THE BOOK WAS DRENCHED

Contents

Foreword

The Review Committee in Chemistry was appointed by the University Grants Commission in May 1960 and consisted of the following members :

1. Prof. T. R. Seshadri, F.R.S., Head of the Chemistry Deptt., Delhi University, Delhi. .. *Chairman*
2. Prof. M.R.A. Rao, Head of the Department of General Chemistry, Indian Institute of Science, Bangalore. .. *Member*
3. Dr. (Mrs.) Asima Chatterjee, Department of Chemistry, Calcutta University, Calcutta. ,,
4. Prof. S.K. Bhattacharya, Indian Institute of Technology, Kharagpur. ,,
5. Prof. G. Gopala Rao, Head of the Chemistry Deptt., Andhra University, Waltair. ,,
6. Dr. Jagdish Shankar, Head, Chemistry Division, Atomic Energy Establishment, Trombay, Bombay-28. ,,
7. Prof. R.C. Mehrotra, Head of the Chemistry Deptt., Rajasthan University, Jaipur. ,,

8. Prof. S.R. Palit, .. *Member*
Professor of Chemistry,
Indian Association for the
Cultivation of Science,
Jadavpur (Calcutta).

9. Dr. B.D. Laroia,* ,,
Development Officer,
University Grants Commission,
New Delhi. .. *Member-Secy*

(*Since the retirement of Dr. B.D. Laroia from the services of the U.G.C., Dr. D. Shankar Narayan, Education Officer (Science), U.G.C., took over as Secretary of the Committee.)

The Chairman, Prof. T.R. Seshadri and the members of the committee have devoted considerable time and energy in the preparation of this report on the teaching and research in Chemistry in Indian Universities. The Commission is grateful to them and other individuals for their work and assistance in making this review.

The report emphasises, above everything else, the need for improvement of the courses of study and re-orientation in the methods of research in our universities so as to bring it in line with the trends elsewhere in other countries. The report contains several useful suggestions with regard to the model syllabi indicating the extent of training to be provided at various levels of University education, introduction of newer disciplines of study, assessment of students performance, examination pattern and training for research degrees.

I have no doubt that the report of this committee will be of real value in the advancement of teaching and research in the subject of Chemistry in our universities and colleges.

D.S. KOTHARI
Chairman
University Grants Commission

NEW DELHI
December 9, 1963

Preface

Chemistry is an advanced branch of science and it extends over a large area of study. It is essentially concerned with the composition and structure of materials and the methods consist of analytical as well as synthetic aspects. Vast expansion during the past hundred years has been due largely to its vital application to primary needs of man like foods, drugs, clothing and housing. The study of dyes, textiles and plastics has meant enormous advance not only in the descriptive part of chemistry but also in theoretical aspect of chemistry. The subject has been changing very fast in its methods and expression. However, we could say that these advances do not mean any destruction of the old, but they mean fulfilment and amplification. In spite of the large expansion in the field of chemistry there is simplification also in that our ideas are becoming more definite because some of the vital secrets of chemical phenomena are better understood. Another characteristic of chemistry is its marked adaptability to changing needs and changing conditions.

All these have to be reflected in the methods of teaching and research. They have been continuously changing though not always spectacularly. The post-war years have brought about enormous transformations in available facilities and techniques and these have their impact on teaching and research. But there is one special feature to be noted. The more advanced universities move with accelerated pace and the less advanced ones are likely to be left behind. This difficulty presents itself not only in India but also in other advanced countries. However, the spirit of modern democracy is to make benefits available to all. This has also been the spirit of missionary work all through ancient and mediaeval times and upto the present day; the needy should be served. Hence a special effort is now being made to help the less developed universities by providing adequate guidance in matters of teaching and research. The present Report is an effort in this direction.

As a consequence of the vastness of the areas covered by chemistry, there has been need not only to specialize but also to pick out the

essentials for teaching. This is not to decry the need for experience and wide knowledge. But within the time available for training, one has to concentrate attention on the essentials for understanding the principles of chemistry which are capable of being applied to large areas. The old practice of drilling students into all the techniques, particularly laboratory techniques, has to change. Scientists have now to give more attention to scientific thought and principles and to the development of new ideas and new methods leading to original contributions. For routine repetitions and controls they have to depend on technicians. This was realized decades back in certain advanced countries where technicians and research assistants were specially trained to do this part of work.

The development of modern chemistry in India is of recent date and the Chemistry Review Committee has made a study of the progress so far made and the manner in which this has taken place. A detailed survey of the existing facilities for teaching at both undergraduate and post-graduate levels in different parts of India has revealed the seriousness of the situation particularly in areas removed from advanced university centres. In most of the colleges, there is inadequate provision of laboratory facilities and inefficient lecture and practical courses. There seems to be a serious lack of interest in the intensive training of the students. No doubt conditions vary from area to area but in general the position has been unsatisfactory. Similarly examination system and assessment of proficiency of students showed considerable variation leading to large differences in standards. A similar large variation existed regarding standards of training and examination for research degrees and the availability of research facilities in the universities.

The Committee took great pains to study the details and make recommendations as to how to improve not only the facilities for methods of teaching but also the methods of examination. Model syllabi and examination systems have also been recommended. The Committee has also given thought to future lines of development in regard to University teaching and research in Chemistry. There is no doubt that continuous vigilance and intelligent help is necessary to maintain standards in most colleges and universities and the Committee feels that the University Grants Commission could make some permanent arrangement for periodical review of the progress in this regard.

The Committee is grateful to the University Grants Commission for their interest in the work entrusted to it and in the preparation of this report and to different individuals who helped it at various stages.

T.R. SESHADRI
Chairman
Chemistry Review Committee

Delhi
November 23, 1963

1

Introduction

During the past few years, the University Grants Commission has been giving liberal grants to various universities in our country for purposes of rehabilitation and construction of buildings, purchase of new and modern equipment needed for research, improvement of libraries and providing better workshop facilities. Since a systematic evaluation of the results achieved in raising the standards of teaching and in furthering research work as a result of these grants made by the University Grants Commission was not made for sometime, the Commission, in early 1959, felt it desirable to undertake an assessment in the above line in various science subjects and the Chairman of the University Grants Commission appointed a few Review Committees of experts in specific scientific fields.

The Chemistry Review Committee was appointed in May 1960 and consisted of the following members :

1. Prof. T.R. Seshadri, F.R.S., ...Chairman
   Head of the Chemistry Department,
   Delhi University,
   Delhi-6.

2. Prof. S.R. Palit, ...Member
   Professor of Chemistry,
   Indian Association for the Cultivation of Science,
   Jadavpur, Calcutta.

3. Prof. G. Gopala Rao, ,,
   Head of the Chemistry Department,
   Andhra University,
   Waltair.

4. Prof. S.K. Bhattacharya,
Head of the Chemistry Deptt., *Member*
Indian Institute of Technology,
Kharagpur.

5. Prof. M.R.A. Rao, "
Head of the Department of General Chemistry,
Indian Institute of Science,
Bangalore.

6. Prof. R.C. Mehrotra,* "
Head of the Chemistry Department,
Gorakhpur University,
Gorakhpur.

7. Dr. Jagdish Shankar, "
Head, Chemistry Division,
Atomic Energy Establishment, Trombay,
Bombay-28.

"

8. Dr. (Mrs) Asima Chatterjee,
Department of Chemistry,
Calcutta University,
Calcutta.

9. Dr. B.D. Laroia,**
Development Officer (Science),
University Grants Commission, ...Member Secretary
New Delhi.

Since the retirement of Dr. B.D. Laroia from the services of the U.G.C., in June, 1962 Dr. D. Shankar Narayan, Education Officer (Science), University Grants Commission, took over as Secretary of the Committee.

The Chemistry Review Committee enjoyed wide terms of reference and was free to make its own programme and procedure of work. In order to carry out its assignment satisfactorily, the Committee was, in

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**Retired from Service of UGC

particular, requested to examine the following important aspects :

i) The stage of development achieved so far in the specific field under reference, viz., chemistry

ii) Revision of the syllabi and suggestion for the modifications in our present examination system

iii) Evaluation of research work done so far and examination of trends of research, their potentialities and relationship to the general needs of the development programmes in the country

iv) The action which may be taken for the development and expansion of training and research in certain special fields in chemistry, keeping in view the avoidance of duplication of efforts

v) Measures for improving the teaching personnel

vi) Suggestion of ways and means of co-ordination between universities themselves and between universities and other centres of research like the National Laboratories

The Chemistry Review Committee held the following four meetings :

i) First meeting at Bangalore on June 17 and 18, 1960

ii) Second meeting at Delhi on January 24 and 25, 1961

iii) Third meeting at Delhi on March 27 and 28, 1961

iv) Fourth meeting at Delhi on December 15, 1962

In order to make its work efficient, the Committee decided to set up two fact-finding sub-committees, one for under-graduate level and the other for post-graduate level.

Besides these sub-committees, a number of notes were prepared by the members for the use of the Committee on the following topics :—

i) Historical background of the growth and development of the study of chemistry in Indian Universities

ii) Development of plant chemistry in India

iii) Development of organic chemical research in India

iv) Nuclear and radiation chemistry research

v) Chemical kinetics

vi) Teaching of radiochemistry in Indian Universities

vii) Research work done in various Indian research laboratories in the field of catalysis

viii) Physical chemistry

ix) Research work done in India in the field of analytical chemistry during 1951-1961.

In order to prepare model syllabi two sub-committees were appointed; one each for Under-graduate (B.Sc.) level and Post-graduate (M.Sc.) level.

The Committee as a whole went into the various aspects of teaching and research in chemistry in our country and the Report prepared as finalized after the discussions is now submitted to the University Grants Commission. The Committee places on record its thanks to all persons who helped in this work.

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Development of Chemistry in India
A Historical Sketch

While discussing the historical background of the growth and development of the study of chemistry in Indian universities, it is worth recalling that in ancient times India made phenomenal progress in the sphere of chemistry. Contributions were also made in the field of medicine and use of metallic compounds in medicine. This is amply confirmed by the evidences available in the book entitled 'History of Hindu Chemistry' by Acharya P.C. Ray. However, after striking achievements of the ancient Hindus and the significant growth of chemical knowledge during the early medieval period, the late middle ages unfortunately witnessed a serious setback to the development of chemistry in our country owing to various reasons like socio-political conditions and pursuit of alchemy and occultism.

A few universities which were started in the latter half of the last century started teaching chemistry first as an additional subject and subsequently as a separate branch of science. The teaching of chemistry was first undertaken by Calcutta University as an additional subject in the B.A. syllabus. However, in 1872, the syllabus was divided into 'A' course comprising humanities and 'B' course consisting of science and mathematics. Chemistry as a distinct subject appeared in the curriculum of studies for the so-called first Examination in Arts. There was no practical examination and no laboratory was provided for the students to do any experimental work. The lectures were almost without any demonstrations. When the Calcutta University started the B.Sc. course for the first time in 1902, practical work was introduced as part of the course.

The facilities for teaching of chemistry at the post-graduate level were available for a number of years only in a few colleges affiliated to the universities. These colleges had the help of a few British professors

like Prof. (Sir) Alexander Pedler. Acharya P.C. Ray pursued his pioneering research at the Presidency college, Calcutta, around the close of the 19th century.

The 20th century heralded the dawn of a new era in the teaching of chemistry in Indian universities. The University Act of 1904 added responsibilities to the universities which included promotion of teaching and research, creation of professorships and award of doctorate degree based on submission of thesis. Subsequently, post-graduate teaching and research in chemistry started in a number of colleges including University Colleges and new teaching and residential universities with well equipped chemistry departments were established. Post-graduate department in chemistry was first started by the Calcutta University in 1916. Much later, the Universities of Bombay and Madras followed this lead.

In the early stages of the development of chemistry in our country in this century, the services of a number of English professors were available of whom the names of J.L. Simonsen (Madras), J.J. Sudborough (Bangalore), E.R. Watson (Dacca) and Meldrum (Bombay) may be mentioned as more prominent and all these four were specialists in organic chemistry and vigorously pursued teaching and research in this branch of chemistry in the universities and institutions to which they were attached. They trained a considerable number of young men in research. During the years following the First World War, there was a spurt in physical chemistry under the leadership of Professors N.R. Dhar, J.C. Ghosh, J.N. Mukherjee and S.S. Bhatnagar who had returned from Europe and established themselves in important centres ; organic chemistry appeared to be somewhat in the background. But soon a large number of new centres were opened and active research work was carried out in the organic field in other centres besides those mentioned above and the position was fairly satisfactory by the beginning of the Second World War.

During war-time and in early post-war period great difficulty was experienced regarding the availability of apparatus and chemicals which were badly needed for advanced research. However, since 1950 the situation has improved and consequently there has been a rapid and continued progress not only in the number of centres engaged in research work but also in the intensity of the work. Now practically every one of the major university centres has equipment and personnel for research work of good standard in all major branches of chemistry. Besides the universities, a number of organizations like the National Chemical

Laboratory (Poona), The Indian Association for the Cultivation of Science (Calcutta) and the Bose Research Institute (Calcutta) also foster chemical research.

