19 |
| TOTAL | | $24,787.47 |

## COLLEGE GEOLOGY

The geology courses listed below are offered to undergraduate students in the colleges of the United States. No undergraduate need take all these courses for a major for the baccalaureate degree, but various combinations are chosen, depending upon the student's interests. For example, a student majoring in paleontology would be required to take all of the paleontology courses, plus general and historical geology and stratigraphy.

| COURSES OFFERED | USUAL CREDIT HOURS | OPEN TO |
|---|---|---|
| General Geology | 3 | Freshmen |
| Historical Geology | 3 | Freshmen |
| Mineralogy | 4 - 5 | Sophomores |
| Elementary Petrography | 4 - 5 | Sophomores |
| Map Interpretation | 2 | Sophs., Juniors and Seniors |
| Economic Geology | 4 - 5 | Juniors and Seniors |
| Field Geology | 3 - 5 | Sophs., Juniors and Seniors |
| Structural Geology | 2 | Juniors and Seniors |
| Sedimentation | 2 | Juniors and Seniors |
| Paleontology | 5 | Sophs., Juniors and Seniors |
| Micropaleontology | 2 | Juniors and Seniors |
| Stratigraphy | 5 | Juniors and Seniors |

These courses include class recitation, lecture, student laboratory exercises, and individual study, and frequently incorporate field study.

## GENERAL GEOLOGY

I. Introduction—Definitions

II. Atmosphere
- Origin
- Composition and extent
- Temperature and climatic effects
- Geological effects—Erosive; Depositional

III. Surface waters
- Precipitation
- Streams—Formation; stream history; weathering, transportation and corrosion; cycle of erosion; falls and rapids; effect on streams by changes in level
- Depositional work of streams

IV. Ground water
- Source
- Water table
- Vadose water
- Geologic work of caves and caverns, land slides, springs and wells

V. Snow and ice
- Snow fall—Amount and accumulation
- Snow fields and ice fields
- Glaciers, valley type—Classification; work; debris
- Ice caps—Character; ancient and modern; erosional and depositional history
- Glacial motion—Causes
- Causes of extensive glaciation

VI. Lakes
- Fresh and salt—Agencies forming lakes; history; relation to erosion cycle; lakes of the world

VII. The ocean
- The ocean basin and its margin
- Characteristics of the sea bottom
- Origin and composition of sea water
- Sedimentation on sea bottom—Mechanical, biochemical, deep sea deposits

VIII. Movements of sea water
- Causes—General circulation; ocean currents, storm driven, tides
- Effects—Erosional, depositional

IX. Vulcanism
- Movements of magmas and lavas—Hot solutions and magnetic water
- Intrusive vulcanism—Forms assumed
- Extrusive vulcanism—Volcanic eruptions; fissure eruptions; distribution of volcanoes
- Volcanic products

X. Igneous rocks
- Origin and classification

XI. Metamorphism
- Definition and divisions
- Causes
- Metamorphic rocks—Metaigneous, metasedimentary

XII. Ore deposits, general consideration
- Igneous deposits
- Metamorphic processes
- Sedimentary processes

XIII. Structure, a phase of condensation
- Simple structures—Bedding, jointing, ripple marks, unconformities, dip and strike
- Major structure—Faulting, folding and overthrust, types of resulting structures

XIV. Diastrophism, a major process
- Definition
- Kinds of movement—Small and rapid—earthquake; slow and massive—mountain forming
- Regions affected
- Causes of movement

XV. Internal heat condition
- Physical condition of earth's interior—Evidence based on transmission of shock; evidence based on specific gravity; evidence based on magnetism
- Internal heat data from deep wells
- Theoretical original heat condition
- Modified hypotheses—Convection hypothesis; central solidification hypothesis; accretion hypothesis

XVI. Theoretical causes of surface deformation
- Internal heat transfer
- Denser aggregates at center—Partial loss of atomic energy
- Extrusion of lavas
- Changes in rate of rotation

XVII. Age of deformation periods
- Mountains—Age
- Erosion and rejuvenation
- Role played by life

## LABORATORY EXPERIMENTS

Laboratory study of materials that constitute the earth's crust
- Common rock-forming minerals—Methods of identification—physical properties; chemical composition; geologic and geographic distribution; commercial uses
- Common rocks—Igneous rocks; sedimentary rocks; metamorphic rocks

Laboratory study of land forms, using topographic maps and models

Laboratory study of earth structures, using geologic cross-sections, block diagrams, and specially prepared models

# HISTORICAL GEOLOGY

## OUTLINE OF COURSE CONTENT

I. A general survey of the past history of the earth
II. How records in stone are read
III. The scale of time, how determined
IV. The constant change of living things
V. The living record of the dead
VI. The earth's changing physical features during the major units of geologic time
VII. The unfolding of the features of earth that we see today
VIII. The recent ice sculpturing of parts of the earth
IX. The Paleozoic inhabitants of the earth
X. The reign of reptiles
XI. Mammals inherit the earth
XII. The coming of man

# MINERALOGY

**Chemistry is a prerequisite for this course**

## OUTLINE OF COURSE CONTENT

I. Introductory discussion of the physical and chemical properties of minerals and how to test for them in the laboratory—Hardness; specific gravity; fusibility; cleavage; parting; principles of crystal structure and its bearing on these properties

II. Crystallography—General principles; systematic discussion of systems, classes, forms, symmetry and twinning

III. Crystal habits, imperfections, markings, inclusions, aggregates—Reflected and transmitted light; luster, color, streak; refracted and polarized light

IV. Origin of minerals—Melt, solution, gases, metamorphism, pseudomorphism, polymorphism, isomorphism

In the laboratory the student sees what has been discussed in the lectures and especially handles crystal models and performs simple chemical and blowpipe tests. Also, minerals are systematically examined and classified, with the help of tables following Dana's system of classification.

V. Descriptive and determinative mineralogy

Individual and groups of minerals are taken up with respect to their physical and chemical properties, their geological associations and occurrences, their geographical distribution and uses to man.

This is the order in which the minerals are discussed:

elements
sulfides
sulfo-salts
oxides
hydroxides
carbonates
silicates
niobates, tantalates, tungstates, phosphates, arsenates, vanadates
sulfates
halides

Particular emphasis is laid on the modern conception of atomic structure and in this way it is possible to make a formerly rather dull descriptive subject highly interesting to the student.

The work in the laboratory during this quarter gives the student knowledge of the 120 most important minerals. He spends most of his time identifying hundreds of unknowns and learning their associations and occurrences.

## ELEMENTARY PETROGRAPHY

### OUTLINE OF COURSE CONTENT

I. Introduction—Review of minerals

II. Classification of rocks

III. Igneous rocks
- Generalities
- Families in detail
- Summaries—Economic interest

IV. Sedimentary rocks
- Families in detail
- Summaries—Economic interest
- Correlation

V. Metamorphic rocks
- Generalities
- Detail of families
- Summaries—Economic interest

VI. Calculations
- Composition
- Transportation
- Alteration

## MAP INTERPRETATION

### OUTLINE OF COURSE CONTENT

I. Topographic maps
- Reading topographic maps—Scales, grids, elevations, slope calculations, topographic profiles
- Ground water features
- Wind action—Dunes and blowouts
- Stream erosion—Stream patterns; cycle of erosion
- Stream deposition—Deltas, levees, alluvial fans
- Glaciation—Mountain; continental
- Vulcanism
- Horizontal and tilted rocks
- Folded rocks
- Shorelines

II. Geological maps
- Horizontal rocks—Outcrop patterns, thicknesses, structure sections
- Tilted rocks—Outcrop patterns, determination of altitudes, calculations of thickness and depth, structure sections
- Folded rocks—Outcrop patterns, types of folds and recognition, calculations of plunge, structure sections
- Structure contour maps—Construction and interpretation; isopach and regional dip maps
- Igneous rocks—Recognition of various igneous bodies on maps
- Unconformities—Recognition and interpretation of geological history
- Faults—Determination of attitudes and direction and amount of displacements; age of faulting; problems in displaced beds and veins

# ECONOMIC GEOLOGY

## OUTLINE OF COURSE CONTENT

I. Metallic ores
- Classification of ore deposits
- Magmatic segregations
- Pegmatites
- Pyrometasomatic deposits
- Hypothermal deposits
- Mesothermal deposits
- Epithermal deposits
- Deposits formed by meteoric waters
- Sedimentary deposits
- Deformation of ore deposits
- Secondary enrichment
- Openings in rocks
- Metasomatic processes
- Mineral associations and wall rock alterations
- Associations of ores and igneous rocks
- Structural control
- Deposits—Iron; copper; gold and silver; lead and zinc; nickel, platinum and chromium; tin and tungsten; mercury, antimony, arsenic, manganese; miscellaneous metals

II. The non-metals
- Introduction and classification of the non-metallic economic minerals
- Coal—Classification of types of coal; physical and chemical properties; origin; structural features and metamorphism; coal field of the United States; coal fields of the world; reserves and economic aspects of world distribution
- Building stone—Types of stone utilized; physical properties; geologic occurrence
- Clay and clay products—Occurrence; physical and chemical properties affecting use
- Cement and lime—Raw materials; geologic occurrence; physical and chemical properties; impurities
- Salines—General occurrence and chemistry and theory of deposition of soluble salts; common salt; potash salts; nitrates; gypsum and lesser salts
- Origin, mineralogy, geologic occurrence and commercial aspects of important non-metallics—One lecture each for phosphates, abrasives, asbestos, barite, mica, feldspar and lithium minerals, graphite, magnesite, talc, sulfur, fluorspar
- Minor minerals
- Gems—Varieties; origin and occurrence

# FIELD GEOLOGY

Field course. Four weeks of field work of at least eight hours per day. The program involves systematic work conforming with standards of official surveys. Preparation of geology maps, structure sections, reports are included.

The actual work is somewhat flexible to allow for weather conditions, variation in permission to work in different mines, and road conditions. The usual program may be about as follows:

I. Stratigraphic studies
   Mainly detailed measurements and study of marine sedimentary rocks

II. Traverse mapping with Brunton compass and pacing

III. Investigation of special areas, mines and mills
   Involves a wide range of structural, petrographic, mining and metallurgical problems

IV. Plane table mapping of an important stratigraphic and structural area

V. Individual mapping of a selected area, including the main types of problems involved in geologic field work

# STRUCTURAL GEOLOGY

## OUTLINE OF COURSE CONTENT

I. Introduction

II. Definitions and relations between stress and strain, mechanical principles

III. Folds—Classification; methods of recognition; mechanical interpretation; relation to economic deposits

IV. Faults—Classification; evidence of faulting; effect on distribution of beds; importance in connection with commercial deposits

V. Joints—Same outline as for faults

VI. Cleavage—Types; origin; mechanical principles; use in structural work; significance

VII. Igneous rock structures—Classification and origin

VIII. Structures in unconsolidated sediments and mine subsidence

IX. Breccias—Classification and recognition

X. Physiographic expressions of structure

XI. Earthquakes and their relation to structure

XII. Unconformity—Types and significance

XIII. Interior of the earth and isostasy

XIV. Major earth structure—Continents; ocean basins; mountains; plateaus

XV. Causes of earth failure

XVI. Field methods and descriptive geometry applied to structural problems

XVII. Experimental studies of structural problems

# SEDIMENTATION

## OUTLINE OF COURSE CONTENT

I. The environments in which sediments accumulate
   - Continental environments and their sediments
   - Mixed continental and marine environments
   - Marine environment
     - The above environments are discussed from the standpoint of the various types of sedimentary processes that are active; the characteristics and associations of the sediments; criteria for the determination of sediments formed in such environments and the geologic importance of each type

II. The sources of the sediments that accumulate in the various environments
   - Land-derived or terruginous sources
   - Organic sources and forms of life involved
   - Volcanic and magmatic sources

III. The transportation and deposition of sediments
   - Agents of transportation
   - Structures in sediments with reference to those which may be used in interpreting major field relations
   - Overlapping and offlapping relations—Their bearing on stratigraphic problems; numerous actual cases with maps and diagrams

IV. Textures of sediments
   - Clastic sediments—Classifications
   - Non-clastics—Biogenic or organic—examples; hydrogenic or chemical precipitates—examples

V. The lithification of sediments and diagenetic processes accompanying and following lithification
   Differential compaction during lithification—Percentage decrease in porosity; structure resulting, such as oil reservoirs—examples
   Cementation processes
   Mineralogic changes involved (authigenic minerals)
VI. Methods for field and laboratory studies
   Schedule for field descriptions
   Methods of sampling sediments
   Mechanical analyses
   Mineral analyses

## LABORATORY STUDY

I. Sampling and preparation of samples for analysis
   From large composite sample—By quartering method; with Jones splitter; with Otto micro-splitter
   Channel sampling from outcrop
   Serial sampling, horizontally, vertically
   Disintegration of samples—Mechanically, chemically

II. Textural analyses of medium grained clastic sediments by screening
   Determination of—Median grain size; coefficient of sorting; effective size; coefficient of skewness; cumulative percentage curves; calculations of size ratio from various screen scales

III. Graphs and diagrams plotted

IV. Textural analyses of fine grained sediment
   The disaggregation, dispersion, and deflocculation of sample, use of peptizers —By pipette method; by hydrometer; by differential settling; by centrifuge

V. Mineral analyses of sediments (clastics)
   Separation of light and heavy minerals—By means of heavy liquids; magnetic separation; dielectric separation; by means of centrifuge

VI. Mineral analyses of sediments (non-clastics)
   Insoluble residues of limestones, dolomites, saline sediments, phosphates

VII. Frequency distribution of accessory minerals
   Variations between formations and within same formation
   Correlation of stratigraphic units by means of accessory minerals
   Mineral counts and statistical methods

VIII. Study of subsurface samples
   Construction of well logs from drilling cuttings
   Samples from deep artesian wells in Minnesota and from oil wells in Kansas and Oklahoma

IX. Correlations of stratigraphic units from drill cuttings, using accessory minerals and insoluble residues

X. Unknown sample problem
   A complete textural and mineral analysis and a report on its probable source and environment of accumulation

## LABORATORY EXPERIMENTS

Methods of sampling—In the field; in the laboratory; from large sample; from small sample; from very small sample (microsplit)
Preparation of samples for study
Screen analysis of sand
Heavy mineral separation from sand
Calculate percentage distribution of heavy minerals in sand
Mechanical analysis of fine-grained sediment—Hydrometer method; Krumbein method
Separation of grit from Bentonite—Petrographic analysis of grit
Separation of feldspar and quartz in sandstone—Centrifuge method
Separation of heavy residual from a limestone (compare residuals from many limestones)
Determination of degree of roundness and sphericity of pebbles
Determination of degree of roundness and sphericity of small sand grains
Surface textures of mineral grains

# PALEONTOLOGY

## OUTLINE OF COURSE CONTENT

I. Fossils—Their preservation and use

II. The plants—Classification, distribution and importance
- Thallophyta—Primitive plants as rock builders; blue-green algae; aldae; diatoms; algae and bacteria
- Bryophyta—Of little paleontological importance
- Pteridophyta—Filicales; Equisetales; Lycopodiales; and Sphenophyllales most important
- Spermatophyta—Gymnospermae—an exceedingly important class including the seed ferns, cyeads, Ginkgos and conifers; angiospermae—the modern, common plants

III. The animals—Their characters distinctive from plants and their record as fossils
- Protozoa—Foraminifera and Radiolaria important
- Porifera—Common fossils
- Coelenterata—Very important as fossils; Hydrozoa, Graptozoa and Anthozoa
- Vermes—Chiefly Annelida (Polychaeta)
- Echinodermata—Of prime importance; attached forms—Cystoidea, Edriasteroidea, Blastoidea, and Crinoidea; free forms—Asteroidea, Ophiuroidea, Echinoidea and Holothiuroidea
- Bryozoa—Abundant as fossils
- Brachiopoda—Exceedingly important in Paleozoic—Articulate and inarticulate
- Mollusca—Amphineura and Scaphipoda of little importance; Pelecypoda, Gastropoda and Cephalopoda very important
- Arthropoda—Trilobita—Highly important Paleozoic form; Phyllopoda and copepoda of slight importance; Cirripedia and Malacostraca common in Tertiary; Merostomata—rare but good index fossils, Cambrian to present; Insecta—Abundant since Pennsylvanian
- Chordata—General discussion and primitive forms; Pisces—Ordovician to present—the true fishes (modern, bony fishes), developmental characters, characteristic form and structure of Ostracodermi, Cyclostomata, Placodermata and Elasmobranchii; Amphibia—Stegocephalia and Labyrinthodontidae; Reptilia—Permian to present—Dinosauria, Ichthyosauria, Pterosauria, etc., characteristic form and structure, modern reptiles and living fossils, developmental characters; birds—Jurassic to present—"feathered reptiles"; Mammalia—Triassic to present—developmental characters of foot and tooth

Laboratory consists of sketching and study of representatives of those forms, fossil and living, taken up during lecture and recitation periods.

# MICROPALEONTOLOGY

## OUTLINE OF COURSE CONTENT

I. Care of equipment
- The binocular microscope—Its use and abuse; magnification used; care of parts; check condition frequently
- Light, screens, burners, reagents

II. Private equipment
- "oo" sable brush, black metal tray, containers
- Materials for making slides and slide box

III. Collecting material for laboratory
- Recent—label carefully
- Fossil—label carefully—outcrops and well samples

IV. Kinds of micro-fossils
- Plants—Diatoms; pollen grains, spores and spore cases, fragments of woody tissue
- Animals—Radiolaria and Foraminifera; Graptolites, sponge spicules and fragments of any larger form; Ostracoda; Scolecodents; Conodonts and otoliths; larval forms of many larger forms

V. Preparation of material for study
- Disintegration, screening, mounting
- Methods of recovery
- Making and mounting slides

VI. Use of key and tables
- The key and text
- Literature and how to use it
- Final determinations

VII. Correlation charts
- How to make them
- How to use them

VIII. Criteria tor correlation of micro-fossils
- General faunal aspect
- Evolutional stages or homologous species
- Abundance of specimens of same genus or species
- Percentage of like species
- Percentage of like species occurring abundantly
- Sequence of faunas
- Index genera and species
- Guide fossils

IX. All correlations checked through three horizons, above and below

X. Check by all available methods

## STRATIGRAPHY OF NORTH AMERICA

I. Principles of stratigraphy

Doctrine of uniformitarianism—Sedimentary types—strata, clastic and chemical sediments, red beds, black shales, dolomites, chert; geosynclines—Mississippi delta; epeiric seas—continental shelves; shields and domes; paleogeography

Doctrine of superposition—Stratigraphic classification—rock and time terms, type section; principles of correlation—method of stratigraphic superposition, paleontologic method, doctrine of faunal succession, faunal realms, migration of faunas, ecology of faunas, facies, guide fossils; petrologic and ecologic methods, insoluble residues, heavy and residual minerals, areal geologic method, structural and diastrophic method—unconformities, angular unconformity, disconformity, diastem, overlap and offlap, Ulrich's philosophy of oscillation, Grabou's philosophy of pulsation; facies method

II. Regional stratigraphy
- New York
- Appalachian geosyncline
- Cincinnati arch
- Ohio basin
- Michigan basin
- Mississippi valley
- Ozark dome
- Ouachita geosyncline
- Gulf coast
- Texas Permian basin
- Western high plains
- Black Hills
- Great Basin
- Grand Canyon
- Pacific coast ranges

## GENERAL GEOLOGY

### GENERAL APPARATUS

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| | | 1 | Alpine glaciation | $ 3.50 |
| | | 1 | Continental glaciation | 3.50 |
| | | 1 | Youthful stream | 3.50 |
| | | 1 | Mature stream | 3.50 |
| | | 1 | Old stream | 3.50 |
| | | 1 | Underground water | 3.50 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| | | 1 | Shoreline of emergence | $ 3.50 |
| | | 1 | Cuesta escarpments | 3.50 |
| | | 1 | Stream capture | 3.50 |
| | | 1 | Antecedent stream | 3.50 |
| | | 1 | Anticlinal dome | 3.50 |
| | | 1 | Hogbacks | 3.50 |
| | | 1 | Horsts and grabens | 3.50 |
| 6890 | | 20 | Topographic sheets illustrating different geological processes | 2.00 |
| 7025 | | 1 | Wall map of each continent | 60.00 |
| | | 1 | Lb. hydrochloric acid | .75 |
| | | 1 | Lb. acetic acid | .75 |
| | | 200 | Lantern slides (selected) | 200.00 |
| | | 1 set | Film strips (selected) | 25.00 |
| 3962 | 78270A | 1 | Lantern slide projector | 159.60 |
| 3967 | | 1 | Film slide projector | 46.60 |
| 3931A | 78345A | 1 | Projection screen (7′ x 7′) | 22.50 |
| | | | Total | $562.70 |

## STUDENT SUPPLIES:

### Minerals

Each student should have a specimen 2″ x 3″ of each of the following:

| | | | |
|---|---|---|---|
| 20 | Apatite (crystalline fragments) | $.15 | $3.00 |
| 20 | Apatite (chlor-apatite, massive | .15 | 3.00 |
| 20 | Augite (showing parting) | .10 | 2.00 |
| 20 | Biotite (cleavages) | .10 | 2.00 |
| 20 | Calcite (rhombic cleavages) | .10 | 2.00 |
| 20 | Calcite (chalk) | .10 | 2.00 |
| 20 | Calcite (marble, white) | .10 | 2.00 |
| 20 | Calcite (oolite) | .10 | 2.00 |
| 20 | Calcite (travertine, golden-brown "Onyx marble") | .10 | 2.00 |
| 20 | Chlorite (dark green masses) | .10 | 2.00 |
| 20 | Epidote (crystalline, rocky) | .15 | 3.00 |
| 20 | Fluorite (antozonite, massive purple) | .10 | 2.00 |
| 20 | Fluorite (cleavages, small purple) | .20 | 4.00 |
| 20 | Galena (cleavable) | .20 | 4.00 |
| 20 | Garnet (almandite — crystalline in micaschist, dodecahedrons) | .10 | 2.00 |
| 20 | Garnet (andradite — massive, brown, with Wollastonite) | .10 | 2.00 |
| 20 | Garnet (grossularite—masses, greenish gray "South African Jade" | .20 | 4.00 |
| 20 | Garnet (pyrope—in serpentine) | .10 | 2.00 |
| 20 | Garnet (rhodolite—masses in mica-schist) | .10 | 2.00 |
| 20 | Graphite (foliated, pure) | .25 | 5.00 |
| 20 | Graphite (crystalline in schist) | .10 | 2.00 |
| 20 | Gypsum (massive, pink or gray) | $.10 | $2.00 |
| 20 | Gypsum (columnar, pink) | .10 | 2.00 |
| 20 | Gypsum (satin spar, choice, long fibrous masses) | .10 | 2.00 |
| 20 | Halite (transparent cleavages) | .10 | 2.00 |
| 20 | Hematite (micaceous, sparkling mass with magnetite) | .15 | 3.00 |
| 20 | Hematite (massive) | .10 | 2.00 |
| 20 | Hematite (oolitic) | .10 | 2.00 |
| 20 | Hornblende (cleavable) | .15 | 3.00 |
| 20 | Kaolinite (compact) | .10 | 2.00 |
| 20 | Limonite (amorphous) | .10 | 2.00 |
| 20 | Limonite (yellow ochre) | .10 | 2.00 |
| 20 | Magnetite (crystalline) | .15 | 3.00 |
| 20 | Muscovite (common sheet mica) | .10 | 2.00 |
| 20 | Olivine (crystalline) | .10 | 2.00 |
| 20 | Orthoclase (sanidine) | .15 | 3.00 |
| 20 | Plagioclase (albite — crystalline) | .10 | 2.00 |
| 20 | Pyrite (crystalline) | .15 | 3.00 |
| 20 | Quartz (translucent) | .10 | 2.00 |
| 20 | Quartz (greasy quartz—masses) | .10 | 2.00 |
| 20 | Quartz (milky quartz—masses) | .10 | 2.00 |
| 20 | Quartz (rose quartz—pink) | .10 | 2.00 |
| 20 | Serpentine (massive) | .10 | 2.00 |
| 20 | Talc (foliated—sea green) | .10 | 2.00 |
| | Total | | $105.00 |

### Rocks

Each student should have a specimen 2" x 3" of each of the following

| | | | |
|---|---|---|---|
| 20 | Granite | $.15 | $3.00 |
| 20 | Granite porphyry | .15 | 3.00 |
| 20 | Syenite | .15 | 3.00 |
| 20 | Syenite porphyry | .15 | 3.00 |
| 20 | Felsite porphyry | .15 | 3.00 |
| 20 | Diorite | .15 | 3.00 |
| 20 | Diorite porphyry | .15 | 3.00 |
| 20 | Gabbro | .15 | 3.00 |
| 20 | Gabbro porphyry | .15 | 3.00 |
| 20 | Basalt porphyry | .15 | 3.00 |
| 20 | Obsidian | .15 | 3.00 |
| 20 | Pitchstone | .15 | 3.00 |
| 20 | Pumice | .15 | 3.00 |
| | Shale | | |
| 20 | Arenaceous shale | .15 | 3.00 |
| 20 | Calcareous shale | .15 | 3.00 |
| 20 | Ferruginous shale | .15 | 3.00 |
| 20 | Bituminous shale | .15 | 3.00 |
| 20 | Tillite | .15 | 3.00 |
| | Limestone | | |
| 20 | Arenaceous limestone | .15 | 3.00 |
| 20 | Lithographic limestone | .15 | 3.00 |
| 20 | Carbonaceous limestone | .15 | 3.00 |
| 20 | Fossiliferous limestone | .15 | 3.00 |
| 20 | Oolite | .15 | 3.00 |
| 20 | Coquina | .15 | 3.00 |
| 20 | Chalk | .15 | 3.00 |
| 20 | Scoria | $.15 | $3.00 |
| 20 | Tuff | .15 | 3.00 |
| 20 | Volcanic breccia | .15 | 3.00 |
| 20 | Breccia | .15 | 3.00 |
| 20 | Conglomerate | .15 | 3.00 |
| 20 | Sandstone | .15 | 3.00 |
| 20 | Siliceous sandstone | .15 | 3.00 |
| 20 | Calcareous sandstone | .15 | 3.00 |
| 20 | Ferruginous sandstone | .15 | 3.00 |
| 20 | Carbonaceous sandstone | .15 | 3.00 |
| 20 | Argillaceous sandstone | .15 | 3.00 |
| 20 | Arkose | .15 | 3.00 |
| 20 | Flint | .15 | 3.00 |
| 20 | Chert | .15 | 3.00 |
| 20 | Tripolite | .15 | 3.00 |
| 20 | Peat | .15 | 3.00 |
| 20 | Lignite | .15 | 3.00 |
| 20 | Bituminous coal | .15 | 3.00 |
| 20 | Anthracite coal | .15 | 3.00 |
| 20 | Big iron ore | .15 | 3.00 |
| 20 | Gypsum | .15 | 3.00 |
| 20 | Rock salt | .15 | 3.00 |
| | Total | | $141.00 |
| | Grand Total | | $808.70 |

## ADDITIONAL MATERIALS NEEDED FOR HISTORICAL GEOLOGY

### FOSSILS

One each of the following items are needed for the class:

#### Protozoa

| | | | |
|---|---|---|---|
| Fusulina (Pennsylvanian) | $ .25 | Orbitolina (Recent) | $ .25 |
| Nummulites (Eocene) | .25 | | |

#### Porifera

| | | | |
|---|---|---|---|
| Calcarea: | | Desmospongia: | |
| Paleozoic sponge | .25 | Astylomanon (Silurian) | .50 |
| Sycon (Recent) | .25 | Porocystis (Cretaceous) | .25 |
| Hexactinellida: | | Cliona (Recent) | .35 |
| Hydnoceras (Devonian) | 1.00 | Euspongia (Recent) | .25 |
| Euplectella (Recent) | 2.00 | | |
| Receptaculites (Ordovician) | .50 | | |

#### Coelenterata

| | | | |
|---|---|---|---|
| Hydrozoa: | | Prismatophyllum (Devonian) | .50 |
| Hydroid colony (Recent) | .25 | Cystiphyllum (Devonian) | .50 |
| Stromatoporoid (Devonian) | .50 | Hexacoralla: | |
| Stylaster (Recent) | .25 | Solenastraea (Pliocene) | .50 |
| Graptozoa: | | Cyclolites (Cretaceous) | .50 |
| Diplograptus or Discranograptus (Ordovician) | .50 | Porites (Pliocene) | .50 |
| Monograptus (Silurian) | .50 | Acropora (Recent) | .25 |
| Anthozoa: | | Alcyonaria: | |
| Tetracoralla: | | Tubipora (Recent) | .50 |
| Microcyclus (Devonian) | .50 | Protaraea (Ordovician) | .25 |
| Heliophyllum (Devonian) | .25 | Tabulata: | |
| Columnaria (Ordovician) | .50 | Favosites (Devonian) | .25 |
| | | Syringopora (Devonian) | .50 |
| | | Halysites (Silurian) | .50 |

### Echinodermata

Cystoidea:
- Caryocrinus (Silurian) ..... $1.00

Blastoidea:
- Pentremites (Mississippian) ..... .25
- Granatocrinus (Mississippian) ..... .50

Crinoidea:
- Glyptocrinus (Ordovician) ..... 1.00
- Eucalyptocrinus (Silurian) ..... 1.00
- Batocrinus (Mississippian) ..... .75
- Arthracantha (Devonian) ..... 2.00

Asteroidea:
- Renaster (Devonian) ..... $1.50
- Asterias (Recent) ..... .25

Ophiuroidea:
- Ophiura (Recent) ..... .75

Echinoidea:
- Cidaris, test (Recent) ..... .50
- Strongylocentrotus, test (Recent) ..... .25
- Acrosalenia (Jurassic) ..... .50
- Holaster (Cretaceous) ..... .50
- Echinolampas (Oligocene) ..... .50
- Dendraster (Miocene) ..... .25

### Molluscoidea

Bryozoa:
- Stomatopora or Corynotrypa (Ordovician) ..... .25
- Constellaria (Ordovician) ..... .25
- Archimedes (Mississippian) ..... .50
- Lepralia (Recent) ..... .25

Brachiopoda:
- Obolus (Cambrian) ..... .50
- Lingula (Pennsylvanian) ..... .25
- Lingula (Recent) ..... .75
- Orbiculoidea (Pennsylvanian) ..... .25
- Crania (Ordovician) ..... .25
- Platystrophia (Ordovician) ..... .25
- Schizophoria (Devonian) ..... .25
- Pentamerus (Silurian) ..... .50
- Rafinesquina (Ordovician) ..... .25
- Juresania ("Productus") (Pennsylvanian) ..... .25
- Rhynchotrema (Ordovician) ..... .25
- Cyclothyris (Cretaceous) ..... .25
- Atrypa (Devonian) ..... .25
- Spirifer (Devonian) ..... .25
- Athyris (Devonian) ..... .25
- Composita (Pennsylvanian) ..... .25
- Terebratula (Eocene) ..... .50
- Laqueus (Recent) ..... .50

### Mollusca

Pelecypoda:
- Clinopistha (Pennsylvanian) ..... .25
- Glycimeris (Miocene) ..... .25
- Byssonychia (Ordovician) ..... .50
- Inoceramus (Cretaceous) ..... .75
- Myalina (Permian) ..... .50
- Ostrea (Recent) ..... .25
- Gryphaea (Cretaceous) ..... .50
- Megalomus (Silurian) ..... .75
- Pecten (Pliocene) ..... .50
- Crasatellites (Miocene) ..... .50
- Toucasia (Cretaceous) ..... .50
- Lucina (Recent) ..... .25
- Venus (Recent) ..... .25
- Martesia (Cretaceous) ..... .50

Amphineura:
- Chiton (Recent) ..... .25

Scaphopoda:
- Dentalium (Pleistocene) ..... .25

Gastropoda:
- Protowarthia (Ordovician) ..... .50
- Euphemus (Pennsylvanian) ..... .50
- Bembexia (Devonian) ..... .25
- Trepospira (Pennsylvanian) ..... .25
- Cyclonema (Ordovician) ..... .25
- Trochus (Recent) ..... .25
- Callonema (Devonian) ..... .50
- Platyceras (Devonian) ..... .50
- Voluta (Recent) ..... .50
- Turris (Miocene) ..... .25
- Conus (Recent) ..... .50
- Cylichna (Eocene) ..... .25
- Tentaculites (Devonian) ..... .50

### Trilobita

- Agnostus (Cambrian) ..... 2.00
- Olenellus (Cambrian) ..... 1.00
- Paradoxides (Cambrian) ..... 3.00
- Bathymiscus (Cambrian) ..... 2.00
- Isotelus gigas (Ordovician) ..... 2.00
- Calymena (Silurian) ..... 2.00
- Cyphasis (Devonian) ..... 2.50
- Proctus (Carboniferous) ..... 1.00

Total ..... $60.10

## ADDITIONAL MATERIALS NEEDED
## MINERALOGY

**Each student should have a specimen 1" x 2" of each of the following:**

| | | |
|---|---|---|
| 20 | Albite (crystalline) | $7.00 |
| 20 | Allanite (massive) | 2.00 |
| 20 | Alunite (crystalline) | 2.00 |
| 20 | Amblygonite (cleavable mass) | 2.00 |
| 20 | Amphibole (actinolite—crystalline) | 2.00 |
| 20 | Amphibole (asbestos—loose fibers) | 3.00 |

| | | |
|---|---|---|
| 20 | Amphibole (asbestos—long fibers) | $ 3.00 |
| 20 | Amphibole (Cummingtonite—fibrous) | 2.00 |
| 20 | Amphibole (Fasciculite—crystals in schist) | 2.00 |
| 20 | Amphibole (hornblende—cleavable) | 3.00 |
| 20 | Amphibole (tremelite—crystalline) | 2.00 |
| 20 | Andalusite (massive) | 3.00 |
| 20 | Andesine (crystalline) | 2.00 |
| 20 | Anglesite (massive with cerussite and galena.) | 7.00 |
| 20 | Anhydrite (crystalline) | 3.00 |
| 20 | Anhydrite (massive) | 2.00 |
| 20 | Anorthite (crystalline in rock) | 3.00 |
| 20 | Anorthoclase (larvikite, xline-granular) | 2.00 |
| 20 | Anthophyllite ("asbestos") | 2.00 |
| 20 | Antimony (with cervantite) | 4.00 |
| 20 | Apatite (asparagus stone) | 4.00 |
| 20 | Apatite (crystalline fragments) | 3.00 |
| 20 | Apatite (chlor-apatite, massive) | 3.00 |
| 20 | Aragonite (fibrous mass) | 3.00 |
| 20 | Argentite (masses on calcite) | 10.00 |
| 20 | Arsenopyrite (crystalline) | 3.00 |
| 20 | Axinite (crystalline) | 5.00 |
| 20 | Azurite (crystalline) | 6.00 |
| 20 | Barite (cleavages) | 2.00 |
| 20 | Bauxite (pisolitic—red and black) | 2.00 |
| 20 | Bauxite (pisolitic—gray) | 2.00 |
| 20 | Bauxite (nodules) | 2.00 |
| 20 | Bentonite (partly powdered) | 3.00 |
| 20 | Beryl (massive—pale bluish green) | 2.00 |
| 20 | Beryl (massive—white) | 2.00 |
| 20 | Biotite (cleavages) | 2.00 |
| 20 | Bornite (massive) | 5.00 |
| 20 | Brucite (massive) | 3.00 |
| 20 | Bytownite (crystalline) | 2.00 |
| 20 | Bytownite (crystalline, in gabbro) | 2.00 |
| 20 | Calcite (rhombic cleavages) | 2.00 |
| 20 | Calcite (chalk) | 2.00 |
| 20 | Calcite (marble, white) | 2.00 |
| 20 | Calcite (oolite) | 2.00 |
| 20 | Calcite (travertine, golden-brown "Onyx marble") | 2.00 |
| 20 | Carnotite (high grade) | 5.00 |
| 20 | Celestite (crystalline, pure) | 3.00 |
| 20 | Cerussite (crystalline, nearly pure) | 7.00 |
| 20 | Chalcocite (massive, high grade) | 7.00 |
| 20 | Chalcopyrite (massive, high grade, auriferous) | 4.00 |
| 20 | Chromite (massive) | 2.00 |
| 20 | Chrysocolla (blue-green) | 10.00 |
| 20 | Columbite (masses, nearly pure) | 6.00 |
| 20 | Copper (masses in amygdaloid) | 4.00 |
| 20 | Cordierite (blue masses, in rock) | 5.00 |
| 20 | Corundum (crystalline fragments in andesine) | 2.00 |
| 20 | Cristobalite (pure pseudo-isometric silica) | 20.00 |
| 20 | Crocidolite (fibers, matted) | 2.00 |
| 20 | Cryolite (pure white mass) | 3.00 |
| 20 | Datolite (crystalline) | 7.00 |
| 20 | Diaspore (massive, diaspore-clay) | 2.00 |
| 20 | Dolomite (coarse crystalline, white) | 2.00 |
| 20 | Dolomite (fine crystalline, white) | 2.00 |
| 20 | Enstatite (crystalline, partly altered to serpentine) | 2.00 |
| 20 | Epidote (crystalline, rocky) | 3.00 |
| 20 | Fayalite (in metamorphosed taconite) | 2.00 |
| 20 | Fluorite (antozonite, massive purple) | 3.00 |
| 20 | Fluorite (cleavages, small purple) | 4.00 |
| 20 | Franklinite (crystalline mass, magnetic) | 3.00 |
| 20 | Fuller's Earth (masses—attapulgite) | 2.00 |
| 20 | Garnet (almandite—crystalline in mica-schist, dodecahedrons) | 2.00 |
| 20 | Garnet (andradite—massive, brown, with Wollastonite) | 2.00 |
| 20 | Garnet (grossularite—masses, greenish gray "South African Jade") | 4.00 |
| 20 | Garnet (pyrope—in serpentine) | 2.00 |
| 20 | Garnet (rhodolite—masses in mica-schist) | 2.00 |
| 20 | Glauconite (sand) | 3.00 |
| 20 | Goethite (fibrous mass) | 5.00 |

| | | |
|---|---|---|
| 20 | Gold (gold quartz) | $ 3.00 |
| 20 | Graphite (foliated, pure) | 5.00 |
| 20 | Graphite (crystalline in schist) | 2.00 |
| 20 | Gypsum (massive, pink or gray) | 2.00 |
| 20 | Gypsum (columnar, pink) | 2.00 |
| 20 | Gypsum (satin spar, choice, long fibrous masses) | 2.00 |
| 20 | Halite (transparent cleavages) | 2.00 |
| 20 | Halloysite (Indianaite, partly powdered) | 2.00 |
| 20 | Hematite (micaceous, sparkling mass with magnetite) | 2.00 |
| 20 | Hematite (massive) | 2.00 |
| 20 | Hematite (oolitic) | 2.00 |
| 20 | Ilmenite (crystalline mass) | 2.00 |
| 20 | Kaolin (compact) | 2.00 |
| 20 | Kyanite (crystalline) | 2.00 |
| 20 | Labradorite (coarse-crystalline) | 2.00 |
| 20 | Lazulite (massive) | 5.00 |
| 20 | Lepidolite (crystalline) | 2.00 |
| 20 | Leucite (crystal) | 3.00 |
| 20 | Limonite (amorphous) | 2.00 |
| 20 | Limonite (yellow ochre) | 2.00 |
| 20 | Magnesite (crystalline) | 2.00 |
| 20 | Magnetite (crystalline) | 3.00 |
| 20 | Malachite (crystalline masses) | 3.00 |
| 20 | Manganite (massive with hematite) | 5.00 |
| 20 | Marcasite (crystals) | 3.00 |
| 20 | Microcline (cleavage) | 2.00 |
| 20 | Microcline (soda-microcline) | 2.00 |
| 20 | Molybdenite (veinlets) | 3.00 |
| 20 | Monazite (sand) | 3.00 |
| 20 | Muscovite (common sheet mica) | 2.00 |
| 20 | Nepheline (crystalline—massive) | 2.00 |
| 20 | Oligoclase (cleavage) | 2.00 |
| 20 | Olivine (crystalline) | 2.00 |
| 20 | Opal (diatomaceous [infusorial] earth) | 2.00 |
| 20 | Opal (green) | 3.00 |
| 20 | Opal (wood opal) | 3.00 |
| 20 | Orpiment (crystalline) | 5.00 |
| 20 | Orthoclase (sanidine) | 3.00 |
| 20 | Pectolite (radiated mass) | 5.00 |
| 20 | Pentlandite (crystalline in pyrrhotite) | 10.00 |
| 20 | Perthite (pink cleavage) | 2.00 |
| 20 | Prehnite (crystalled, odd forms) | 4.00 |
| 20 | Psilomelane (massive) | 2.00 |
| 20 | Pyrite (crystalline) | 3.00 |
| 20 | Pyrolusite (pure) | 3.00 |
| 20 | Pyroxene (augite—showing parting) | 2.00 |
| 20 | Pyroxene (diallage—crystalline) | 3.00 |
| 20 | Pyrophyllite (radiated) | 3.00 |
| 20 | Pyrrhotite (niceliferous—massive) | 2.00 |
| 20 | Quartz (translucent) | 3.00 |
| 20 | Quartz (greasy quartz—masses) | 2.00 |
| 20 | Quartz (milky quartz—masses) | 2.00 |
| 20 | Quartz (rose quartz—pink) | 2.00 |
| 20 | Realgar (crystalline—massive) | 5.00 |
| 20 | Rhodochrosite (crystalline mass) | 5.00 |
| 20 | Rutile (massive) | 2.00 |
| 20 | Scapolite (cleavable) | 2.00 |
| 20 | Scheelite (massive) | 5.00 |
| 20 | Serpentine (massive) | 2.00 |
| 20 | Siderite (crystalline) | 2.00 |
| 20 | Smaltite (massive) | 4.00 |
| 20 | Smithsonite (crystalline) | 5.00 |
| 20 | Sodalite (colorless in nepheline-syenite) | 2.00 |
| 20 | Sphalerite (cleavable) | 3.00 |
| 20 | Spodumene (cleavable) | 2.00 |
| 20 | Staurolite (crystalline) | 5.00 |
| 20 | Stibnite (crystalline mass) | 5.00 |
| 20 | Strontianite (crystalline) | 3.00 |
| 20 | Sulfur (crystalline) | 3.00 |
| 20 | Talc (foliated—sea green) | 2.00 |
| 20 | Topaz (cleavage—mass) | 3.00 |

| | | |
|---|---|---|
| 20 | Tourmaline (rose-pink radiating crystals) | $ 3.00 |
| 20 | Tourmaline (columnar) | 5.00 |
| 20 | Wavellite (radiated) | 3.00 |
| 20 | Willemite (massive) | 5.00 |
| 20 | Witherite (crystalline) | 2.00 |
| 20 | Wollastonite (fibrous) | 4.00 |
| 20 | Zincite (with franklinite) | 4.00 |
| 20 | Zircon (small crystals) | 2.00 |
| | Total | $496.00 |

### General Student Apparatus

| Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|
| 5440C | 20 | Streak plates | $ 5.20 |
| 4560 | 20 | Blow pipes | 10.00 |
| | 10 | Lb. charcoal | 7.50 |
| 3942 | 20 | Sets of "Hardness" pencils | 130.00 |
| 4620 | 80 | Small acid dropper bottles | 20.00 |
| 5620 | 10 | Doz. test tubes | 4.00 |
| 1136 | 10 | Picnometers | 32.50 |
| | | Total | $209.20 |
| | | **General Apparatus** | |
| | 1 | Scale of hardness collection | 1.65 |
| | 1 | Luster collection | 13.25 |
| | 1 | Fracture collection | 3.30 |
| | 1 | Cleavage collection | 1.90 |
| | 1 | Tenacity collection | 1.35 |
| | 1 | Mineral structures collection | 5.00 |
| | 1 | Set of crystal models | 30.00 |
| | 1000 | Paste board trays 2" x 3" | 25.00 |
| 4060 | 1 | Jolly balance | 75.00 |
| 8010 | 1 | Binocular microscope, stereoscopic | 184.00 |
| 112 | 1 | Geologist's pick or hammer | 2.75 |
| 5 | 1 | Small anvil | 3.00 |
| | | Total | $346.20 |

## ADDITIONAL MATERIALS NEEDED FOR PETROGRAPHY

| | | | |
|---|---|---|---|
| 8066 | 20 | Triplet Aplanat magnifiers (hand lens) | $240.00 |
| 7978 | 3 | Polarizing microscopes—with rack and pinion coarse adjustment, micrometer type fine adjustment with graduations to .001 mm., equipped as follows: | |

a. Body—large diameter with standard diameter eye-piece tube with built-in

a Bertrand lens—in sliding mount with fixed focus

a" Analyzer—polaroid in non-rotatable mount

b. Stage—rotating ball bearing, 150 mm. diameter, graduated with vernier

c. Substage—fork type, with rack and pinion focusing adjustment: combined N. S. 1.0 condenser and polarizer (polaroid)

d. Nosepiece—Quick change type, with 3 objective centering rings

e. Objectives—strain free, achromatic—25 mm. 5.1XX; 8 mm. 20X; 4 mm. 44X

| Welch No. Cat. | Quantity | Description | Price Total |
|---|---|---|---|
| | | f. Eyepieces—standard diameter, pinhole. Cross hair with focusing eyelens 10X; micrometer eyepiece with focusing eyelens 10X and 6X | |
| | | g. Compensators—full wave place. Quartz wedge K-III order ¼ wave plate<br>Complete in polished hardwood cabinet with velvet-lined accessory case | $2116.50 |
| 8008 | 3 | Mechanical stages, petrographic microscope stands, in leatherette case | 150.00 |
| 8002 | 3 | Burton Fresnel Lights | 35.85 |
| 8003 | 3 | Blue diffusing filters | 3.00 |
| | 1 | Collection of 100 rocks (selected) | 45.00 |
| | 1 | Set of thin-sections of above rocks | 150.00 |
| | 1 | Rock-forming mineral collection (selected) | 75.00 |
| | 1 | Shillaber's certified index of refraction liquids—RF-1/5 fifth set intervals 0.01; 31 liquids | 37.50 |
| | | Total | $2852.85 |

## ADDITIONAL MATERIALS NEEDED FOR MAP INTERPRETATION

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 328 | | 10 | Sets, drawing instruments | $150.00 |
| 225 | 330B | 20 | Protractors | 5.00 |
| 325 | | 20 | Sets, triangles, transparent, xylonite, 6", 9" 12", 18" | 75.00 |
| 331 | | 20 | T squares, wood with xylonite lining | 50.00 |
| 330 | | 20 | Drawing boards (18" x 24") | 30.00 |
| 116 | | 10 | Sets, 3 bottles of drawing ink (waterproof black, blue, red) | 7.50 |
| 3944 | | 10 | Sets, 8 colored pencils | 12.50 |
| 3941 | | 20 | Penholders and assorted pens | 20.00 |
| 324 | | 1 | Roll, 150 yd. x 36" tracing paper | 3.00 |
| 321 | | 10 | Pads, graph paper | 5.00 |
| 5616 | | 20 | Rolls, drafting tape (10 yd. carton) | 10.00 |
| 160 | | 20 | Rulers | 5.00 |
| 6890 | | 1 | Lot, assorted topographic and geologic maps | 50.00 |
| | | | Total | $423.00 |

## ADDITIONAL MATERIALS NEEDED FOR ECONOMIC GEOLOGY

The student should have access to the minerals and rocks listed for General Geology, Mineralogy, and Engineering Geology, plus the following:

1 Set of technological minerals and ores. This set should include also abrasives, ceramic raw materials, mineral paints and pigments, refractories, mineral fertilizers, fuels, paving materials, and rough specimens of precious and semi-precious stones.
700 specimens, 3" x 4" ..... $1200.00

## ADDITIONAL MATERIALS NEEDED FOR FIELD GEOLOGY

**(10 students)**

The student should have access to the drawing instruments and supplies listed for Map Interpretation, plus the following:

| | | | |
|---|---|---|---|
| 112 | 10 | Geologic picks or hammers | $ 27.50 |
| 8339C | 10 | Collecting bags | 45.00 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 9635A | | 500 | Sample bags (small - cloth) | $ 35.00 |
| 8319 | | 10 | Field notebooks | 10.00 |
| 321 | | 10 | Graph sheets (pad) | 5.00 |
| 320 | | 10 | Pads, degree polar coordinate paper | 5.00 |
| 70 | | 20 | French curves | 15.00 |
| 323 | | 60 | Drawing paper sheets (Pkg.) | 18.00 |
| 1888 | | 10 | Branton compasses (pocket transit) | 450.00 |
| 178C | | 10 | Measuring tapes, 50 ft. steel | 100.00 |
| 124 | | 10 | Hand levels | 70.00 |
| | | For each two students, working as a team: | | |
| 3765 | | 5 | Telescopic alidades | 1500.00 |
| 3770 | | 5 | Plane table tripods | 250.00 |
| 3775 | | 5 | Plane table boards (18" x 24") | 75.00 |
| 3780 | | 5 | Plane table canvas cases | 20.00 |
| 3785 | | 5 | Stadia leveling rods | 200.00 |
| | | | Total | $2825.50 |

## ADDITIONAL MATERIALS NEEDED FOR SEDIMENTATION

**(10 students)**

| | | | | |
|---|---|---|---|---|
| 8010 | | 4 | Binocular microscopes, stereoscopic | $736.00 |
| 8118-26 | | 250 | Optical glass slides and cover glasses | 10.00 |
| 4516P | 44300 | 30 | Beakers, 50 cc. | 7.50 |
| 4516P | 44300 | 30 | Beakers, 250 cc. | 9.00 |
| 5140 | 71260 | 30 | Funnels, glass 75 mm. diameter | 15.00 |
| 5259 | | 5 | Cylinders, glass, liter | 7.50 |
| 5056W | 69800 | 5 | Filter paper (selected size) | 5.00 |
| 5517 | 78845B | 50 | Ft. rubber tubing, small diameter | 10.00 |
| 4630 | 48730 | 5 | Wash bottles, flask, 500 cc | 5.00 |
| 1810 | 11155 | 5 | Magnets, small horseshoe (Alnico) | 2.50 |
| 4050 | 1872 | 3 | Balances, beam | 75.00 |
| 4005 | 40100 | 1 | Balance, chemical chainomatic, with weights | 362.00 |
| 4028 | 40750 | 1 | Balance, Westphal | 50.00 |
| 5533 | | 1 | Sieve set, brass frame, 8" diam., 2" depth, size of openings: 8, 4, 2, 1, ½, ¼, ⅛, 1/16, 1/32 mesh with cover and pan | 60.00 |
| 5531 | | 1 | Sieve shaker with automatic controls | 125.00 |
| 8333 | | 1 | Centrifuge, electric, with rheostat, head, trunnions, shields and glassware | 275.00 |
| 5279 | 74109A | 3 | Hotplates, electric, 3 heats | 31.50 |
| 9630 | | 1 | Soil dispersion machine | 40.00 |
| 9635 | | 1 | Sample splitter (Riffler type) | 35.00 |
| | | | Total | $1861.00 |

## ADDITIONAL MATERIALS NEEDED FOR PALEONTOLOGY

| | | | | |
|---|---|---|---|---|
| 4612B | 75744 | 20 | Doz. sample jars, wide mouth, screw cap, 16 oz. capacity | $ 45.00 |
| | | 1 | Set, refractive index liquids | 50.00 |
| | | 1 | Set, heavy liquids (½ lb. each) | 35.00 |
| | | 5 | Gal. alcohol, methyl | 12.00 |
| | | 5 | Lb. hydrochloric acid | 1.50 |
| | | 1 | Lb. calcium oxalate | 3.00 |
| | | 1 | Lb. sodium silicate | 1.50 |
| | | | Total | $148.00 |

## ADDITIONAL MATERIALS NEEDED FOR MICROPALEONTOLOGY

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| | | | Each student should have access to the following: | |
| | | 1 | Set, type slides, 1000 forms on 20 slides | $ 75.00 |
| | | | Diatoms | |
| | | 1 | Globigerina, microscopic slides | .50 |
| | | 1 | Chalk, microscopic thin sections | 1.00 |
| | | 1 | Foraminiferal limestone—section | 1.00 |
| | | 1 | Foraminiferal sands—capsules, 100 | 125.00 |
| | | 1 | Ostracoda slides | 1.25 |
| | | 1 | Radiolaria, microscopic slide | .75 |
| | | 1 | Conodonts, microscopic slide | 1.00 |
| 8118 | 76805 | 50 | Glass microscopic slides, 5" x 1" | 1.00 |
| 5050 | 69700 | 1 | Pkg. lens paper, 50 sheets | .25 |
| 4601 | | 24 | Glass bottles or vials—2 oz. | 1.50 |
| | | 1 | Lb. acetic acid | .75 |
| 4694 | 49230A | 1 | Camel hair brush—small pointed | .50 |
| 5314 | 75810 | 10 | Boxes, gummed paper labels | 1.50 |
| | | 5 | 2 oz. bottles Canada balsam | 1.50 |
| | | | **General Apparatus** | |
| | | 1 | Set, lantern slides of protozoa, larva and other microfossils, 100 selected slides | 75.00 |
| 3962 | 78270A | 1 | Balopticon, combined opaque and lantern slide projector | 175.00 |
| 3931A | 78345B | 1 | Projection screen, 7' x 7', on spring roller | 20.00 |
| 5286 | | 1 | Slide warmer, electric, 24½" | 35.00 |
| 5533A | | 1 | Set, sieves, graduated, and nested, 6" diam., 2" deep—0 mm. to ½ mm. openings | 50.00 |
| | | | Total | $567.50 |

## COLLEGE GEOLOGY

### RECAPITULATION

| | | |
|---|---|---|
| GENERAL GEOLOGY | | |
| General Apparatus | $562.70 | |
| Student Supplies | | |
| Minerals | 105.00 | |
| Rocks | 141.00 | |
| | | 808.70 |
| Additional supplies for: | | |
| HISTORICAL GEOLOGY | | |
| Fossils | | 60.10 |
| MINERALOGY | | |
| Minerals | 496.00 | |
| General Student Apparatus | 209.20 | |
| General Apparatus | 346.20 | |
| | | 1051.40 |
| PETROGRAPHY | | 2852.85 |
| MAP INTERPRETATION | | 423.00 |
| ECONOMIC GEOLOGY | | 1200.00 |
| FIELD GEOLOGY | | 2825.50 |
| SEDIMENTATION | | 1861.00 |
| PALEONTOLOGY | | 148.00 |
| MICROPALEONTOLOGY | | 567.50 |
| GRAND TOTAL | | $11798.05 |

# COLLEGE MATHEMATICS

The mathematics courses listed below are usually required in the same order of all students who are majoring in the physical sciences. This offering is thus an integral part of the total science offering of the undergraduate college. Some students complete the work of the first two courses while in high school.

The courses include class recitation, lecture, and individual study. Usually the only equipment or supply items used, other than the usual texts and notebooks provided by students, are blackboards and accessories, slide rules, and various forms of graph paper.

| COURSE | USUAL CREDIT HOURS |
|---|---|
| College Algebra | 3 |
| Plane Trigonometry | 3 |
| Plane Analytic Geometry | 3 |
| Differential Calculus | 4 |
| Integral Calculus | 4 |
| Differential Equations | 3 |

## COLLEGE ALGEBRA

### OUTLINE OF COURSE CONTENT

I. Quadratic equations
II. Ratio, proportion and variation
III. Binomial theorem
IV. Arithmetic and geometric progressions
V. Mathematical induction
VI. Complex numbers
VII. Theory of equations
VIII. Logarithms
IX. Permutations and combinations
X. Probability
XI. Determinants

## PLANE TRIGONOMETRY

### OUTLINE OF COURSE CONTENT

I. Trigonometric functions of any angle
II. Solution of right triangles by natural functions
III. Reduction formulas—Line values; graphs
IV. Fundamental identities involving one angle
V. Addition, subtraction, double and half angle formulas
VI. Radian and mil measure
VII. Inverse functions
VIII. Trigonometric equations
IX. Logarithms
X. Solution of triangles by logarithms

## ANALYTIC GEOMETRY

### OUTLINE OF COURSE CONTENT

I. Cartesian and polar coordinates
II. Graphs of curves
III. The straight line
IV. The circle
V. The parabola
VI. The ellipse
VII. The hyperbola
VIII. Translation and rotation of axes
IX. General equation of the second degree
X. General methods for tracing curves in rectangular and polar coordinates
XI. Parametric equations

## DIFFERENTIAL CALCULUS

### OUTLINE OF COURSE CONTENT

I. Variables, functions and limits
II. Differentiation of powers of x
III. Differentiation of algebraic forms
IV. Applications of the derivative
V. Successive differentiation and applications—Curve tracing
VI. Differentiation of transcendental functions and applications
VII. Parametric equations, polar equations and roots
VIII. Differentials
IX. Curvature, radius and circle of curvature
X. Theorem of mean value—Indeterminate forms

## INTEGRAL CALCULUS

### OUTLINE OF COURSE CONTENT

I. Integration of standard elementary forms
II. Constant of integration
III. Definite integrals
IV. Integration a process of summation
V. Applications of the definite integral to areas, volume and centroids

# DIFFERENTIAL EQUATIONS

## OUTLINE OF COURSE CONTENT

I. Definitions and elementary problems

II. Differential equations of the first order and the first degree

III. Applications—Family of curves; orthogonal trajectories; physical problems

IV. Simultaneous equations and problems involving first-order differential equations

V. First-order equations of degree higher than the first

VI. Singular solutions

VII. Linear differential equations with constant coefficients and applications

VIII. Miscellaneous differential equations of order higher than the first

IX. Integration in series

X. Partial differential equations of the first order

XI. Partial differential equations of the second order

# APPARATUS AND SUPPLIES FOR COLLEGE MATHEMATICS

## STUDENT APPARATUS

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 244 | | 20 | Individual Slide Rules | $ 24.00 |
| 1585 | | 20 | Sine—Cosine Demonstration Boards | 250.00 |
| 1586 | | 20 | Tangent Demonstration Boards | 280.00 |
| 1587 | | 20 | Surveying Boards | 520.00 |
| 415 | | 20 | Adjustable Parallel Rules, 12" | 35.00 |
| 330 | | 20 | Drawing Boards, size 17 x 22" | 40.00 |

## GENERAL APPARATUS

| | | | | |
|---|---|---|---|---|
| 252 | | 1 | Demonstration Slide Rule, 4' long | 8.00 |
| 329 | | 1 | Blackboard Drawing Set | 5.75 |
| 425 | | 1 | Blackboard Stencil Chart | 8.75 |
| 738 | 7900 | 1 | Composition of Forces Apparatus | 3.75 |
| 430 | | 1 | Cross Staff | 3.50 |
| 385 | | 1 | Transit | 385.00 |
| 375 | | 1 | Plane Table | 250.00 |
| 435 | | 1 | Traverse Table | 13.25 |
| 3535A | | 1 | Sextant | 200.00 |
| 405 | 9650 | 1 | Hypsometer | 15.50 |
| 410 | | 1 | Angle Mirror | 14.50 |
| 440 | | 1 | Clinometer | 23.00 |
| 395 | | 2 | Leveling Rods | 50.00 |
| 178C | | 2 | Steel Tapes | 20.00 |
| 253 | | 1 | Slide Rule Polyphase, 10" | 17.00 |
| 254 | | 1 | Slide Rule Log—Log Duplex | 18.50 |
| 255 | | 1 | Slide Rule Polyphase, 20" | 23.50 |
| 420 | | 2 | Proportional Dividers, 10" | 70.00 |
| 234 | | 2 | Sets full Circle Protractors 6, 8, and 10" | 54.00 |
| 390 | | 1 | Hand Level | 50.00 |
| 593 | | 1 | Dissectible Cone (Conic Sections) | 9.75 |
| 425 | | 1 | Blackboard Stencil Chart | 8.75 |
| 445 | | 1 | Ellipsograph | 19.00 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 591 | 2920 | 1 | Geometrical Curves, Solids and Surfaces | $ 3.85 |
| 833 | 8500 | 1 | Sand Pendulum | 1.35 |
| 1737 | 10590 | 1 | Pair of Parabolic Reflectors | 15.00 |
| 857 | 7660 | 1 | Center of Gravity Block | 1.00 |
| 511 | | 1 | Soap film wire frames for showing minimal surfaces | 1.50 |
| 907 | 9140 | 1 | Rotator or whirling table (solids of revolution) | 11.75 |
| 852 | | 1 | Acceleration Apparatus | 14.00 |
| 858 | | 1 | Center of Gravity Cards | .35 |
| 450 | | 1 | Planimeter | 46.00 |
| 455 | | 1 | Integraph | 320.00 |
| 5724 | 8960 | 1 | Moment of Inertia Demonstration Apparatus | 5.00 |
| | | | TOTAL | $2640.30 |

# COLLEGE PHYSICS

The physics courses listed below are offered to undergraduate students in the colleges of the United States. Many additional courses are also provided, depending upon the special interests of the staff, the physical equipment of the institution, and the departments for which special services are provided.

| COURSES OFFERED | USUAL CREDIT HOURS |
|---|---|
| General Physics | 8 - 10 |
| Intermediate Physics: | |
| Mechanics | 4 |
| Heat | 4 |
| Electricity and Magnetism | 4 |
| Optics | 4 |
| Modern Physics | 3 - 6 |

The physics major usually takes some special courses in addition to the courses listed above.

## A FIRST COURSE IN PHYSICS FOR COLLEGES

Two course outlines for General Physics are presented. The first one is characteristic of the offering for liberal arts students. The second is typical of the course given to students majoring in either engineering or one of the physical sciences.

These are usually 8 to 10 semester hour courses, incorporating class recitations, demonstration lectures, student laboratory exercises, and individual student study.