Due to the establishment of a number of new universities, there was phenomenal progress in chemical education and research in Indian Universities. This growth of teaching of chemistry in the various universities is reflected from the number of chemists turned out by the universities since 1910 as given below :—

Year	Number of candidates awarded Master's degree in Chemistry
1910-1915	97
1916-1920	112
1921-1925	328
1926-1930	449
1931-1935	553
1936-1940	739
1941-1945	930
1946-1950	1588
1951-1955	2966
1956-1960	3634

There has been a marked steep rise in the number of graduates in chemistry since Independence.

In the early development of chemistry in our country, there were few scholarships available even to the highly deserving persons who could be encouraged to pursue lines of work in this subject. However, the situation has been fast improving and today we have a number of organizations like the Ministry of Education, University Grants Commission, Council of Scientific and Industrial Research, National Institute of Sciences of India, Atomic Energy Commission, Indian Council of Agricultural Research, Indian Council of Medical Research etc., which offer a number of scholarships and fellowships for pursuing advanced research. The problem at present is not so much lack of funds as of their proper utilization to the fullest advantage for the development of chemistry in our country.

3

Existing Facilities

Under-Graduate Teaching

As compared with post-graduate teaching, under-graduate teaching is done in our country on a much larger scale. Almost every university has chemistry as one of the science subjects offered by the students. This under-graduate teaching in some universities is done by affiliated colleges and the university department does the post-graduate teaching. In a few universities, the constituent colleges are responsible for the under-graduate teaching. In several others this teaching is done directly by the Universities. From the data available with the Chemistry Review Committee, an analysis was made under different heads such as the number of lectures and practicals in chemistry at the under-graduate level, the total number of students taking chemistry as a subject in their study and the number of teachers as well as their teaching load.

In general, a student in a Pre-University class attends in a year about 60 to 80 lectures of 45 minutes duration and on an average 50 practical classes of two to three periods each. Similarly in colleges which have the Intermediate course instead of the Pre-University, the position is also more or less the same.

At the B.Sc. level, the laboratory conditions in the majority of private colleges are not at all satisfactory. Usually the students are not given individual sets of apparatus which they could use without serious time limits. In general, laboratory work is not well-managed either due to lack of adequate staff or of apparatus and chemicals. The level in the lecture courses is also not satisfactory. The main object seems to be to coach students for the examination and no serious effort is made to develop efficiency in the understanding of chemistry. One of the serious defects is the lack of demonstrations in the lecture classes. Generally speaking, four lectures and four periods of practicals per week is prescribed

during the three-year course. There seems to be some need to increase the periods in practicals from four to six.

Post-Graduate Teaching

The post-graduate teaching and research in chemistry in Indian Universities is at present conducted in nearly 40 universities. Thirty universities of these have university departments and in the remaining ones the departments are located in constituent or affiliated colleges of the universities. Several new university departments are being set up at present. There are thus a total of nearly 85-90 teaching departments which provide facilities for post-graduate studies and research in chemistry. In addition to these, there are a number of research institutions which take advanced students for research work in pure and applied branches of chemistry. Wherever the departments cater to both under-graduate and post-graduate teaching of the subject, much of the teaching load in particular is due to the undergraduate teaching because chemistry happens to be one of the subjects which the students, taking both physical science as well as biological science groups, have to study. Leaving aside the bulk of under-graduate students in chemistry, the number of students admitted to post-graduate (M.Sc.) course varies to a great extent from department to department and in each university. There is a wide range of admissions from as low as 5 and going upto as many as 60 admissions in each year. It may roughly be said that the total annual output of post-graduate students in chemistry is now in the vicinity of about 1300-1400. Similarly on an average, there are 5 to 20 research students working towards the Ph.D. degree in chemistry in most of the University centres having research facilities in this subject. With the introduction of a three-year degree course in most of the Universities and consequent abandoning of the post-intermediate three-year Honours and one-year M.Sc. course, it is likely that the number of students who will go into the two-year M.Sc. course will naturally increase.

Research

General

Generally speaking in the field of Chemistry a fairly good amount of research work is being done in several university centres. The research problems engaging the attention of these workers fall into various branches of chemistry and it is a good feature that side by side with fundamental research a fair amount of attention is being paid to problems of industrial importance especially relating to medicinal plants, insecticides, essential oils, antibiotics etc.

Topics related to plant chemistry are being studied at several universities and cover such fields as colouring matters of plants, Indian medicinal plants, Indian lichens and antibiotics, new antioxidants related to plant pigments, synthetic insecticides, fungicides, alkaloids, steroids, saponins and less familiar essential oils. The other problems of interest include studies in stereochemistry, problems in reactivity, synthetic investigation of heterocyclic compounds, synthesis of natural products, investigation of indigenous seeds and their fats.

More popular fields of work in physical chemistry are colloids, surface chemistry, chemistry of silicate minerals, polymerizations, ion-exchange behaviour of clay minerals, synthetic resins and chemical kinetics. More attention is being at present given to problems relating to analytical chemistry and several new methods of analysis are being developed. Other problems under investigation in the sphere of inorganic chemistry include studies in oxidation, complex compounds, rare earth elements, soils, calorific value of solid and liquid fuels, photolysis etc. Several universities are engaged in work relating to applied chemistry, radiochemistry, agricultural chemistry and chemical technology.

The University Grants Commission has been giving financial assistance to promote and improve post-graduate studies and research in chemistry in Indian Universities. The Commission also has been awarding several fellowships and scholarships to students going in for post-graduate as well as post-doctorate research work in chemistry.

Organic Chemical Research

Till the beginning of the present century, very little teaching and research in organic chemistry could be noted in our universities. However, after the reorganisation of old universities and founding of new universities, the situation is far better now. In the beginning, as already mentioned in Chapter 2, the services of organic chemists like Watson, Sudborough, Simonsen and Meldrum were available and they trained a considerable number of young men in different lines of organic chemical research. During war time, organic chemical research was handicapped from lack of apparatus and chemicals. Since 1950, there has been, however, a rapid and continued progress not only in universities but also in institutions like the National Chemical Laboratory (Poona), the Indian Association for the Cultivation of Science (Calcutta), the Bose Research Institute (Calcutta), the Indian Institute of Science (Bangalore) etc.

Natural products have attracted considerable attention in our country as compared with other lines of investigation and hence the developments in this line are separately indicated after this account. Synthetic methods, dyestuffs and high polymers are also finding place in our organic chemical research. For example, centres like Delhi, Bombay, Lucknow, Bangalore and Patna are engaged in this line of work. Physico-organic chemistry is also being studied in some places like the Annamalai University, Annamalainagar, and Madras Christian College, Tambaram. With a little more encouragement with regard to the availability of apparatus and chemicals and some more dedication by the investigators, organic chemical research in our country can be brought in the near future to a level comparable to that in other countries.

The present generation is in a period of transition and instability not only in sciences but also in many national affairs. There is large expansion in sciences in our country and hence the demand for chemists. However, there is an equal demand for our scientists for temporary placements in richer countries. There is an exaggerated value attached to foreign training particularly a higher degree. Hence the choice of the correct leaders in research and their proper placement is somewhat difficult. The future progress depends much on this and also on the spirit of dedication in the leaders.

The following is a list of centres connected with the different lines of organic chemical research in our country.

Natural Products: Universities of Andhra, Calcutta, Delhi, Kerala, Madras and Osmania ; the Indian Association for the Cultivation of Science (Calcutta); the Bose Research Institute (Calcutta); the Central Drug Research Institute (Lucknow) and the National Chemical Laboratory (Poona).

Oils and Fats : Universities of Bombay, Calcutta and Nagpur. *Sugar and Forest Products* : National Sugar Institute (Kanpur) and the Forest Research Institute (Dehra Dun). *Synthetic Organic Chemistry* : (a) *Steroids and related compounds* : Indian Institute of Science (Bangalore) and the Indian Association for the Cultivation of Science (Calcutta); (b) *Oxygen heterocyclics* : Andhra, Baroda, Bombay, Calcutta, Delhi, Karnatak and Osmania Universities, the National Chemical Laboratory (Poona) ; (c) *Nitrogen heterocyclics* : Calcutta, Madras and Osmania Universities ; (d) *Sulphur compounds* : Annamalai, Banaras, Lucknow, Osmania and Utkal Universities; the Department of Chemical Technology, Bombay University; (e) *Synthetic*

drugs : Delhi, Lucknow and Osmania Universities, the Central Drug Research Institute (Lucknow) and the National Chemical Laboratory (Poona); (f) *Synthetic dyes*; the National Chemical Laboratory (Poona) and the Department of Chemical Technology, Bombay University; (g) *Synthetic high polymers* : the National Chemical Laboratory (Poona) and the Indian Association for the Cultivation of Science (Calcutta).

Physical organic Chemistry : Annamalai University (Annamalainagar) and the Madras Christian College (Tambaram).

Plant Chemistry

Although the use of plant extracts in the treatment of ailments was known in India from early times, development of research in plant chemistry on a scientific basis began in our country only towards the middle of the nineteenth century. A number of books and monographs were written on Indian drugs, e.g., Pharamacographia Indica, Materia Medica, Indigenous Drugs of India, Dictionary of Economic Products of India, Indian Medicinal Plants etc. During the three decades (1914-1944), a good progress was made in plant chemistry investigations, e.g., terpenes (J.L. Simonsen at Dehra Dun and Bangalore), essential oils and alkaloids (E.R. Watson at Dacca), essential and fatty oils (J.J. Sudborough at Bangalore), lac (G.J. Fowler at Bangalore), pharmacology of Indian medicinal plants (R.N. Chopra at Calcutta), oxygen and nitrogen heterocyclics (B.B. Dey at Madras), alkaloids (S.S. Siddiqui at Delhi and J.N. Ray at Lahore) and plant colouring matters, drugs and synthesis of natural products (T.R. Seshadri at Waltair).

During the past 15 years research work in phytochemistry has been receiving encouragement through grants given, besides the universities, by the Council of Scientific & Industrial Research, Indian Council of Agricultural Research, Indian Council of Medical Research, the National Institute of Sciences of India and the University Grants Commission.

At present phytochemical investigations are pursued in the following universities and research institutions : In Delhi University (T.R. Seshadri et al.) plant colouring matters belonging to flavonoids and related compounds, quinones, lichen constituents, heart-wood components, rotenoids, antioxidants, coumarins, and biogenesis of natural products are intensively studied. In Presidency College, Madras (T.R. Govindachari* et al.) work on alkaloids from Indian medicinal plants,

*At present in CIBA Research Centre, Bombay.

terpenoids and their synthesis is going on. Kerala University (P.P. Pillay et al.) has been concentrating its attention on essential oils, terpenes, phenolics and alkaloids. In Andhra University (S. Rangaswami* et al., L. R. Row et al.) research pertaining to cardiac glycosides, plant colouring matters, insecticidal plant constituents and components of medicinal plants and woods is pursued. In Osmania University (N.V. Subba Rao et al.) insecticides of plant origin have attracted attention. In Calcutta University (Asima Chatterjee et al.) the important lines of investigation in phytochemistry are medicinal plants particularly those containing alkaloidal constituents, terpenoids, steroids, coumarins and bitter principles.

The National Chemical Laboratory, Poona (K. Venkataraman, R.C. Shah, S.C. Bhattacharya, Sukh Dev et al.) have undertaken the investigations on flavonoids, terpenoids, quinones, essential oils, xanthones and saponins. In the Central Drug Research Institute, Lucknow (M.L. Dhar et al.), work is going on in the fields of alkaloids, glycosides (particularly saponins) and investigation of plants reputed to have therapeutic properties. In the Regional Research Laboratory, Jammu & Kashmir (R.N. Chopra et al.), the main interest is on the flora of the Himalayas and pharmacology of drugs grown in these areas. At the Bose Research Institute, Calcutta (P.K. Bose et al.) work is progressing on natural coumarins and related products. The School of Tropical Medicine, Calcutta, was known for its early contributions (R.N. Chopra and S. Ghosh). At present, work is going on in the field of saponins particularly from indigenous sources and their utilization for the preparation of steroid hormones (R.N. Chakravarti et al.). The Indian Institute of Science, Bangalore, was largely responsible for the contributions on essential oils (P.C. Guha, B.H. Iyer et al.).

Importance of phytochemistry has been recognized not only in India but throughout the world because of its role in medicine. Indian medicinal plants have been attracting considerable attention of foreign workers also. A serious effort should, therefore, be made for the proper development of this branch of chemistry in our country.

Research in Physical Chemistry

Various aspects of physical chemistry have formed the subject of research in India in different centres and at different times. Some of these are briefly indicated in the sequel.

*At present in Delhi University, Delhi

Chemical Kinetics

Chemical kinetics has been a major field of interest to the physical chemists in India. Outstanding work in this subject has been carried out on reactions in solutions, such as olefine-bromine reactions, chromic acid oxidation of organic compounds etc. (Madras Christian College, Tambaram) . Similar work is carried out at Lucknow University and at the Indian Institute of Technology, Kharagpur. Interesting work is reported on the reaction between ketones and halogens and the salt effects (Saugar University). Reactions in the vapour phase and the kinetics of decomposition of metal alkyls, the kinetics of adsorption, isomerization and polymerization have also been studied (Loyola College, Madras). The kinetics of reactions in the solid phase, phase transformation and crystallization have also been studied (National Chemical Laboratory, Poona and the Atomic Energy Establishment, Bombay). Considerable amount of work on the kinetics of electrode processes has been carried out at different places (National Sugar Institute, Kanpur, Central Electrochemical Research Institute, Karaikudi and the Indian Institute of Technology, Powai). Kinetics of coagulation of colloidal systems have been studied in a number of laboratories in Calcutta, Bombay and Allahabad Universities and at the Indian Institute of Science, Bangalore.