## OUTLINE OF COURSE CONTENT

### Characteristic Offering for Liberal Arts Students

I. Mechanics

Measurement—Units; standards; scalar and vector quantities

Uniformly accelerated motion—Uniform velocity; uniform acceleration; free fall; trajectory

Concurrent forces—Resolution and composition; principle of equilibrium; inclined plane; friction

Nonconcurrent forces—Torque; extended principle of equilibrium; centroids; beam balance

Strength of materials—Stress and strain; Hooke's Law; types of stress; moduli of elasticity; shear and moment diagrams

Fluid statics—Archimedes' Principle; density and specific gravity; Pascal's Principle; barometer; Boyle's Law; volume modulus of a gas

Dynamics of translation—Newton's laws of motion; mass and weight; units of force; uniform circular motion

Gravitation—Newton's law of gravitation; constant of universal gravitation; area opened up by Newton's law

Kinetic and potential energy—Development of fundamental concepts; work and power; conservation of energy; lever and pulleys; mechanical advantage and efficiency

Fluid dynamics—Streamline motion; speed of efflux; Bernoulli's Principle; Venturi tube

Impact—Momentum and it conservation; impulse; inelastic and elastic impact; energy relation in impact; molecular and subatomic impacts

Harmonic motion—Definition and properties; displacement, velocity and acceleration; period; phase; elastic displacement; simple pendulum; compound pendulum; isochronism; vibration of stretched strings

Rotation—Angular displacement, velocity and acceleration; moment of inertia; geometric forms; radius of gyration and center of oscillation; gyroscope; gyrohorizon; gyro pilot; gyroscopic stabilization

II. Heat

Temperature—Scales; absolute zero; expansivity of gases, liquids and solids; Law of Gay Lussac

Quantity and transfer of heat—Caloric and British Thermal Unit; specific heat; calorimeter; thermal conductivity; radiation; Prevost's theory of exchanges; laws of cooling

Change of phase—Heat of fusion; heat of vaporization; influence of pressure; triple point; liquefaction of gases; critical temperature and pressure

Heat as a form of energy—Rumford, Mayer and Joule; ratio of specific heats of gases; general principle of conservation of energy (first law of thermodynamics); degradation of energy and second law of thermodynamics

Heat engines—History of steam engine; indicator diagram; events in steam engine cycle; reversibility of cycle; mechanical refrigeration; Carnot cycle; efficiency; internal combustion engine; Otto and Diesel cycles

III. Sound

Nature of sound—General properties of wave motion; transverse and longitudinal waves; speed of sound; stationary waves; energy in representative sounds

Acoustics of rooms—Reverberation; sound absorption; Sabine's Equation; diagnosis and treatment of acoustic defects

Pitch and intensity—Relation of pitch to frequency and intensity; limits of audible frequency; intervals and scales; Doppler Effect; limits of audible intensity; bel and decibel; deafness; beats and their uses; combination tones

Quality—Overtones and wave form; wave analysis; sound spectra; stationary waves in strings and pipes; boundary conditions; bars, diaphragms and plates

IV. Light

General properties—Speed; rectilinear propagation; reflection; refraction; Snell's Law; intensity; photometry

Image formation by reflection—Light "rays" and localization; plane mirror; coincidence range finder; stereoscope; camera; real and virtual images; spherical mirrors; grafical construction on rays; object-image relation; lateral magnification; spherical aberration; parabolic reflector

Image formation by refraction—Single refracting surface; simple lens as combination of two refracting surfaces; lens maker's equation; effect of lens thickness; astigmatism; chromatic aberration and its correction

Prisms—Dispersion; achromatic prisms and direct vision spectroscope; minimum deviation; total reflection

Optical instruments—Camera; projector; telescope; microscope

Color—Additive and subtractive combination; complementary colors and colorimetry; color vision; color photography; rainbow

Interference and diffraction—Thin films; "black spot" and reduction of reflection in optical systems; interference and wave length; Huygen's Principle; double slit; single slit; circular aperture; resolving power; grating

Spectroscopy—Solar spectrum; continuous spectrum and absorption lines; spectra of gases; comparison of solar and terrestrial spectra; Doppler Effect; ultra violet and infra red; origin of spectra; spectral series; band spectra

Polarized light—Nature; common polarizers; applications; polarization by reflection; Brewster's Law; polarization in double refractior; half wave and quarter wave plates; circular and elliptic polarization; photoelasticity

V. Electricity and magnetism
- Electrostatics—History; conductors and insulators; early electrostatic machines; condenser; capacitance; electrostatic induction; modern electrostatic machines; lightning; Coulomb's Law and dielectric constant; unit of quantity; work, potential difference and the volt
- Magnetism—Attraction and repulsion; magnetic compass; declination and dip; magnetic maps; field strength; permeability; magnetic flux; magnetic moment
- Electric currents—Galvani and Volta; Faraday and his laws; atomicity of electricity; quantity and current; the ampere
- Electromagnetism—Oersted and Ampere; Faraday and electromagnetic phenomena; right hand screw rule; forces between parallel currents; current balance; galvanometer and ammeter
- Ohm's Law—Resistance; the ohm; resistivity and temperature coefficient; potential distribution in a circuit; conductors in series and parallel; Ohm's Law; shunts and resistors in ammeters and voltmeters; Wheatstone's bridge; potentiometer; networks and Kirchhoff's rules
- Electromagnetic induction—Henry and Faraday; induction coil, alternating current and transformer; mutual and self induction; Lenz's Law; induced electromotive force; electric transients; electric oscillations; resonance
- Dynamos—Faraday and the early generator; Henry, Davenport, Jacobi and the early motor; counter electromotive force; shunt, series and compound field coils; the synchronous motor; the rotating magnetic field and the induction motor
- Alternating currents—Instantaneous and effective values; phase displacement in resistance, inductance and capacitance; power consumption; inductive reactance and impedance; capacitative reactance and impedance; circuits containing resistance, inductance and capacitance
- Electric communication—Telegraph; telephone; line capacitance and the loading coil; pictures by wire; photoelectric cell
- Vacuum tube in radio—Electromagnetic waves; rectification; the diode; the triode; amplification; carrier and audio frequencies; modulation and detection; amplitude and frequency modulation; the radio spectrum

VI. Electron and nuclear physics
- Cathode rays and the electron—Cathode rays; positive rays; the electron, its charge and mass; oil drop experiment; Zeeman effect; X-rays; X-ray absorption; ray diffraction
- Radioactivity, spontaneous and induced—Becquerel and the Curies; radium and its series; other series; alpha, beta, and gamma "rays"; radioactive transformations; chemical elements and types of atom; radioactivity as a nuclear process; the first transmutation; the neutron; the cyclotron; nuclear fission
- Quantum theory and atomic structure—The "black body"; Planck's theory of radiation; photoelectric effect; Einstein's Equation; inverse photoelectric effect; cloud chamber; Geiger counter; scattering of alpha particles; the Bohr atom; simple and more complex atoms; X-ray spectra and Moseley's Law; X-ray spectra and electron shells; photon hypothesis; "matter waves"; wave particle duality

**Characteristic Offering for Engineering and Science Students**

I. Mechanics
- Fundamental quantities—Measurement of length, angle, area, volume, mass and time
- Vectors—Graphical and analytical solutions; distinction between vector and scalar quantities; moment of force; torque
- Uniform motion—Linear; instantaneous and average speeds in non-uniform motion
- Uniformly accelerated motion—Units; equations; falling bodies; projectile motion
- Force—Newton's Laws; units; friction
- Rotational motion—Laws of angular motion; angular acceleration; centripetal and centrifugal force; moment of inertia
- Statics—Conditions of equilibrium; parallel forces; center of gravity; conditions of stability
- Mechanical energy—Work; energy; power; machines
- Simple harmonic motion—Simple and physical pendulum
- Elasticity—Hooke's Law
- Impact—Impulse and momentum
- Liquids at rest—Pressure; Pascal's Principle; Archimedes' Principle; density; specific gravity; Brownian Movement; surface phenomena; diffusion
- Liquids in motion—Energy of a moving liquid; Bernoulli's Theorem; viscosity
- Mechanics of gases—Kinetic theory; Boyle's Law; Dalton's Law; Avogadro's Number

II. Heat
- The effects of heat—Temperature measurements; expansion
- Calorimetry—Heat units; thermal capacity and specific heat; heat of combustion; heat of formation
- Change of state—Fusion; evaporation; boiling; sublimation
- Thermal behavior of gases—Pressure, volume and temperature relations; thermal capacity and specific heat; isothermal and adiabatic processes
- Work and heat—Laws of thermodynamics; mechanical equivalent of heat; Carnot Cycle; efficiency of the ideal engine; engines; refrigeration
- Transfer of heat—Conduction, convection and radiation

III. Electricity and magnetism
- Electric charge—Coulomb's Law; charging by contact and by induction; distribution of electric charge; conduction; electric fields; potential
- Magnetism—Coulomb's Law; magnetic fields
- Current and resistance—Units; simple circuit; Ohm's Law; resistance of conductors; equivalent resistance of series and parallel circuits; Kirchhoff's Laws; measurement of resistance; temperature coefficient of resistance
- Electric cells—Electrolytic action; Faraday's laws of electrolysis; Voltaic cells, primary and secondary; measurement of cell resistance; the potentiometer
- Electromagnetism—Magnetic effect of a current; magnetic field about current-carrying conductors; Ampere's Law; measuring instruments; induced electromotive force; Lenz's Law
- Inductance—Mutual and self induction; growth and decay of current in inductive circuits; energy of a magnetic field; magnetic substances, hysteresis and magnetic circuits
- Capacitance—Condensers; energy of charged condenser; condensers in series and parallel
- Alternating currents—Generation of an alternating e.m.f.; effective values; phase relations; circuits containing resistance, inductance and capacity; power and power factor
- Electrical machinery—Generator construction; e.m.f. of a generator; motor construction; motor, characteristics; transformers
- Thermoelectricity—Seebeck, Peltier and Thompson effects
- Thermionics—Thermionic emission; rectifiers; triodes; X-ray tubes; photoelectric cells

IV. Sound
- Wave motion—Types of waves; wave propagation; energy transmission by waves; equations of wave motion; propagation of sound; velocity of wave transmission; Huygen's Principle; interference of waves; stationary waves
- Sound production—Characteristics of sound; vibrating strings, rods, air columns; resonance; Doppler's Principle
- Sound reception and control—The ear; intensity levels; acoustics

V. Light
- Sources and velocity of light—Measurement of intensity of light sources; illumination of surfaces; measurement of light velocity
- Reflection and refraction—Images formed by plane mirrors, spherical mirrors; spherical aberration; refractive index; deviation by a prism; total reflection
- Dispersion, spectra and color—Dispersion; types of spectra; spectrum analysis; spectral series; color of luminous objects; color by reflective light
- Lenses—Types; lens equations; lens combinations; lens defects
- Optical instruments—The eye; aids to vision; camera; microscope; telescope
- Interference and diffraction—Interference of light, thin films; interferometer; diffraction grating; diffraction of X-rays
- Polarized light—Methods of polarization; optical rotation; interference effects.
- Radiation and atomic structure—X-ray spectra; nature of light; electron diffraction; relativity; radioactivity; nuclear structure; cosmic rays

## LABORATORY EXPERIMENTS

Errors and significant figures
Propagation of errors
Verniers and micrometers
Measurement of mass by the analytical balance
Force and accelerated motion, using the Atwood Machine
Friction
Centripetal force
Moment of inertia

Static equilibrium—the crane
Work, mechanical advantage, and efficiency
Momentum and energy—ballistics
Simple harmonic motion
Young's modulus of elasticity
Archimedes' Principle—specific gravity
Specific heat of solids
Heat of fusion and heat of vaporization
Coefficient of linear expansion of a solid
The electroscope and Coulomb's Law; electrostatic induction
Gas laws (Boyle's Law)
Gas laws (Boyle's and Charles' laws)
The magnetometer and Coulomb's Law; the earth's magnetic field
Mechanical equivalent of heat by an electrical method (Joule's law)
Ohm's Law
The Wheatstone Bridge
Resistances in series and parallel
The sensitive moving coil galvanometer
Electrolysis; the electrolytic cell
The potentiometer and the thermocouple
Velocity of sound in metals
Spherical mirrors
Change of wave front on refraction
Principle of a lens and its constants; refraction through a single thin lens
The telescope
The plane diffraction grating

**Additional Desirable Experiments**

Composition and resolution of forces
Static equilibrium of a rigid body, forces and torques
Resistance measurement by voltmeter-ammeter method
The three-electrode vacuum tube
Laws of vibrating strings
Polarized light (polaroids)

## INTERMEDIATE PHYSICS

General physics, differential calculus, and integral calculus are prerequisite to all courses in intermediate physics.

## MECHANICS

This is usually a four semester hour course, incorporating class recitation, lecture, and individual study.

### OUTLINE OF COURSE CONTENT

I. The statics of a particle
   Introduction—The statical idea of force; early mechanics an art; definition of a particle; position of a particle defined; rectangular coordinates; transformation of coordinates
   Vector quantities—Equilibrium of a particle; definition of a vector; direction cosines; scaler quantities; free and localized vectors; addition and subtraction of vectors; the analytical method of adding vectors; historical
   Some applications of the principles of vectors—Case of two forces; case of three forces—Lami's Theorem; equilibrium of a particle on a smooth surface

II. The statics of a rigid body
   The fundamental problem in statics—The principle of the lever; the moment of force about an axis; the moment of force about a point; the vector product of two vectors; scalar product of two vectors; the unit vector; torque on a rigid body; the inclined plane; other simple machines; solving problems in statics

III. General case of equilibrium of a rigid body—Resume; Poinsot's theory of couples; the addition of couples; composition of forces directed at random in space; an interesting special case; Poinsot's central axis: the wrench; work done by a couple; statics from the analytical point of view; relation of moment of a given force about a point to its moment about an axis; conditions of equilibrium of a rigid body

IV. The principle of virtual work—Historical resume; virtual displacements; the principle of virtual work; the constraints

Some applications of the principle of virtual work—Case of a free particle; case of two parallel forces; the analytical balance; the platform balance of Roberval

V. Friction

Introductory—Coefficient of friction—angle of friction; angle of repose; cone of friction; static friction and kinetic friction; summary of the laws of solid friction

Devices for diminishing frictional resistance—The wheeled vehicle; ball bearings; friction wheels; step bearing; work of friction; power wasted in the step bearing; power wasted in horizontal shaft bearing; power saved by use of anti-friction wheels; the Prony dynamometer; ship resistance; comparison of fluid and solid friction

VI. Some applications of the principles of statics—The bifilar suspension; the problem of the triangular frame; the graphical solution; the analytical solution; the simple king-post truss; a typical braced girder bridge: the Warren truss; shearing force and bending moment in a beam; equilibrium of a flexible string supporting weights; an analytical solution of the same problem; string of negligible weight loaded with beads of equal weight, so spaced that their lines of action are equi-distant

VII. Kinematics

Introductory—Relative displacement of two particles; degrees of freedom of a particle; degrees of freedom of a rigid body; pure translation: linear displacement; pure rotation: angular displacement; composition and resolution of angular displacements; constrained motions; uniplanar motion; rotation with one point fixed: Euler's Theorem; screw motion: Chasles' Theorem; the rigid body under constraint; time and its measurement; position a continuous function of time; rate of change of position, velocity; distinction between speed and velocity; constant velocity; distinction between mean velocity and instantaneous velocity; summary in vector notation; composition and resolution of velocities; angular velocity: the analogue of linear velocity; relation between angular and linear velocity; radial and transverse velocities of a particle moving in a plane; motion of a particle on a car wheel

Acceleration—Rate of change of velocity; tangential and normal components of acceleration; scalar values of the components of acceleration

Three important special cases—I. Rectilinear motion—a particle falling freely under gravity; II. uniform circular motion; III. simple harmonic motion; angular acceleration—the analogue of linear acceleration; relation between linear and angular acceleration

Analogue—Three important special cases—I. rotation about a fixed axis under constant acceleration; II. rate of spin constant: direction of spin changing at uniform rate; III. simple harmonic oscillation

VIII. Kinetics

Mass and force—Introductory; the idea of inertia and gravitational mass; the concept of force; the dynamical measure of mass; Newton's Third Law of Motion; summary of Newton's laws of motion

The dynamics of rotation—D'Alembert's Principle; rotation of a rigid body about a fixed axis; moment of inertia; laws of motion for rotation in their simplest form; statics of a special case of dynamics

Centers of gravity—Resume on parallel forces; center of gravity with respect to any origin; analytical expressions for center of gravity; case of a body whose mass is concentrated in a line; case of a body whose mass is concentrated in a plane surface; illustrative problem: center of gravity of a right circular cone; illustrative problem: center of gravity of a quadrant of an ellipse; illustrative problem: center of gravity of a plane triangle; the theorems of Pappus; motion of center of gravity; action of a

couple; independence of rotation and translation; application of the general equations to uniplanar motion

Moments of inertia—Plan of discussion

Some important special cases—Case of a uniform straight wire, of a uniform rectangular plane lamina, of a uniform circular plate, of a homogeneous sphere about any diameter as axis, of a plane right-angled triangle, of an elliptical lamina, about the minor axis

General theorems concerning moments of inertia—The theorem of moments, for plane laminae; the theorem of parallel axes; the theorem concerning a uniform right prism; the theorem of the six inertia constants; principal axes; the inertia ellipsoid; Routh's Rule; the radius of gyration

Experimental determination of inertia—The laboratory equation for comparison of masses; the laboratory equation for moments of inertia

IX. Work, power and energy

Work—Work done by a force; analogue: work done by a torque

Power—Definition of power of an agent

Energy—Definition of energy; dissipation of energy; conservation of energy; kinetic energy of translation; analogue: kinetic energy of rotation; potential energy—case of translation; analogue: potential energy—case of rotation; use of principle of conservation of energy in the solution of problems; forces as derivatives of potential energy; analogue: torques as derivatives of potential energy; equilibrium in the case of conservative forces

Illustrative examples—Kinetic energy of a system of particles; kinetic energy of a rigid body in translation and rotation; the principle of conservation of energy and the principle of virtual velocities

X. The units of mechanics: the two common systems of units

The Metric System—The fundamental units; standard of length—unit of length; unit of angle—radian; standard of mass—unit of mass; unit of rotational inertia; standard of time—definition of the second

Derived units of the Metric System—Units of speed; units of acceleration; units of momentum; units of force and torque—the dyne; unit of energy and work—the erg; unit of power—the watt

The Engineers' System—The fundamental units; unit of length; unit of angle; unit of time; unit of force—the pound

Derived units of Engineers' System—Speed; acceleration; unit of mass—the slug; unit of work and energy—the foot-pound; unit of power

Dimensions of mechanical units—"Dimensions" defined; dimensions of vector quantities; changing from one set of units to another

Illustrative examples

XI. Some applications of the principles of kinetics—Resume; the collision of two moving bodies; the coefficient of restitution; loss of energy on impact

The rotation of a rigid body about a fixed axis under the influence of gravity—The physical pendulum; the simple pendulum; the reversible pendulum; the correction for amplitude; Robins' ballistic pendulum

The rotation about a fixed axis of a rigid body acted upon by forces other than gravity—The shock received by the axis from an impulsive blow; the theory of a baseball bat; conditions for no shock on the axis; case of a rigid body acted upon by steady forces; a rotating rigid body, free from any external force; a numerical illustration; effect of a single couple about the fixed axis; an interesting analogy; the gyroscope in its steady state; short digression on centripetal force; the precessional couple; an analogue

XII. Hydromechanics

Introductory

Hydrostatics—Liquids at rest; viscosity of fluids; pressure defined; the experimental facts; the general equation of hydrostatics; case of a liquid at rest under gravity; determination of altitude from barometric pressure; center of pressure defined and determined; the center of buoyancy; equilibrium of a floating body

Hydrodynamics—Introductory; the equation of continuity; Euler's equations of motion; the equation of state

Special cases of fluid motion—I. Very slow motions; II. steady motion; Bernoulli's Theorem; Torricelli's Theorem; illustrative problem; the Venturi water meter

# HEAT AND THERMODYNAMICS

This is usually a four semester hour course, incorporating class recitation, lecture, student laboratory exercises, and individual study.

## OUTLINE OF COURSE CONTENT

I. Temperature—Thermal equilibrium; scales; types of thermometer-temperature standards

II. General heat relations—Variables and notation; types of thermal capacity and their relations; specific heats, isothermals and adiabatics; p-v diagrams; work and path; quasistatic processes

III. First law of thermodynamics—Types of equilibrium (mechanical, chemical, thermal, thermodynamic); work and heat; internal energy; heat conduction; convection; radiation; Kirchhoff's Law; Stephan Boltzmann Law

IV. Heat conduction—Steady state (slab, cylinder, sphere); unsteady state; general equations; sudden change; periodic change; Fourier's Theorem

V. Ideal gases—Virial equation; equation of state; internal energy; specific heats and molecular constitution; adiabatic process; Clement and Desormes; velocity of wave

VI. Second law of thermodynamics—Interconversion of work and heat; Otto cycle; Diesel cycle; generalized heat engine cycle; reversed operation; refrigeration; second law and varieties of statement

VII. Carnot cycle—Reversibility and irreversibility; Carnot cycle; Carnot's Theorem; efficiency; absolute zero; Kelvin scale

VIII. Entropy—Clausius' Theorem; entropy and second law; T-S diagram; entropy, reversibility and irreversibility; principle of increase of entropy; entropy and unavailability; entropy, disorder and direction

IX. Properties of pure substances—Critical point; triple point; P-V-T surfaces; equations of state; T-S diagrams; enthalpy; Mollier diagrams; Helmholtz and Gibbs functions

X. Energetics of saturated steam—Vaporization; specific heats; dryness and liquefaction; fusion; three-phase equilibrium; steam tables

XI. Engine and refrigerator—Rankine cycle; T-S and h-s diagrams of Rankine cycle; refrigeration cycle; coefficient of performance; heating by refrigeration; compression vs. absorption system

XII. Applications of thermodynamics—Maxwell's equations; difference in heat capacities; ratio of heat capacities; expansivity; compressibility; heat capacity at constant pressure and volume; Joule-Kelvin effect; black body radiation; thermoelectricity; adiabatic demagnetization; magnetic temperature and Kelvin temperature

XIII. Change of phase—Van der Waal's and Clapeyron's equations; heat of vaporization; Kirchhoff's equation; sublimation curve; monatomic vapors; Richardson's equation; Ehrenfest's equations; super conductivity

## LABORATORY EXPERIMENTS

Heat of fusion of ice
Thermal conductivity of metal
Volume expansivity of glass
Expansivity of air
Heat of vaporization of water
Gas calorimeter
Mechanical equivalent of heat, continuous flow method
Pressure-temperature curve of saturated water, vapor-static method
Pressure-temperature curve of saturated water, vapor-dynamic method
Resistance thermometer
Ratio of specific heats of air

Specific heat by method of cooling
Surface tension of water
Calibration of thermocouples
Radiation and optical pyrometer
Thermal conductivity of an insulator
Properties of air
Air compressor
The analysis of the exhaust and the operation of a gas engine

## ELECTRICITY AND MAGNETISM

Credit hours and class procedure are the same as indicated for Heat and Thermodynamics

## OUTLINE OF COURSE CONTENT

I. Electrostatics
- Coulomb's Law
- Charge units
- Electric field intensity
- Gauss' Theorem
- Derivation of electric field expressions by application of Gauss' Theorem
- Screening
- Force acting on a charged surface
- Millikan oil-drop experiment
- Dielectric strength
- Potential difference
- Potential at a point
- Equipotential surfaces and lines of force
- Derivation of potential difference formulas
- Capacity
- Derivation of capacity formulas
- Energy stored in capacitors
- Condensers in parallel and series
- Nature of a dielectric
- Polarization of a dielectric
- Electrostatic displacement
- Boundary conditions for dielectric surfaces
- Electrical images
- Application of image method to infinite conducting plane and spherical conductor

II. Magnetostatics
- Magnetic poles and Coulomb's Law
- Magnetic field intensity
- Magnetic moment
- Derivation of magnetic intensity formulas
- Oscillation of magnet suspended in magnetic field
- Magnetometer
- Absolution determination of M and H
- Earth's magnetic field

III. Direct Current Non-reactive Circuits
- Simple electric circuit
- Practical units
- Energy, power and heat
- Magnetic field about a current
- Magnetic field at center of circular coil
- Tangent galvanometer
- Other galvanometers
- Ammeter
- Voltmeter
- Hot-wire instruments
- Resistance of homogeneous regular conductors
- Temperature coefficient of resistivity

Electron theory of conductivity
Network of conductors
Kirchhoff's Laws and their uses
Internal resistance and terminal voltage
Wheatstone Bridge
Carey-Foster Bridge
Kelvin double bridge
Measure of potential difference with electrostatic instruments, voltmeter, potentiometer
Electrolytic conduction
Faraday's laws of electrolysis
Concentration and chemical cells
Primary, secondary, and standard cells
Thevenin's power-transfer theorem
Grouping of cells in series and parallel
Magnetic field about a long straight wire
Magnetic field inside a rectangular coil
Force on current-carrying wire
Induced electromotive force, Lenz's Law, and Faraday's Law of induction
Charged particle moving in magnetic field
Forces between currents in parallel wires
Torque on coil carrying current
Magnetic moment of a coil
Magnetic field of solenoid and toroid
Earth inductor
Ballistic galvanometer, measurement of charge
Motion of damped system, electromagnetic damping, critical damping
Uses of ballistic galvanometer
Magnetic susceptibility, permeability, and induction
Magnetic circuit
Magnetization curves
Hysteresis curves, Steinmetz's relation, and hysteresis losses
Eddy currents and losses
Theory of magnetism, atomic diamagnetism and paramagnetism, Stern-Gerlach experiment, exchange force theory of ferro-magnetism, domain theory and Barkhausen effect
Direct-current dynamos, essential parts and principles of operation, commutation
Power losses and efficiencies of D. C. dynamos

IV. Reactive circuits
Current rising and falling in D. C. inductive circuit, time constant
Charge and discharge of condenser in non-inductive circuit
Inductance and capacity in parallel
Discharge of condenser through inductive circuit, damped oscillating circuit
Sinusoidal electromotive forces applied to circuit containing resistance, inductance, capacitance in turn
Circuit containing resistance, inductance, capacitance in series and sinusoidal power source
Impedance, reactance, phase lag
Skin effect
Average and effective values of current and e.m.f.
Power in A. C. circuits, power factor
A. C. networks with parallel connections, admittance, conductance, susceptance
Mutual inductance and its measurement
Measurement of capacitance
Dimensional equations in electricity
Relations between systems of electrical units
Two- and three-phase systems, delta and wye connections
Ideal transformer, power losses in transmission
Power losses in transformer and elements of transformer design

## LABORATORY EXPERIMENTS

Relation between the terminal potential difference of a primary cell and the current flowing in the circuit; useful power from a primary cell
Slide wire potentiometer
Use of student type and type K potentiometers to calibrate an ammeter and a voltmeter
The magnetometer
The current constants of a galvanometer; determination of figure of merit, current sensitivity, megohm sensitivity

Calibration of thermocouples
The direct deflection method of comparing low resistances by means of a potential galvanometer
Study of the ballistic galvanometer, galvanometer damping, measurement of e.m.f. and capacitance with a ballistic galvanometer
Measurement of very high resistance by condenser leakage
The capacitance bridge
The inductance bridge
Calibration of a variable mutual inductance by the Carey-Foster method
Voltage, current, and power relations in a simple inductive A. C. circuit
Step-by-step method for magnetic measurements; determination of magnetization curve and hysteresis curve for a ring sample

## PHYSICAL OPTICS

Credit hours and class procedure are the same as indicated for Heat and Thermodynamics.

### OUTLINE OF COURSE CONTENT

I. Reflection and refraction on Huygens' Principle

II. The formation of images by mirrors

III. The formation of images by thin lenses

IV. Lens combinations and thick lenses

V. Optical instruments—The magnifying glass; the telescope; the microscope

VI. Dispersion—The spectrometer

VII. A brief study of spectra

VIII. Wave motion—Simple harmonic motion; addition of two S. H. M.; the equation of a train of waves

IX. Interference
Interference between two sources of light—Young's double slit; the Fresnel biprism; the Fresnel mirrors; Lloyd's single mirror; Rayleigh's refractometer
Interference of thin films—The wedge; Newton's rings; the Perot-Fabry etalon; the Lummer plate; Michelson's interferometer

X. Diffraction
Fresnel diffraction—Circular opening—the zone plate; straight edge—the Cornu spiral
Fraunhofer diffraction—Single rectangular opening—resolving power of a telescope and microscope; the double slit

XI. Double refraction—Double refraction in crystals; Huygens' explanation of double refraction; the Nicol prism

XII. Plane polarized light
The meaning of polarized light
The production of polarized light—By scattering; by double refraction; by reflection
Interference of polarized light—photoelasticity

XIII. Elliptically and circularly polarized light—The quarter-wave plate

XIV. Rotatory polarization—The polarimeter

XV. The electromagnetic theory of light—The work of Hertz; the electromagnetic spectrum

XVI. The origin of spectra—Doppler Effect; Zeeman and Stark Effects

XVII. The quantum theory and origin of spectra—Planck's radiation formula; photoelectric effect and quantum theory; the Bohr Theory

## LABORATORY EXPERIMENTS

Plane and spherical mirrors—Measurement of focal length of concave mirror using spherometer; determination of focal length of concave mirror by location of image
The thin lens—Measurement of focal length of thin lens by location of image; calculation of index of refraction of thin lens
Lens aberrations—Spherical aberration; astigmatism; distortion; curvature of field; chromatic aberration
The thick lens—Magnification methods of determining focal length of thick lens; location of focal points and principal planes of thick lens
The telescope—Determination of magnifying power of telescope; measurement of angle of resolution of telescope
The spectrometer—The adjustment of the spectrometer; measurement of the refracting angle of a prism; determination of index of refraction of a prism—dispersion curve; the spectrometer used as a refractometer
The spectroscope—Calibration of a spectroscope; spectroscopic identification of unknown salts using flame spectra; identification of the prominent Fraunhofer Lines
Young's double slit and Fresnel mirrors—Determination of wave length of light using Young's double slit; Fresnel's mirrors
Newton's rings—Determination of wave length of sodium light from measurements made on Newton's rings
The Michelson interferometer
The diffraction grating
Polarization and double refraction

# INTRODUCTION TO MODERN PHYSICS

This is an introductory course in modern physics at the undergraduate level. It is characteristically offered for either one semester only or as a two-semester sequence, with either 3 or 6 semester hours credit. The course outline which follows suggests enough material for two semesters.

Prerequisites include mathematics through the calculus, general physics, and intermediate physics courses in mechanics and electricity.

## OUTLINE OF COURSE CONTENT

I. The atomic nature of matter
- Early atomic theories
- Molecular velocities
- The distribution of velocities
- Direct experimental determination of molecular speeds
- Temperature and molecular energy
- Molecular heats of gases
- Real gases
- Mean free paths
- Brownian movements and molecular reality

II. The atomic nature of electricity
- Early electrical theories
- The electronic charge
- The mass of the electron
- Variation of mass with velocity
- The electromagnetic nature of mass
- The size of the electron and of the proton
- Positive ions and the mass spectrograph
- The whole-number rule
- The structure of atoms

III. The corpuscular nature of radiant energy
- Black-body radiation and Planck's quantum theory
  - Introduction
  - The electromagnetic conception of radiation
  - Temperature radiation
  - Black-bodies
  - Origin of the quantum theory

The photoelectric effect
Early observation on photoelectricity
Experimental results
Some photoelectric experiments
Theoretical developments
Comparison between theory and experiment
The significance of Einstein's Equation

IV. Spectroscopy
Spectroscopy as a key to atomic structure
The prism spectroscope
The diffraction grating
Types of spectra
Units of measurement
The complete electromagnetic spectrum
The radio and far infra-red regions
The near infra-red region
The visible and ultra-violet regions
X-rays, gamma rays and cosmic rays
Modern spectroscopy

V. The planetary model of the atom
The hydrogen spectrum
Bohr's Theory of the hydrogen atom
Extension of the theory
Insufficiency of the Bohr model

VI. X-rays
Production and measurement of X-rays
Absorption of X-rays
Secondary X-rays
The wave properties of X-rays
Bragg's Law
Simple crystals
Emission spectra
Absorption spectra
Scattering of hard X-rays and gamma rays

VII. Waves and corpuscles
Introduction
The nature of light
Reconciliation of the wave and corpuscular aspects of light
The nature of matter
Wave mechanics
Reconciliation of the wave and corpuscular views of matter
Application of Schrodinger's Theory to special problems
Summary

VIII. Atomic spectra
Alkali spectra
A model for explaining the alkali spectra
Atoms with two valence electrons
The rule for the displacement of spectra
Ionization potentials
Resonance potentials
The Stern-Gerlach experiment on atomic magnetic moments

IX. The periodic system
Classification of the elements
Simple rules for predicting chemical behavior
Assignment of quantum numbers
Application of Pauli's exclusion principle to the periodic table
Chemical properties of the elements
Valence and the formation of molecules

X. Molecular structure
The number of atoms in a molecule
Specific heats of gases
Rotational band spectra
Vibration-rotation bands
Electronic bands

XI. Radioactivity
- Introduction to the study of the nucleus
- The discovery of radioactivity
- The detection of individual particles and rays
- Some properties of alpha, beta and gamma rays
- The breakdown of a typical radioactive element
- The radioactive families
- The measurement of alpha and beta ray energies
- Alpha ray spectra
- Beta ray line spectra
- Gamma ray spectra
- Continuous beta ray spectra and the possible failure of the law of conservation of energy
- The scattering of alpha particles

XII. Neutrons, positrons and nuclei
- Disintegration by alpha particles
- Discovery of the neutron
- Properties of the neutron
- Scattering and absorption of fast neutrons
- The neutron as a nuclear building-stone
- Discovery of the positron
- Pair production and annihilation
- Dirac's Theory of positrons and negatrons
- Production of fast charged particles
- Survey of transmutation processes
- Reactions of light elements
- Discovery of induced radioactivity—Chemical identification of active substances
- Radioactivity produced by neutrons
- The Barrier model of the nucleus
- The Geiger-Nuttall Law
- Yield curves for artificial disintegration
- Specific nuclear forces
- Essential points in the history of cosmic ray investigations
- Experimental methods
- Intensity of the rays
- The east-west effect
- Interaction of fast positrons and negatrons with matter
- Energy distribution of the rays
- Facts about showers
- Origin of the cosmic rays

XIII. The theory of relativity
- Relative motion
- Uniform motion through space—The Michelson-Morley experiment
- Pre-relativity explanations
- Einstein's solution
- The general theory of relativity
- Consequences of the theory

XIV. Astrophysics
- The growth of astrophysics
- Stellar magnitudes
- Stellar motions
- Stellar distances—Parallax
- Stellar temperatures
- Stellar diameters
- Stellar masses
- Stellar densities
- Eddington's star model
- The evolution of a star according to Eddington

XV. New light on old problems
- The limitations of mechanical atom models
- Ultimate limits of accuracy in measurement
- The trend toward unity in physical thought
- The operational viewpoint
- Realms unexplored

# APPARATUS AND GENERAL SUPPLY REQUIREMENTS FOR ELEMENTARY COLLEGE PHYSICS

**(for 20 Students)**

## MISCELLANEOUS STOCK ROOM SUPPLIES

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 4030 | 40450 | 1 | Sensitive Triple Beam Balance | $ 21.50 |
| 4000B | 40220 | 1 | Analytical Balance, Student Type (200 x 1/10) | 95.00 |
| 4050 | 40100 | 4 | Triple Beam Trip Scales (Single Pan) with Extra Riders (2-500g) | 60.00 |
| 4041D | 40420 | 2 | Double Beam Trip Scales | 27.50 |
| 4086 | 40860 | 4 | Spring Balances, 15 kg x 200 g | 16.00 |
| 4077 | 40822 | 10 | Spring Balances, 250 g x 10 g | 16.00 |
| 4078 | 40812 | 12 | Spring Balances, 500 g x 20 g | 21.00 |
| 4079 | 40802 | 12 | Spring Balances, 2000 g x 25 g | 16.20 |
| 4109 | 42130 | 1 | Set Analytical Balance Weights, Student Type | 19.00 |
| 4156 | 42480E | 2 | Sets Brass Weights, 1 to 500 g, in block | 13.20 |
| 4180 | 42580 | 6 | Sets Slotted Weights, 10 to 500 g, in holder | 21.00 |
| 787 | 42585 | 20 | Replacement Weights, 1 g | 5.60 |
| 787 | 42585 | 20 | Replacement Weights, 2 g | 5.60 |
| 787 | 42585 | 20 | Replacement Weights, 5 g | 5.60 |
| 787 | 42585 | 20 | Replacement Weights, 100 g | 10.00 |
| 4194 | 42502 | 3 | Sets Hooked Weights, 10 g to 1 kg | 15.60 |
| 785 | 42595 | 12 | Weight Hangers, 50 g | 6.60 |
| 3360 | 42555B | 10 | Weight Hangers, 1 kg | 13.50 |
| 3362 | 42550A | 10 | 1 kilogram Weights | 10.00 |
| 3362 | 42550A | 20 | 2 kilogram Weights | 30.00 |
| 4255 | 1090 | 10 | Hook Collars, 10 mm | 7.50 |
| 4256 | 1380B | 10 | Hook Collars, 13 mm | 7.50 |
| 4257 | 1380C | 10 | Hook Collars, 19 mm | 7.50 |
| 4202 | 1000A | 6 | Support Bases for 10 mm Rods | 5.70 |
| 4203 | 1000B | 10 | Support Bases for 13 mm Rods | 12.50 |
| 4205 | 1000D | 10 | Support Bases for 19 mm Rods | 18.00 |
| 4225 | 1090 | 4 | Support Rods, 10 mm by 10 cm long | 1.20 |
| 4225 | 1090 | 2 | Support Rods, 10 mm by 15 cm long | .70 |
| 4225 | 1090 | 4 | Support Rods, 10 mm by 25 cm long | 1.60 |
| 4225 | 1090 | 2 | Support Rods, 10 mm by 40 cm long | 1.20 |
| 4226 | 1100 | 4 | Support Rods, 13 mm by 20 cm long | 2.40 |
| 4226 | 1100 | 6 | Support Rods, 13 mm by 50 cm long | 4.20 |
| 4226 | 1100 | 6 | Support Rods, 13 mm by 100 cm long | 7.50 |
| 4227 | 1110 | 6 | Support Rods, 19 mm by 50 cm long | 5.70 |
| 4227 | 1110 | 2 | Support Rods, 19 mm by 75 cm long | 2.52 |
| 4227 | 1110 | 6 | Support Rods, 19 mm by 100 cm long | 9.90 |
| 4227 | 1110 | 2 | Support Rods, 19 mm by 125 cm long | 4.20 |
| 4227 | 1110 | 2 | Support Rods, 19 mm by 185 cm long | 5.80 |
| 4238 | 1080 | 4 | Table Clamps, Right Angle, V Groove | 14.00 |
| 4260 | 1165B | 10 | Right Angle Clamps, 13 mm | 9.20 |
| 4268 | 1140B | 10 | Right Angle Clamps, 19 mm | 12.50 |
| 4268 | 1140B | 2 | Right Angle Clamps | 2.50 |
| 4270 | 1170 | 2 | Swivel Clamps | 5.20 |
| 4247 | 1200A | 2 | T Clamps, 13 mm Rods | 4.00 |
| 4247A | 1200B | 2 | T Clamps, 19 mm Rods | 4.40 |
| 4297 | 1190A | 2 | Extension Clamps | 2.00 |
| 4299A | | 2 | Extension Clamps, V Groove | 4.50 |
| 4325A | | 3 | Meter Stick Clamps | 6.15 |
| 59 | 26030A | 2 | C Clamps, 3 inches high, 1⅛ inches deep | 1.50 |
| 59 | 26030B | 2 | C Clamps, 4 inches high, 1⅝ inches deep | 1.80 |
| 59 | 26030C | 2 | C Clamps, 6 inches high, 1⅞ inches deep | 2.50 |
| 60 | | 1 | C Clamp, 2½ inches high, 2½ inches deep | .55 |
| 60 | | 1 | C Clamp, 2½ inches high, 4½ inches deep | .80 |
| 163 | | 24 | Rulers, English and Metric, 12 inch | 7.00 |
| 153B | | 12 | Half Meter Sticks | 3.72 |
| 153 | 76145B | 12 | Meter Sticks | 12.24 |
| 225 | 3300B | 24 | Protractors, small brass | 5.00 |
| 156 | 76145C | 2 | Double Meter Sticks | 4.20 |
| 40 | 2650 | 10 | Micrometer Calipers, Metric | 63.50 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 42 | | 10 | Micrometer Calipers, English | $ 63.50 |
| 46 | | 10 | Vernier Calipers | 36.50 |
| 576 | | 5 | Rolls Coated Paper | 3.00 |
| 576 | | 5 | Pkgs. Sensitized Charts for Rotational Inertia Apparatus | 11.50 |
| 175A | 3220 | 2 | Steel Tape Measures, 2 Meter | .90 |
| 175B | 3230B | 1 | Steel Tape Measure, 3½ Meter | 3.45 |
| 2706G | 67050 | 1 | Telescope and Scale | 61.80 |
| 1413 | 6045 | 2 | Oz. Stopcock Grease | 1.00 |
| 5670 | 80060A | 24 | Thermometers, 10° C to 110° C | 27.60 |
| 1263D | | 12 | Thermometers, 0° to 50° C | 48.00 |
| 1625 | 9650 | 6 | Steam Generators and Accessories | 30.00 |
| 1689 | 9880 | 12 | Calorimeters, Double Wall | 36.00 |
| | | 1 | 5 Lb. Package Aluminum Shot | 5.00 |
| | | 1 | 5 Lb. Package Copper Shot | 2.50 |
| | | 1 | 25 Lb. Package Lead Shot | 5.75 |
| 4750B | 50220B | 10 | Bunsen Burners, Artificial Gas | 9.00 |
| 756 | 8170 | 5 | Pulleys | 5.40 |
| 1141 | 64960G | 10 | Hydrometer Jars, 12 x 2 inches | 7.50 |
| 5517 | 78845C | 200 | Ft. Rubber Tubing, ¼ inch I. D. | 40.00 |
| 1215 | 43012 | 1 | Mercurial Barometer | 27.50 |
| 4516P | 44300 | 25 | Beakers, 250 cc, Pyrex | 4.25 |
| 4516P | 44300 | 10 | Beakers, 400 cc, Pyrex | 2.40 |
| 5140 | 71260 | 10 | Funnels, 100 mm diameter | 4.60 |
| 4922 | 56740D | 10 | Pinch Clamps | 3.00 |
| 8244 | 65620G | 1 | Stop Clock, Electric | 30.00 |
| 821 | 3350 | 1 | Stop Watch | 17.45 |
| 1137 | 4940 | 10 | Density Specimens | 4.80 |
| 1126 | 5090 | 5 | Hydrometers, Specific Gravity, Light Liquids | 3.50 |
| 1128 | 5080 | 5 | Hydrometers, Specific Gravity, Heavy Liquids | 3.50 |
| 2962 | 14415 | 12 | Four-way Connectors | 7.20 |
| 5706 | 80505 | 8 | Developing Trays | 18.80 |
| 1690 | 9890 | 6 | Calorimeters | 15.00 |
| 2248 | 66565 | 5 | Daniell Cells | 19.25 |
| 2202A | 66600B | 5 | Replacement Porous Cups | 3.60 |
| 2248A | 66570B | 5 | Replacement Copper | 8.00 |
| 1166A | 75600A | 5 | Replacement Glass Jars | 5.75 |
| 2248B | 66575B | 5 | Replacement Zinc | 4.75 |
| 3060B | | 6 | D. C. Ammeters, 1% Accuracy, Triple Range, 1.5/3/15 amps | 168.00 |
| 3060G | | 3 | D. C. Ammeters, 1% Accuracy, Triple Range, 1/5/10 amps | 84.00 |
| 3060X | | 2 | Milliammeters, 0-50 ma | 44.00 |
| 3081G | | 1 | A. C. Ammeter, 2% Accuracy, 10 amp Range | 15.00 |
| 3081D | | 2 | A. C. Ammeters, 2% Accuracy, 1 amp Range | 30.00 |
| 3081X | | 2 | A. C. Ammeters, 2% Accuracy, 5/15 amp Range | 50.00 |
| 3081K | | 1 | A. C. Ammeter, 2% Accuracy, 30 amp Range | 18.00 |
| 3081X | | 2 | Milliammeters, A. C., 0-50 ma | 30.00 |
| 3060A | | 8 | D. C. Voltmeters, 1% Accuracy, 3/15/150 Volt Range | 224.00 |
| 3081A | | 4 | A. C. Voltmeters, 2% Accuracy, 15/150 Volt Range | 60.00 |
| 3081X | | 1 | A. C. Voltmeter, 2% Accuracy, 300/8/4 Volt Range | 25.00 |
| 2307C | 66670D | 2 | 6 Volt Lead Storage Batteries | 31.70 |
| 2320AX | | 6 | Edison Storage Batteries, Double Cell Trays | 141.00 |
| 2321A | 66660B | 2 | Edison Storage Batteries, Five Cell Trays | 132.50 |
| 2990 | 14760 | 12 | S.P.S.T. Knife Switches | 3.60 |
| 2992 | 14780 | 12 | D.P.S.T. Knife Switches | 6.60 |
| 2993 | 14790 | 12 | D.P.D.T. Knife Switches | 9.60 |
| 2916 | 14720 | 6 | D.P.D.T. Reversing Switches | 9.00 |
| 2751 | 67680 | 2 | Rheostats, Slide Wire, 720 ohm, 0.78 amp | 21.00 |
| 2751 | 67680 | 2 | Rheostats, Slide Wire, 180 ohm, 1.6 amp | 21.00 |
| 2751 | 67680 | 2 | Rheostats, Slide Wire, 90 ohm, 2.2 amp | 21.00 |
| 2751 | 67680 | 5 | Rheostats, Slide Wire, 22 ohm, 4.4 amp | 52.50 |
| 2751 | 67680 | 2 | Rheostats, Slide Wire, 11 ohm, 6.2 amp | 21.00 |
| 2751 | 67680 | 2 | Rheostats, Slide Wire, 5.6 ohm, 8.7 amp | 21.70 |
| 2751 | 67680 | 2 | Rheostats, Slide Wire, 2.8 ohm, 12 amp | 21.70 |
| 2754B | | 5 | Resistance Boxes, .1 to 111 ohm | 83.75 |
| 2754C | | 5 | Resistance Boxes, 1 to 1,110 ohm | 93.75 |
| 2754D | | 1 | Resistance Box, 1 to 11,110 ohm | 23.50 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 2704 | 66950A | 6 | Portable Galvanometers | $102.00 |
| 2266 | | 2 | Edison Primary Cells | 11.00 |
| 2268 | | 2 | Renewals | 5.40 |
| 2900 | 67200 | 6 | Tap Keys, Single Contact | 7.50 |
| 2900A | | 4 | Tap Keys, Single Contact, Lock Down | 14.00 |
| 2977D-E-F | | 200 | "Littelfuses," Assortment ⅛ amp to 2 amp | 30.00 |
| 2238 | 66515 | 24 | Dry Cells | 12.00 |
| 2983C | 14900 | 250 | Fuse Links, Assortment, 10, 15, and 30 amp | 7.50 |
| 2983B | 14920B | 50 | Each, Instrument Fuses, 5, 10, and 20 amp, Assorted | 22.50 |
| 2968A | 14380 | 200 | Fahnstock Binding Posts | 14.00 |
| 2976A | | 24 | Test Clips, Small | 1.92 |
| 2976C | 14445 | 12 | Test Clips, Lead Plated for Storage Batteries | 1.44 |
| 2824 | 17200 | 2 | Single Spools, 1 ohm | 2.50 |
| 2824 | 17200 | 2 | Single Spools, 5 ohm | 2.50 |
| 2824 | 17200 | 2 | Single Spools, 10 ohm | 2.50 |
| 2824 | 17200 | 2 | Single Spools, 25 ohm | 2.80 |
| 2824 | 17200 | 2 | Single Spools, 100 ohm | 3.30 |
| 2824 | 17200 | 4 | Single Spools, 1000 ohm | 8.00 |
| 2824 | 17200 | 4 | Single Spools, 5000 ohm | 12.00 |
| 2839X | | 4 | Resistance Units, 10,000 ohm | 20.00 |
| 5882 | 25140 | 5 | Lb. Wire, Copper Annunciator No. 16 | 3.50 |
| 5882 | 25140 | 5 | Lb. Wire, Copper Annunciator No. 18 | 3.75 |
| 5888 | 25150 | 5 | Lb. Wire, Copper Bare No. 10 | 4.00 |
| 5886 | 25150 | 2 | Lb. Wire, Copper Bare No. 24 | 2.60 |
| 5886 | 25150 | 1 | Lb. Wire, Copper Bare No. 30 | 1.60 |
| 5888A | 25160 | 5 | Lb. Wire, Copper, D. C. C. No. 16 | 5.00 |
| 5888A | 25160 | 5 | Lb. Wire, Copper, D. C. C. No. 24 | 7.50 |
| 5888A | 25160 | 2 | Lb. Wire, Copper, D. C. C. No. 30 | 4.50 |
| 5885 | 25120 | 4 | Oz. Wire, Nickel Chromium No. 18 | 2.00 |
| 5885 | 25120 | 4 | Oz. Wire, Nickel Chromium No. 24 | 2.10 |
| 2998 | 25190 | 200 | Ft. Wire, Rubber Covered Cord No. 18 Double Conductor | 20.00 |
| 2998X | | 200 | Ft. Wire, Rubber Covered Flexible Cord No. 16, Single Conductor | 15.00 |
| 5885X | | 1 | Spool Wire, Constantan No. 28 | .90 |
| 5469A | 78197A | 30 | Ft. Platinum Wire No. 32 | 26.40 |
| 5898 | 25290 | 5 | Spools Wire, Steel, No. 28 | .90 |
| 2980C | | 12 | Attachment Plugs, Edison | 3.60 |
| 2983A | | 20 | Fuse Plugs, 10 amp | 2.00 |
| 2983A | | 20 | Fuse Plugs, 15 amp | 2.00 |
| 2983A | | 20 | Fuse Plugs, 30 amp | 2.00 |
| 1882 | | 12 | Magnetic Compasses, 50 mm | 13.80 |
| 1887 | 63400A | 12 | Magnetic Compasses, 16 mm | 3.00 |
| 1809 | 11010A | 12 | Magnets, Bar, 15 cm | 5.40 |
| 1823 | 11100B | 2 | Magnets, Horseshoe, 10 cm | .84 |
| 1803 | 11240B | 6 | Soft Iron Rods, 15 cm | .90 |
| 1835 | 63470 | 2 | Packages Darning Needles | 1.00 |
| 1848 | 11490B | 2 | Lbs. Iron Filings | .70 |

## GENERAL SUPPLIES AND RAW MATERIAL

| | | | | |
|---|---|---|---|---|
| | | 2 | Gallons Alcohol Denatured, Ethyl | $ 3.20 |
| | | 3 | Lbs. Ether, Ethyl, U.S.P. | 1.83 |
| | | 5 | Lbs. Copper Sulfate Crystal Tech. | 1.10 |
| | | 4 | Oz. Silver Nitrate CP Crystal | 4.00 |
| | | 1 | Lb. Rosin, Powdered (Kundt's Exp) | .45 |
| | | 10 | Lbs. Mercury CP Redistilled | 50.00 |
| 3303D | 20590 | 2 | Cartons Cork Dust (Kundt's Exp) | .50 |
| | | 1 | Carton Lycopodium Powder | 1.00 |
| 779 | 8260 | 1 | Ball Cord, Flax | 1.25 |
| 783 | 8250 | 1 | Cord Silk Line | 1.50 |
| 5619 | | 4 | Rolls Scotch Tape, ½ inch x 60 yards | 2.40 |
| 4947 | 63800 | 100 | Each, Cords, Sizes, 4, 7, 9, 11, 14, 16, 18, 20 | 31.00 |
| 4949 | 63830 | 10 | Each, Corks, Flat, Sizes 1¼, 2, 2⅜ in. | 7.00 |
| 5235 | 73765 | 5 | Lbs. Glass Tubing, 7 mm | 2.75 |
| 5225 | 73755 | 5 | Lbs. Glass Rod, 5 mm | 2.75 |
| 5239 | | 2 | Lbs. Glass Tubing, Capillary, 1 and 2 mm | 2.20 |
| 321 | | 10 | Tablets, Coordinate Paper | 1.60 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 5230 | 71180 | 6 | Forceps, Iron | $ .90 |
| 5813A | 24670 | 1 | Spool Thread, Linen, Black | .60 |
| 5930 | 25800 | 10 | Sheets Mica, 5 x 7 inch | 8.00 |
| | | 2 | Lbs. Each Common Nails, Polished, Flat Head, 2d, 3d, 4d, and 5d | 2.00 |
| | | 1 | Lb. Wire Brads, ¾ inch and 1 inch, 1 lb. each | 1.00 |
| | | 1 | Lb. Each Wood Screws, Flat Head, Galvanized, ⅝, ¾, 1, 1½ inch | 2.00 |
| | | 1 | Gross Each Machine Screws, Steel, Round Head, 8-32 x ¾ inch, 8-32 x 1 inch, 8-32 x 1¼ inch, 10-24 x 1 inch, 10-24 x 1½ inch | 7.50 |
| | | 1 | Gross Each Nuts, Steel Machine, Sizes 8-32 and 10-24 | 2.50 |
| 5916 | 25700 | 1 | Copper Sheet, 12 x 60 inches, No. 26 Gage | 3.25 |
| 5916 | 25700 | 1 | Copper Sheet, 12 x 60 inches, No. 30 Gage | 2.50 |
| 5925 | 25770 | 6 | Sheets Russia Iron, 12 x 12 x .016 inches thick | 1.50 |
| 5908 | 25610 | 12 | Ft. Brass Rod, ¼ inch | 1.20 |
| 5908 | 25610 | 12 | Ft. Brass Rod, ⅜ inch | 2.00 |
| 5908 | 25610 | 12 | Ft. Brass Rod, ½ inch | 4.20 |
| 5924 | 25760 | 8 | Ft. Norway Iron Rod, ⅛ inch | 1.35 |
| 5936 | 25850 | 24 | Ft. Steel Rod, Coppered Bessemer, ⅛ inch | 2.40 |
| 5937 | 25800 | 12 | Ft. Each Steel Rod, Cold Rolled, ¼, ⅜, and ½ inch | 3.40 |
| | | | Total | $3325.46 |

## SHOP SUPPLIES

| | | | | |
|---|---|---|---|---|
| 1400B | 78402 | 1 | Vacuum Pump, 115 v, 60 cycle (1 micron) | $ 90.00 |
| 1410B | | 1 | Blower and Vacuum Pump, 115 v, 60 cycle (10 lbs. Pressure) | 65.00 |
| 5557A | | 1 | Water Still, 1 gallon per hour, Gas Heated | 83.00 |
| 2605 | 14293 | 1 | Battery Charger | 26.50 |
| 235 | | 2 | Steel Scales, E & M | 4.30 |
| 125 | 26650A | 3 | Levels | 3.00 |
| 11 | 26080 | 1 | Set Auger Bits, ¼ inch to 1 inch | 8.50 |
| 19 | 26070 | 1 | Bit Brace | 4.60 |
| 57 | 26020 | 1 | Cold Chisel, ½ inch | .28 |
| 82 | 26190 | 1 | Set Twist Drills, No. 1 to 60 | 13.80 |
| 84 | | 1 | Breast Drill | 7.50 |
| 8266A | | 1 | Scissors, 4 inch | 1.75 |
| 8272 | 65760A | 1 | Scissors, 6 inch | 2.50 |
| 25 | 51105 | 1 | Caliper Inside | .60 |
| 23 | 51110 | 1 | Caliper Outside | .60 |
| 103A | 73860 | 1 | Glass Disk Cutter | 2.35 |
| 101 | 73835 | 1 | Glass Cutter | .35 |
| 301 | 27200 | 1 | Try Square | 1.45 |
| 325 | 27730 | 3 | Triangles, Celluloid, 30 and 60° | .90 |
| 5858 | 78950 | 12 | Each, Sand Paper, Sizes 00, 0, 1, 2 | 1.15 |
| 5817 | 68990 | 12 | Each, Emery Paper, Sizes 0000, 000, 00, 0, 1 | 3.00 |
| 93 | 69600 | 2 | Files, Flat, 8 inch | 1.00 |
| 89 | 69620 | 6 | Files, Rat Tail, 6 inch | 1.50 |
| 91 | 69630 | 6 | Files, Triangular | 1.20 |
| 90 | | 2 | Files, Half Round, 10 inch | .60 |
| 95 | | 6 | File Handles | .60 |
| 111 | 26570A | 2 | Claw Hammers | 3.50 |
| 185 | 26740 | 1 | Oil Stone | 1.30 |
| 195 | 26810 | 2 | Pliers, Flat Nose | 3.50 |
| 197 | 26780 | 1 | Pliers, Side Cutting | 1.50 |
| 208 | 26770 | 2 | Pliers, Combination | 2.00 |
| 201 | 26790 | 1 | Pliers, Nippers | 1.65 |
| 208 | 26770 | 2 | Pliers, Wire Cutting | 2.50 |
| 263 | 26950 | 1 | Saw, Cross Cut | 2.75 |
| 105 | 26960 | 1 | Saw, Hack | 1.50 |
| 109 | 26970 | 12 | Blades, 12 inch | 1.45 |
| 272J | 26290 | 1 | Screw Die and Tap Set | 20.00 |
| 267 | 26990 | 3 | Screw Drivers, 7¼ inch | 2.10 |
| 267 | | 3 | Screw Drivers, 10½ inch | 2.25 |
| 269 | 27010 | 2 | Screw Drivers, Instrument | .90 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 289 | 27160 | 5 | Lbs. Solder, Resin Center | $ 6.00 |
| 277 | 27140 | 2 | Soldering Coppers, 6 oz | 1.50 |
| 278 | | 2 | Soldering Coppers, 3 oz | 1.50 |
| 3 | | 1 | Anvil Vise, 7 lb | 4.00 |
| 4 | | 1 | Vise, Swivel Base, 5 lb | 7.20 |
| 311 | 27290 | 1 | Wrench, Adustable, 6 inch | 2.50 |
| 311 | 27290 | 1 | Wrench, Monkey, 8 inch | 1.50 |
| 315 | 27310 | 1 | Wrench, Stillson, 10 inch | 2.50 |
| 275 | 27100 | 1 | Shears (Tinners Snips) | 1.50 |
| | | | Total | $400.53 |