Structural and Quantum Chemistry

This field has received considerable attention. An important line of investigation coming under this category is the application of quantum mechanical methods of the calculation of charge densities of polycyclic hydrocarbons (S. Basu et al., Calcutta). Other lines of investigations include the study of the influence of structure on optical rotatory power of salts of substituted aromatic acids and alkaloids at Saugar, the study of mixed liquid crystals and the effect of structure on their transition temperatures at Baroda and magnetism and molecular structure especially magnetic susceptibilities of organic compounds at Bombay and Gujarat. Another significant line of research has been the study of dipole moments and structure of organic compounds by S.K.K. Jatkar, Poona. Similar work on charge transfer in molecular complexes is carried out at the Indian Institute of Science, Bangalore.

Adsorption, Surface Phenomena and Catalysis

In view of rapid industrialization of India, the scope of contact catalysis need not be over-emphasized. Research on contact catalysis

in our country was first initiated by J.C. Ghosh in 1924 at Dacca. Since then, investigations in this field have been vigorously pursued by different workers. Among the active centres of research on catalysis in our country, the Indian Institute of Technology (Kharagpur), the Central Fuel Research Institute (Jealgora), the National Chemical Laboratory (Poona), the Indian Institute of Science (Bangalore), Loyola College (Madras) and Shri Ram Institute for Industrial Research (Delhi), are worth mentioning.

At present investigations on catalysis are carried out mainly on the following lines : (i) Studies on the physico-chemical properties of solid catalysts ; (ii) Investigations on various important catalytic reactions at normal pressure ; (iii) Catalytic reactions under high pressures ; (iv) Studies on the mechanism and kinetics of catalytic reactions and (v) Homogeneous catalysis.

The physico-chemical properties such as surface area, adsorption, pore-size distribution, surface structure, semi-conductivity, etc., of solid catalysts are very intimately related to their catalytic activity. Hence a number of workers in different parts of the country are concentrating their attention on this aspect of catalysis. In the field of adsorption, notable contributions have been made by J.C. Ghosh and S.K. Bhattacharya and coworkers. Studies on the chemisorption of gases on different catalysts are also pursued by G. Yeddanapalli and by M.R.A. Rao and coworkers. The application of X-ray diffraction to the study of solid catalyst structures has been investigated at the National Chemical Laboratory (Poona). Important investigations are being carried out at the National Chemical Laboratory, Poona, on the electron diffraction pattern of solid catalysts and also some catalyst clay samples. Other lines of investigation in the field of catalysis are measurement of magnetic properties of catalysts, semi-conductivity of oxide catalysts at the Indian Institute of Technology (Kharagpur), the National Chemical Laboratory (Poona) and the Research and Development Section of the Sindri Fertilizer Factory.

Thermodynamics

Though this branch of Physical Chemistry has not received the attention it deserves in India, in recent times there has been a growing interest in this field. In the Punjab University, work on different aspects of thermodynamics is carried out by R.P. Rastogi.

Electrochemistry

Electrochemistry is a favourite subject of research in our country and both the theoretical and practical aspects have been studied intensively by T.L. Rama Char (Bangalore), B.N. Ghosh (Calcutta) and K.S.G. Doss (Karaikudi).

Colloids and High Polymers

Various aspects of colloid chemistry and high polymer chemistry have been studied by different workers all over the country. Of these, special mention may be made of B.N. Bhosh, S. Basu and S.R. Palit at Calcutta. Work in this field is also carried out at Bangalore, Ahmedabad, Saugar, Allahabad and Delhi. Work in Chemical Spectroscopy is carried out at Cuttack, Hyderabad, Bangalore and Trombay.

Inorganic Chemistry Research

Much of the research work in Inorganic Chemistry going on in India is concerned with a study of complex ion reactions in solutions. Structural relationship of biguanide complexes and related compounds has been studied extensively during the last three decades by P. Ray and his coworkers at Calcutta. The subject of complex formation has been studied extensively at Allahabad (H.L. Nigam, A.K. De, S. Ghosh), Calcutta (N.K. Dutt, D. Bannerjee), Lucknow (M.R. Navar, C.S. Pande), Bombay (M.S. Mehta, M.K. Kabadi, B.C. Haldar), Delhi (B.D. Jain, R.P. Singh), Gorakhpur (R.C. Mehrotra) and Saugar (A.K. Bhattacharya). Work on the Chemistry of non-aqueous solvents particularly acyl halides has been initiated at Chandigarh (R. C. Paul) and on the synthesis of organic derivatives of metals and non-metals at Gorakhpur (R.C. Mehrotra). Solvent extraction techniques have been developed at Poona (J. Gupta) and at Bombay (J. Shankar) for the separation of rare earth elements.

Analytical Chemistry

Analytical Chemistry with particular reference to the estimations of various ions including those of rare earth elements has been subjected to considerable study in our country. Use of organic reagents in this connection may be mentioned as an important development. P. Ray (Calcutta) can be said to be the initiator in this field and two of the reagents suggested by him in early thirties, quinaldinic and rubeanic acids, have been the subject of numerous investigations in many important analytical laboratories of the world. The work has been continued extensively at Jadavpur (A.K. Majumdar) and Andhra (Bh. S.V. Raghava Rao).

Oxidation—reduction systems in volumetric analysis have been studied extensively at Waltair where a flourishing school of analytical chemistry (G, Gopala Rao) has been established. Almost all aspects of the redox system (particularly with ceric and vanadate salts) have been studied. Other centres active in this direction are at Chandigarh (Balwant Singh) and at Gorakhpur (J.P. Tandon).

Work on Adsorption Indicators initiated at Allahabad (R.C. Mehrotra) is being continued. Another important study carried out at Allahabad (I.K. Taimni) consists in the use of sulphide in quantitative estimations of a large number of common and uncommon cations and an extensive scheme for qualitative analysis of cations and anions has been suggested.

Nuclear and Radiation Chemistry

Nuclear and radiation chemistry is a comparatively new branch. Since work in this line requires special facilities, a few laboratories only have taken to this field so far. Atomic Energy Establishment, Trombay, is the major one in this respect where effort is made to develop processes for extension and purification of uranium, thorium and other elements of the actinide group, and to do research on the radiation chemistry of solvents to be used in the full scale plants which the Atomic Energy Commission is setting up.

Work on the extraction characteristics of protoactinium and the nature of the complexes it forms is also carried out at Trombay. Similarly, progress has been made on the study of the chemistry of plutonium and americium. At the Atomic Energy Establishment, the Tata Institute of Fundamental Research (Bombay) and the Saha Institute of Nuclear Physics (Calcutta) work is progressing on nuclear reactions, fission yields and decay schemes.

Recently increasing interest is being shown on the subject of radiation damage in crystalline solids which is of fundamental importance. An application of such studies is the effect of nuclear radiations on activity of catalysts and ion-exchangers.

A number of laboratories are engaged in work using radioactive isotopes as tracers. Work has been carried out on the adsorption kinetics in the micro and tracer concentration range (Banaras Hindu University). Mixed crystal formation and co-separation of thorium and rare earths with calcium sulphate using radioactive tracers are important lines of investigation in Calcutta (Saha Institute of Nuclear Physics).

Radioisotopes are in use for the study of corrosion of metals (National Chemical Laboratory, Poona). A new procedure of preparing high specific activity P^{32} has been worked out (Delhi University).

The lack of personnel trained in handling radioactive substances and radiation sources as well as of adequate facilities and equipment in many of the Indian Universities is responsible for the small volume of work turned out in our country. Isotopes will soon be available within the country and hence it is expected that our universities will then receive encouragement for this line of work.

Demand for Chemists in India

Before 1935, scope for the employment of chemists in our country was very small and only a few industries like sugar, cement and textiles were available. Many of the qualified chemists were more attracted by administrative posts because they were lucrative. However, the situation improved after the last World War when large developments of universities and research institutions like the National Laboratories and other organizations started. After Independence, the Five Year Plans started and these have facilitated the starting of new industries like coal, steel, fertilizers etc., and also offered much scope for chemists. The establishment of the Atomic Energy Commission and of Drug Development Projects have also contributed a considerable share in this respect. As a result of development of industries there is a phenomenal demand for chemists and hence there is an easy opening for trained chemists. The number of universities teaching chemistry as a science subject has been increasing and this has led to chemists being employed as teachers. Even from some of the foreign countries there is demand for Indian teachers and countries like the U.S.A., offer posts for Indian chemists and also assistantships in teaching and research, as a result of which some of the Indian workers have settled down in these countries, a situation which is not very healthy as far as the progress of our country is concerned.

4

Syllabi and Examination System

Existing Syllabi

Under-graduate Level: Even for the first degree in chemistry, there is no standardized course in the Indian Universities. Frequently distinction between B.Sc. (Hons.) and B.Sc. (Pass) is made. In certain universities this distinction makes little difference except that students who secure more than 50% marks are declared eligible for the award of the Honours degree. In others, there are two separate courses with separate syllabi. There is emphasis on specialization in one subject and in addition some universities have courses in one minor subject while in others there are two such minor subjects. Here again there are categories, viz., one requiring four years after matriculation and other five years. In general, the Pass course involves the study of three subjects all of which are of the same standard. There are some universities where only two science subjects are studied. There are others in which there is one major and two minor subjects.

Examining the details of the syllabus, the standards again seem to vary considerably. The B.Sc. (Honours) course as followed in the Delhi University (with six written papers and three practicals in chemistry) is comparatively a heavy course whereas it is less heavy in certain other universities. The B.Sc. (Pass) course varies much more considerably especially in the content of the practicals. These variations create difficulties when students migrate from one university to another. It is therefore necessary to lay down a standard syllabus which could, in general, be followed in all the universities in our country. The sub-committee of the Chemistry Review Committee has undertaken this task and its various recommendations are presented in this Chapter in detail.

Post-graduate Level: The M.Sc. degree is awarded in different universities based on very varying sets of standards. In some universities, the

submission of a thesis on a piece of research work is the sole criterion not only for pass in the examination but also to get a class. The University Grants Commission has requested the universities to give up this practice. In most universities, this is only in one branch of Chemistry. In a few like the Delhi University, specialization is comparatively smaller. Many universities permit a thesis in lieu of a written or practical examination. Here again there is an urgent need for some sort of a general standardization so that a graduate with M.Sc. degree may satisfy certain minimum requirements. In view of the large advances in the field of chemistry during the last few decades it seems to be necessary to train the students more by general courses with the minimum of specialization rather than by large specialization in branches, which should be left largely to the Ph.D. level.

Examination Systems

Examinations and examination systems have been the subject of discussions for several years. These seem to vary considerably not only from country to country but also frequently their different universities have different types of examinations. In general, it has been felt that final assessment at the end of a course should not be left to one examination. This would give scope for chance. The remedy may lie in holding more examinations and/or providing for assessment of sessional work. As in all other human endeavours, advantages and disadvantages exist here also in any system proposed or adopted. But when human agencies involved are of the right type and the moral code is high, the difficulties are at a minimum. Greater care in the selection of students and of the staff followed by intensive teaching, including tutorial work, will minimize failures in examinations and the standards will automatically go up. This will also create an atmosphere where better traditions can hold. At the same time there should be provision in the examination for personal and impersonal aspects and for full assessment of the capacity and training of the students. At the present time, in the science subjects there is provision for written examination, practical examination and in some cases oral also. Some marks are also allotted for the session records for laboratory work and the situation is not fully left to chance. Still there can be improvement in this system by giving more weightage to sessional work in regard to the written part of the examination.

The problem becomes less difficult in the post-graduate studies if centres are limited and are directly under the control of the universities. The sessional work in this case is easier to assess and moderation of the final examination results can be properly done.

In the Ph.D. course, the following points need consideration : (i) Limit to the number of students under each teacher; (ii) Time limit for the submission of the thesis; (iii) Eligibility of instructors and laboratories for the Ph.D. degree; (iv) Acquaintance with modern developments in the respective branches of chemistry, for example, in organic chemistry, developments like microanalysis, spectroscopy and instrumental analysis, and (v) Requirement of seminar lectures. The Ph.D. course could not be a mere training in a narrow line but should involve experience in a larger field. The test of competence should be broad-based and should involve understanding of fundamentals. It is, therefore, necessary that Ph. D. students should put in at least one year in a university teaching centre or a similar institution of higher learning where they can have ample scope for attending lectures and seminars and have discussions with larger groups.

For future development, there is great need for uniformity in standards and courses in various universities that are functioning. More attention should be given to the teaching of fundamentals of up-to-date chemistry and developing the understanding of chemical techniques. The lecture courses will be more useful if they are coupled with demonstrations of all possible types. Probably a great deal could be achieved by having conventions of college and university teachers to discuss teaching methods and examination systems. A journal devoted to this subject which will reach all the teachers will also be highly useful to pull up the level of teaching in our country.