## SUGGESTED ADDITIONAL EQUIPMENT FOR CLASS AND LECTURE DEMONSTRATIONS NOT INCLUDED IN MISCELLANEOUS SUPPLY LIST

| | | | | |
|---|---|---|---|---|
| 4182 | 42570A | 1 | Weight, 1 lb. | $ 1.00 |
| 837 | 3430 | 1 | Seconds Pendulum | 21.00 |
| 882 | | 1 | Ladder Model | 12.60 |
| 809 | 8850 | 1 | Inclined Plane | 8.40 |
| 818 | 8900 | 1 | Hall's Carriage | 1.50 |
| 738 | 7900 | 1 | Composition of Forces Apparatus | 3.75 |
| 543 | 8950 | 1 | Inertia Apparatus | 1.80 |
| 545 | 8635 | 1 | Inertia Ball | 1.45 |
| 572H | 8960 | 1 | Moment of Inertia Demonstration Cylinders | 5.40 |
| 883 | | 1 | Wheel and Knife Edge | 18.00 |
| 816 | 8790 | 1 | Inclined Plane | 15.00 |
| 817A | 8780 | 1 | Acceleration Demonstration Apparatus | 6.60 |
| 884 | | 1 | Trajectory Apparatus (Projectile Motion) | 10.75 |
| 877 | 8140 | 1 | Newton's Second Law—Motion Apparatus | 3.50 |
| 975 | 9500 | 1 | Newton's Third Law—Gyroscopic Wheel | 27.00 |
| 570B | 9510 | 1 | Rotating Platform with Stool | 33.00 |
| 925 | 9240 | 1 | Centrifugal Force Apparatus | 3.50 |
| 917 | 9230 | 1 | Centrifugal Hoops | 1.75 |
| 923 | 9250 | 1 | Centrifugal Separator | 3.90 |
| 929 | 9270 | 1 | Governor | 7.20 |
| 863 | 7700 | 1 | Leaning Tower of Pisa | 2.00 |
| 865 | 7750 | 1 | Loaded Wheel | 3.90 |
| 867 | 7650 | 1 | Equilibrium Toy | .50 |
| 857 | 7660 | 1 | Center of Gravity Block | 1.00 |
| 853 | 7690 | 1 | Double Cone and Plane | 2.25 |
| 569 | 4210 | 1 | Hooke's Law Apparatus | 2.30 |
| 710B | 8560 | 1 | Collision Balls Apparatus | 26.50 |
| 834B | | 1 | Wilberforce Loaded Spring | 7.20 |
| 734D | 7780 | 1 | Demonstration Balance | 3.50 |
| 893 | 8280 | 1 | Pulley Demonstration Set | 36.00 |
| 799 | 7980 | 1 | Jack Screw | 2.50 |
| 1108 | | 1 | Archimedes' Pump | 15.00 |
| 833 | 8500 | 1 | Sand Pendulum | 1.35 |
| 550A | 4070 | 1 | Elasticity of Flexure Apparatus | 13.50 |
| 1014 | 4590 | 1 | Pressure Syringe | 2.25 |
| 1046 | 4770 | 1 | Hydraulic Press | 3.00 |
| 1026 | 4650 | 1 | Pascal's Vases | 3.25 |
| 1004 | 4640 | | Equilibrium Tubes | 7.50 |
| 1042 | 4720 | 1 | Cartesian Diver | 1.20 |
| 1092 | 4690 | 1 | Bucket and Cylinder | 1.85 |
| 1150 | 4830 | 1 | Waterproof Wooden Cylinder | .45 |
| 1152 | 4820 | 1 | Waterproof Wooden Block | .45 |
| 1148 | 4790 | 1 | Overflow Can | .95 |
| 1146 | 4800 | 1 | Catch Bucket | .90 |
| 1518 | 5940X | 1 | Baroscope | 16.00 |
| 4794 | 73480A | 1 | U Tube | .40 |
| 1167 | 4970 | 1 | Density Ball | 3.60 |
| 1110 | 4990 | 1 | Hare's Balancing Column | 1.25 |
| 537 | 3760 | 1 | Diffusion Apparatus | .90 |
| 540A | 3910 | 1 | Osmosis Apparatus | 2.65 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 885 | | 1 | Bernoulli's Principle Apparatus | $ 13.20 |
| 1034 | | 4 | Demonstration Manometers | 6.00 |
| 1090 | 4750 | 1 | Hydraulic Ram | 6.00 |
| 1082 | 6500 | 1 | Gas Laws Apparatus, Demonstration Form | 6.60 |
| 4860 | 3750 | 1 | Brownian Movements Apparatus | 4.00 |
| 7969X | | 1 | Microscope | 102.00 |
| 1724 | 9755 | 1 | Molecular Demonstration Apparatus | 2.75 |
| 1263G | | 1 | Alcohol Thermometer | 4.50 |
| 1263H | | 1 | Toluene Thermometer | 6.80 |
| 1260 | 80190 | 1 | Triple Scale Thermometer | 1.50 |
| 1273 | 80180 | 1 | Maximum and Minimum Thermometer | 10.00 |
| 886 | | 1 | Galilean Thermometer | 1.20 |
| 2349 | 19500 | 1 | Thermoelectric Magnet | 17.50 |
| 2349A | 19510 | 1 | Auxiliary Coil for above | 3.50 |
| 1623 | 10140 | 1 | Tyndall's Specific Heat Apparatus | 3.75 |
| 1661 | 10210 | 1 | Ball and Ring Apparatus | 1.75 |
| 1663 | 10230 | 1 | Compound Bar | .60 |
| 1073 | | 1 | Hero's Engine | 2.50 |
| 1665 | 10620 | 1 | Franklin's Pulse Glass | 1.25 |
| 1671 | 10190 | 1 | Maximum Density of Water Apparatus | 6.50 |
| 1675 | | 1 | Clement and Desormes Apparatus for Comparing Specific Heat of Gas at Constant Pressure to Specific Heat at Constant Volume | 6.60 |
| 1031 | 72370 | 1 | Monometer for above | 7.20 |
| 1031A | | 1 | T Tube for above | .55 |
| 1424 | 5250 | 1 | Hand Pressure Pump for above | 6.00 |
| 1504 | | 1 | Freezing Point Apparatus | 5.00 |
| 5063A | 70130 | 1 | Filter Pump for use with above | 1.65 |
| | | 1 | Quart Freezing Solution | 1.50 |
| 1683 | 10750 | 1 | Mechanical Equivalent of Heat Tube | .50 |
| 1651 | 10400 | 1 | Conductometer | .70 |
| 1653A | 10412 | | Ignition Solution for above | .35 |
| 1655 | | 1 | Conductometer | 10.25 |
| 1649 | 10440 | 1 | Conductivity Comparator | .75 |
| 1647 | 10430 | 1 | Conductivity of Water Apparatus | 1.10 |
| 1729A | 10528 | 1 | Hot Water Heater Model | 2.25 |
| 1727 | 10490 | 1 | Convection of Gases Apparatus | 2.40 |
| 1732 | 10565 | 1 | Radiation Outfit | 1.35 |
| 1736 | 10563 | 1 | Radiant Heat Box | 3.90 |
| 1731 | | 1 | Radiation Thermopile | 12.75 |
| 1617 | 10560 | 1 | Leslie's Cube | 4.75 |
| 1930 | 11840 | 1 | Friction Rod, Polystyrene | .60 |
| 1939 | 11860 | 1 | Cat Skin | 1.25 |
| 1953 | 11920 | 1 | Electrophorus | 5.00 |
| 1959 | | 1 | Electrostatic Needle | 3.60 |
| 1965 | 12090 | 1 | Electroscope | 6.60 |
| 1685 | 9860 | 1 | Faraday's Ice Pail | .75 |
| 2025 | 12190 | 1 | Hollow Globe | 4.80 |
| 2015 | 12160 | 1 | Induction Cylinder | 5.50 |
| 2013 | 12170 | 1 | Induction Spheres (Pair) | 7.00 |
| 1912 | 12510 | 1 | Wimshurst Static Machine | 42.50 |
| 1989 | 12270 | 1 | Leyden Jar | 8.05 |
| 1993 | 12280 | 1 | Discharger | 3.50 |
| 2011 | 12180 | 1 | Hollow Cylinder | 5.00 |
| 2041 | 12390 | 1 | Volta's Hail Storm and Smoke Condenser | 4.80 |
| 2009 | 12230 | 1 | Faraday Cage | 1.85 |
| 2150 | | 1 | Lightning Demonstration Apparatus | 7.80 |
| 1801 | 11000 | 1 | Lodestone | .30 |
| 1832 | 11390 | 1 | Floating Magnet | 2.25 |
| 1809A | 11050B | 1 | Alnico Magnet | 1.85 |
| 1841 | 11600 | 1 | Tube with Iron Filings | .65 |
| 1800 | 11610 | 1 | Magnet Model | 15.00 |
| 1809 | 11010A | 1 | Bar Magnet | .45 |
| 1804 | | 1 | Set Magnet Combinations | 3.00 |
| 1873 | 11380 | 1 | Magnetic Needle | 1.85 |
| 1875 | 63480 | 1 | Magnetic Needle, Dipping | 3.25 |
| 5924 | 25760 | 2 | Ft. Norway Iron Rod, ⅜ inch | .36 |
| 2423 | | 1 | Laws of Resistance Apparatus | 6.60 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 2692X | | 2 | Galvanometers, Lecture Table | $200.00 |
| 1967 | 12100 | 1 | Condenser Attachment | 5.00 |
| 2259 | | 1 | Bunsen Cell | 2.50 |
| 2246 | 66560 | 1 | Daniell Cell | 1.25 |
| 2206 | 13915 | 1 | Zinc Electrode | .18 |
| 2922 | 14580A | 1 | D. C. Electric Bell | .75 |
| 1166A | 75600A | 3 | Battery Jars | .45 |
| 2350 | 16980 | 1 | Copper Coulometer | 4.80 |
| 2354 | 16910 | 1 | Electroplating Outfit, Copper | 2.50 |
| 2356 | 16930 | 1 | Electroplating Outfit, Nickel | 3.00 |
| 2369A | 63760 | 1 | Conductivity of Solution Apparatus | 1.75 |
| 2365 | 16790 | | | |
| 2370 | 16780 | 1 | Electrolysis Apparatus | 16.80 |
| 2352 | 78330 | 2 | Projection Cells, Electrolytic | 18.00 |
| 2461 | | 1 | Complete Set Electromagnetism Apparatus (Crowe) | 300.00 |
| 941 | 9410 | 1 | Earth Induction Apparatus | 18.00 |
| 904A | 9090 | 1 | Motor Rotator | 60.00 |
| 2487 | | 1 | Demonstration Generator | 25.00 |
| 2488 | 18860 | 1 | Magneto Electric Generator | 8.75 |
| 2465 | | 1 | Generator, Demonstration | 21.60 |
| 2465A | | 1 | Two Pole Armature | 16.75 |
| 2618 | | 1 | Variable Transformer (Powerstat) 115 v, 7.5 amp | 20.00 |
| 2618A | | 1 | Transformer, 1 kva, 25,000 volt | 85.00 |
| 2727 | | 1 | Galvanometer, Demonstration | 45.00 |
| 2604C | | 1 | Rectifier Demonstration Apparatus | 16.80 |
| 2143 | 12900 | 1 | Crookes' Tube for Heating Effect | 15.75 |
| 2145 | 12860 | 1 | Crookes' Tube for Magnetic Effect | 15.00 |
| 2142G | | 1 | Crookes' Tube for Fatigue Effect | 10.50 |
| 2145A | 12880 | 1 | Rolling Wheel Tube | 24.50 |
| 2145B | 12940 | 1 | Vacuum Tube for Fluorescence | 15.75 |
| 2619 | 67160 | 1 | Induction Coil, Hand Type | 10.75 |
| 3340 | 20820 | 1 | Spring | 2.40 |
| 3306 | 20430 | 1 | Tube | 5.00 |
| 3284 | | 1 | Pair of Supports | 2.50 |
| 3343 | 20850 | 1 | Traveling Wave Apparatus | 60.00 |
| 3345 | | 1 | Ripple Tank | 36.00 |
| 3332 | 20420 | 1 | Galton's Whistle | 9.00 |
| 3267 | | 1 | Vibrating String Apparatus | 14.50 |
| | | 1 | Resonance Apparatus (Make locally with telescoping tubes from stock) | |
| 1511 | 5960 | 1 | Bell in Vacuo | 3.90 |
| 1470 | | 1 | Bell Jar | 4.25 |
| 937 | 9330 | 1 | Savart's Toothed Wheel | 4.50 |
| 949 | 9320 | 1 | Siren Disk | 1.70 |
| 3213 | 20000 | 1 | Tuning Fork | 1.75 |
| 3314 | 20910 | 1 | Set Chladni's Plates | 4.20 |
| 3372 | 20380 | 1 | Xylophone | 2.25 |
| 3364 | 20800 | 1 | Violin Bow | 3.00 |
| 3288 | 20550 | 1 | Singing Tube Set | 2.50 |
| 3246 | 20230 | 1 | Pair Tuning Forks, Sympathetic | 15.00 |
| 3270 | 20500 | 1 | Organ Pipe | 6.30 |
| 3300 | 20400 | 1 | Quincke's Interference Tubes | 1.85 |
| 3336 | 20600 | 1 | Acoustic Oscillograph | 1.00 |
| 963 | 9366 | 1 | Manometric Flame Apparatus | 10.20 |
| 2142A | | 1 | Cathode Ray Oscillograph, 5 inches | 100.00 |
| 3744 | 21200 | 1 | Pinhole Apertures | 2.40 |
| 3673A | | 2 | Illuminators | 40.00 |
| 3643 | 22300 | 1 | Ground Screen | 3.50 |
| H3550C | | 1 | Optical Box | 8.50 |
| 3499 | | 1 | Auto-Collimating Reflector | .55 |
| 3525A | | 1 | Large Spherical Concave Mirror | 6.00 |
| 1737 | | 1 | Set Parabolic Mirrors | 15.00 |
| 3525A | | 1 | Large Spherical Concave Mirror | 6.00 |
| 3675 | 21100 | 1 | Optical Disk | 27.50 |
| 3498 | 22650 | 1 | Refraction Cube | 2.25 |
| 3484 | 22760 | 2 | Demonstration Prisms | 17.00 |
| 3476 | 22770B | 1 | Right-Angled Prism | .60 |
| 3530 | 22455 | 1 | Lumirod | 3.00 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 3496 | | 1 | Refraction Trough | $ 60.00 |
| 3468 | 22750B | 2 | Prisms, Flint Glass | 4.80 |
| 955 | 9420 | 1 | Set Newton's Color Disks | 1.65 |
| 959 | 9430 | 1 | Set of Color Disks (17 in number) | 2.50 |
| 3492 | | 1 | Prism Holder and Deflecting Prisms | 15.00 |
| 3623 | | 1 | Auxiliary Bench | 12.60 |
| 3673 | | 1 | Illuminator | 57.00 |
| 3648 | 22370 | 1 | Light Shield | 4.75 |
| 3420 | 22910E | 2 | Double Convex Lenses | 3.30 |
| 3448 | 22990 | 1 | Achromatic Lens | 4.20 |
| 3642 | 22270 | 1 | Mounted Iris Diaphragm | 12.00 |
| 3802 | | 1 | Plane Reflection Grating | 16.20 |
| 4856A | | 1 | Spectrum Chart | 5.00 |
| 638 | | 6 | Jars Fluorescent Paints, Assorted | 4.50 |
| 639 | | 1 | Fluorescent Mineral Plaque | .80 |
| 638H | 13325 | 1 | Fluorescent Liquid Set | 12.00 |
| 3720G | | 1 | Mercury Arc Light Source | 45.00 |
| 2438 | 15160 | 1 | Argon Lamp | .65 |
| 3720H | | 1 | Sodium Arc Lamp | 67.50 |
| 3422 | 22910F | 1 | Lens, Double Convex, 35 cm focus | 5.00 |
| 3438 | 22930C | 1 | Lens, Double Concave, 20 cm focus | 2.00 |
| 3456 | 22980D | 1 | Lens, Plano-Convex, 25 cm focus | 2.00 |
| 3462 | 23010 | 1 | Lens, Double Convex, Mounted | 10.00 |
| 3460 | 23020 | 1 | Lens, Plano-Convex, Mounted | 9.00 |
| 3461 | | 1 | Wire Gauze to show barrel and pincushion distortion | .50 |
| 3461A | | 1 | Wire Gauze to show barrel and pincushion distortion | .75 |
| 3448 | 22990 | 1 | Achromatic Lens | 4.20 |
| 3536 | 23185 | 1 | Sextant, Student Type | 4.95 |
| 3479D | | 1 | Double and Single Slit Sources | 4.50 |
| 3479E | | 1 | Single and Multiple Slits for Demonstration of Diffraction | 5.50 |
| 3633 | | 2 | Object Holders | 24.00 |
| 3684 | | 1 | Double Slit to show Young's Interference Experiment | 12.50 |
| 3684A | | 1 | Diffraction Wedge and Double Slit to show Young's Interference Experiment | 3.50 |
| 3552 | 23550 | 1 | Newton's Rings Apparatus | 2.75 |
| 3660X | | 1 | Incandescent Lamp, Straight, Filament for use with Double Slits | 1.60 |
| 3658 | 22350 | 1 | Lamp Socket | 1.50 |
| 2608C | | 1 | Transformer for 6 volt Lamp No. 86615 | 5.00 |
| 3808C | | 1 | Diffraction Grating | 6.00 |
| 3808D | | 1 | Coarse Ruled Grating for showing Missing Orders | 5.00 |
| 3809A | | 1 | Plane Transmission Grating | 15.00 |
| 3523 | | 1 | Polarizing Mirror | 7.20 |
| 3730 | | 1 | Glass Strip to illustrate Strains produced by Vibrations | 3.60 |
| 3731 | | 1 | Plate Holder for producing Compression | 7.20 |
| 3732 | | 1 | Unannealed Glass Plate | .50 |
| 3733 | | 1 | Mica Plate, Quarter Wave | 3.75 |
| 3733A | | 1 | Mica Plate, Half Wave | 4.50 |
| 3732A | | 1 | Annealed Glass Plate | .50 |
| 3734 | | 1 | Polarization Tube | 13.50 |
| 3734A | | 1 | Polarizer and Analyzer | 15.00 |
| 3734B | | 1 | Projection Objective | 34.00 |
| 4850 | 56300 | 1 | Atomic Weight Chart | 3.25 |
| 4854X | | 1 | Periodic System Chart | 3.25 |
| 4854 | 56305 | 1 | Chart of the Atoms | 7.50 |
| 4840 | | 1 | Chart, Dimensions of Natural Objects | .75 |
| 1730 | 7600 | 1 | Cloud Chamber | 4.00 |
| 628 | | 1 | Source of Alpha and Beta Rays | 3.60 |
| | | | Total | $2716.34 |

## ADDITIONAL EQUIPMENT FOR STUDENT EXPERIMENTS NOT INCLUDED IN GENERAL SUPPLY LIST

**(For class of 20 students working in groups of 2, and for a few experiments, 5 groups working on each of 2 experiments)**

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 153A | 76145A | 10 | Meter Sticks (Half Meter) cut from square type Meter Sticks | $ 10.00 |
| 297 | 3570 | 5 | Spherometers | 33.75 |
| 1687A | 2840 | 5 | Measuring Cups | 2.90 |
| 1687A | 2840 | 5 | Measuring Cylinders | 2.70 |
| 5219 | 5775A | 5 | Glass Plates | .60 |
| 1136 | 48520 | 5 | Pycnometers | 7.25 |
| 4192 | 42660 | 5 | Riders for Analytical Balances, 10 mg | 1.50 |
| 851 | | 5 | Atwood Machines | 200.00 |
| 576 | | 5 | Rolls Coated Paper | 3.75 |
| 976 | 8840 | 5 | Friction Boards | 9.00 |
| 977 | 8810 | 5 | Friction Blocks with Hook | 3.25 |
| MM852C | | 5 | Glass Plates, 15 x 140 cm | 27.00 |
| 815 | 8330 | 5 | Pulleys for Friction Board | 4.25 |
| 928 | 9260 | 5 | Centripetal Force Apparatus | 92.50 |
| 907 | 9140 | 5 | Rotators, Hand Type | 60.00 |
| 570J | | 1 | Rotational Inertia Apparatus | 60.00 |
| 807 | 7940 | 5 | Crane Booms | 51.00 |
| 4257 | | 5 | Adapter Collars for Crane Boom | 7.50 |
| 776B | 8340 | 5 | Heavy Duty Pulleys for Crane Experiment | 33.75 |
| 4260 | 1165B | 10 | Mounting Clamps for Crane Experiment | 15.00 |
| 221 | 3310 | 5 | Paper Protractors | .60 |
| 765 | 8230 | 2 | Triple Tandem Pulleys | 6.00 |
| 4085 | | 2 | Hand Dynamometer | 30.00 |
| 711 | | 3 | Ballistic Pendulums | 162.00 |
| 569D | 8120 | 5 | Loaded Springs for Harmonic Motion | 5.00 |
| 566 | | 1 | Inertia Balance | 23.00 |
| 572D | | 5 | Young's Modulus Apparatus | 175.00 |
| 4028 | 40750 | 1 | Mohr Westphal Balance | 36.75 |
| 1160 | 4860 | 5 | Lead Sinkers | 1.50 |
| 1629 | 9680 | 10 | Steam Traps | 5.00 |
| 1631 | 10260 | 5 | Linear Expansion Apparatus | 30.00 |
| 1635 | 10275 | 5 | Expansion Rods, Aluminum | 1.50 |
| 1639 | 10280 | 5 | Expansion Rods, Brass | 1.80 |
| 1637 | 10285 | 5 | Expansion Rods, Copper | 2.00 |
| 1645 | 10290 | 5 | Expansion Rods, Steel | 2.50 |
| 1961 | 12050 | 5 | Electroscopes | 6.25 |
| 2019 | 12220 | 5 | Proof Planes | 2.00 |
| 1925 | 11820 | 5 | Friction Rods, Glass | 2.25 |
| 1929 | 11810 | 5 | Friction Rods, Vulcanite | 1.75 |
| 1935 | 11850 | 5 | Friction Pads, Silk | 3.25 |
| 1937 | 11880 | 5 | Friction Pads, Flannel | 1.50 |
| 1957 | 11960 | 5 | Electroscopes, Pith Ball | 6.25 |
| 1945 | 11940 | 1 | Package Pith Balls, Large | .60 |
| 1086 | | 5 | Boyle's and Charles' Law Apparatus | 238.75 |
| 1893 | 11630 | 5 | Magnetometers | 30.00 |
| 1880 | | 5 | Magnetic Compasses | 6.25 |
| 1693A | 9950 | 5 | Calorimeters, Electric | 30.00 |
| 1693 | 9960 | 5 | Heating Coils, Extra, 5 ohm | 17.50 |
| 2807 | | 5 | Slide Wire Bridges, 2 meter | 50.00 |
| 2818 | | 5 | Wheatstone Bridges, Slide Wire | 28.75 |
| 2822 | 17170 | 5 | Resistance Test Spool Sets | 30.00 |
| 2392B | | 5 | Inductive Coils | 37.50 |
| 2350 | 16980 | 5 | Copper Coulombmeters | 15.00 |
| 2376 | 68950B | 10 | Copper Electrodes for above | 4.50 |
| 2273B | | 2 | Standard Cells, Eppley | 27.00 |
| 3302 | 20560 | 5 | Kundt's Apparatus | 43.75 |
| 3600 | 21860 | 5 | Optical Benches, Elementary, complete with Lens Holder and Screen | 10.00 |
| 3606 | 21910 | 5 | Extra Lens Supports | 1.00 |
| 3570 | 22045 | 5 | Lamp Support and Light Sources | 12.50 |
| 4330 | | 5 | Measuring Telescopes | 210.00 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 3516 | 22570 | 5 | Mirrors, Concave and Convex | $ 3.00 |
| 3404 | | 5 | Lenses, Double Convex, 15 cm focal length | 2.00 |
| 3399 | 22900A | 5 | Lenses, Double Convex, 4 cm Diameter x 5 cm focal length | 3.75 |
| 3400 | 22900B | 5 | Lenses, Double Convex, 4 cm Diameter x 10 cm focal length | 2.30 |
| 3414 | 22910B | 5 | Lenses, Double Convex, 5 cm Diameter x 50 cm focal length | 8.40 |
| 3424 | 22920A | 10 | Lenses, Double Concave, 4 cm Diameter x 10 cm focal length | 6.50 |
| 5000 | | 5 | Glass Dishes for Refraction Experiment | 2.70 |
| 3498 | 22650 | 5 | Glass Cubes for Refraction Experiment | 11.25 |
| 3494A | 22640 | 5 | Glass Plates, 2 x 2 inches | 2.00 |
| 3556 | 23530G | 5 | Glass Filters, Red | 1.50 |
| 3556 | 23530G | 5 | Glass Filters, Blue | 1.50 |
| 3644 | | 5 | Slit and Scale for Diffraction Experiment | 11.25 |
| 3683 | | 5 | Grating Holders | 5.00 |
| 3806C | | 5 | Coarse Diffraction Gratings | 7.50 |
| 3720F | | | | |
| 4752 | | 5 | Bunsen Burners with Manometric Flame Attachment | 7.50 |
| 740 | 7920 | 2 | Force Tables | 70.00 |
| 740B | | 1 | Moments Attachment for above | 23.00 |
| 745 | 7810 | 3 | Lever Holders | 1.20 |
| 2619 | 67160 | 1 | Vacuum Tube Testing Outfit | 16.00 |
| 2618B | | 1 | Transformer, Electronic Tube Current Source | 6.00 |
| 3350 | 20720 | 1 | Sonometer | 17.50 |
| 3250 | 20190 | 1 | Rubber Hammer | .40 |
| 3705 | 23592 | 1 | Set Polarizing Disks (Polaroids) | 6.00 |
| 3703A | 23595 | 1 | Polaroid Experimental Kit | 35.00 |
| | | | Total | $2175.95 |

## ADDITIONAL EQUIPMENT REQUIRED FOR INTERMEDIATE COURSE IN HEAT

| | | | | |
|---|---|---|---|---|
| 1709 | | 2 | Calorimeters, Vacuum Jacketed | $ 66.00 |
| 1691B | 9920 | 2 | Calorimeter Stirrers | 3.60 |
| 1654 | | 2 | Heat Conductivity Apparatus | 53.00 |
| 1607 | 9630 | 5 | Weight Thermometers | 2.00 |
| 1704 | 10020 | 1 | Gas Calorimeter, Junker | 25.00 |
| 1708 | 73410 | 1 | Gas Meter | 95.00 |
| 1708A | | 1 | Constant Pressure Tank | 85.00 |
| 1718 | | 5 | Constant Level Weirs | 20.00 |
| 1705 | | 5 | Calorimeters, Continuous Flow | 54.00 |
| M1078 | 10710 | 2 | Vapor Pressure Apparatus | 29.00 |
| 1031 | 72370 | 2 | Manometers | 14.40 |
| 2744A | 67910 | 1 | Wheatstone Bridge | 65.00 |
| 2706F | 67000A | 2 | Wall Type Galvanometers | 70.00 |
| 2713 | | 1 | Galvanometer Shunt | 25.00 |
| 2835 | | 1 | Temperature Coefficient Coil | 20.00 |
| 2706G | 67050 | 2 | Telescope and Scale | 52.00 |
| 1675 | | 4 | Clement and Desormes' Apparatus | 26.40 |
| 5745 | 80840 | 5 | Connecting Tubes, 3 way | 2.75 |
| 4794 | 73480A | 5 | Calcium Chloride Tubes, 6 inch | 2.60 |
| 1620 | | 2 | Radiation Calorimeters | 36.00 |
| 4060 | | 1 | Jolly's Balance | 57.50 |
| 4061 | | 1 | Platform, Slow Motion, for above | 3.45 |
| 4063X | | 1 | Platinum Ring for Surface Tension Experiment | 5.75 |
| 73A | | 1 | Micrometer Microscope | 125.00 |
| 5486 | | 1 | Optical Pyrometer | 200.00 |
| 4539 | | 1 | Blast Burner, Gas | 27.50 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 1694 | | 1 | Set of Calorimetric Vessels<br>(a) Unsilvered and unevacuated<br>(b) Unsilvered and evacuated<br>(c) Silvered and unevacuated<br>(d) Silvered and evacuated<br>Set | $ 21.00 |
| 1654 | | 1 | Thermal Conductivity Apparatus | 27.00 |
| 1290 | 74600 | 5 | Sling Psychrometers | 42.50 |
| 1726 | 7340 | 5 | Alluard Hygrometers | 65.00 |
| 4702 | 78774B | 5 | Hand Pressure Bulbs | 1.50 |
| 1280 | 74610 | 5 | Mason Hygrometers | 30.00 |
| 293 | 64080 | 1 | Revolution Counter | 3.50 |
| 1750 | | 1 | Gas Engine (Automobile Type) | 27.50 |
| 4935 | | 1 | Combustion Analyzer, Allen | 150.00 |
| | | | Total | $1533.95 |

## ADDITIONAL EQUIPMENT FOR INTERMEDIATE COURSE IN ELECTRICITY AND MAGNETISM

| | | | | |
|---|---|---|---|---|
| 2749 | 67660 | 2 | Potentiometers, Student Type | $160.00 |
| 2756 | 16110 | 4 | Resistance Boxes, 0-9999 ohm | 280.00 |
| 2755 | | 2 | Resistance Boxes, 0-999 ohm | 112.00 |
| 2836 | | 2 | Resistances, Standard, 1.0 ohm | 30.00 |
| 1894E | | 2 | Magnetometer, MH and $\frac{M}{H}$ | 80.00 |
| 1814A | | 2 | Magnets, Alnico, for MH | 1.15 |
| 5295B | 9685A | 2 | Electric Immersion Heaters | 13.90 |
| 1701 | 10580A | 2 | Thermos Bottles, 500 cc | 2.70 |
| 2836 | | 2 | Resistances, Standard, 0.1 ohm | 30.00 |
| 2836 | | 2 | Resistances, Standard, 0.01 ohm | 30.00 |
| 2836 | | 2 | Resistances, Standard, 0.001 ohm | 30.00 |
| 2706H | 67010 | 2 | Galvanometers, Ballistic | 90.00 |
| 2833B | | 4 | Standard Condensers, 1 mf | 220.00 |
| 2915 | 67220 | 2 | Charge-Discharge Keys | 30.00 |
| 2909 | | 2 | Damping Keys | 48.00 |
| 2765C | | 4 | Condensers, Unknown, Approx. 2 mf | 5.40 |
| 2765B | 66800 | 4 | Condensers. Unknown, Approx. 1.0 mf | 4.40 |
| 2915 | | 2 | Condenser Discharge Keys | 48.00 |
| 2833 | 66790 | 2 | Condensers, .05 to 1 mf | 250.00 |
| 2840 | | 6 | Resistance Units, 100 megohms | 30.00 |
| 2833B | 66795 | 2 | Condensers. Standard, 0.5 mf | 100.00 |
| 2633 | 18125 | 2 | Telephone Receivers (Head Phones) | 10.00 |
| 2962 | 14415 | 8 | Connectors, Four Way | 4.80 |
| 1968 | 17800 | 2 | Condensers, Parallel-Plate | 40.00 |
| 1968A | | 2 | Mica Plates for above | 4.00 |
| 2623 | | 2 | Audio Oscillators | 68.00 |
| 2624 | | 2 | Ratio Arm Boxes | 130.00 |
| 2625 | | 2 | Standard Inductometers | 300.00 |
| 2698 | | 4 | Inductances, Unknown | 40.00 |
| 2608D | | 2 | Transformers | 70 00 |
| 2744A | 67910 | 2 | Wheatstone Bridges | 130.00 |
| 1862 | | 2 | Solenoids, about 275 mh, without iron core | 20.00 |
| 1862A | | 2 | Copper Cores for above | 2.50 |
| 1862B | | 2 | Iron Wire Cores for above | 2.00 |
| 2596 | 11710 | 2 | Steel Ring Samples for Hysteresis | 45.00 |
| 2916 | 14720 | 2 | Reversing Switches | 3.00 |
| 2850 | | 2 | Standard Mutual Inductances | 100.00 |
| 3673C | | 2 | Transformers, 6 v, 18 amp, for Demagnetizing Ring Samples | 12.00 |
| 2917 | | 2 | Hysteresis Switches | 47.00 |
| | | | Total | $2491.85 |

## ADDITIONAL EQUIPMENT REQUIRED FOR INTERMEDIATE COURSE IN PHYSICAL OPTICS

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 298A | 3580A | 2 | Spherometers, Precision | $ 33.60 |
| 5218 | 73740 | 2 | Glass Plates, 100 x 100 m/m | .20 |
| 3520A | | 2 | Mirrors, Concave, 20 cm focus | 1.70 |
| 3522 | 22580 | 2 | Mirrors, Concave, 25 cm focus | 1.70 |
| 3623 | | 2 | Optical Benches | 90.00 |
| 3623A | | 2 | Extra Carriages | 7.00 |
| 3623B | | 2 | Hooded Screens | 7.20 |
| 3623C | | 2 | Combined Object and Image Screens | 6.60 |
| 3629 | 1490 | 4 | Lens Holders | 6.00 |
| 3623D | | 2 | Object Holders with Lamp | 24.00 |
| 3432 | 22920C | 2 | Single Thin Lenses, Double Concave, 20 cm focus | 1.30 |
| 3450 | 22980A | 1 | Single Thin Lens, Plano-Convex, 15 cm focus | 2.00 |
| 3623E | | 1 | Iris Diaphragm | 12.00 |
| 3623F | | 1 | Combined Image Screen and Eyepiece | 9.00 |
| 3556 | 23530G | 1 | Glass Light Filter, Red | .30 |
| 3556 | 23530G | 1 | Glass Light Filter, Blue | .30 |
| 3662 | | 1 | Modal Slide | 36.00 |
| 4294 | | 1 | Plane Mirror, Mounted | 8.00 |
| 4326 | | 1 | Telescope Support for Optical Bench | 5.00 |
| 3663 | | 1 | Eyepiece—Micrometer | 55.00 |
| 3664 | | 1 | Adapter | 3.45 |
| 3640 | | 1 | Adjustable Slit | 9.20 |
| 3720G | | 1 | Mercury Arc Lamp | 75.00 |
| 3720H | | 1 | Filter Holder for above | 5.40 |
| 3666 | | 1 | Object Screen | 2.30 |
| 173K | | 1 | Measuring Microscope | 138.00 |
| 3668 | | 1 | Glass Scale, 0.1 mm Divisions | 12.00 |
| 3669 | | 1 | Light Filter, Green | 23.50 |
| 3694 | 23370 | 1 | Spectrometer, Prism Type | 300.00 |
| 3491D | | 1 | Spectrometer Prism, 22.5 mm | 20.00 |
| 3671 | | 1 | Prism Clamp | 4.00 |
| 3720J | | 1 | Sodium Lamp | 67.50 |
| 3606 | 21910 | 1 | Mirror Holder | 3.90 |
| 3634A | | 1 | Plane Mirror | 1.50 |
| 3687 | 79360 | 1 | Spectroscope, Direct Vision | 24.00 |
| 3693 | | 1 | Spectroscope, Grating Type | 38.50 |
| 2384 | 27140B | 1 | Spark Coil | 13.50 |
| 2170D | 13020 | 1 | Spectrum Tube, Helium | 4.85 |
| 2170H | 13040 | 1 | Spectrum Tube, Neon | 4.85 |
| 2170G | 13035 | 1 | Spectrum Tube, Mercury Vapor | 4.00 |
| 5215 | 73730 | 1 | Glass Filter, Cobalt | .12 |
| 3491E | | 1 | Diffraction Apparatus | 16.25 |
| 3479E | | 1 | Single Slit, Precision | 1.50 |
| 3479F | | 1 | Double Slit, Precision | 3.50 |
| 3479G | | 1 | Slit for Determination of Thickness of Transparent Lamina | 4.50 |
| 3485 | | 1 | Fresnel Biprism | 9.60 |
| 3510 | 22470 | 2 | Mirrors, 4 x 15 cm | .30 |
| 3552 | | 1 | Newton's Rings Apparatus | 3.00 |
| 3404 | 22900C | 1 | Lens, Double Convex, 12.5 cm focus | .60 |
| 173D | 3610 | 1 | Measuring Microscope | 30.00 |
| 173J | | 1 | Filar Micrometer Eyepiece | 47.50 |
| 173H | 3650 | 1 | Support for Measuring Microscope | 18.00 |
| 173K | | 1 | Micrometer Slide | 125.00 |
| 3690 | | 1 | Interferometer | 30.00 |
| 3690A | | 1 | Objective | 10.00 |
| 3623H | | 1 | Scale and Slit for Optical Bench | 2.50 |
| 3806C | | 1 | Diffraction Grating, Coarse | 1.80 |
| 3806A | | 1 | Diffraction Grating, 7500 line | 2.00 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 3805 | | 1 | Diffraction Grating, 14,500 line | $ 2.00 |
| 3817 | | 1 | Diffraction Grating, 25,000 line | 9.00 |
| 3691 | | 1 | Polarization Apparatus | 25.00 |
| 3560 | 22710A | 2 | Iceland Spar | 1.00 |
| 3696 | | 1 | Polarimeter, Lippich, Half Shadow with Laurent Polarizer | 200.00 |
| | | | Total | $1605.52 |

# COLLEGE PHYSICS

## RECAPITULATION

ELEMENTARY PHYSICS

| | |
|---|---|
| Miscellaneous Stock Room Supplies | $3325.46 |
| Shop Supplies | 400.53 |
| Additional Equipment for Class and Lecture Demonstrations | 2716.34 |
| Total | 6442.33 |

Additional Special Equipment for:

| | |
|---|---|
| GENERAL PHYSICS | 2175.95 |
| HEAT | 1533.95 |
| ELECTRICITY AND MAGNETISM | 2491.85 |
| OPTICS | 1605.52 |
| Total | $8087.27 |
| GRAND TOTAL | $14,249.60 |

# COLLEGE ZOOLOGY

The zoology courses listed below are offered to undergraduate students in the colleges of the United States. Many additional courses are also provided, depending upon the special interests of the staff, the physical equipment of the institution, and the departments for which special services are provided.

| COURSES OFFERED | USUAL CREDIT HOURS |
|---|---|
| General Zoology | 3 - 4 |
| Invertebrate Zoology | |
| I | |
| II | |
| III | 3 - 4 |
| Field Zoology | 3 - 4 |
| Comparative Vertebrate Anatomy | 3 - 4 |
| Vertebrate Embryology | 3 - 4 |
| Histological Technique | 3 - 4 |
| Elementary Genetics | 3 - 4 |
| Parasitology | 3 - 4 |
| Animal Ecology | 3 - 4 |

# GENERAL ZOOLOGY

The attempt has been made in developing this course to bring the student in contact with meaningful zoological experience with as much variety as is consistent with the time which can be devoted to this portion of his education. It is also the aim to correlate the studies with the courses in botany and physiology so that the student may emerge from the course sequence with a well rounded biological experience.

The emphasis is placed upon giving the student first-hand contact with this material and developing an independent ability to draw conclusions from this experience. In both the laboratory and during the discussion periods, the aim is to lead the student toward accurate and critical inquiry concerning the facts and conclusions derived from his laboratory observations.

## OUTLINE OF COURSE CONTENT AND LABORATORY WORK

I. Introduction
Use of the microscope
II. The organization and function of the protoplasm in Amoeba
III. The organization and function of the protoplasm in Paramecium
IV. The organization and function of the parts of Hydra
V. The structure and function of the parts of Gonionemus
VI. Colonial organization and alternation of generations in Obelia
VII. The organization and function of the parts of a flatworm
VIII. The organization and function of the parts of a bivalve mollusc
IX. Comparison between a bivalve mollusc and a squid
X. External morphology of the sandworm (Nereis)
XI. Internal organization and functions of the earthworm
XII. Organization and function of the parts of a crayfish
XIII. External morphology of the grasshopper and comparison with the crayfish
XIV. The organization and function of the parts of a starfish
XV. The structure and function of the parts of Amphioxus
XVI. Classification of the major groups of animals
XVII. The development of the frog
XVIII. The results of crossing two animals which differ from each other by one or two unit factors
XIX. Adaptations for the collection and manipulation of pollen
XX. Modifications associated with parasitism
XXI. Organization of social life among insects
XXII. A study of some factors influencing the distribution of animals
XXIII. A study of some factors involved in speciation
XXIV. Distribution of fossil invertebrate animals through time
XXV. The evidence of evolution among fossil vertebrates
XXVI. The evidence of evolution among fossil mammals
XXVII. Adaptive radiation among the mammals
XXVIII. Adaptive radiation among birds
XXIX. The anatomy of the rat

## INVERTEBRATE ZOOLOGY — I

### Protozoa through Rotifera

A thoroughgoing study of the general biological principles and problems illustrated by the lower invertebrates, with laboratory exercises based primarily on morphology.

## OUTLINE OF COURSE CONTENT

I. Introduction

General problems
Methods of attack
Points of view
History

II. Protozoa

Protozoa—Cells or organisms?

Mastigophora—Conception of the primitive organism Phytomastigina, especially, Euglena and plant-animal separation, Dinoflagellata and cellulose, Volvocina and colony formation;

Zoomastigina, especially, Rhizomastigina and other connections with plant-like flagellates, Choanoflagellata and a forward look towards choanocytes of sponges, Giardia and bilateral symmetry, Trypanosoma—disease-producing protozoans, Polymastigina and association with termites, Trichonympha, etc.;

The rhizoplast system

The origin of transverse fission

Sarcodina—Conception of the primitive organism
Amoeba and the theories of amoeboid movement;
Arcella and evolution within clones;
Foraminifera and Radiolaria and relation to oceanography and geology;
Heliozoa;
Mycetozoa and the plant-animal problem

Sporozoa—Complicated life histories; protozoans and disease
Telesporida
Neosporida

Ciliophora—Trophochromatin and idiochromatin; mitosis in protozoa
Ciliates—sex types;
Holotricha—Allelocatalysis theories and the ideas concerning natural automatic cooperation;
Heterotricha, Hypotricha—neuro-motor system, Peritricha;
Suctoria
Evolution and behavior at the protozoan level

III. Mesozoa

IV. Parazoa

Porifera—The problem of individuality; reconstitution from cellular fragments; Pütter's Theory—the origin of muscles

V. Metazoa—Theories of gastrulation; gastrodermis and epidermis; general embryology and the diphyletic tree

Coelenterata—Tissues; individuals or organs; polymorphism; Hydrozoa—diploblastic; metagenesis—Calyptoblastes, Gymmoblastea, Hydrida, Graptolithnia and Paleontology; Scyphomedusa—synapse and the coelenterate nerve net; Actinozoa—Alcyonaria, marine zoogeography, Zoantharia, coral reefs, etc.

Ctenophora—What constitutes a phylum?

Platyhelminthes—Origin, coelenterate or ctenophore? Turbellaria—axial gradients—Polycladida, Müller's larva and the trochophore theories;

Trematoda and Gestoda—problems of parasitism

Acanthocephala—Phylogeny

Nematoda—Free-living or parasitic emphasis; taxonomy of phyla

Nematomorpha—Minor

Gastrotricha—Minor

Rotifera—Adaptive control of sexes

VI. Comparative physiology of these phyla

## LABORATORY EXERCISES

**The laboratory work is concerned with the microscopic and macroscopic study of the following living type specimens supplemented where possible by the dissection of preserved material.**

I. Protozoa
- Euglena
- Volvox and other free-living mastigophera
- Protozoans from termites
- Chaos chaos and Actinophrys (Arcella and Difflugia are sometimes studied)
- Foraminifera, Radiolaria, and Vorticella
- Paramecium
- Hypotricha
- Monocystis
- Stentor

II. Porifera
- Leucosolenia and Sycon
- Sycon and Ephydatia

III. Coelenterata
- Campanularia and Pennaria
- Tubularia
- Craspedacusta
- Aurelia
- Metridium
- Astrangia

IV. Ctenophora
- Pleurobrachia

V. Platyhelminthes
- Planarians
- Bdelloura
- Pneumnoeces
- Fasciola
- Moniezia

VI. Aschelminthes
- Rhabditis
- Ascaris
- Rotifera

Special exercises of one kind or another, mainly with restricted instructional aid, are given now and then with diagrammatic forms such as Astrangia. Practical examinations are set up to test retention and other teaching devices are used to keep the students alert. Trained laboratory instructors are almost a necessity. They should be young enough to be easy of approach by the students and mature enough to supply flexibility.

## INVERTEBRATE ZOOLOGY — II

This course is designed to give the student an integrated view of comparative animal biology by using examples from the coelomate invertebrates, Annelids through Echinoderms (exclusive of Arthropods), to illustrate fundamental principles of morphology, physiology, histology, biochemistry, embryology, evolution, and behavior. The lectures deal entirely with the general and comparative aspects, as indicated in the following outline.

### OUTLINE OF COURSE CONTENT

I. Basic common constituents of organisms

II. Embryology and phylogeny of coelomates—Constitution of egg; fertilization; cleavage; gastrulation

III. Differentiation, growth, regeneration, role of environment—Microscopic, ultramicroscopic, colloidal and molecular structure of cells and ground substances; tissue formation

IV. Assimilation, metabolism, enzyme action, respiration, cell movements, mitosis

V. Skin, coloration, color change, gland action, luminescence, ciliary activity

VI. Visual receptors, dioptrics, color vision, pattern vision—Chemoceptors; pain

VII. Nervous system—Structural and physiological properties of neurons, excitation, conduction, tone, periodicity, coordination, trophic effects—Cephalization; learning

VIII. Nutrition—Collection of food; mastication, digestion, resorption; specificity of nutrient factors

IX. Connective tissues, skeletons, coelom.—Muscles—biochemistry, contractility, functional adaptation, antagonism; animal locomotion

X. Blood—Oxygen requirements, ventilation, blood pigments, carbon dioxide elimination; clotting; immunological properties; vascular systems; propelling mechanisms; heart physiology

XI. Excretion—Filtering, excreta, water balance, detoxication; sexual function, gonads, sex determination, biology of sex; asexual reproduction

**Special Topics**

I. Morphology of Annelida; Polychaeta
II. Oligochaeta
III. Hirudinea, Gephyrea, Archiannelida
IV. Morphology of Mollusca
V. Amphineura, Gastropoda
VI. Scaphopoda, Lamellibranchiata
VII. Cephalopoda
VIII. Phoronidea, Bryozoa
IX. Brachiopoda; summary
X. Deuterostomia; Enteropneusta
XI. Morphology of Echinoderma
XII. Crinoidea, Asteroidea
XIII. Ophiuroidea, Echinoidea
XIV. Holothuria; summary

## LABORATORY EXPERIMENTS

The laboratory work is concerned with the dissection, macroscopic and microscopic study of type specimens as follows:

| | |
|---|---|
| Annelida: | |
| Chaetopoda: | |
| Polychaeta | —**Nereis** |
| Oligochaeta | —**Lumbricus** |
| Hirudinea | —**Hirudo** |
| Mollusca: | |
| Amphineura | —**Chiton** |
| Gastropoda | —**Busycon** |
| Scaphopoda | —**Dentalium** |
| Lamellibranchiata | —**Anodonta** |
| Cephalopoda | —**Loligo** |
| Bryozoa | —**Bugula** |
| Brachiopoda | —**Lingula** and **Terebratulina** |
| Echinodermata: | |
| Asteroidea | —**Asterias** |
| Ophiuroidea | —**Ophiurus** |
| Echinoidea | —**Strongylocentrotus** |
| Holothuroidea | —**Thyone** |
| Crinoidea | —**Antedon** |

## INVERTEBRATE ZOOLOGY — III

**(The Arthropoda)**

The purposes of this course are (1) to give the student a knowledge in some detail of the phylogeny of Arthropods, both their derivation from pre-Annelid stock and their breaking up into classes within the phylum, (2) to study in the laboratory representative Arthropods as follows: Peripatus, Trilobites, Eurypterids, Paleostrachans, Scorpions and Spiders, Crustacea, Myriapods, primitive, specialized and generalized insects.

The laboratory work is coordinated with the lectures, (3) to study the morphological diversity of insects, their physiological systems, their embryogeny and metamorphosis, and their ecology.

## OUTLINE OF COURSE CONTENT

I. Nature of phylogenetic evidence

II. Relations between Annelids, Onychophora, and Arthropods

III. The Onychophora

IV. The Trilobites (fossils and casts studied in addition to lectures)

V. The Chelicerata
- Class Paleostracha
- Class Eurypterida
- Class Arachnida
- Class Pycnogonida

VI. The Mandibulata
- Class Crustacea
- The Labiata—Class Diplopoda; Class Pauropoda; Class Symphyla; Class Insecta
- Class Chilopoda

VII. The Insecta
- References
- General features
- Zoogeography and habitat inches
- Organ-systems—Tracheal system; vascular system; malpighial system; alimentary system; integument and its modifications; reproductive system
- Embryogeny
- Metamorphosis
- Special problems

## LABORATORY EXERCISES

The laboratory work is concerned with dissection, macroscopic and microscopic study. The following representative Arthropods are studied:

Peripatus
Trilobites
Eurypterids
Paleostrachans
Scorpions and Spiders
Crustacea
Myriapods
Insects—primitive, specialized and generalized

# FIELD ZOOLOGY

I

The objectives are two: (1) To familiarize the student with the orderly classification of animals by means of taxonomic keys; and (2) to acquaint the student with the simple natural history of local animals, e.g. their habitat adjustments, simple behaviors, food and feeding mechanisms, and reproduction phenomena.

II

The Course is divided into three integrated sections: (1) lectures; (2) field work; and (3) laboratory exercises.

(1) **Lectures**

A. Organized around two habitat types (eight lectures each)

1. Terrestrial
   a. Forest
   b. Grassland
2. Fresh-water
   c. Pond
   d. Stream

B. The lectures take up each habitat in sequence, stressing:

1. Similarities and dissimilarities in the physico-chemical environment;
2. Convergent behavior of organisms to a given habitat type, e.g. fossorial and arboreal adjustment;
3. Foods and food-chains of the abundant or characteristic animals of a given habitat type;
4. Seasonal response, e.g. emigration, migration, hibernation, and estivation;
5. Daily response, e.g. diurnal and nocturnal activity.

(2) **Field Work**

A. About ten field trips are taken per quarter. These usually last from 7 A.M. to 6 P.M. The trips range from 20 to 200 miles round-trip.

B. Trips are taken in sequence to follow the lectures to forests, grasslands, fresh-water ponds, streams and marshes

C. Animals are collected in the field, and carried back alive to the laboratory.

D. An informal quiz period is held after lunch in which we attempt to integrate field observations with subjects discussed in preceding lectures.

(3) **Laboratory Work**

A. Animals collected on the previous Saturday are identified by standard keys. Accuracy is stressed rather than completeness, e.g. some organisms can be identified only to subspecies, while others can be identified only to order.

B. This taxonomic part of the work is complemented by simple experiments designed to give empirical data on food, shelter, and reproductive requirements.

C. The results of these experiments are discussed with respect to their bearing on the observed behavior, activities and distribution of animals in the field. Such discussion leads to the examination of general tendencies and principles, and demonstrates that field work and laboratory experimentation are not disparate but are mutually beneficial.

## III

## Selected Laboratory Exercises

(1) **General**

A. Construction of a taxonomic key by the student (using empty shells of about a dozen species of the small, **Polygyra**).

B. The experimental method (controlled experiment on the role of moisture in the life of pill-bugs—terrestrial oniscoid Crustacea); tolerances and aggregation phenomena.

(2) **Terrestrial Animals**

A. Ants, and the social medium. (Termites can be used)

B. Feeding and digging behavior of toads.

C. Behavior of box-turtles (**Terrapene**).

(3) **Fresh-water Animals**

A. Identification of Sporngillidae by microscope slides of gemmules and spicules.

B. Feeding, locomotion and reproduction in **Hydra**.

C. Feeding, locomotion and reproduction in **Planaria.**
D. Quantitative methods in the analysis of plankton samples.
E. Behavior of crayfishes (**Cambarus**).
F. Photoresponses of clam-mites (**Unionicola** and **Atax**) as a controlled experiment
G. Behavior of pond turtles (**Chrysemys**)

## COMPARATIVE VERTEBRATE ANATOMY

A course in the comparative anatomy, development, and phylogeny of vertebrates with emphasis on the comparative antomy and evolution of organs and organ systems. The course is required of all pre-medical students and all students majoring in zoology.

### OUTLINE OF COURSE CONTENT

I. Phylogeny
II. Embryology
III. Exoskeleton
IV. Endoskeleton
V. Muscular system
VI. Coelom and digestive system
VII. Respiratory system
VIII. Circulatory system
IX. Lymphatic system
X. Urogenital system
XI. Nervous system
XII. Phylogeny

### LABORATORY EXERCISES

The laboratory work involves dissection and comparison of various systems such as the skeletal, muscular, digestive, respiratory, circulatory, urogenital, and nervous systems. All vertebrates are studied but usually only the dogfish (Squalus), mud puppy (Necturus), turtle and cat are dissected by the student. A large variety of skeletons, some special dissections, and museum preparations are usually available for demonstration.

Phylogeny
Exoskeleton
Endoskeleton
Muscular system
Coelom, digestive system, and respiratory system
Circulatory system
Urogenital system
Nervous system

## VERTEBRATE EMBRYOLOGY

A course in the development of the vertebrate body with special emphasis on avian and mammalian ontogeny, including the study of early differentiation, organogenesis, and some aspects of the physiology of reproduction. This course is primarily designed for pre-medical students.

### OUTLINE OF COURSE CONTENT

I. Introduction—Scope; history
II. Formation of gametes
III. Maturation of gametes; parthenogenesis; sex determination
IV. Early cleavage; "laws" of cleavage
V. Gastrulation in Amphioxus and Amphibia
VI. Gastrulation and pr. stk. formation in the chick
VII. Ovulation and the reproductive cycle
VIII. Physiology of reproduction

IX. Embryo and membrane formation in the chick
X. Typical mammalian development
XI. Early development in primates
XII. Placentation in man; comparative anatomy of placentae; development of man
XIII. Problems of differentiation
XIV. Organizer phenomena
XV. Spinal cord and peripheral nerves
XVI. Experimental studies on development of nervous system
XVII. Brain and eye
XVIII. Cranial nerves and ear
XIX. Ectodermal derivatives
XX. Mesodermal derivatives
XXI. Entodermal derivatives
XXII. Urogenital system
XXIII. Experimental studies of development of urogenital system
XXIV. Heart and arteries
XXV. Fetal circulation
XXVII. Venous system
XXVIII. Growth and aging

## LABORATORY EXERCISES

The laboratory work includes the study of living chick embryos, the dissection of preserved pig embryos including extra-embryonic membranes, and the microscopic examination of whole mounts and serial cross sections of chick and pig embryos of various stages in development.

33 hour chick, living and whole mount
Sections of 33 hour chick
48 hour chick, living and whole mounts
72 hour living chick and whole mount
5 day living chick; 10 mm. pig
15 and 25 mm. pigs; 33 hour chick sections
Sections, 48 and 72 hour chicks
Coelom and mesenteries of pig
Pig placenta
Nervous system
Special sense organs
Digestive and respiratory systems
Urogenital system
Heart
Arteries of chicks
Arteries of pig
Venous system of chick
Venous system and somites

# HISTOLOGICAL TECHNIQUE

### Purpose

A course designed to introduce the student of Biology to the fundamental principles and methods requisite for microscopic studies, and to develop some skill in the use of these methods.

### Outline of Course Content

The microscope
Properties of living and fresh tissues
Methods of studying fresh tissues
Methods for preserving tissues
Preparation of preserved tissues for microscopic study
Principles of staining
Methods applicable to specific histological problems

### Student Laboratory Exercises

The use of the microscope
Study of fresh tissue
Study of vital and supravital stains
Reactions of fixatives
Knife sharpening
Frozen sections
Quick celloidin imbedding
Long celloidin inbedding
Paraffin imbedding
Double imbedding
Celloidin sections
Paraffin sections
Staining free sections
Staining celloidin sections on the slide
Staining paraffin sections
Specific stains

## ELEMENTARY GENETICS

The aim of the course is to acquaint general college students and students in training to become teachers with the basic principles of heredity in plants and animals and with the roles played by heredity and environment in the development of the individual. The historical approach is used, and special emphasis is placed upon the application of the principles to man.

## OUTLINE OF COURSE CONTENT

The following principles are considered in lectures, discussions, and reading assignments. Questions and problems requiring the application of the principles are assigned and students are expected to prepare reports.

1. Mendel's Laws of Segregation and Independent Assortment
2. The relation of chromosome behavior to the foregoing principles (Mitosis and Meiosis)
3. The action and interaction of Genes (Factor Principles); Multiple Alleles
4. Linkage and Crossing-over
5. Sex Determination and Sex Differentiation
6. Sex-linked Heredity
7. The Interaction of Heredity and Environment
8. Nature of the Gene; Mutation; Structure of Chromosomes
9. Inbreeding and Crossbreeding
10. Genetics and Evolution
11. Improvement of the Human Species (Eugenics)

## LABORATORY EXERCISES

The laboratory work consists of demonstrations, observations, and individual experiments. Following the order and numbers in the preceding section these are—

1. Observation of numerous varieties of peas in the seed stage, illustrating the seed characters studied by Mendel. Observation, including statistical studies, of ears of maize showing segregation and assortment of seed characters.
2. Microscopic studies of stained sections of the whitefish blastula showing various stages of mitosis. The same with section of testis of **Anasa tristis** showing meiosis.
3. A study of ears of maize showing various multiple factor ratios involving color and form of the seed. Demonstration of living guinea pigs illustrating the operation of multiple factors and multiple alleles affecting coat color, hair direction, and extra toes, with demonstration matings of some of these. Student experiments with Drosophila involving two independently assorting, physiologically interacting genes affecting eye-color. Individual testing of students for their blood group (O, A, B, AB).
4. Student experiments with Drosophila involving linkage in the X-Chromosome (eosin-miniature X Bar).

5. Individual study of microscope slides of **Anasa tristis** illustrating the XO type of sex-determination.
6. Drosophila experiment (eosin-miniature X Bar). Individual testing of students for red-green blindness by means of Ishihara plates.
7. Demonstration experiment with growing maize seedlings segregating for albinism in the ratio of 3 : 1. One-half of the growing-box is covered to exclude light and a comparison is made between the effects of the albino gene and the lack of light on the growing plants. The effect of cold on the development of pigment in the extremities of an albino guinea pig is observed.

Note: Students who do not intend to specialize in the biological sciences are given the option of writing a term paper in place of the Drosophila experiments.

## PARASITOLOGY

The course in parasitology is intended to teach the principles of parasitism as illustrated through knowledge of the animal parasites. The first third of the course is devoted to the parasitic worms, the second third to the parasitic protozoa and the final third to the parasitic arthropods. Malaria is given especial emphasis since through a study of it many of the principles of parasitism can be illustrated. The parasites of man and of domestic animals receive greatest attention primarily because more is known about these parasites. No attempt is made to train the students to be expert in laboratory diagnosis of parasitic infections.

### Outline of Course Content

I. Helminthology

A. Trematodes

| | | |
|---|---|---|
| 1. | **Clonorchis sinensis** | S, P |
| 2. | **Heterophyes heterophyes** | D |
| 3. | **Paragonimus westermani** | S |
| 4. | **Schistosoma mansoni** | S |
| 5. | **Schistosoma haemotobium** | S |
| 6. | **Schistosoma japonicum** | S |
| 7. | **Fasciolopsis buski** | S, P |
| 8. | **Fasciola hepatica** | S, P |

B. Costodes

| | | |
|---|---|---|
| 1. | **Taenia saginata** | S, P |
| 2. | **Taenia solium** | D |
| 3. | **Taenia taeniaeformis** | S, P |
| 4. | **Echinococcus granulosus** | S, P |
| 5. | **Multiceps multiceps** | D |
| 6. | **Diphyllobothrium latum** | S, P |
| 7. | Hymenolopis nana | S |

C. Nematodes

| | | |
|---|---|---|
| 1. | Oxyurids from cockroach | L |
| 2. | **Euterobius vermicularis** | S, P |
| 3. | **Trichuris trichiura** | S, P |
| 4. | **Ascaris lumbricoides** | L, S, P |
| 5. | **Macracanthorhynchus hirudinaceous** | L, P |
| 6. | **Trichinella spiralis** | L, S |
| 7. | **Wuchereria bancrofti** | S, P |
| 8. | **Onchocerca volvulus** | S |
| 9. | **Strongyloides stercoralis** | L, S |
| 10. | **Necator americanus** | S, P |
| 11. | **Ancylostoma duodenale** | S, P |
| 12. | **Dracunculus medinensis** | D |

D = By demonstration
L = Living material studied by class
P = Preserved material studied by class
S = Prepared slides used by class

II. Protozoology

A. Ciliates

| | | |
|---|---|---|
| 1. | **Balantidium coli** | L, S |
| 2. | Opalinid ciliates | D |

B. Amoebae

| | | |
|---|---|---|
| 1. | **Endamoeba histolytica** | L, S, P |
| 2. | **Endamoeba coli** | L, S, P |
| 3. | **Endolimax nana** | S |
| 4. | **Iodamoeba williamsi** | S |

C. Flagellates

| | | |
|---|---|---|
| 1. | **Trypanosoma lewisi** | L, S |
| 2. | **Trypanosoma cruzi** | S |
| 3. | **Trypanosoma rhodesiense** | D |
| 4. | **Trypanosoma melophagium** | L, S |
| 5. | **Leishmania donovani** | S |
| 6. | **Leishmania americana** | D |
| 7. | **Giardia lamblia** | L, S |
| 8. | **Chilomastix mesnili** | S |
| 9. | Symbiotic flagellates from termites | L, S |

D. Sporozoa

| | | |
|---|---|---|
| 1. | **Plasmodium vivax** | S |
| 2. | **P. falciparum** | S |
| 3. | **P. malariae** | S |
| 4. | **P. cathemerium** | L, S |
| 5. | **P. elongatum** | S |
| 6. | **Haemoproteus columbae** | S |
| 7. | **Leucocytozoon simondi** | S |
| 8. | **Babesia canis** | D |
| 9. | **Eimeria dispersa** | S |
| 10. | **Eimeria stiedae** | S |
| 11. | Myxosporida | S |
| 12. | **Sarcocystis** | S |
| 13. | **Lankasteria culicis** | S |
| 14. | **Adelina sp.** | S |
| 15. | **Anaplasma marginale** | D |
| 16. | **Bartonella muris** | D |
| 17. | **Aegyptianella pullorum** | D |
| 18. | **Toxoplasma** | D |

III. Medical Entomology

A. Diptera

| | | |
|---|---|---|
| 1. | **Anopheles** sp. | L, S, P |
| 2. | **Culex** sp. | L, S, P |
| 3. | **Aedes aegypti** | L, S, P |
| 4. | **Tabanus** | S, P |
| 5. | **Culicoides** | S, P |
| 6. | **Phlebotomus** | S |
| 7. | **Simulium** | S, P |
| 8. | **Musca domestica** | S, P |
| 9. | **Auchmeromyia luteola** | D |
| 10. | **Cordylobia anthropophaga** | D |
| 11. | **Melophagus ovinus** | L, S, P |
| 12. | **Hippelates** | D |
| 13. | **Glossina** | D |

B. Siphonaptera

| | | |
|---|---|---|
| 1. | **Ctenocephalides felis** | S |
| 2. | **Xenopsylla cheopis** | S |

D = By demonstration
L = Living material studied by class
P = Preserved material studied by class
S = Prepared slides used by class

3. **Tunga** ..... S
4. Various rodent fleas ..... S
5. **Cimex lectularius** ..... L, S
6. **Triatoma megista** ..... P

C. Anoplura

1. **Pediculus humanus** ..... S
2. **Phthirius pubis** ..... S
3. **Heterodoxus longitarsus** ..... S
4. **Columbicola columbae** ..... S

D. Ixodoidea

1. **Argas** ..... S, P
2. **Ornithodores** ..... S, P
3. **Haemaphysalis** ..... S, P
4. **Dermacentor andersoni** ..... S, P
5. **Ixodes holocyclus** ..... S
6. **Rhipicephalus sanguineus** ..... S

E. Parasitic Mites

1. **Dermanyssus** ..... S
2. **Sarcoptes** ..... S
3. **Psoroptis** ..... S
4. **Demodex canis** ..... S
5. **Trombicula** ..... S

F. Miscellaneous noxious arthropods

1. **Armillifer** ..... P
2. **Latrodectus mactans** ..... D
3. Scorpions ..... P
4. Urticarious caterpillars ..... D

D = By demonstration
L = Living material studied by class
P = Preserved material studied by class
S = Prepared slides used by class

## Student Laboratory

| Experiment No. | Title |
|---|---|
| 1 | Calibration of Microscope |
| 2 | Trematodes |
| 3 | Trematodes |
| 4 | Cestodes |
| 5 | Cestodes |
| 6 | Cestodes |
| 7 | Nematodes |
| 8 | Nematodes |
| 9 | Nematodes |
| 10 | Fecal Diagnosis |
| 11 | Parasitic Ciliates |
| 12 | Endamoeba histolytica |
| 13 | Endamoeba coli |
| 14 | Trypanosomes |
| 15 | Trypanosomes and Leischmania |
| 16 | Intestinal Flagellates |
| 17 | Malarial Parasites |
| 18 | Malarial Parasites |
| 19 | Other Haemosporidea |
| 20 | Coccidia and Cndosporidia, etc. |
| 21 | Mosquitoes |
| 22 | Anopheline Larvae |
| 23 | Culicine Mosquitoes and Other Nematocera |
| 24 | Flies |
| 25 | Siphonaptera |
| 26 | Anoplura |
| 27 | Ixodoidea |
| 28 | Parasitic Mites |

# ANIMAL ECOLOGY

The objective of this course is to bring the student through lecture, laboratory, reading, and field experience into contact with the problems of animal ecology. The student studies both the ecology of the individual organism in relation to its natural environment and the ecology of populations and communities.