RECOMMENDED SYLLABI

Under-graduate Level

At the B.Sc. level, the following syllabus is recommended and given in three forms, viz., (i) B.Sc. (General) for students who offer chemistry as one of the three science subjects which are given equal weightage; (ii) B.Sc. (Special) for those who have chemistry as the major and (iii) B.Sc. (Subsidiary) for those who offer any of the other science subjects as the major with chemistry as a minor (subsidiary) subject.

Recently there has been a tendency to create other types at the B.Sc. level. Probably they are introduced as experiments in education. For example, some universities have one science subject as the main, another as the subsidiary and a third as the auxiliary. Sometimes these auxiliary subjects are arts subjects. These create considerable confusion in the assessment of standards and pose difficulties in the migration of

students from one place to another which is inevitable in a country like ours. It is better that they are all brought at least under two major types : (i) B.Sc. (General) with three science subjects and (ii) B.Sc. (Special) with chemistry as major and two other science subjects as subsidiaries which will be useful for the main subject.

I. *Syllabus in Chemistry for B.Sc. (General) Course* (Equal weightage for all the three science subjects)

A. Physical Chemistry

Atomic Theory : Simple concept of atomic structure (Rutherford and Bohr models). Atomic number in relation to periodic classification. Simple ideas about isotopes and radioactivity.

Development of the concept of valency including a simple treatment of electronic theory of valency.

The Gaseous State of Matter: Ideal gases. Kinetic theory, Fundamental equation of the kinetic theory. Graham's law of diffusion. Deviations from gas laws. Specific heat. Vapour density and its determination. Molecular weight and thermal dissociation. Van der Waal's equation of state and critical phenomena. Continuity of state and law of corresponding states. Liquefaction of gases.

The Liquid State of Matter : Vapour pressure. Surface tension. Molecular weights of pure liquids. Viscosity. Relationship between physical properties and chemical constitution. Binary Liquid Mixtures—their miscibility and distillation; Nernst Distribution law, Henry's law.

The solid State : Elementary ideas about crystal structure.

Chemical Equilibrium : Reversible and irreversible reactions. Law of mass action, its applications to homogeneous and heterogeneous systems. Le Chatelier's principle and its applications. Phase rule as applied to mono-component systems.

Chemical Kinetics : Elementary ideas. Order of reaction and its determination in simple cases. Temperature coefficient, Energy of Activation.

Elements of Thermochemistry and Thermodynamics : Hess's law of constant heat summation. Heats of combustion, solution etc., Elementary ideas of the first law and second law of thermodynamics and some simple applications including derivation of Clausius-Clapeyron equation, Reaction isotherm and isochore. Definitions of Free energy and Entropy and their applications to define equilibrium condition of a system.

Catalysis : Criteria of catalysis. Homogeneous and heterogeneous catalysis. Autocatalysis. Catalytic poison. Enzymes as catalysts. Mechanism of catalytic reactions (elementary treatment only).

Solution : Solutions in general. Theory of dilute solutions. Osmosis and osmotic pressure. Lowering of vapour pressure and its relation with osmotic pressure. Elevation of boiling point and depression of freezing point and their laws. Experimental determination of molecular weights of solutes. Abnormal molecular weights.

Electrochemistry : Electrolysis and electrolytic dissociation. Faraday's laws of electrolysis. Arrhenius theory of electrolytic dissociation. Specific, equivalent and molar conductivity. Measurement of conductivity of solutions. Transport number. Kohlrausch's law. Strong and weak electrolytes. Degree of dissociation. Ostwald's dilution law. Solubility product and its application in analytical chemistry. Abnormality of strong electrolytes. Strength of acids and bases and the determination. Ionization of water. Ionic product of water. Hydrolysis of salts. Neutralization. Hydrogen ion concentration and pH. Determination of pH. Buffer solutions. Indicators and their theory. E.M.F. of simple electrochemical cells and half-cells including concentration cells. Standard electrode potential and its simple application to corrosion.

Colloidal State : Colloids and crystalloids. Classification of colloids. Preparation of colloids. Peptization. Lyophobic and Lyophilic colloids. Brownian movement. Cataphoresis. Coagulation of colloidal solutions. Optical properties of colloidal solutions. Protective colloids and gold number.

B. *Inorganic Chemistry*

Atomic Theory : Methods of determination of equivalent and atomic weights. Standard of atomic weights. Physical atomic weights. Double and Complex salts. Stability.

Periodic Classification of Elements : Historical development. Modern periodic table. Atomic number. Isotopes. Transition elements.

Comparative study of Elements : Groups Zero to VIII from the point of view of periodic classification with a detailed study of the following elements and their compounds.

Elements : Inert gases. Hydrogen. Lithium. Copper. Silver. Gold. Beryllium. Magnesium. Zinc. Cadmium. Mercury. Radium. Boron. Aluminium. Silicon. Titanium. Tin. Lead. Nitrogen. Phosphorus. Arsenic. Antimony. Bismuth. Oxygen. Sulphur. Chromium. Uranium. Halogens. Manganese. Iron. Cobalt. Nickel. Platinum.

Compounds: Hydrides, halides, oxides and oxy-acids of the non-metals mentioned above. Hydrides, halides, oxides, hydroxides, sulphides, sulphates, nitrates and carbonates of the metals mentioned above (Simple valence bond structures of oxides and oxy-acids and electronic structures of simple compounds are also included).

Chemical Principles Involved in the Manufacture of the following :

Sodium carbonate. Sodium hydroxide. Cement. Fuel gases. Glass. Pigments and paints. Ammonia. Nitric acid. Superphosphate. Artificial manures. Sulphuric acid. Potassium dichromate. Potassium permanganate. Bleaching powder.

Active nitrogen and fixation of nitrogen.

C. *Organic Chemistry* :

The growth and scope of organic chemistry. Purification of organic solids and liquids.

Analysis of organic compounds : Qualitative tests and quantitative estimation of carbon, hydrogen, nitrogen, halogens and sulphur. Determination of molecular weight of organic compounds. Empirical and molecular formulae.

Constitution and classification : Linking of carbon atoms. Classification of organic compounds. Homologous series. Nomenclature.

Aliphatic hydrocarbons : Alkanes upto and including four carbon atoms. Isomerism. Petroleum industry. Unsaturated hydrocarbons. Alkenes and alkynes upto four carbons atoms.

Halogen derivatives of alkanes: Methyl and ethyl halides. Reactions of alkyl halides. Dihalogen derivatives (ethylene and ethylidene derivatives). Trihalogen derivatives of methane. Carbon tetrachloride.

Alcohols: Preparation, manufacture and properties of alcohols. Constitution of alcohols. Primary, secondary and tertiary alcohols (upto four carbon atoms only). Fermentation.

Ethers : Preparation, properties and constitution of ethers. Metamerism. Diethyl ether.

Aldehydes and ketones : Preparation, properties and constitution of aldehydes and ketones. Formaldehyde, acetaldehyde, paraldehyde, chloral, acetone. Condensation and polymerization.

Fatty acids : Preparation, properties and constitution of fatty acids. Formic acid, acetic acid. Vinegar. Propionic acid, butyric acid.

Derivatives of fatty acids : Acid chlorides, preparation of acetyl chloride. Acid anhydrides, preparation of acetic anhydride. Amides, preparation of acetamide. Esters, preparation of ethyl acetate. Esters of organic and inorganic acids. Hydrolysis of esters. Elementary ideas of oils, fats and waxes.

Amines : Primary, secondary and tertiary amines. Quaternary ammonium compounds.

Cyanogen derivatives : Cyanogen, hydrocyanic acid. Nitriles and isonitriles.

Organo-metallic compounds : Compounds containing magnesium and their applications.

Derivatives of unsaturated hydrocarbons : Allyl derivatives. Acrolein and acrylic acid.

Polyhydric alcohols. Ethylene glycol. Ethylene oxide. Glycerol and its structure. Glycerol trinitrate.

Dibasic and tribasic acids : Preparation and properties of oxalic acid, malonic acid, succinic acid and citric acid including their structures.

Stereochemistry : Optical and geometrical isomerism. Isomerism of lactic, tartaric, maleic and fumaric acids. Their preparation, properties and constitution. Resolution of tartaric acids. Simple synthetic uses of malonic and acetoacetic esters.

Carbonic acid derivatives : Carbonyl chloride, urea.

Carbohydrates : Nomenclature. Glucose, fructose and their structures. Properties and manufacture of sucrose, starch and cellulose. Nitrocellulose.

Aromatic Hydrocarbons: Kekule's theory and constitution of benzene (excluding electronic structures). Aromatic properties. Coal tar distillation, Benzene, toluene and xylenes, their properties and reactions. Friedel and Craft's reaction, Fittig's reaction. Körner's absolute method of orientation.

Aromatic halogen derivatives: Monohalogenated derivatives. Chlorobenzene, bromobenzene, iodobenzene, Benzyl chloride, Benzal chloride, Benzotrichloride and their properties.

Aromatic Nitro Compounds: Nitrobenzene and trinitrotoluene and their preparation, properties.

Aromatic Amines: Preparation and properties of aniline, methylaniline, dimethylaniline, toluidines, benzylamine.

Diazo Compounds: Their preparation and properties (omitting constitution). Preparation and properties of phenylhydrazine and Methyl Orange.

Aromatic Sulphonic Acids: Benzene sulphonic acid, sulphanilic acid.

Phenols: Preparation and properties of phenol. Mononitrophenols, picric acid. Anisole.

Aromatic alcohols, aldehydes and ketones: Benzyl alcohol, benzaldehyde, acetophenone, benzophenone.

Phenolic Aldehydes: Salicylaldehyde. Reimer-Tiemann Reaction.

Aromatic acids and their Derivatives: Benzoic acid, benzoic anhydride, benzamide, benzoic esters. Phenylacetic acid. Cinnamic acid. Salicylic acid. Acetylsalicylic acid. Formation and simple properties of diphenylmethane and triphenylmethane.

Naphthalene and its simple derivatives. Pyridine and its simple derivatives.

D. Practicals

Qualitative analysis of mixtures containing six ions from the followings :

NH_4, K, Mg, Ca, Sr, Ba, Zn, Mn, Ni, Co, Al, Cr, Fe, Cu, Bi, Hg, Cd, As, Sb, Sn, Pb, Ag; Carbonate, Nitrite, Sulphide, Sulphite, Sulphate, Fluoride, Chloride, Bromide, Iodide, Nitrate, Acetate, Borate, Oxalate and Phosphate.

Acidimetry and alkalimetry. Iodimetry using sodium thiosulphate and sodium arsenite. Estimation of cupric and dichromate salts iodimetrically. Standardisation of permanganate using oxalic acid. Titration of ferrous iron using permanganate and dichromate. Argentimetry. Titrations against chloride and thiocyanate in neutral solutions.

Gravimetric estimation of copper, silver, lead, zinc, iron, chromium, barium, sulphate and chloride.

Systematic identification of the following organic compounds including the determination of their boiling or melting points wherever possible, detection of elements, application of tests characteristic of groups contained and of compounds themselves and preparation of at least one solid derivative in a pure condition : Benzene, toluene, naphthalene, methanol, ethanol, butanol, benzyl alcohol, ethylene glycol, glycerol, phenol, α-naphthol, β-naphthol, resorcinol, pyrogallol, o-cresol, m-cresol, p-cresol, hydroquinone, acetaldehyde, benzaldehyde, chloral hydrate, acetone, acetophenone, benzophenone, formic acid, acetic acid, oxalic acid, succinic acid, citric acid, tartaric acid, benzoic acid, salicylic acid, phthalic acid, cinnamic acid, ethyl acetate, ethyl oxalate, ethyl benzoate, methyl oxalate, methyl salicylate, phenyl benzoate, glucose, sucrose, starch, aniline, o-toluidine, p-toluidine, α-naphthylamine, β-naphthylamine, diphenylamine, dimethylaniline, urea, acetamide, benzamide, acetanilide, nitrobenzene, m-dinitrobenzene, p-nitrotoluene, α-nitronaphthalene, o-nitrophenol, p-nitrophenol, chloroform, carbon tetrachloride, iodoform, chlorobenzene, bromobenzene, p-dichlorobenzene and p-dibromobenzene.

II. Syllabus in Chemistry for B.Sc. (Special) course with Chemistry as Major subject.

A. *Physical Chemistry*

Physico-Chemical problems on topics covered by the syllabus.

Atomic Theory : Simple concept of atomic structure (Rutherford and Bohr models). Atomic number in relation to periodic classification. Simpler ideas about isotopes and radioactivity. Development of the concept of valency including a simple treatment of the elctronic theory of valency.

The Gaseous State of Matter: Ideal gases. Kinetic theory. Fundamental equation of the kinetic theory. Graham's law of diffusion. Deviation from Gas laws. Specific heat. Vapour density and its determination. Molecular weight and thermal dissociation. Van der Waal's

equation of state and critical phenomena. Continuity of state and law of corresponding states. Liquefaction of gases. Maxwell's distribution law (without derivation), Mean free path, Collision number etc., Dieterici's equation, Bertholet's equation, Limiting density. Avogadro number—its determination.

The Liquid State of Matter: Vapour pressure. Surface tension. Molecular weights of pure liquids. Viscosity. Relationship between physical properties and chemical constitution. Dipole moment (elementary), parachor, refractivity.

The Solid State: Elementary ideas about crystal structure.

Chemical Equilibrium: Reversible and irreversible reactions. Law of mass action and its applications to homogeneous and heterogeneous systems. Le Chatelier's principle and its applications. Phase rule as applied to mono-component systems. Application of phase rule to two component systems, Nernst's distribution law.

Chemical Kinetics: Elementary ideas. Order of reaction and its determination in simple cases. Temperature coefficient. Chemical Kinetics—mechanism of chemical changes, acid-base catalysis.

Elements of Thermochemistry: Hess's law of constant heat summation.

Thermodynamics: Elementary treatment of First and Second law. Carnot's cycle. Specific heat relations. Joule-Thomson effect. Kirchoff's equation. Clausius-Clapyron equation. Gibbs-Helmholtz equation. Concepts of entropy, free energy, Gibb's potential and their simple relations. Application of thermodynamics to simple problems of chemical equilibrium, dilute solutions, and e.m.f. of cells. etc.

Catalysis: Criteria of catalysis. Homogeneous and heterogeneous catalysis. Catalyst poisons. Enzymes as catalysts. Mechanism of catalytic reactions (elementary treatment).

Solutions: Solutions in general. Theory of dilute solutions. Osmosis and osmotic pressure. Lowering of vapour pressure and its relation with osmotic pressure. Elevation of boiling point and depression of freezing point and their laws. Experimental determination of molecular weights of solutes. Abnormal molecular weight.

Electrochemistry: Modern concepts of acids and bases. Redox potential, decomposition potential, polarisation, overvoltage. Electro-

lysis and electrolytic dissociation. Faraday's laws of electrolysis. Arrhenius theory of electrolytic dissociation. Specific, equivalent and molar conductivity. Measurement of conductivity of solutions. Transport number. Kohlrausch's law. Strong and weak electrolytes. Degree of dissociation. Ostwald's dilution law. Solubility product and its application in analytical chemistry. Abnormality of strong electrolytes Strength of acids and bases and their determination. Ionization of water. Ionic product of water. Hydrolysis of salts. Neutralization. Hydrogen ion concentration and pH. Determination of pH. Buffer solutions. Indicators and their theory. E.M.F. of electrochemical cells and half-cells. Temperature coefficient, Concentration cells, Standard Electrode Potential and its significance.

The Colloidal State: Colloids and crystalloids. Classification of colloids. Preparation of colloids. Peptization. Lyophobic and lyophilic colloids. Brownian movement. Cataphoresis. Coagulation of colloidal solutions. Optical properties of colloidal solutions. Protective colloids and gold number. Adsorption, Activated Adsorption, Freundlich equation, Langmuir equation, Monomolecular films, Deionisation of water.

Photochemistry (elementary ideas): Beer's law, Lambert's law, Einstein's law, Chain reaction.

B. *Inorganic Chemistry*:

Atomic Theory: Methods of determination of equivalent and atomic weights. Standard of atomic weights. Physical atomic weights.

Double and Complex Salts: Stability. Werner's theory of coordination compounds. Sidgwick's E.A.N.

Periodic classification of elements: Historical developments. Modern periodic table. Atomic number. Isotopes. Transition elements.

Comparative study of elements: Groups Zero to VIII from the point of view of periodic classification with a detailed study of the following and their compounds.

Elements: Inert gases, H, Li, Cu, Ag, Au, Be, Mg, Zn, Cd, Hg, Ra, B, Al, Si, Ti, Sn, Pb, N, P, As, Sb, Bi, S, Cr, U, O, Halogens, Mn, Fe, Co, Ni, and Pt.

Compounds: Hydrides, halides, oxides and oxy-acids of the non-metals mentioned above. Hydrides, halides, oxides, hydroxides, sulph-

sulphates, nitrates and carbonates of the metals mentioned above (Simpler valence bond structures of oxides and oxy-acids and electronic structures of simple compounds are also included).

Chemical Principles in the Manufacture of the Following: Sodium carbonate, sodium hydroxide, cement, fuel gases, glass, pigments and paints, ammonia, nitric acid, superphosphates, artificial manures, sulphuric acid, potassium dichromate, potassium permanganate, bleaching powder.

Reactions in liquid ammonia.

C. *Organic Chemistry*

The growth and scope of organic chemistry. Purification of organic compounds (solids and liquids).

Analysis of organic compounds : Qualitative tests and quantitative estimation of carbon, hydrogen, nitrogen, halogens and sulphur. Determination of molecular weights of organic compounds. Empirical and molecular formulae.

Constitution and classification : Linking of carbon atoms. Classification of organic compounds. Homologous series. Nomenclature.

Aliphatic hydrocarbons: Alkanes upto and including four carbon atoms. Isomerism. Petroleum industry. Unsaturated hydrocarbons. Alkenes and alkynes upto five carbon atoms.

Halogen derivatives of alkanes : Methyl and ethyl halides. Reactions of alkyl halides. Dihalogen derivatives (ethylene and ethylidene derivatives). Trihalogen derivatives of methane. Carbon tetrachloride.

Alcohols: Preparation, manufacture and properties of alcohols. Constitution of alcohol. Primary, secondary and tertiary alcohols (upto four carbons only). Fermentation.

Ethers: Preparation, properties and constitution of ethers. Metamerism. Diethyl ether.

Aldehydes and ketones: Preparation, properties and constitution of aldehydes and ketones. Formaldehyde, acetaldehyde, paraldehyde, chloral, acetone. Condensation and polymerization.

Fatty acids : Preparation, properties and constitution of fatty acids. Formic acid, acetic acid. Vinegar. Propionic acid, butyric acid.

Derivatives of fatty acids : Acid chlorides, preparation of acetyl chloride. Acid anhydrides, preparation of acetic anhydride. Amides, preparation of acetamide. Esters, preparation of ethyl acetate. Esters of organic and inorganic acids. Hydrolysis of esters. Elementary ideas of oils, fats and waxes.

Amines : Primary, secondary and tertiary amines. Quaternary ammonium compounds.

Cyanogen derivatives: Cyanogen, hydrogen cyanide, nitriles and isonitriles.

Organo-metallic compounds : Compounds containing magnesium and their applications.

Derivatives of unsaturated compounds : Allyl derivatives, acrolein and acrylic acid.

Polyhydric alcohols : Ethylene glycol, ethylene oxide, glycerol and its structure. Glycerol trinitrate.

Dibasic and tribasic acids: Preparation and properties of oxalic, malonic, succinic and citric acids including their structures.

Stereochemistry : Optical and geometrical isomerism. Isomerism of lactic acid, tartaric acid, maleic and fumaric acids. Their preparation, properties, and constitution. Resolution of tartaric acids.

Simple synthetic uses of malonic ester and acetoacetic ester.

Carbonic acid derivatives : Carbonyl chloride, urea.

Carbohydrates : Nomenclature, Glucose, fructose, their structures, properties and manufacture of sucrose, starch and cellulose. Nitrocellulose.

Aromatic hydrocarbons : Kekule's theory and constitution of benzene (excluding electronic structures). Aromatic properties. Coal tar distillation. Benzene, toluene and xylenes, their properties and reactions. Friedel and Craft's reaction, Fittig's reaction. Korner's absolute method of orientation.

Aromatic halogen compounds: Monohalogenated derivatives. Chlorobenzene, bromobenzene, iodobenzene, benzyl chloride, benzal chloride, benzotrichloride and their properties.

Aromatic nitro compounds: Nitrobenzene and trinitrotoluene and their preparation and properties.

Aromatic amines: Preparation and properties of aniline, methylaniline, dimethylaniline, toluidines and benzylamine.

Diazo compounds: Preparation and properties of diazo compounds (omitting constitution). Preparation and properties of phenyl hydrazine and Methyl Orange.

Aromatic sulphonic acids: Benzene sulphonic acid, Sulphanilic acid.

Phenols: Preparation and properties of phenol. Mononitrophenols. Picric acid, Anisole.

Aromatic alcohols, aldehydes and ketones: Benzyl alcohol, benzaldehyde, acetophenone and benzophenone. *Phenolic aldehydes*: Salicylaldehyde. Reimer-Tiemann reaction.

Aromatic acids and their derivatives: Benzoic acid, benzoic anhydride, benzamide, benzoic esters, phenylacetic acid, cinnamic acid, salicylic acid, acetylsalicylic acid. Formation and simple properties of diphenylmethane and triphenylmethane.

Naphthalene and its simple derivatives. Pyridine and its simple derivatives.

Simpler applications of electronic theory in elucidation of the course of organic reactions. Theory of resonance.

Elementary study of the following reactions with two examples in each case : (i) Reformatsky's, (ii) Michael, (iii) Hoesch and (iv) Gattermann.

Practicals:

Qualitative analysis preferably by semimicro technique of mixtures containing six ions from the following :-

NH_4, Na, K, Mg, Ca, Sr, Ba, Zn, Mn, Co, Ni, Al, Cr, Fe, Cu, Bi, Hg, As, Sb, Sn, Pb, Ag, carbonate, nitrite, sulphide, sulphite, sulphate,

flouride, chromate, chloride, bromide, iodide, nitrate, acetate, borate, oxalate and phosphate. (Sodium silicate may be included for training purposes).

Acidimetry and alkalimetry. Iodometry using sodium thiosulphate and sodium arsenite. Estimation of cupric and dichromate salts iodometrically. Standardization of permanganate using oxalic acid. Titration of ferrous iron using permanganate and dichromate. Argentimetry. Titrations against chloride and thiocyanate in neutral solutions.

Gravimetric estimation of copper, silver, lead, zinc, iron, chromium, barium, sulphate and chloride.

Systematic identification of the following organic compounds including the determination of their boiling or melting points wherever possible, detection of elements, application of tests characteristic of groups contained and of compounds themselves and preparation of at least one solid derivative in a pure condition :

Benzene, toluene, naphthalene, methanol, ethanol, butanol, benzyl alcohol, ethylene glycol, glycerol, phenol, α-naphthol, β-naphthol, resorcinol, pyrogallol, o-cresol, m-cresol, p-cresol, hydroquinone, acetaldehyde, chloral hydrate, acetone, acetophenone, benzophenone, formic acid, acetic acid, oxalic acid, succinic acid, citric acid, tartaric acid, benzoic acid, salicylic acid, phthalic acid, cinnamic acid, ethyl acetate, ethyl oxalate, ethyl benzoate, methyl oxalate, methyl salicylate, phenyl benzoate, glucose, sucrose, starch, aniline, o-toluidine, p-toluidine, α-naphthylamine, β-naphthylamine, diphenylamine, dimethylaniline, urea, acetamide, benzamide, acetanilide, nitrobenzene, m-dinitrobenzene, p-nitrotoluene, α-nitronaphthalene, o-nitrophenol, p-nitrophenol, chloroform, carbon tetrachloride, iodoform, chlorobenzene, bromobenzene, p-dichlorobenzene and p-dibromobenzene.

Organic preparations (about 8) involving simple reactions.

Determination of density of liquids and solutions. Surface tension by drop method. Viscosity using Ostwald's viscometer. Molecular weight determination by Victor Meyer's method. Partition coefficient and adsorption experiments. Preparation of buffer solution and determination of pH, Determination of solubility product, Conductometric titration.

III. Syllabus in Chemistry for B.Sc. (Subsidiary) course with Chemistry as minor.

Theory : The syllabus under theory is the same as that of B.Sc. Chemistry (General) as given on pages 22—26.

Practicals

Qualitative analysis of mixtures containing four ions (excluding insolubles) from the following :-

NH_4, K, Mg, Ca, Sr, Ba, Zn, Mn, Co, Ni, Fe, Al, Cr, Cu, Bi, Hg, Cd, As, Sb, Sn, Pb, Ag, carbonate, nitrite, sulphide, sulphite, sulphate, flouride, chloride, bromide, iodide, nitrate, acetate, borate, oxalate and phosphate.

Acidimetry and alkalimetry; iodometry using sodium thiosulphate and sodium arsenite. Estimation of cupric and dichromate salts iodometrically. Standardization of permanganate using oxalic acid. Titration of ferrous iron using permanganate and dichromate. Argentimetry. Titrations against chloride and thiocyanate ions in neutral solution.

Gravimetric estimation of copper, silver, zinc, iron, barium, sulphate and chloride.