## OUTLINE OF COURSE CONTENT

The lecture material, following a brief historical orientation, is divided into two roughly equivalent parts. The first part examines the physical-chemical environment of terrestrial and aquatic organisms by a consideration of important environment factors (e.g., water, temperature, light, nutrition, chemical factors, substratum, etc.); the second part of the lectures deals with the organization of biotic groups into communities and an examination of these communities from a functional point of view. It is pointed out in the course that the ecologist works with three levels of organization in relation to the natural environment, the individual organism, the population, and the community. In this course the stress is upon the individual and the community because a more advanced seminar course is devoted entirely to the population.

1. Lectures
   - A. Definitions and orientation
   - B. History of ecology
   - C. The organism—environment nexus
   - D. Factors of the environment considered from an ecological point of view ("conditions of existence"):
     1. Water 2. Temperature 3. Light
     4. Humidity 5. Substratum 6. Chemical factors (e.g., oxygen, carbon dioxide, pH, contaminating and polluting substances, etc.) 7. Food
   - E. The biotic environment
     1. The single-species population
     2. The mixed-species population
        (1 and 2 considered in a separate course on "population ecology")
     3. The animal community
        a. Definitions
        b. Structure and function in space
        c. Structure and function in time
        d. Food-chains and energy relationships
   - F. Summary

The field work is organized into two major problems: The first concerned with aquatic environments; the second with terrestrial environments. Problem One is entitled "An Ecological Analysis of Flowing versus Standing Water." Problem Two is entitled "The Successional Development of Forest Communities." The students usually take about four trips for each problem and analyze in detail the physical and biotic environments of each field location and then, on the basis of discussions, reports, reading, plus their own observations, prepare two extensive reports; the first covering Problem One; the second, Problem Two.

II. Field trips
   - A. **Study I.** "An ecological analysis of flowing compared with standing water."
     1. Trips to vernal (temporary) ponds
     2. Trips to swift-flowing streams
     3. Trips to slow-flowing streams
     4. Toleration experiments
     5. Literature reports by students on pertinent topics and determination of specimens
     6. Preparation of student report on Study I.

B. **Study II.** "The successional development of forest communities."

1. Trips to sand dunes where beach, fore-dune, cottonwood, pine, and oak seres are studied.
2. Trips to a climax beech-maple forest
3. A trip to the same forest at night to study the nocturnal communities
4. Literature reports by students on pertinent topics and determination of specimens
5. Preparation of student report on Study II.

The laboratory work is entirely supplementary to the lectures and taxonomic determinations are made there on forms collected in the field. Students are assigned certain groups of animals for taxonomic identification and these are then made available to the class as a whole. No student is admitted to the course unless he has had a course in animal taxonomy. A novel laboratory feature of the course is called "Toleration Physiology." The student tests for himself the differential survival values exhibited by certain animals coming from certain habitats and relates the laboratory experience of himself and his classmates to the general field problems under study.

## GENERAL ZOOLOGY

### STUDENT APPARATUS

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 8251 | 65830B | 20 | Dissecting Pans wax lined, size 7¼ x 11¼ x 1½" | $ 29.00 |
| 8279 | 65810 | 20 | Dissecting Probes, blunt point | 12.00 |
| 8278 | 65815 | 20 | Dissecting Probes, sharp point | 15.00 |
| 8290B | | 20 | Dissecting sets Leatherette two-fold case, containing two scalpels, fine and coarse scissors, cartilage knife, hook and chain, tenaculum, needle holders with needles, blowpipe and metric ruler | 120.00 |
| 8332 | 65660 | 20 pkgs. | Insect pins No. 1, 100 to package | 15.00 |
| 4503A | 36385 | 20 | Laboratory coats, white drill | 95.00 |
| 8351 | 76865 | 20 books | Lens paper, size 4 x 6 inches, 50 sheets to book | 3.00 |
| 8052 | 76200 | 20 | Magnifiers tripod | 20.00 |
| 7970B | 76262 | 20 | Microscope compound, Model A, 16 x 4 MM objectives, 5 and 10 x eye pieces, with condenser, in case | 3080.00 |
| 8124 | 76830E | 4 oz. | Microscopic cover glasses No. 1, 18 MM square | 14.00 |
| 8118A | 76805 | 288 | Microscopic slides, 3 x 1 inches | 4.00 |
| 8122 | 76825A | 24 | Microscope slides, concave center, 75 x 25 MM | 2.30 |
| 5431 | 78080 | 48 | Pipettes | 1.60 |
| 5809E | 24650 | 20 yds. | Towelling | 7.00 |
| | | | Total | $3417.90 |

### GENERAL APPARATUS

| | | | | |
|---|---|---|---|---|
| 8326 | 94858 | 1 | Animal cage, 12 x 12 x 16 inches | $ 11.00 |
| 4030 | 40450 | 1 | Balance triple beam, weights to 111 grams | 21.50 |
| 4050 | 1872 | 1 | Balance triple beam trip, weights to 1610 grams without additional weights | 15.00 |
| 3962 | 78270A | 1 | Balopticon, B & L model L R M for Lantern slides and opaque objects | 159.60 |
| 4516P | 44300 | 6 | Beakers pyrex glass 250 ML | 1.02 |
| 4516P | 44300 | 2 | Beakers pyrex glass 1000 ML | 1.12 |
| 4612B | 75744 | 24 | Bottles, screw cap, 8 oz. | 3.20 |
| 4752A | | 6 | Bunsen Burners | 4.50 |
| 6951-4 | | 1 set | Charts, bird set of four | 10.00 |
| 6940 | | 1 set | Charts smallwood zoology, set of 30 charts on a tripod | 27.50 |
| 4948 | 63805A | 1 pkg. | Corks, 144 sizes 0 to 11 assorted | .95 |
| 5106P | 70750 | 6 | Flasks, pyrex 250 ML | 1.38 |
| 5143P | 71220 | 2 | Funnels, glass 3" diameter | .76 |
| 1166A | 75600A | 6 | Jars, glass clear glass 6 x 8" | 6.90 |
| 5218 | 73740 | 12 | Glass plates 4 x 4" | .84 |
| 5235 | 73765 | 5 lbs. | Glass tubing assorted | 2.50 |
| 5259 | 64840B | 2 | Graduate cylindrical 250 ML | 2.00 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 8352A | | 1 | Incubator, electric 9½ x 8¾ x 7½ | $ 35.00 |
| 226 | | 1 set | Lantern slides, set of 155 on Zoology | 87.50 |
| 8010G | 76420B | 1 | Microscope, binocular, stereoscopic | 310.00 |
| 7976 | B | 1 | Microscope, compound, B & L Model B8, 16 x 4 MM dry objectives, 1.8 MM oil Immersion objectives, 5 and 10 x eyepieces | 212.00 |
| 8006 | 76720 | 1 | Microscope Lamp | 5.00 |
| 8123 | 76820 | 36 | Microscopic slides, hanging drop | 27.00 |
| 8023D | 76470A | 1 | Micro-projector, Model B | 187.00 |
| 76-03 | | 1 | Microtome improved with freezing attachment and knife | 223.50 |
| 9491 | 91506 | 1 | Model Clam | 15.00 |
| 9490 | 91508 | 1 | Model Crayfish | 17.00 |
| 9489 | 91502 | 1 | Model Earthworm | 22.50 |
| 9492 | 91526 | 1 | Model Perch | 18.50 |
| 8338 | | 1 | Net, insect | 5.00 |
| 8386P | 65270A | 24 | Petri Dishes, pyrex, 100 x 15 MM | 9.12 |
| 5227 | 79625 | 12 | Rods, stirring 8 x 5/16" | .50 |
| 5505 | 78780 | 5 lbs. | Rubber stoppers, assorted | 6.00 |
| 3930A | 78345A | 1 | Screen Aluminum 6 x 6 foot | 17.50 |
| 8492 | | 1 | Skeleton, bullfrog in glass case | 15.00 |
| 8492 | | 1 | Skeleton cat on wood base | 14.00 |
| 8492 | | 1 | Skeleton Perch in glass case | 17.00 |
| 8492 | | 1 | Skeleton Pigeon on a wood base | 15.00 |
| 8492 | | 1 | Skeleton Snake on a wood base | 14.00 |
| 8492 | | 1 | Skeleton Squalus in museum jar | 35.00 |
| 9356 | 65860 | 3 | Spreading boards | 8.55 |
| 5572 | 79905A | 3 | Supports ring stand 3 rings | 4.05 |
| 8281 | | 1 | Syringe, injecting | 5.00 |
| 5629 | 80610C | 72 | Test tubes 6 x ¾" | 2.70 |
| 5516 | 78840A | 24 ft. | Tubing rubber 5/16" diameter | 2.88 |
| 5517 | 78845B | 12 ft. | Tubing rubber ¼" diameter | 2.40 |
| 5750 | 80890A | 36 | Watch glasses 3" plain | 2.16 |
| 5752 | 80895A | 24 | Watch glasses Syracuse | 3.00 |
| | | | Total | $1608.63 |

## CHEMICALS

| | | |
|---|---|---|
| 1x1 lb. | Acid Acetic CP glacial | $ .65 |
| 1x1 lb. | Acid Boric, pure crystal | .30 |
| 1x1 lb. | Acid Carbolic USP | .60 |
| 1x1 lb. | Acid Hydrochloric CP concentrated | .75 |
| 1x1 lb. | Acid Nitric CP concentrated | .90 |
| 1x4 oz. | Acid Picric CP | .85 |
| 1x1 lb. | Acid Sulphuric CP concentrated | .80 |
| 1x4 oz. | Agar Agar shreds | 2.00 |
| 1x1 qt. | Alcohol Ethyl denatured | .65 |
| 1x1 lb. | Ammonium hydroxide CP concentrated | .70 |
| 1x4 oz. | Ammonium nitrate pure | .25 |
| 1x2 oz. | Beef extract | .60 |
| 1x1 lb. | Calcium oxide pure lump | .35 |
| 1x4 oz. | Canada Balsam clear | 1.00 |
| 1x1 lb. | Carbon tetrachloride pure | .45 |
| 1x1 oz. | Carmine | .70 |
| 1x1 lb. | Chloroform CP | .80 |
| 1x1 lb. | Dextrose pure | .30 |
| 1x10 G. | Eosin yellow | .75 |
| 1x1 lb. | Ether ethyl CP | .65 |
| 1x4 oz. | Fehling solution A | .25 |
| 1x4 oz. | Fehling solution B | .30 |
| 1x5 lb. | Formaldehyde pure | 2.25 |
| 1x1 lb. | Gelatine granular | .95 |
| 1x4 oz. | Glycerine CP | .48 |
| 1x1 lb. | Lead Acetate CP | $ .65 |
| 1x1 lb. | Lime water | .30 |
| 1x1 lb. | Manganese dioxide PWD. technical | .30 |
| 1x4 oz. | Mercuric oxide red CP | 1.90 |
| 1x10 G. | Methyl blue stain | .75 |
| 1x10 G. | Methyl green stain | .75 |
| 1x1 oz. | Pancreatin USP | .45 |
| 1x1 oz. | Pepsin USP powder | .50 |
| 1x1 oz. | Peptone dry from meat | .40 |
| 1x1 oz. | Phenolphthale in CP | .50 |
| 1x4 oz. | Phosphorus red amorphous | .50 |
| 1x4 oz. | Potassium Bichromate CP | .55 |
| 1x1 lb. | Potassium chlorate CP | 1.00 |
| 1x4 oz. | Potassium cyanide pure | .70 |
| 1x1 oz. | Potassium iodide CP | .55 |
| 1x1 lb. | Sodium bicarbonate pure | .25 |
| 1x5 lb. | Sodium chloride pure | .60 |
| 1x1 lb. | Sodium hydroxide pellets CP | .75 |
| 1x1 lb. | Sodium hypochlorite | .60 |
| 1x1 lb. | Corn starch | .25 |
| 1x1 lb. | Sulphur roll | .25 |
| 12 vials | Test paper litmus blue | .80 |
| 12 vials | Test paper litmus red | .80 |
| 1x1 pt. | Turpentine | .50 |
| 1x5 lb. | Xylol CP | 2.55 |
| 1x1 lb. | Zinc metal mossy technical | .45 |
| | Total | $35.88 |

## PRESERVED MATERIAL

| | | |
|---|---|---|
| 20 | Astrangia | $ 5.00 |
| 20 | Butterflies, monarch | 1.15 |
| 3 | Crayfish, large 4 inches and over | 5.00 |
| 20 | Crabs | 6.00 |
| 20 | Cow eyes | 8.00 |
| 1 | Chiton 2 to 3 inches | .50 |
| 20 | Earthworms | 2.00 |
| 20 | Frogs, medium | 3.00 |
| 20 | Fasciola | 6.00 |
| 20 | Grantia | 1.00 |
| 20 | Grasshopper, Romalea | 2.00 |
| 20 | Gonionemus, large hydroid medusa | 4.00 |
| 20 | Garden spiders, argiope | 2.00 |
| 20 | House fly | 1.00 |
| 20 | Hydra | 1.00 |
| 20 | Helix, edible land snail | 4.00 |
| 20 | June beetles | 1.00 |
| 20 | Leucoselenia, Ascon type sponge | 1.00 |
| 20 | Locusts, Cicada | 1.25 |
| 1 | Leech, Hirudo SP | .50 |
| 1 | Limulus, King Crab, 3 to 4" | .75 |
| 20 | Mussel, freshwater, medium size, pegged open | $ 3.00 |
| 20 | Mosquito, adults | .80 |
| 1 | Moniezia, sheep tapeworm | .50 |
| 20 | Nereis, sandworms 5 to 8" | 4.00 |
| 20 | Obelia, Hydroid colony | 1.00 |
| 20 | Paramoecium | 1.25 |
| 20 | Perch 6" to 7" | 2.50 |
| 20 | Planaria | 1.25 |
| 1 | Pig embryo 7 to 10 inches, arteries and veins injected with color | 2.25 |
| 1 | Rat, white | 2.00 |
| 20 | Starfish, medium 5 to 6 inches | 4.00 |
| 20 | Squid, medium, 8 inches long | 4.50 |
| 20 | Sea Cucumbers | 5.00 |
| 1 | Sheep brain | 2.00 |
| 1 | Sheep Kidney | .75 |
| 20 | Tobacco worm | 8.00 |
| 20 | Tomato worm moth | 4.00 |
| 20 | Volvox | 1.00 |
| 20 | Vorticella | 1.50 |
| | Total | $105.45 |

Microscopic slides:

| | | |
|---|---|---|
| 20 | Starfish egg | $10.00 |
| 20 | Paramoecium | 10.00 |
| 20 | Paramoecium, fission | 25.00 |
| 20 | Paramoecium, conjugation | 20.00 |
| 20 | Amoeba proteus | 15.00 |
| 20 | Mixed protozoa | 20.00 |
| 20 | Grantia, C. S. | 10.00 |
| 20 | Grantia, L. S. | 10.00 |
| 20 | Hydra, W. M. | 10.00 |
| 20 | Hydra, C. S. | 10.00 |
| 20 | Obelia colony | 12.00 |
| 20 | Parypha | 12.00 |
| 20 | Trichina | 10.00 |
| 20 | Earthworm L. S. | 12.00 |
| 20 | Earthworm C. S. | 10.00 |
| 20 | Daphnia | 10.00 |
| 20 | Culex, Mosquito head (female) | 10.00 |
| 20 | Mosquito, leg and leg | $10.00 |
| 20 | Mosquito larvae | 10.00 |
| 20 | Fly wing and leg | 10.00 |
| 20 | Fly proboscis | 10.00 |
| 20 | Antennae | 15.00 |
| 20 | Trachea | 10.00 |
| 20 | Wing feather | 10.00 |
| 20 | Grantia, spicules | 10.00 |
| | Total | $301.00 |
| | Student apparatus | $3417.90 |
| | General apparatus | 1608.63 |
| | Chemicals | 35.88 |
| | Preserved materials | 105.45 |
| | Microscope slides | 301.00 |
| | GRAND TOTAL | $5468.86 |

## ADDITIONAL MATERIAL FOR INVERTEBRATE ZOOLOGY I

Microscopic slides:

| | | |
|---|---|---|
| 20 | Foraminifera, fossil | $195.00 |
| 20 | Radiolaria, mixed species | 150.00 |
| 20 | Monociptis, earthworm parasites | 45.00 |
| 20 | Hydra, adult with bud, W. M. | 17.00 |
| 20 | Hydra, showing ectoderm and endoderm, C. S. | 10.00 |
| 20 | Hydra, female, showing ovaries, W. M. | 20.00 |
| 20 | Hydra, male, showing spermaries, W. M. | 30.00 |
| 20 | Pneumonoeces, frog lung fluke, W. M. | 20.00 |
| 20 | Starfish egg, for typical cell parts, W. M. | 10.00 |
| 20 | Amoeba proteus, W. M. | 15.00 |
| 20 | Paramoecium, fission, W. M. | 25.00 |
| 20 | Paramoecium, conjugation, W. M. | 20.00 |
| 20 | Volvox, daughter cells and zygotes, W. M. | $ 10.00 |
| 20 | Mixed Protozoa, W. M. | 20.00 |
| 20 | Jelly fish, Gonionemas, W. M. | 20.00 |
| 20 | Obelia, colony, W. M. | 14.00 |
| 20 | Obelia, medusa, W. M. | 18.00 |
| 20 | Tubularia, hydroid, W. M. | 14.00 |
| 20 | Metridium, Sea Anemone, C. S. | 14.00 |
| 20 | Planaria, W. M. | 10.00 |
| 20 | Stentor, Cilia and Peristome, W. M. | 15.00 |
| 20 | Fasciola hepatica, W. M. | 15.00 |
| 20 | Tapeworm, scolex, W. M. | 20.00 |
| 20 | Monieza, mature and immature progottids, W. M. | 25.00 |
| 20 | Facenia serrata, proglottids, and scolex, W. M. | 25.00 |
| | Total | $777.00 |

Living material:

| | | |
|---|---|---|
| 20 | Euglena | $ 1.75 |
| 20 | Chaos, chaos, giant ameba | 5.00 |
| 20 | Paramoecium | 1.75 |
| 20 | Hydra | 2.25 |
| 20 | Planaria | 2.50 |
| 20 | Rotifers | $ 2.25 |
| 20 | Volvox (available early spring and September) | 3.00 |
| | Total | $18.50 |

Preserved material:

| | | |
|---|---|---|
| 20 | Lencoselenia, branching ascon | $ 1.75 |
| 20 | Grantia, sycon sponge 1" or more | 1.75 |
| 20 | Spongilla—fresh water sponge | 1.50 |
| 20 | Hydra, large, extended | 1.40 |
| 20 | Campanularia, colonies | 1.50 |
| 20 | Tubularia, colonies | 1.50 |
| 20 | Gonionemus, with medusae | 5.00 |
| 20 | Craspedacusta, large | 4.00 |
| 20 | Aurelia, 2" diameter | 5.20 |
| 20 | Metridium, sea anemone, 2" or more | 11.00 |
| 20 | Astrangia | $ 6.00 |
| 20 | Pleurobrachia | 5.00 |
| 20 | Fasciola, sheep liver fluke | 8.00 |
| 20 | Monieza, large, with scolex | 7.00 |
| 20 | Planaria, large | 2.00 |
| 20 | Bdellura | 4.00 |
| 20 | Ascaris, large | 2.75 |
| 20 | Rotifers | 1.85 |
| 20 | Pennaria, colonies | 1.50 |
| | Total | $72.70 |

| | |
|---|---|
| Microscopic Slides | $777.00 |
| Living Material | 18.50 |
| Preserved Material | 72.70 |
| GRAND TOTAL | $868.20 |

## ADDITIONAL MATERIAL FOR INVERTEBRATE ZOOLOGY II

Preserved material:

| | | |
|---|---|---|
| 20 | Nereis, large sandworm, 8" | $ 5.50 |
| 20 | Lumbricus, giants | 5.00 |
| 20 | Hirudo, leech | 6.00 |
| 20 | Chiton, medium | 3.00 |
| 20 | Busycon, the Conch | 6.00 |
| 20 | Dentalium | 11.50 |
| 20 | Loligo, squid, medium, 8" long | 6.50 |
| 20 | Bugula | 2.60 |
| 20 | Lingula | 3.50 |
| 20 | Terebratulina, small | $ 2.50 |
| 20 | Asterias, starfish, 5" - 6" | 5.00 |
| 20 | Ophiura, brittle starfish | 3.50 |
| 20 | Strongylocentrotus, spiny Sea Urchin | 5.00 |
| 20 | Thyone, sea cucumber | 5.00 |
| 20 | Antedon, crinoid | 2.50 |
| | Total | $73.10 |

## ADDITIONAL INVERTEBRATES III—ARTHROPODA

Preserved material:

| | | |
|---|---|---|
| 20 | Lumbricus 7" - 9" | $ 2.40 |
| 10 | Peripatus, 1¼" - 1½" | 15.00 |
| 20 sets | Arachnid types | 15.00 |
| 20 | Dermacentor andersoni (Rocky Mt. fever tick) | 2.90 |
| 10 | Trapdoor spider nest | 25.00 |
| 20 | Argiope, northern garden spider | 1.80 |
| 20 | Crayfish, cambarus, large, 4" | 2.50 |
| 20 | Romalea, life history | 14.00 |
| 20 | Springtail | 1.50 |
| 20 | Romalea, large lubber grasshopper | 2.70 |
| 20 | Dragon fly, large | 3.80 |
| 20 | Termite, life history set | $ 8.00 |
| 20 | Pediculus humanis corporis (human body louse) | 2.50 |
| 20 | Leptinotarsa, potato beetle, life history set | 16.00 |
| 20 | Monarch butterfly | 2.00 |
| 20 | Samia, cecropia moth | 2.25 |
| 20 | Apis mellifera, workers | .90 |
| 20 | Musca domestica, adults | .90 |
| 20 | Culex, adults | .75 |
| | Total | $119.90 |

## ADDITIONAL FOR FIELD ZOOLOGY

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 8493 | | 1 | Live Box Turtle | $ 1.50 |
| 8493 | | 1 | Live Pond Turtle | 1.50 |
| 8493 | | 20 | Toads | 15.00 |
| 8488 | | 20 | Slides Grantia Spicules, W. M. | 10.00 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 8493 | | 1 | Culture of Hydra for 25 Students | 1.75 |
| 8493 | | 1 | Culture of Planaria for 25 students | 1.75 |
| 8493 | | 20 | Crayfish (Live) | 3.00 |
| 823A | | 2 | Stop Watches open face, chromium case, one-fifth second divisions | 30.00 |
| 8325A | 36415 | 3 | Aquariums, welded steel frame, 6 gallon capacity, 18" long, 10" wide, 9½" deep | 27.00 |
| 8386P | 65270A | 20 | Petri Dishes, 4 inches | 7.60 |
| 8393 | | 20 | Finger Bowls, nesting glass, diam. 4" | 9.00 |
| 8393 | | 20 | Finger Bowls, diameter 7" | 32.00 |
| 5750 | 80890A | 36 | Watch Glasses, diameter 4" | 3.60 |
| 8118A | 76800 | 720 | Microscope Slides, 72 x 25 mm | 10.00 |
| 8132 | 76835A | 3 oz. | Cover Glasses, diameter 18 mm | 12.00 |
| 5671 | 80062A | 20 | Thermometers, chemical, Centigrade to 110° | 26.00 |
| 5050 | 69700 | 20 pkgs. | Filter Paper, diameter 15 cm. | 7.00 |
| | | | Total | $198.70 |

## FIRST AID SUPPLIES

| | | | |
|---|---|---|---|
| | 12 pkgs. | Adhesive Compress, pkg. of 12 | $ 1.80 |
| | 12 | Adhesive Plaster ½" x 2½ yd. | 1.20 |
| | 12 botls. | Antiseptic Solution | 2.10 |
| | 12 pkgs. | Aromatic Ammonia Capsules, pkg. of 3 | 2.50 |
| | 12 pkgs. | Burn Dressing Packet | 7.20 |
| | 12 pkgs. | Cotton, Absorbent, 4 oz. | 1.20 |
| | 12 | First Aid For Burns | 1.80 |
| | 12 | First Aid Instruction Book | 2.50 |
| | 12 | Gauze Bandage, 1" x 10 yd. | .60 |
| | 12 | Bottles, iodine tincture, U.S.P. (1 oz. bottles) | 2.50 |
| | 12 | Bottles, mercurochrome solution H.W.D. (1 oz. bottles) | 2.40 |
| | 12 | Cards, Safety Pins, (Card of 12) | 1.00 |
| | | Total | $26.80 |

## COMPARATIVE VERTEBRATE ANATOMY

| | | | |
|---|---|---|---|
| | | Selected materials: | |
| 9499 | 1 | Human Skeleton | $150.00 |
| 8492 | 2 | Cat Skeleton, large | 40.00 |
| 8492 | 2 | Squalus skeletons | 60.00 |
| 8492 | 2 | Bullfrog skeleton | 28.00 |
| 8492 | 2 | Perch skeleton | 22.00 |
| 8492 | 2 | Snake skeleton 18" - 24" | 24.00 |
| | | Total | $324.00 |

## APPARATUS

| | | | | |
|---|---|---|---|---|
| 8256 | 65470 | 1 | Bone saw | $ 10.00 |
| 8253 | | 10 | Dissecting Pans, 16" x 24" x 1" | 40.00 |
| 5310 | 75780A | 5 | Stone Crock, 5 gal. | 12.50 |
| 9654 | | 1 | Waste bin, galvanized, with lid, 6½ gal. | 3.50 |
| 8220 | 65480 | 10 | Bone forceps, 200 MM | 95.00 |
| | | | Total | $161.00 |
| | | | Injecting, preserving, and embalming: | |
| | 5 lb. | | Glycerine, pure | $ 2.50 |
| | 1 gal. | | Formaldehyde, pure | 2.00 |
| | 1 lb. | | Acid, carbolic, liquid CP | 1.75 |
| | 1 lb. | | Acid, Glacial Acetic, CP, 36% | 2.25 |
| | 1 lb. | | Lead Chromate, CP | 2.00 |
| | 1 lb. | | Iron Ferrocyanide, soluble | 1.40 |
| | 1 pt. | | Latex, liquid | 2.00 |
| | | | Total | $13.90 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| | | | Preserved specimens: | |
| 8492 | | 10 | Cat, arteries and veins injected | $85.00 |
| 8492 | | 10 | Dogfish, arteries and veins injected | 22.50 |
| 8492 | | 10 | Mudpuppy, arteries and veins injected | 20.00 |
| 8492 | | 10 | Pigeon | 20.00 |
| 8492 | | 10 | Snake, garter | 35.00 |
| 8492 | | 10 | Turtle, arteries and veins injected | 22.50 |
| | | | Total | $205.00 |
| 4503 | 36390 | 1 | Laboratory Coat and apron | Total 5.00 |

## ADDITIONAL MATERIAL FOR VERTEBRATE EMBRYOLOGY

| | | | |
|---|---|---|---|
| 8489 | | 20 sets prepared slides containing: | |
| | | 1 whole mount of 33 hour chick embryo | |
| | | 1 whole mount of 48 hour chick embryo | |
| | | 1 whole mount of 72 hour chick embryo | |
| | | serial sections of one 33 hour chick embryo | |
| | | serial sections of one 48 hour chick embryo | |
| | | serial sections of one 72 hour chick embryo | |
| | | serial sections of one 10 MM pig embryo | $480.00 |
| 8492 | | 10 sets preserved 10, 15 and 25 MM pig embryos for dissection | 30.00 |
| 8492 | | 4 specimens preserved pregnant sow uteri with one or two inch fetuses | 16.00 |
| | | Total | $526.00 |

**—SECURE LOCALLY TWO FOR EACH STUDENT FERTILE CHICK EGGS FOR INCUBATION—**

## ADDITIONAL EQUIPMENT FOR HISTOLOGICAL TECHNIQUE

### STUDENT APPARATUS

| | | | | |
|---|---|---|---|---|
| 8274 | 65790 | 20 | Section Lifters, all metal, blade 20 x 17 mm | $ 9.00 |
| 4694 | 49230A | 20 | Brushes, camel's hair | 2.00 |
| 8236 | 65620A | 40 | Teasing Needles | 2.00 |
| 8264C | 65740 | 20 | Scalpels, all steel, 38 mm edge | 15.00 |
| 8266 | 65770 | 20 | Scissors, fine point | 15.00 |
| 8259 | | 20 | Knife, Gillette with replaceable blades | 20.00 |
| 8209 | | 40 | Forceps, straight, fine | 20.00 |
| 8116 | 77050 | 20 | Microtome knives with fitted backs and handle | 350.00 |
| 8118 | 76805 | 60 | Boxes slides 3 x 1 inch, 72 to box | 60.00 |
| 8124 | | 20 | Boxes Cover Glasses, No. 1, 18 mm square | 30.00 |
| 8138 | 76850B | 20 | Boxes Slide Labels | 4.00 |
| | | 20 | Padlocks | 17.00 |
| | | | Total | $542.00 |

### GENERAL APPARATUS

| | | | |
|---|---|---|---|
| 8355 | | 1 | Constant Temperature Incubator, Inside 36 x 24 x 24 inches | $600.00 |
| 8365 | | 1 | Constant Temperature Paraffin oven, Inside 20 x 18 x 30 inches | 175.00 |
| 8110 | | 10 | Sliding Microtomes | 1150.00 |
| 8111 | | 2 | Rotary Microtomes | 650.00 |
| 8112 | | 1 | Microtome with Freezing Attachment | 185.00 |
| | | 1 | Cylinder Carbon Dioxide Gas | 30.00 |
| 8150 | | 2 | Microtome Knife Hones, yellow | 20.00 |
| 8151 | | 2 | Microtome Knife Hones, blue-green | 7.00 |
| 8156 | | 2 | Block Straps, coarse | 9.00 |
| 8157 | | 2 | Block Straps, fine | 9.00 |
| 7976 | | 1 | Microscope Compound, 16 and 4 mm dry objectives 5 and 10X eyepieces | 212.00 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 8351A | 76860 | 2 | Books Lens Paper, 9 x 12 inches | $ 1.20 |
| 7970B | 76262 | 10 | Microscopes, compound 16 and 4 mm objectives 5 and 10X eyepieces with condenser in case | 1540.00 |
| 5279 | 74109A | 2 | Electric Hot Plates, three-heat switch | 25.00 |
| 5334P | 49930 | 10 | Alcohol lamps, Pyrex Glass | 9.00 |
| 5420 | | 12 | Carborundum Pencils | 4.20 |
| 5050 | 69700 | 12 | Boxes Filter paper, diameter 15 cm | 4.20 |
| 4948 | 63805A | 10 | Pkg. Corks, 0 to 11 asst. gross packages | 9.50 |
| 4948A | C | 5 | Pkg. Corks, 12 to 26 asst. gross packages | 17.50 |
| 5517 | 78845B | 100 ft. | Rubber tubing 1/16" | 15.00 |
| 5517 | 78845B | 100 ft. | Rubber tubing 1/4" | 18.00 |
| 5517 | 78845B | 50 ft. | Rubber tubing 3/16" | 12.50 |
| 5517 | 78845B | 50 ft. | Rubber tubing 1/2" | 17.50 |
| 5755 | 43860AA | 6 | Copper Water Baths 6" diameter | 15.00 |
| 4670 | | 1000 | Pill Boxes 1½" diameter | 50.00 |
| 5407 | 64680X | 1 | Mortar and Pestle, 185 mm. diameter | 3.18 |
| 4675C | B | 6 | Test Tube Brushes | .60 |
| 187 | | 12 | Oil Cans | 4.20 |
| 9965 | | 6 | White Enamel Trays 17 x 10 x 2½ inches | 15.00 |
| 4922 | 56740D | 12 | Pinch Clamps | 2.16 |
| 8290B | | 1 | Dissecting Set | 6.00 |
| 5813A | 24670 | 1 | Spool Silk Twist | .60 |
| 5813A | 24670 | 1 | Spool linen thread | $ .60 |
| 8283 | 95908 | 12 | Hypodermic Needles | 2.50 |
| | | 1x1 lb. | Cotton Absorbent | .85 |
| 5809 | 24550 | 100 yd. | Cheese Cloth | 20.00 |
| 5810 | | 24 | Laboratory Towels | 6.00 |
| 8006 | 76720 | 10 | Microscope Lamps | 50.00 |
| 5616 | 95250 | 15 | Rolls, Adhesive Tape | 1.75 |
| 5314 | 75810 | 12 | Boxes, Assorted Labels | 1.80 |
| 5841 | 75820 | 10 | Cartons, Safety Matches | 2.00 |
| | | | Total | $4902.84 |