Systematic identification of the following organic compounds including their boiling point or melting point determination, detection of elements, application of tests characteristic of the groups present and of the compounds themselves and preparation of at least one solid derivative in a pure condition :

Benzene, toluene, naphthalene, methanol, ethanol, butanol, benzyl alcohol, ethylene glycol, glycerol, phenol, α-naphthol, β-naphthol, resorcinol, pyrogallol, o-cresol, m-cresol, p-cresol, hydroquinone, acetaldehyde, benzaldehyde, chloral hydrate, acetone, acetophenone, benzophenone, formic acid, acetic acid, Oxalic acid, Benzoic acid, Succinic acid, Citric acid, tartaric acid, salicylic acid, phthalic acid, cinnamic acid, ethyl acetate, ethyl oxalate, ethylbenzoate, methyl-salicylate, phenyl-benzoate, glucose, sucrose, starch, aniline, o-toluidine, p-toluidine, α-naphthylamine, β-naphthylamine, di-phenylamine, dimethylaniline, urea, acetamide, benzamide, acetanilide, nitrobenzene, m-dinitrobenzene, p-nitrotoluene, ∝-Nitro-Naphthalene, o-Nitrophenol, p-nitrophenol, chloroform, carbon tetrachloride, iodoform, chlorobenzene, bromobenzene, p-dichlorobenzene, p-dibromobenzene.

Syllabus in Chemistry for the Post-graduate Course

For the M.Sc. degree, the syllabus that is recommended now is meant for a two-year course after the B.Sc. degree. In the first year of the M.Sc. course, the students will study all the three branches of chemistry, viz.,

organic, physical and inorganic chemistry and also carry out practicals in these three branches. The second year of the course will be devoted to the study of these three branches at a general level as far as the theory is concerned. In addition, the student will take any one of the above three branches as a special paper also for the theory. The practical work, however, in the second year will be confined only to the subject which is taken as the special paper.

Opinion was expressed by some members of the Chemistry Review Committee that it will be desirable to have radiochemistry also as part of the M.Sc. curriculum. To avoid narrow specialization, the Committee recommends that, in view of the importance of radiochemistry in the development of any country, this subject, viz. radiochemistry may be considered as a subject which may be specialized at the level of the second year of the M.Sc. course just as any one of the three branches mentioned above. Since opening of such a course (radiochemistry course) will involve much finance for special equipment etc., proper planning in the topics to be included in the syllabus may be needed. The syllabus for the radiochemistry course suggested in the sequel is a typical one year course like the inorganic, organic or physical chemistry course for the specialization in the second year.

First year of the M.Sc. Course

Syllabus in Organic Chemistry

Theory

Study and uses of aliphatic hydrocarbons including fuel industry. Natural and synthetic rubber. Synthetic plastics. Polythene and polyvinyl resins. Synthetic fibres.

General theories of organic chemistry. Valency. Addition and substitution reactions. Isomeric changes, molecular rearrangements. Mechanism of important organic reactions.

Stereochemistry of compounds of carbon, nitrogen and sulphur. Asymmetric synthesis. Racemisation. Epimeric change. Walden inversion.

Unsaturation and conjugation. Ketenes.

Chemistry of disaccharides (maltose, lactose, surcrose and cellobiose) and polysaccharides (starch, glycogen and cellulose).

Polypeptides and proteins. Synthesis, general properties and structure. General study of purines and pyrimidines.

Organic derivatives of phosphorus and arsenic.

Chemistry of diphenyl, anthracene, phenanthrene and polycyclic hydrocarbons.

Depsides and tannins.

Terpenes : Open chain, monocyclic and bicyclic (one member in each group).

Heterocyclic compounds containing nitrogen, oxygen and sulphur (derivatives of pyrrole, pyridine, furan and thiophene).

General study of alkaloids with special reference to those derived from benzene, pyridine and pyrrolidine (ephedrine, nicotine, coniine, cocaine and atropine). Synthetic dyestuffs.

Practicals :

General operations for the purifications of compounds. Preparation of organic compounds of an advanced type.

Identification of simple organic compounds by systematic procedure. Separation of compounds from two-component mixtures containing acidic, basic and neutral substances and their identification.

Quantitative determination of hydroxyl, amino, ester, amide and carboxyl groups. Estimation of aldehydes. Equivalent weight of an acid by the silver salt method and by titration.

Syllabus in Physical Chemistry

Theory :

States of Matter : Characteristic properties of solids. Crystallographic system and properties. Specific heat of solids. Theories of thermal and electrical conductivity.

Surface tension, refractive index, viscosity, structure of liquids. Dipole moments.

Kinetic theory. Gas laws. Maxwell's law of distribution. Equations of state. Theory of corresponding state. Compressibility. Liquefaction. J.T. Effect. Specific heats of gases. Viscosity and density.

Thermodynamics and thermochemistry : First law. Adiabatic and isothermal processes. Reversible and irreversible processes. Internal energy. Carnot's cycle. Thermodynamic scale of temperature. Laws

of radiation. Energy change ($\triangle H$, $\triangle E$ etc.) in a chemical reaction and its measurement. Kirchoff's law and its application in chemistry.

Second law. Entropy. Free energy, Activity. Partial and total heat quantities. Efficiency of natural processes. Changes in thermodynamic functions in different processes. Chemical and thermodynamic potentials. Clausius-Clayperon equation. Gibbs-Helmholtz equation. Applications of second law of thermodynamics in Chemistry.

Third law, Nernst's heat theorem. Derivation of the law and its applications.

Solutions : Dalton's and Henry's laws. Vapour pressure of a mixture. Partial molar quantities. Raoult's laws. Thermodynamics of dilute solutions, Osmotic pressure. Distillation. Gibbs-Duhem equation and its application. Solid solution. Solvation. Polarity.

Chemical equilibrium : Law of mass action. Determination of equilibrium constant. Effect of temperature and pressure. Le-Chatier-Braun principle. Reaction isotherm and isochore. Homogeneous equilibria in gaseous, liquid and solid systems. Heterogeneous equilibrium. Derivation of phase rule. Phase diagrams of important one, two and three components. Extraction.

Kinetics of chemical reactions : Order and molecularity of reactions. Typical examples of first, second and third order. Theories of reaction rates. Period of induction. Intermediate compounds. Acceptor and inductor molecules. Activation. Theories of catalysis. Physical and chemical adsorption. Promotors. Poisons. Industrial applications of catalysis. Chain reactions. Atomic reactions. Ionic reactions. Kinetics of heterogeneous reactions.

Practicals :

Determination of vapour density and viscosity of liquids and gases. Refractive index. Surface tension. Heat of solution and neutralization. Partition coefficient. Velocity of reactions. First and second order reactions. Chemical equilibrium study.

Preparation and coagulation of colloids. Cataphoresis. Adsorption studies. Column and paper chromatography. Ion exchange chromatography.

Photochemical measurements. Colorimetry. Spectroscopy. Absorption spectra.

Theory

Inert gases, hydrogen and hydrides, lithium, rubidium, caesium, beryllium, gallium, indium, thallium, scandium, yttrium, lanthanum, cerium, and rare earths, titanium, zirconium, hafnium, thorium, germanium, vanadium, niobium, tantalum, molybdenum, tungsten, uranium, selenium, tellurium, rhenium, ruthenium, rhodium, palladium, osmium, iridium, platinum.

A critical study of the periodic classification. Atomic structure. Electronic theory of Valency. Werner's coordination theory. Double and complex salts.

Radioactivity and atomic disintegration. Artificial radioactivity. Isotopes and isobars. Modern methods of atomic weight determination.

Semi-micro methods of analysis. Common organic reagents. Colorimetric analysis. Solvent extraction.

Redox titrations—the employment of chromous sulphate, titanous chloride, potassium bromate, alkaline permanganate, vanadate and ceric salts.

Adsorption and redox indicators.

Practicals

Semi-micro qualitative analysis of Inorganic mixtures containing not more than seven radicals in any combination from the following list :—

Ammonium, sodium, potassium, magnesium, calcium, strontium, barium, zinc, manganese, nickel, cobalt, aluminium, chromium, iron, copper, bismuth, mercury, cadmium, arsenic, antimony, tin, lead, silver.

Carbonate, nitrite, sulphide, sulphite, thiosulphate, sulphate, fluoride, chloride, bromide, iodide, nitrate, acetate, borate, oxalate, tartrate, arsenate, phosphate, ferro and ferri-cyanides, permanganate, chlorate and silicate.

Quantitative estimation of the following involving not more than one separation :—silver, lead, copper, aluminium, chromium, iron zinc, manganese, nickel, barium, calcium, magnesium, ammonium, carbonate, chloride, iodide, sulphate, phosphate, oxalate.

Analysis of the following minerals and alloys :—

Dolomite, calcspar, pyrolusite; Silver, nickel and brass coins. Available chlorine in bleaching powder.

Preparation of complex, unstable and hydrolysable inorganic compounds.

Second year of the M.Sc. Course :

Organic Chemistry (General)

Theory

Chemistry of quinones.

Flavones (chrysin), flavonols (quercetin), anthocyanidins (cyanidin) and xanthones (euxanthone).

Chemotherapy. Structure and physiological action. General study of synthetic drugs mainly belonging to the following major classes : antipyretics, narcotics, antiseptics and antimalarials, medicinal dyes.

Antibiotics and insecticides (a general study). Vitamins (vitamin A, thiamin, riboflavin, pyridoxine, niacin, ascorbic acid, vitamin D and tocopherols) and hormones (adrenaline and thyroxine). Sterols (cholesterol) and bile acids (cholic acid), Sesquiterpenes.

Alkaloids derived from quinoline (quinine), isoquinoline (papaverine) and phenanthrene (morphine).

Physical Chemistry (General)

Theory

Colloids : Preparation and classification. Physical, colligative, kinetic and electrical properties of colloids. Colloids. Colloidal electrolytes. Emulsion. Formation of liquid films. Adsorption.

Electrochemistry : Electrolytic conduction. Faraday'sl aws. Theories of electrolysis. Measurement of conductance and its applications. Primary and secondary cells. Different types of reversible electrodes and cells. Their theoretical treatment. Application of E.M.F. measurements. Irreversible phenomenon in electrochemistry. Polarization and overvoltage, and their importance. Indicators. Theory of acids and bases. Ionic equilibria. Hydrolysis. Solubility.

Polarography. Capillary electrometer.

Theories of strong electrolytes. Applications of electrochemistry in industry. Electrometallurgy and electroplating.

Photochemistry: Laws of absorption of light. Measurement of light absorption and its applications. First and second laws of photochemistry and their implications. Elements of theoretical and practical photochemistry.

Atoms and molecules: Structure of the atom. Fundamental particles. Different classical theories and experiments. Importance of Mosley's experiment. Isotopes and isobars. Atomic spectra. Combination of atoms. Molecular spectra. Elements of quantum mechanics and wave mechanics. Elements of nuclear structure.

Radioactivity: Natural radioactivity. Ra, Th and Ac series. Law of radioactive disintegration and its uses. Induced radioactivity. Methods and applications. Nuclear bombs.

Inorganic Chemistry (General)

Theory

Periodic table, its completion and extension. Chemistry of technetium, promethium, astatine, francium and trans-uranic elements.

Radioactivity, atomic disintegration, nuclear fission and fusion. Nuclear stability. Radioactive indicators. Isotopes and their separation. Radiochemical methods of analysis.

Abnormal valencies with particular reference to silver, gold, chromium, molybdenum, tungsten and nickel.

Fluorine and fluorocarbons. Interhalogen compounds and polyhalides. Pseudo-halogens and basic properties of iodine.

Polythionic acids.

Oxyacids of phosphorus and their behaviour as polyelectrolytes. Phosphorus chloronitrides.

Silicon hydrides and orthosilicates. Silicones and siloxanes. Silicic acid and silicates-their classification and structure.

Hydrides, oxides, oxyacids and organic derivatives of boron.

Peroxides and per-acids.

Reactions in non-aqueous solvents.

Stereochemistry of 6 and 4 coordination compounds.

Inner and polynuclear complexes.

Electrochemical methods of analysis.

Chromatography and ion-exchange.

SYLLABI IN THE SPECIAL SUBJECTS FOR THE M.Sc. COURSE
(To be done in the Second Year)

Syllabi have been indicated for only a few branches. The Universities could frame their own syllabi for branches of specialisation other than those given below :

I. *Organic Chemistry*

Theory

Use of acetylenic compounds in organic synthesis. Carotenoids (β-carotene).

Alkaloids (Colchicine, emetine and reserpine). Azulenes and tropolones (one typical member in each).

Chemistry of oxytocin and insulin.

Chemistry of nucleotides and nucleic acids.

Synthesis of porphyrins. Structure of chlorophyll, haematin and vitamin B_{12} (a general study). Chemistry of coenzymes.

Sex hormones : Oestrone, androsterone and progesterone. Synthetic oestrogens. Cortex hormones (deoxycorticosterone and cortisone). Diterpenes and triterpenes (one example in each).

Cardiac glycosides (digilanides, strophanthin and scillaren A).

Antibiotics : Penicillin, streptomycin, chloramphenicol, tetracyclines and macrolides (one example only).

Natural insecticides (pyrithrins and rotenone). Naturally occuring benzoquinones, naphthaquinones and anthraquinones (one important example in each). Free radicals. Mechanism of polymerizations. Recent trends in synthetic organic chemistry. Use of the following reagents in synthetic organic chemistry.

Lithium aluminium hydride, sodium borohydride, N-bromosuccinimide, lead tetra-acetate, periodic acid, alkali metals in liquid ammonia, diazomethane and organo-lithium compounds.

Physical properties and chemical constitution :

A general study of U.V., I.R. and N.M.R. spectra as applied to organic structures. Dipole moments. Optical rotatory dispersion.

Practicals

Preparations : Preparation of organic compounds involving two or three stages and based on reactions like Hoesch reaction, Fries migra-

tion, Pechmann condensation, Friedel and Craft's reaction, Grignard reaction, Reformatsky reaction, Diels-Alder addition and diazo reaction.

Use of special equipment for small scale preparations. Semi-micro preparations. Resolution of racemic mixtures by chemical method.

Special techniques. Paper chromatography. U.V. and I.R. spectra. Catalytic hydrogenations. Periodate titrations. Molecular weight by Rast's method.

Qualitative analysis : Identification of difficult compounds containing not more than two functional groups.

Quantitative analysis : Semi-micro determination of carbon, hydrogen, nitrogen and halogens. Semi-micro estimation of carboxyl, methoxyl and acetoxyl groups. Determination of unsaturation. Estimation of sugars.

II. *Physical Chemistry*

Theory

Quantum mechanics and its applications :

Limitations of old quantum theory. Heisenberg's uncertainity principle. Origin of wave mechanics based on the analogy between optics and mechanics (semi-quantitative treatment). de Broglie relation. Electron diffraction. Dual nature of light and matter. Reconciliation in wave and particle aspects. Schroedinger equation for a particle in a box. Quantization of wave mechanics. Schroedinger equation for linear hormonic oscillator. Solution by the polynomical methods. Schroedinger equation for the hydrogen atom. Separation of variables and indication of the method of solution. Discussion of spherically symmetrical solutions of the wave equation of the hydrogen atom considered as one body problem. Angular momentum and its directional quantization. Problem of two electrons. Exchange degeneracy. Elements of perturbation theory. Exchange energy of helium atom. Electron spin. Hydrogen molecule. Valency. Resonance. Periodic system of elements.

Elementary statistical thermodynamics :

Maxwell-Boltzmann statistics. The distribution law. Maxwell's law of distribution of velocities. Entropy and probability. Partial functions. The translational entropy. Free energy. Pressure and specific heat of a perfect monatomic gas. Partition function of a monatomic crystal. Einstein's theory of specific heats.

Diffraction of X-*rays and electron waves by crystals*:

Determination of the dimensions of a unit cell and spacings of atomic planes. Bragg method, powder method and rotating crystal method. The reciprocal lattice and its use in structural analysis. Electron diffraction studies of thin films.

Electrochemistry: The Debye-Hückel-Onsager theory of conductance. The Wien effect. Activity coefficients, their measurement and formulation from the point of view of Debye-Hückel theory. Electrocapillary curve of mercury and its interpretation. Theory of polarographic analysis. Electrokinetic phenomena. Zeta potential and electrical double layer. Relation between zeta potential and Nernst's electrode potential. Electrochemistry of colloids. Colloidal electrolytes.

Practicals

Conductivity and cell constant. Electrochemical equivalent. E.M.F. of cells. Transport number. pH of a solution. Solubility and solubility product. Buffer capacity.

Conductometric titrations. Acid-base precipitation and complex salts. Potentiometric titrations: Acid-base, oxidation-reduction. Bimetallic electrodes.

Polarography: Half-wave decomposition potential of a common complex. Amperometric titrations.

Phase diagram of (i) two component systems, eutectic system, mutual solubility; (ii) three component system, three liquid system. Determination of transition temperature, solubility and cooling curve.

Calibration of thermocouple.

X-ray analysis of simple cubic system.

III. *Inorganic Chemistry*

Theory

Modern concept of valency, different types of bonds including odd electron and metallic bonds. Elementary treatment of quantum theory of valency and applications of wave mechanics to valency. Electronegativity. Resonance and its applications to inorganic compounds. Hydrogen bond and its applications.

Structural Inorganic Chemistry. Experimental methods. Size, shape and structure of some characteristic compounds.

Complex salts. Formation constants and their determination. Chelation. Complexones.

Coordination compounds. Field ligand theory. Magnetic and special properties.

Alloys and intermetallic compounds. Phase rule studies. Hume Rothery rules. Corrosion and passivity of metals.

Interstitial and non-stoichiometric compounds; a detailed study of carbides, silicides and nitrides.

Free radicals and intermediate compounds in inorganic reactions. Iso and hetero-polyacids.

Carbonyls and nitrosyls.

Organometallic compounds, methods of formation, properties and stability. Ferrocenes.

Metal alkoxides and silyloxides, preparation, properties and hydrolysis. Inorganic polymers.

Thermogravimetric and differential thermal analysis.

Practicals

Qualitative semi-micro analysis of inorganic mixtures containing not more than 8 ions including all those prescribed in M.Sc. Ist Year syllabus together with thallium, tungsten, molybdenum, selenium, tellurium, cerium and lithium.

Complete analysis of dolomite, cement, felspar, brass, phosphor bronze, solder and white metal. Separation and estimations of silver, lead, copper, bismuth, arsenic, antimony, tin, aluminium, zirconium, thorium, cerium, iron, zinc, manganese, nickel, calcium, strontium, barium, ammonium, chloride, bromide, iodide, sulphate, oxalate, chromate, permanganate.

Simple colorimetric estimations.

Electrolytic estimations of metals.

Measurement of pH of solution and simple electrometric titrations.

Estimations by flame photometry.

Simple exercises involving polarographic analysis.

Preparation of complex salts and unstable inorganic compounds.

IV. *Radiochemistry* :

Theory

Historical development of nuclear theory.

Current picture of nuclear structure, properties of nucleons, nuclear binding energy, nuclear forces, energy levels in nuclei, stability rules.

Radioactive decay processes, equations for decay and growth of radioactive substances. Theories of alpha and beta decay.

Interaction of radiation with matter. range and energy determination of alpha and beta particles. Energy determinations of gamma rays, X-rays, positrons and neutrons.

Detection of radiation; types of detection instruments ; Geiger-Muller tube and types characteristics of; scaling unit, high voltage power supply, ratemeters, survey meters, calibration of counting equipment.

Errors in radioactivity measurements, review of distribution law, radioactive decay as a random process, calculation of standard deviation in counting.

Induced nuclear reactions, reactions with charged particles and neutrons, conservation of energy and momentum, potential barrier, reaction threshold, cross section, excitation function, Oppenheimer-Philips process, spallations, fission process, nuclear chain reactions. Machines which produce charged particles and neutrons.

Nuclear reactors.

Principles of separation and identification of radioactivities from irradiated or naturally occurring substances, precipitation methods, isotopic and non-isotopic carrying, electrodeposition, ion exchange, solvent extraction, adsorption, volatilization.

Chemical effects of nuclear reactions and their physical basis; neutron capture, isometric transition ; other reactions.

Radiations, Radiolysis of aqueous solutions.

Survey of natural radioactivities, heavy radio-elements and other naturally occurring radioactive substances, natural series, artificial series.

Production, chemical properties and place in the periodic table of the new synthetic elements.

Radiation protection, hazards associated with the various types of radiations, shielding, dosage, biological effects of radiation.

Applications of radioisotopes in analytical chemistry.

Tracer chemistry.

Cosmic problems.

Practicals:

(These practicals will pertain to students offering radiochemistry as the special subject and inorganic, organic and physical chemistry as general subjects).

Use of radiation survey equipment, calibration of survey meters. shielding study.

Preparation of sources for counting and of targets for irradiation.

Determination of plateau and effective geometry of Geiger-Muller tube.

Measurement of resolving time of the instrument.

Investigation of errors in radioactive measurements.

Determination of half life of a radioactive sample. Analysis of complex decay curves.

Determination of counting efficiency of the G.M. counter.

Range and energy determination of beta particles by absorption in aluminium and by Feather's comparison methods.

Determination of back-scattering, self-scattering and self-absorption effect.

Determination of gamma ray energies by absorption in lead.

Determination of gamma ray sensitivity of a G.M. counter.

Chemical dosimetry for gamma rays.

Absolute measurement of beta sources with the calibrated counter.

Measurement of total number of thermal neutrons present in a volume of water.

Estimation of an element by the method of isotope dilution. Separation of U_{x-1} from uranyl nitrate. Separation of Ba^{140} and La^{140} by carrier precipitation. Preparation and use of an ion exchange column. Preparation of I^{128} by Szilard-Chalmers reaction. Detection and quantitative estimation of an element by neutron activation method. Electro-deposition of active materials.

Determination of linearity and sensitivity of Lauritsen electroscope, comparison of sensitivity with that of G.M. counter.

5

Future Lines of Development in Chemistry

While recognizing the help given by the University Grants Commission to laboratories and libraries during recent years, it must be mentioned that, by and large, our standards of teaching and research are not comparable to these in other advanced countries and that our country's attention should be directed to improve the situation. The Chemistry Review Committee feels that certain improved facilities like the establishment of centres of intensive research should be considered.

We have, in our country, a number of research schools in chemistry at the Universities but few compare favourably with laboratories in advanced countries. The University Grants Commission has so far given grants on a generalized basis to different universities. This is naturally necessary since all the Universities should reach a minimum standard of efficiency. At the same time it is advisable to have some degree of selection. Those research centres which are specially active and have already distinguished themselves in research should be given special consideration so that they can serve as central laboratories for advanced research work. It may not be possible to take up a number of laboratories immediately for this purpose. But some at least should be raised to the status of premier centres for chemistry research and effort should be made to bring them up to an international level.

In order to encourage the research work done in different centres there should be provision to have visiting professors from other places. Holding of frequent symposia and properly organized Summer Schools in chemistry may be highly useful.

There seem to be difficulties in publishing the results of research work with the minimum of delay. Some workers find that publication of papers become prohibitively costly, particularly with regard to the reprints etc. The University Grants Commission should help in this

direction by giving suitable grants, or by agreeing to meet the expenditure incurred. Another difficulty seems to be that many of the Indian Journals publishing research papers in chemistry are little known outside the country. Though some of these are abstracted in the Chemical Abstracts, a number of investigations get duplicated in other laboratories due to lack of publicity of the journals. It appears to be highly desirable to have a single journal devoted to chemistry rather than a number of journals undertaking the publication of the same type of research papers. Efforts should be made to have an Indian Journal of Chemistry whose editor should be advised by a Committee of experts and whose object should be to keep a high standard not only in its form but also in the quality of the papers published. Too long a time lag between the dates of communication of a paper and of its publication should be avoided. An effort in this direction is urgent and should be made in collaboration with the Council of Scientific and Industrial Research, New Delhi, which is already in charge of a number of publications.

There are certain special requirements of chemistry departments, particularly those engaged in research work, such as a constant temperature room, cold room, rooms for spectroscopy, chromatography, X-ray work, micro-analytical laboratory and radioactivity room for carrying out experiments in radiochemistry. For this, provision must be made in the departmental budgets. Organic chemistry departments which are engaged in plant chemistry research usually need processing rooms. In addition, large quantities of solvents are needed for extraction of plant materials and special grants should be allotted for these.

From the data available to the Chemistry Review Committee, it was noted that the number of students admitted to post-graduate course varied widely from university to university and from institution to institution and many often did not have any consideration for facilities necessary to give efficient training. It would, therefore, be necessary to lay down limits regarding the maximum number of students per unit and also the qualifications for admission. The maximum should preferably be a batch of 20 students and if it is very essential in certain places to have a second batch, then such a department can admit two units of 15 students each. The admission to M.Sc. degree courses should be restricted to only selected students who obtain high marks in the aggregate and also in chemistry. Those who offer biology in addition to physics and chemistry at the undergraduate level may be trained in mathematics to the extent necessary. In Colleges, chemistry departments are generally very poorly equipped, particularly for the post-graduate cours-

es, and therefore strict conditions should be laid down regarding the facilities to be provided to the students before the college is permitted to start the M.Sc. course. It will be better to have the post-graduate teaching confined to the university departments while the colleges look after the undergraduate teaching.

At the Ph.D. level, the number of years taken by a student to complete the work for the degree varies from university to university. In some cases the students prolong even upto 10 years. It would be desirable to put a maximum period within which the work should be completed. It is recommended that 5 years may be the maximum period for this. It is considered by this Committee that a candidate before qualifying for the Ph.D. degree should appear for a written examination in the subject which forms the special line for this degree. Further, there should be an oral examination also. They should give seminars from time to time and also attend a minimum number of seminars. More attention should be given for a wider training than in a narrow research scheme. They should also put in a minimum of one year in a teaching department of a University.

The present system of comprehensive examination at the end of three years for the B.Sc. level and for the M.Sc. is rather unsatisfactory. The introduction of several tests during the year to be conducted by the teachers-in-charge should be favoured. Forty percent of the total marks for any course should be assigned to these tests and the rest to the more comprehensive final examination.

The teacher-pupil ratio at present is not satisfactory and needs improvement. Similarly the ratio between the senior and junior teachers should be brought roughly to 1 : 1. For a large chemistry department having the responsibility of post-graduate teaching there should be a senior teacher (professor or reader) for each of the following subjects, viz. organic chemistry, inorganic chemistry and physical chemistry. In certain special fields wherever facilities are made available a senior teacher should be appointed for that field.