## GLASSWARE

| | | | | |
|---|---|---|---|---|
| 4612B | 75744 | 300 | Wide mouth specimen bottles, 6 oz. | $ 75.00 |
| 8396 | 76915 | 300 | Coplin jars with covers | 180.00 |
| 8391 | 65340A | 72 | Stender Dishes with ground glass covers 36 mm. dia. | 21.60 |
| 4618 | 48100 | 12 | Dropping Bottles Capacity 30 ml. | 4.80 |
| 5235 | 73765 | 2 lb. | Glass Tubing Assorted | 1.20 |
| 5225 | 73755 | 2 lb. | Glass Rod Assorted | 1.10 |
| 5100P | 70400 | 12 | Florence flasks, 1000 cc. | 5.28 |
| 5106P | 70750 | 12 | Erlenmeyer flasks, 1000 cc. | 5.16 |
| 5106P | 70750 | 12 | Erlenmeyer flasks, 500 cc. | 3.36 |
| 5106P | 70750 | 12 | Erlenmeyer flasks, 125 cc. | 2.28 |
| 5106P | 70750 | 12 | Erlenmeyer flasks, 50 cc. | 2.16 |
| 4516P | 44300 | 2 | Beakers, 1000 cc. | 1.12 |
| 4516P | 44300 | 2 | Beakers, 600 cc. | .58 |
| 4516P | 44300 | 2 | Beakers, 250 cc. | .34 |
| 4516P | 44300 | 2 | Beakers, 100 cc. | .40 |
| 4516P | 44300 | 2 | Beakers, 50 cc. | .38 |
| 5256 | 64860B | 4 | Graduates, 1000 cc. | 10.36 |
| 5256 | 64860B | 4 | Graduates, 100 cc. | 3.52 |
| 5256 | 64860B | 2 | Graduates, 50 cc. | 1.54 |
| 5256 | 64860B | 4 | Graduates, 25 cc. | 2.88 |
| 5256 | 64860B | 4 | Graduates, 10 cc. | 2.44 |
| 5436A | 78040A | 6 | Graduated pipettes, 10 cc. | 3.30 |
| 5436A | 78040A | 6 | Graduated pipettes, 1 cc. | 2.64 |
| 4664 | 48420 | 250 | Reagent Bottles, 8 oz. capacity | 125.00 |

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 4666 | 48430 | 250 | Reagent Bottles, 16 oz. capacity | $162.50 |
| 4605 | 48220 | 2 | Wide-mouthed bottles, 2000 cc. glass stoppered | 3.80 |
| 4605 | 48220 | 12 | Wide-mouthed bottles, 5000 cc. glass stoppered | 30.00 |
| 5431 | 78080 | 24 | Medicine Droppers | .80 |
| 4645 | | 2 | Perfusion bottles, 1000 cc. | 1.50 |
| 5140 | 71260 | 6 | Filter funnels, 6" | 4.80 |
| 5620 | 80640A | 12 | Test Tubes, 8½ x 1 inches | .80 |
| 8286 | | 1 | Hypodermic Syringe 50 cc. | 7.50 |
| 8284 | 57600 | 2 | Hypodermic syringes, 10 cc. | 7.00 |
| 8284 | 57600 | 2 | Hypodermic syringes, 5 cc. | 5.00 |
| 8284 | 57600 | 2 | Hyprodermic syringes, 1 cc. | 3.00 |
| | | | Total | $683.14 |

## CHEMICALS

Reagents:

| | | |
|---|---|---|
| 4x5 gals. | Ethyl alcohol, absolute Denatured | $50.00 |
| 4x5 gals. | Ethyl alcohol, 95% Denatured | 27.00 |
| 2x30 lbs. | Ether, Pure | 14.00 |
| 2x5 gal. | Xylol, Pure | 10.00 |
| 5x5 lb. | Chloroform Pure | 15.00 |
| 1x5 gal. | Benzol Pure | 5.00 |
| 1x5 gal. | Toluol Pure | 5.00 |
| 1x5 gal. | Acetone Pure | 8.00 |
| 1x5 gal. | Methyl alcohol, Synthetic | 7.00 |
| 1x5 gal. | Glycerin Pure | 18.00 |
| 1x5 gal. | Formaldehyde, Pure | 12.00 |
| 1x5 lb. | Anilin, Pure | 4.00 |
| 5x5 lb. | Acetic acid cp Glacial | 12.00 |
| 5x6 lb. | Hydrochloric acid cp | 8.50 |
| 5x7 lb. | Nitric acid cp | 12.00 |
| 5x9 lb. | Sulphuric Acid cp | 11.50 |
| 5x4 lb. | Ammonium Hydroxide cp | 8.50 |
| 100 gm. | Veterinary nembutal | 12.50 |
| 2x1 lb. | Soap Castile Powder | 2.00 |
| 2x5 lb. | Tri-basic phosphate tech | 2.00 |
| 5x1 lb. | Gelatin granular | 12.00 |
| 3x1 lb. | Clarite | 10.50 |
| 1x1 lb. | Egg Albumen | 4.00 |
| 10 lb. | Paraffin | 2.50 |
| 20 lb. | Dry ice | Procure Loc. |
| 1x1 pt. | Vaseline | .50 |

| | | |
|---|---|---|
| 1 lb. | Potassium ferrocyanide CP | $ 1.25 |
| 1 lb. | Potassium ferricyanide CP | 2.50 |
| 1 lb. | Cupric acetate CP | 1.50 |
| 2 lb. | Sodium Borate CP | 1.10 |
| 1 lb. | Iron Ammonium Alum CP | .65 |
| 1 lb. | Potassium Carbonate CP | 1.00 |
| 2 lb. | Chromic Acid CP | 3.00 |
| 2 lb. | Acid Sodium Sulphite CP | 1.20 |
| 1 lb. | Aluminum Chloride CP | .90 |
| 2 lb. | Ammonium Molybdate CP | 3.80 |
| 1 lb. | Silver Nitrate CP | 15.00 |
| .4 oz. | Protargol | 5.00 |
| 1 lb. | Hydroquinone | 1.65 |
| 2 lb. | Sodium Sulphite | 1.20 |
| ⅛ oz. | Gold Chloride CP | 4.50 |
| 1 lb. | Metallic Copper | 1.00 |
| 1 lb. | Clove oil | $ 3.00 |
| 1 lb. | Isosafrol | 6.50 |
| 1 lb. | Oil of white thyme | 4.50 |
| 1 lb. | Chloral hydrate | 1.60 |
| 5 lb. | Potassium hydroxide cp pellets | 4.30 |
| 5 lb. | Sodium Hydroxide cp pellets | 3.40 |
| 5 lb. | Sodium Chloride cp | 2.30 |
| 1 gram | Osmic acid | 6.00 |
| 5 lb. | Potassium bichromate cp | 3.60 |
| 2 lb. | Mercuric Chloride cp | 9.00 |
| 1 lb. | Iodine cp | 4.35 |
| 1 lb. | Potassium iodide cp | 6.10 |
| 1 lb. | Sodium Thiosulphate cp | .55 |
| 1 lb. | Potassium Chloride | .68 |
| 5 lb. | Calcium Chloride Pure Ambyrl Gram. | 10.00 |
| 5 lb. | Sodium Bicarbonate cp | 2.25 |
| 5 lb. | Ferric Chloride cp | 2.75 |
| 5 lb. | Copper sulphate cp | 3.00 |
| 1 lb. | Lithium Carbonate cp | 2.75 |
| 1 lb. | Ammonium aluminum sulphate | .60 |
| 1 lb. | Sodium Iodate cp | 8.75 |
| 2 lb. | Oxalic acid | 1.72 |
| 1 lb. | Potassium Permanganate | 1.35 |
| 4 oz. | Phosphotungstic acid | 3.00 |
| 4 oz. | Phosphomolybdic acid | 3.00 |
| 1 lb. | Potassium Chromate cp | .90 |
| 1 lb. | Mercuric Nitrate CP | $ 5.50 |
| 2 lb. | Sodium Nitrate CP | 1.74 |
| 1 lb. | Formic Acid CP | .95 |
| 1 lb. | Sodium Citrate CP | 1.05 |
| 1 lb. | Magnesium Carbonate CP | 1.75 |

DYES:

| | | |
|---|---|---|
| 25 grams | Acid Fuchsin | $ 1.60 |
| 25 grams | Acid violet | 1.50 |
| 25 grams | Acridine red | 4.00 |
| 25 grams | Aniline Blue | 1.60 |
| 25 grams | Azo-Carmine | 2.00 |
| 10 grams | Azure 2 | 10.50 |
| 25 grams | Basic Fuchsin | 1.60 |
| 25 grams | Carmine | 1.00 |
| 25 grams | Crystal violet | 1.60 |
| 25 grams | Eosin | 1.60 |

| | | | | | |
|---|---|---|---|---|---|
| 25 grams | Hrythrosin | $ 2.00 | 25 grams | Resorcin | $ 2.00 |
| 25 grams | Hematoxylin | 5.50 | 25 grams | Safranin | 1.50 |
| 25 grams | Janus Green B. | 2.00 | 25 grams | Sudan III | 1.50 |
| 25 grams | Methyl green | .75 | 25 grams | Thiazin Red | 2.50 |
| 25 grams | Methylene blue | 1.50 | 25 grams | Toluidine Blue | 2.00 |
| 25 grams | Neutral Red | 1.50 | 25 grams | Wright's Stain | 4.00 |
| 25 grams | Orange G. | 1.50 | | | |
| 25 grams | Orcein | 2.00 | | Total | $482.94 |

## ADDITIONAL EQUIPMENT FOR ELEMENTARY GENETICS

1 Di-Hybrid Crossing in Corn Purple-Starchy and white sweet corn are crossed and carried to the $F_2$ generation. This mount shows recessive and dominant characters of corn. Mounted in 8" x 12" glass topped case ..... $3.00

1 Inheritance of Seed Shape in Corn. Sweet (smooth kernel) and shrunken (wrinkled kernels) corns are crossed and carried to the $F_3$ generation. The specimens used were obtained in actual breeding experiments. The kernels of corn are mounted upon printed diagram in an 8" x 12" glass-topped display case.. 5.00

9 Heredity in Corn. The following ears of corn show the results of crosses between two characters which serve to demonstrate Mendel's principles of heredity. The seeds being held in a natural formation make a striking and convincing demonstration.

Mono-hybrid ratio of 3:1
(Red-White) (Smooth-Shrunken)
(Purple-White) (Yellow-White)
(White-Purple) (Starchy-Sweet)

Backcross ratio of 1:1
(Starchy-Sweet)

Di-Hybrid ratio of 9:3:3:1
(Yellow Starchy-White Sweet)
(Purple Starchy-White Sweet)
(White Starchy-Purple Sweet)

Di-hybrid ratio of 9:3:4
(Starchy-Shrunken-Sweet)
(Purple-Red-White)

Di-hybrid ratio of 9:7
(Purple-White)

Di-hybrid ratio of 13:3
(Non-Purple-Purple)

Tri-hybrid ratio of 27:37
(Purple-White)

Tetra-hybrid ratio of 81:27;148
(Purple-Red-White) ..... $ .60 5.40

1 Anasa. Mitosis in testis. To show side view of the second spermatocyte anaphase with the lagging of the X-chromosome as it passes to one pole only ..... 2.00

1 Mitosis in testis of the squash bug showing the heterochromosome, or X-chromosome, or sex-chromosome, as it is variously called by different authors ..... $2.00

24 Drosophila Cultures (fruit flies). Large size cultures in four ounce wide-mouthed bottles (with media). Instruction sheets accompany each culture on "The Rearing and Handling of Fruit Flies." Full directions are given on culture methods, culture media, mating flies, and suggested crosses with ratios obtained.

1. Wild Type
2. Bar Eye
3. Double Bar Eye
9. Forked Bristle
13. Miniature Wing
17. Vermilion Eye
18. White Eye
21. Eosin Eye

22. Eosin Miniature
24. Yellow Body
23. Tinged Body
26. Yellow White Miniature
49. Ebony Body
51. Sepia Eye
53. Bent Wing
54. Eyeless (very small eye)
57. Attached-X Yellow
33. Black Body
34. Black Purple Curved
37. Black Vestigial Brown
38. Brown Eye
39. Curved Wing
42. Heldout Wing
46. Vestigial Wing

84.00

Total ..... $99.40

## ADDITIONAL FOR PARASITOLOGY

### STUDENT EQUIPMENT

| Welch Cat. No. | Chapco Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|---|
| 3925 | | 36 | Drawing Pencils hard lead | $ 3.60 |
| 3926 | | 36 | Sepia crayon, thin lead | 3.60 |
| 3927 | 98512 | 36 | Light Blue Crayon, thin lead | 3.60 |
| 3928 | | 36 | Crayon, thin lead | 3.60 |
| 03611 | | 20 | Notebooks with paper | 40.00 |
| 8214 | 65600 | 25 | Dissecting Forceps, fine, straight | 12.50 |
| 8272 | 65760A | 25 | Scissors, fine | 37.50 |
| 8236 | 65620A | 50 | Dissecting Needles, wood handle, straight | 2.50 |
| 8118 | 76805 | 20 BX | Microscopic Slides, 72 to box | 20.00 |
| 8130 | 76830A | 10 oz. | Cover Glass, 18 mm. diameter | 42.50 |
| | | | Total | $169.40 |

### LABORATORY EQUIPMENT

| | | | | |
|---|---|---|---|---|
| 5750 | 80890A | 36 | Watch Glasses 3" diameter | $ 2.16 |
| 8386P | 65270A | 24 | Petri Dishes 100 x 15 mm. | 9.12 |
| 8055B | | 4 | Hand Lenses, 2½" diameter | 10.00 |
| 5620 | 80640A | 144 | Test Tubes, size 4 x ½" | 2.25 |
| 5607 | 80800 | 8 | Test Tube Supports | 10.80 |
| 4752 | | 12 | Bunsen Burners | 8.40 |
| 5720 | 80560A | 12 | Tripods 5" Diameter | 6.00 |
| 5431 | 78080 | 48 | Medicine Droppers | 1.60 |
| 5140 | 71260 | 6 | Funnels 6" Diameter | 4.80 |
| 5572 | 79905A | 6 | Ringstands with three clamps | 8.10 |
| 8105 | 76625A | 1 | Ocular Micrometer | 4.00 |
| 8109 | | 1 | Stage Micrometer | 14.50 |
| 8008 | | 1 | Mechanical Stage | 50.00 |
| | | | Total | $131.73 |

### STUDENT MICROSCOPIC SLIDE SETS

20 sets Parasitological Slides, Set I ..... $1020.00
(one each as follows)

| | | | |
|---|---|---|---|
| A1 | Balantidium coli, section | A15 | E. coli, vegetative |
| A2 | Balantidium coli, smear | A16 | E. coli, cysts |
| A6 | Opalina, from frog intestine | A19 | Endolimax nana |
| A7 | E. histolytica, section, intest. | A20 | Iodamoeba williamsi |
| A8 | E. histolytica, vegetative | A23 | Tryp. lewisi, 3 day infection |
| A9 | E. histolytica, section, liver | A24 | Tryp. lewisi, 15 day infection |
| A10 | E. histolytica, cysts | A25 | Tryp. cruzi, section, heart |

A26 Leish. donovani, section, spleen
A27 Leish. donovani, liver, section
A28 Giardia, monkey
A29 Giardia lamblia, cysts
A30 Trichomonas cobayae
A31 Chilomastix mesnili
A32 Malaria, thick smear
A33 Oocysts, malaria, section
A34 Plasmodium brasilianum
A35 Plasm. falciparum, smear, brain
A36 }
A37 } Plasm. vivax
A38 }
A39 }
A40 Plasm. falciparum, crescents
A41 Plasm. falciparum, placental smear
A42 Plasm. malariae
A43 Haemoproteus, smear
A44 Haemogregarine
A45 Sarcocystis rileyi, section
A46 Eimeria miyairii
A47 Rabbit coccidia, section, liver
A48 Eimeria dispersa, section, intest.
A49 Myxosporidian of fish, section
A50 Adelina sp., Flour Beetle
A51 Lankesteria culicis, section
A82 Clonorchis sinensis, metacercaria
A83 Clonorchis sinensis, section, liver
A84 Clonorchis sinensis, w. m.
A85 Fasciolopsis buski, w. m.
A86 Dicrocoelium dendriticum, w. m.
A87 Fasciola hepatisa, w. m.
A88 Paragonimus westermani, section
A90 Schistosoma japonicum, w. m.
A91 Schistosoma japonicum, section
A93 Rediae of trematodes
A94 Cercariae of trematodes
A96 Fasciolopsis buski, eggs

20 sets Parasitological Slides, Set II (one each as follows) ..... $1140.00

B5 Taenia, mature, W. M.
B6 Taenia, ripe, W. M.
B7 Taenia, gravid, W. M.
B8 Dipylidium caninum, W. M.
B9 Dipylidium caninum, W. M.
B10 Diphyllobothrium latum. W. M.
B11 Diphyllobothrium latum. W. M.
B12 Diphyllobothrium latum. W. M.
B15 Cysticercus fasciolaris, Sec.
B16 Hydatid sand
B17 Echinococcus granulosus, Sec.
B32 Enterobius vermicularis, monkey
B33 Trichursis trichiura
B35 Necator americanus, male and female
B36 Ancylostoma duodenale, male and female
B37 Necator, infective larvae
B38 Hookworm larvae, Sec.
B39 Microfilariae
B40 Dracunculus medinensis, Sec.
B41 Ascaris lumbricoides, Sec.
B42 Onchocerca volvulus, Sec. in Simulium damnosum
B51 Anopheles, male head
B52 Culex, male head
B53 Anopheles, female head
B54 Culex, female head
B55 Anopheles larva
B56 Culex larva
B57 Culicine larva
B58 Culicine larva
B59 Anopheles pupal skin
B60 Culicine
B61 }
B62 } Anopheles adults
B63 }
B64 Anopheles crucians larva
B65 Streblid fly from bat
B66 Melophagus ovinus
B67 Culicoides adult
B68 Simulium larva
B70 }
B71 } Species of fleas
B72 }
B73 Xenopsylla larva
B74 Tunga penetrans
B76 Cimex lectularius
B78 Pigeon louse
B79 Pediculus H. humanus
B80 Pediculus H. Corporis
B81 Phthirus pubis
B83 Dermacentor andersoni
B84 Hard tick
B85 Soft tick
B88 Demodex, W. M.
B89 Sarcoptes scabei, W. M.
B90 Demodectic mange, Sec.
B91 Sarcoptic mange, Sec.
B92 Dermanyssus gallinae

TOTAL ..... $2,160.00

## SLIDES AND PRESERVED MATERIALS FOR CLASSROOM USE

I. Helminthology

**A Trematodes**

| | | Preserved | Slides |
|---|---|---|---|
| 1 | Clonorchis sinensis | $1.00 | |
| 1 | Clonorchis sinensis, section of liver | | $ 1.25 |
| 1 | Clonorchis sinensis, eggs W. M. | 1.50 | 2.00 |
| 1 | Fasciola Buski | 2.50 | 2.00 |
| 1 | Fasciola Buski, miracidia W. M. | 1.50 | 2.00 |
| 1 | Fasciola Buski, cercariae W. M. | 1.50 | 2.00 |

| | | | | |
|---|---|---|---|---|
| | 1 | Fasciola Buski, metacercaria W. M. | $1.50 | $ 2.00 |
| | 1 | Fasciola Buski, eggs | 1.50 | 2.00 |
| | 1 | Schistoma japonicum | 2.75 | 3.50 |
| | 1 | Schistoma japonicum, eggs W. M. | | 1.00 |
| | 1 | Schistoma japonicum, miracidia W. M. | | 2.50 |
| | 1 | Schistoma japonicum, cercariae W. M. | | 2.50 |
| | 1 | Schistoma japonicum, section of parasite in situ in tissue | | 3.00 |
| | 1 | Schistoma japonicum. Worms in situ in mesenteric veins | | 2.50 |
| | 1 | Fasciola hepatia | .40 | .75 |
| | 1 | Fasciola hepatia in sections of tissue | | 1.00 |
| | 1 | Fasciola hepatica, cercariae stage whole mount | | 1.25 |
| **B** | **Cestoides** | | | |
| | 1 | Taenia saginati segments (12 students) | 2.50 | 1.75 |
| | 1 | Taenia saginata complete with Scolex | 2.00 | 5.00 |
| | 1 | Taenia saginata eggs in faeces (12 students) | 1.50 | 1.00 |
| | 1 | Taenia saginati cysticercus from beef | | 2.50 |
| | 1 | Taenia solium with Scolex | 12.00 | 10.00 |
| | 1 | Taenia solium segments only | | 7.00 |
| | 1 | Taenia solium eggs in faeces (12 students) | 5.00 | 1.25 |
| | 1 | Echinococcus granulosus | 10.00 | 9.00 |
| | 1 | Echinococcus granulosus, Hydatid sand | | 10.00 |
| | 1 | Echinococcus granulosus, Hydatid section | | 10.00 |
| | 1 | Hymenolepis nana with Scolex | | 3.00 |
| | 1 | Hymenolepis nana eggs | | 1.50 |
| | 1 | Diphyllobothrium mansoni with Scolex | 9.00 | 7.00 |
| | 1 | Diphyllobothrium mansoni eggs | | 2.00 |
| | 1 | Diphyllobothrium mansoni Sparaganum | | 8.00 |
| **C** | **Nematodes** | | | |
| | 1 | Trichuris trichura eggs | | 2.00 |
| | 1 | Trichuris trichura in section of appendix | | 2.50 |
| | 1 | Ascaris lumbricoides (per dozen) | 1.00 | 2.50 |
| | 1 | Ascaris lumbricoides cross sections | | .50 |
| | 1 | Ascaris lumbricoides sections in appendix and other organs | | 1.50 |
| | 1 | Ascaris lumbricoides eggs in faeces | | 1.50 |
| | 1 | Macracanthorhyuchus hirudinaceous whole mount | | 1.50 |
| | 1 | Trichinella spiralis in pieces of infested pork 2. (per doz.) | 2.50 | .50 |
| | 1 | Necator americanis male and female | 4.00/dz. | 1.00 |
| | 1 | Ancylostoma duodenale male or female | | 2.00 |
| | 1 | Ancylostoma duodenale larvae | | 1.50 |
| | 1 | Ancylostoma duodenale egg faeces | | 1.25 |
| II. | Protozoology | | | |
| **A** | **Ciliates** | | | |
| | 1 | Balantidium coli in sections of tissue | | 1.50 |
| | 1 | Balantidium coli smear | | 1.25 |
| **B** | **Amoebae** | | | |
| | 1 | Endamoeba Histolytica smear | | 1.75 |
| | 1 | Endamoeba Histolytica, sections of infested tissue | | 1.75 |
| | 1 | Endamoeba coli | | 1.75 |
| | 1 | Endolimax nana smear | | 1.50 |
| | 1 | Iodamoeba butachlii | | 1.75 |
| **C** | **Flagellates** | | | |
| | 1 | Trypanosoma lewisi blood smear | | 1.00 |
| | 1 | Leishmania donovani smear | | 1.75 |
| | 1 | Leishmania donovani sections of infected tissue | | 2.00 |
| | 1 | Giardia lamblia smear | | 1.25 |
| | 1 | Chilomastix mesnili smear | | 1.25 |
| **D** | **Sporozoa** | | | |
| | 1 | Plasmodium vivax smears | | 1.50 |
| | 1 | Plasmodium falciparium smears | | 1.50 |
| | 1 | Plasmodium falciparium sections of infected liver, spleen, kidney or brain from a fatal case | | 1.50 |
| | 1 | Plasmodium malariae smear | | 3.00 |
| | 1 | Sarcocystis, sections of infected tissue | | 1.50 |

III--Medical Entomology

**A—Diptera**

| | | | |
|---|---|---|---|
| 1 | Anopheles whole mount of larva | | $ 1.25 |
| 1 | Anopheles whole mount of pupa | | 1.25 |
| 1 | Anopheles whole mount of adult male | | 1.00 |
| 1 | Anopheles whole mount of adult female | | 1.00 |
| 1 | Anopheles whole mount of male head | | .75 |
| 1 | Anopheles whole mount of female head | | .75 |
| 1 | Culex pipiens whole mount of eggraft | $1.25/dz. | .50 |
| 1 | Culex pipiens whole mount of larva | .25/dz. | .50 |
| 1 | Culex pipiens whole mount of pupa | .25/dz. | .50 |
| 1 | Culex pipiens whole mount of female adult | .25/dz. | .75 |
| 1 | Culex pipiens whole mount of male adult | .25/dz. | .75 |
| 1 | Aedes aegypti whole mount of larva | | 1.50 |
| 1 | Aedes aegypti whole mount of pupa | | 1.50 |
| 1 | Aedes aegypti whole mount of adult male | | 2.00 |
| 1 | Aedes aegypti whole mount of adult female | | 2.00 |
| 12 | Tabanus, horse fly | .90 | |
| 1 | Culicoides sp. | | 1.50 |
| 1 | Simulium sp. | | 1.50 |
| 1 | Musca domestica whole mount of egg | | .50 |
| 1 | Musca domestica whole mount of larva | .60/dz. | .50 |
| 1 | Musca domestica whole mount of pupa | .60/dz. | .50 |
| 1 | Musca domestica whole mount of adult | .35/dz. | .75 |
| 1 | Musca domestica whole mount of proboscis | | .50 |
| 1 | Musca domestica whole mount of wing and leg | | .50 |
| 1 | Melophagus ovinus | .25 | 4.00 |

**B Siphonaptera**

| | | | |
|---|---|---|---|
| 1 | Ctenocephalides felis | .50/dz. | .50 |
| 1 | Xenopsylla cheopis | | 1.50 |
| 1 | Cimex lectularius | .70/dz. | .50 |

**C Anoplura**

| | | | |
|---|---|---|---|
| 1 | Pediculus humanus | 1.00/dz. | .75 |
| 1 | Phthirius pubis | 1.25/dz. | .75 |
| 1 | Haematopinus suis | .17/dz. | .75 |
| 1 | Polyplax spinulosa | 1.00/dz. | .75 |

**D Ixodoidea**

| | | | |
|---|---|---|---|
| 1 | Argas, fowl tick | | 1.00 |
| 1 | Ornithodoros, human tick | | 2.50 |
| 1 | Dermacentor | | 1.00 |
| 1 | Ixodes | | 1.25 |

**E Parasitic Mites**

| | | | |
|---|---|---|---|
| 1 | Dermanyssus Mite (Poultry) | | .75 |
| 1 | Sarcoptes, mange mite | | 1.00 |
| 1 | Psoroptes, scab mite | | 2.00 |
| 1 | Demodex Scab Mite | | 1.50 |
| 1 | Trombicula, chiggers | | 1.00 |

**F Miscellaneous Noxious Arthropoda**

| | | | |
|---|---|---|---|
| 1 | Lactrodectus Mactans | .50 | |
| 1 | Centrurus Gracilis | .75 | |

| | |
|---|---|
| TOTAL MICROSCOPIC SLIDES | $199.75 |
| TOTAL PRESERVED MATERIAL | 74.47 |

## ADDITIONAL EQUIPMENT FOR ANIMAL ECOLOGY

| Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|
| 5271 | 1 | Photometer | $ 10.00 |
| 5272 | 1 | Winkler Oxygen Determination Set | 15.00 |
| 5273 | 1 | Seyler Carbonate Determination Set | 14.00 |
| 5274 | 1 | Nitrate and Nitrite Determination Set | 20.00 |
| 5276 | 1 | Turbidity Determination Set | 22.00 |

| Welch Cat. No. | Quantity | Description | Total Price |
|---|---|---|---|
| 5270B | 1 | Hydrogen-ion Apparatus | $ 55.00 |
| 5277 | 1 | Soil Analysis Apparatus | 35.00 |
| 5288 | 1 Set, | Collecting Equipment | 30.00 |
| | | TOTAL | $201.00 |

# COLLEGE ZOOLOGY

## RECAPITULATION

| | | |
|---|---|---|
| General Zoology | | |
| Student Apparatus | $ 3417.90 | |
| General Apparatus | 1608.63 | |
| Chemicals | 35.88 | |
| Preserved Material | 105.45 | |
| Microscopic Slides | 301.00 | |
| | | $ 5468.86 |
| Additional Material for: | | |
| Invertebrate Zoology I | | |
| Microscopic Slides | 777.00 | |
| Living Material | 18.50 | |
| Preserved Material | 72.70 | |
| | | 868.20 |
| Invertebrate Zoology II | | |
| Preserved Material | | 73.10 |
| Invertebrate Zoology III | | |
| Preserved Material | | 119.90 |
| Field Zoology | | |
| General Apparatus | 198.70 | |
| First Aid Supplies | 26.80 | |
| | | 225.50 |
| Comparative Vertebrate Anatomy | | |
| Skeletons | 324.00 | |
| Apparatus | 161.00 | |
| Chemicals | 13.90 | |
| Preserved Specimens | 205.00 | |
| Student Supplies | 5.00 | |
| | | 708.90 |
| Vertebrate Embryology | | |
| Slides | | 526.00 |
| Histological Technique | | |
| Student Apparatus | 542.00 | |
| General Apparatus | 4902.84 | |
| Glassware | 683.14 | |
| Chemicals | 482.94 | |
| | | 6610.92 |
| Elementary Genetics | | $ 99.40 |
| Parasitology | | |
| Student Equipment | $ 169.40 | |
| Laboratory Equipment | 131.73 | |
| Student Microscopic Slide Sets | 2160.00 | |
| Classroom Microscopic Slides | 199.75 | |
| Preserved Material | 74.47 | |
| | | 2735.35 |
| Animal Ecology | | 201.00 |
| GRAND TOTAL | | $ 17,637.13 |