It is obvious that no real improvement or advancement in chemistry can be brought about unless there are well-trained teachers. For this, proper attention should be paid to inservice training of teachers. To meet this, the Symposia and Summer Schools mentioned earlier will be helpful. The load of teaching staff at the universities who are in charge of post-graduate teaching and who conduct research work should be reduced to a maximum of 14 hours per week (both lectures and practicals combined).

Regarding the time to be devoted by the students in Theory as well as in Practicals, it is recommended that (i) B.Sc. (General) having all the three Science subjects on equal weightage should put in a minimum of 100 hrs. of lecture and 100 hrs. of practicals per year of the three year course; (ii) B.Sc. (Special) having chemistry as a Major subject should have on an average minimum of 150 hrs. of lecture and 200 hrs. of practicals per year of the three year course and (iii) B.Sc. (Subsidiary) with chemistry as a minor subject should have a minimum of 100 hrs. of lecture and 100 hrs. of practicals each year of the two year course.

The Head of the Chemistry Department in a University has to spend considerable part of his time to routine administrative work. To make him comparatively free from the routine work and to enable him to devote more time to guide research workers, it is recommended that each department should have an Administrative Secretary to help the Head of the Department.

6

Summary of Recommendations

1. Model syllabi for undergraduate and post-graduate courses are recommended in order to improve the standard of training in chemistry. The B.Sc. syllabus is given in three forms, viz., (1) B.Sc. (General) for students who offer chemistry as one of three science subjects of equal weightage; (ii) B.Sc. (Special) for those who have chemistry as the major, and (iii) B.Sc. (Subsidiary) for those who offer any other science subject as the major with chemistry as a minor subject.

2. M.Sc. course in Chemistry will be two-year course after the B.Sc. degree. In the first year of the M.Sc., a student be expected to study organic, inorganic and physical chemistry and also carry out practical work in these three branches. The second year of the M.Sc. course will be devoted to the study of these three branches at a general level as far as the theory is concerned. In addition, there will be a special paper in any one of the three branches. The practical work, however, will be confined only to the subject which will form the special subject.

3. Radiochemistry may be introduced at the second year of the M.Sc. course as one of the special subjects, i.e. as an elective subject. The syllabus for this course is also recommended.

4. In order to raise the standard of teaching, lectures should be coupled with demonstrations of all possible types. Holding conventions of college and university teachers to discuss teaching methods and examination systems may be highly useful. A journal devoted to this subject and capable of reaching all the teachers will be useful to pull up the level of teaching.

5. Due recognition should be given to sessional tests in assessing the capacities of students so as to reduce the dependence on one comprehensive annual examination at the end of the course. In order to do this, it is recommended that 40% of the total marks may be allotted to sessional tests.

6. A maximum time limit of 5 years is recommended for completing the work for the Ph.D. degree. Candidates for this degree besides submitting a thesis should also appear for a written as well as an oral examination. They should give seminars from time to time and also attend a certain minimum number of seminars. They should put in a minimum period of one year in a teaching department of a University.

7. It is considered that post-graduate course should be confined to university departments while the colleges may take care of under-graduate teaching.

8. Research centres which are specially active and which have already distinguished themselves in research should be raised to the status of premier centres of chemistry research and efforts should be made to bring them to an international level. The centres which are under-developed should be financially helped so as to come to a higher standard.

9. There should be arrangement for Visiting Professors.

10. Organization of frequent Symposia and Summar Schools may help in the promotion of chemistry research in our country.

11. To raise the standard of publication of research papers and to avoid time lag between dates of communication and of publication of research papers, it is recommended that a single journal under the name 'Indian Journal of Chemistry' may be started in collaboration with the Council of Scientific and Industrial Research, New Delhi, which is already in charge of a number of publications.

12. Special requirements of chemistry laboratories particularly engaged in research work may be considered and grants may be made available for these.

13. The teacher-pupil ratio may require improvement. The teaching load of those who are engaged in post-graduate teaching and research should not be more than 14 hours per week. The ratio between senior and junior teachers should be brought to roughly 1 : 1. Large chemistry departments having the responsibility of post-graduate teaching should have a senior teacher (professor or reader) in each of the three branches, viz. organic, inorganic and physical chemistry and one in certain special fields for which facilities are available (e.g. nuclear chemistry).

14. To make the Head of the Chemistry Department free from routine administrative work, an Administrative Secretary may be appointed in the University Department.

APPENDIX I

List of universities and colleges providing teaching and research facilities at postgraduate level and their students enrolment and major areas of research in chemistry

Universities and their affiliated colleges	*Major area of interest in chemistry (if available)*	*Enrolment at postgraduate level* (1962-63) (as per information available)	
1	2	3	
		M.Sc.	Ph.D.
1. *Agra University*	No University Department		
(a) Agra College, Agra	Inorganic Chemistry	51	5
(b) B.R. College, Agra	Organic Chemistry	36	3
(c) Bareilly College, Bareilly	Organic Chemistry	36	—
(d) Christ Church College, Kanpur	—	16	—
(e) D.A.V. College, Dehra Dun	—	41	6
(f) D.A.V. College, Kanpur	(i) Organic Chemistry (ii) Physical Chemistry	103	11
(g) D.S.B. College, Nainital	(i) Optical activity and organic synthesis (ii) Plant Chemistry (iii) Chemical Kinetics	30	3
(h) D.A.V. College, Muzaffarnagar	—	16	—

1	2	3	
(i) D.S. College, Aligarh	—	35	—
(j) Jat Vedic College, Baraut	—	25	—
(k) M.M.H. College, Ghaziabad	—	8	—
(l) Meerut College, Meerut			
	Organic Synthesis, Plant Chemistry and Synthetic drugs	49	—
(m) M. Modi College, Modinagar	—	12	—
(n) St. John's College, Agra	Organic Chemistry Physical Chemistry	23	3
2. *Aligarh Muslim University* Univ. Deptt., Aligarh	(i) Synthetic Organic Chemistry (ii) Chemistry of Plant Products	68	25
3. *Allahabad University* Univ. Deptt., Allahabad	Analytical Chemistry	86	76
4. *Andhra University* Univ. Deptt., Waltair	—	29	30
5. *Annamalai University* Univ. Deptt., Annamalainagar	—	33	8
6. *Banaras Hindu University* Univ. Deptt., Varanasi	—	82	32
7. *Baroda University* Univ. Deptt., Baroda	(i) Synthetic Org. Chemistry (ii) Liquid Crystals	50	5

1	2	3	
8. *Bihar University*	—	59	—
9. *Bombay University*			
(a) Bhavan's College, Bombay	—	7	—
(b) D.E. Society's Kiati College, Dadar, Bombay	—	1	—
(c) D.G. Ruparel College, Matunga, Bombay	—	17	—
(d) D.H. National W.A. Science College, Bombay	Polarography Membrance Potential	23	2
(e) Institute of Science, Bombay	—	45	16
(f) Jai Hind College, Besant Singh Institute of Science, Bombay	—	8	—
(g) K.J. Samaiya College, Bombay	—	6	—
(h) Khalsa College, Bombay	—	12	—
(i) Kishin Chand Chella Ram College, Bombay	—	12	—
(j) Parle College, Vile Parle, Bombay-7	—	8	—
(k) Ramnarain Ruia College, Matunga, Bombay-19	—	18	2
(l) Siddarth College of Arts & Science, Bombay	—	6	—

1	2	3	
(m) S.I.E.S. College of Arts & Science, Bombay	—	10	—
(n) St. Xavier's College, Bombay	Organic Chemistry	10	4
(o) Wilson College, Bombay	—	8	—
10. *Burdwan University*	—	36	—
11. *Calcutta University* Univ. Deptt., Calcutta	—	78	33
12. *Delhi University*	(1) Organic Chemistry : Chemistry of Natural Products (2) Physical Chemistry (3) Analytical Chemistry	58	60
13. *Gauhati University*	—	32	2
14. *Gorakhpur University*	—	60	24
15. *Gujarat University*			
(a) Bahuddin College, Junagadh	—	11	—
(b) Dharmendra College, Rajkot	(1) Synthesis of Hetero-cyclic compounds	22	—
(c) J & J College of Science & C.B. Patel Institute, Nadiad	(2) Stereochemistry	26	—
(d) M.N. College, Visnagar	—	12	—
(e) Sameldas College & Sir P.P. Institute of Science, Bhawnagar	—	13	—

1	2	3	
(f) Sarvajanik College of Science, Surat	—	49	—
(g) Shai N.K. MSc. & Arts College, Bulsar	—	23	—
(h) St. Xavier's College, Ahmedabad	—	—	4
16. *Jabalpur University*			
1. Univ. Deptt.,	(1) Analytical Chemistry	77	7
2. Mahaboshal Maha Vidyalaya Jabalpur	(2) Chemical Kinetics		
17. *Jadavpur University*	(1) Electro-chemistry	18	3
	(2) Colloids		
	(3) Photo-chemistry		
	(4) Steroidal compounds		
18. *Jammu & Kashmir University*	—	16	—
19. *Jodhpur University*	—	37	—
20. *Kalyani University*	—	23	—
21. *Karnatak University*	Synthetic Organic Chemistry	102	7
22. *Kerala University* Univ. Deptt.,	—	86	1
(a) C.M.S. College, Kottayam	—	13	—
(b) Maharaja's College, Ernakulam	—	15	—
(c) Sacred Heart College, Thevara (Ernakulam)	—	6	—

1	2	3	
(d) St. Thomas College, Trichur	—	14	—
(e) Sree Narayana College, Quilon	—	15	—
(f) University College, Trivandrum	—	24	1
23. *Kurukshetra University*	—	55	—
24. *Lucknow University*	—	118	78
25. *Madras University* Univ. Deptt.	—	24	10
(a) American College, Madurai	—	26	—
(b) Loyola College, Madras	(1) Adsorption & Catalysis (2) Condensation Polymerisation. (3) Mechanism of Reactions in Solution (4) Protein Chemistry	26	9
(c) Madurai College, Madurai	—	29	—
(d) Madras Christian College, Tambaram	—	27	3
(e) Pachaiyappa's College, Madras	—	28	5
(f) Presidency College, Madras	—	23	—
(g) St. Joseph's College, Madras	—	26	—
(h) Vivekananda College, Madras	—	23	—
26. *Marathwada University*	—	18	—

1	2	3	
27. *Mysore University* Univ. Deptt., Central College, Bangalore	—	60	—
28. *Nagpur University*	—		
(a) College of Science, Nagpur	—	29	2
(b) Vidarbha Mahavidyalaya, Amraoti	—	16	—
29. *Osmania University*	(1) Synthetic Organic Chemistry	54	14
	(2) Work on Plant Products		
	(3) Physico-Chemical Work		
30. *Panjab University* Univ. Deptt. Chandigarh	Organic Chemistry	42	25
(a) Khalsa College, Amritsar	—	7	3
31. *Patna University*	—	80	
32. *Poona University*	(1) Electrochemistry	145	6
	(2) Microchemistry		
	(3) Nuclear Chemistry		
33. *Rajasthan University* Univ. Deptt., Jaipur	—	32	12
(a) Birla College of Science, Pilani	—	23	4
(b) Govt. College, Ajmer	(1) Polarography	29	7
	(2) Kinetics in solution		
(c) Govt. College, Kota	—	23	1
34. *Ranchi University*	—	18	—
35. *Roorkee University*	—	19	—

1	2	3	
36. *S.V.V. Peeth*	—	44	6
37. *Saugar University*	(1) Complex salts	55	13
Univ. Deptt.	(2) Studies on sulphur compounds		
(a) Govt. College of Science, Raipur	—	36	1
(b) Govt. Degree College, Shahdol	—	10	—
(c) Maharaja College, Chhatarpur	—	30	—
(d) Thakur R.S. College, Rewa	—	27	—
38. *Sri Venkateswara University*	(1) Analytical Chemistry (2) Thermodynamics	31	2
39. *Utkal University*	—	—	—
(a) Ravenshaw College, Cuttack	(1) Organic (2) Inorganic	63	—
40. *Vikram University* : Univ. Deptt.	—	60	2
(a) Holkar Science College, Indore	—	65	2
(b) Govt. Science College, Gwalior	—	56	—
(c) Govt. Degree College, Ratlam	—	20	—
(d) Govt. Degree College, Guna	—	14	—
(e) Govt. Degree College, Mandsaur	—	21	—
(f) Motilal Vigyan Mahavidyalaya, Bhopal	—	23	—

APPENDIX II

Theses Accepted in Chemistry (1955-60)

(Information available is given; the list is not expected to be comprehensive)

University	*No.*	*Title of Thesis*	*Written by*	*Year of award*	*Degree Awarded*
1	2	3	4	5	6
1. *Agra*	1.	Reactivity of Nuclear Chlorine in some Benzene Derivatives.	S.P. Gupta	1955	Ph.D.
	2.	(i) Condensations of Aromatic Aldehydes with β-keto esters.	R.B. Pandya	1955	Ph.D.
		(b) Condensations of Salicylaldehydes with Malonic Acid			
	3.	Electrode Phenomena	S.L. Gupta	1956	Ph.D.
	4.	Studies on some Essential Oils	S.N. Dhingra	1956	Ph.D.
	5.	Studies in Parachor	S.N. Kaveeshwar	1956	Ph.D.
	6.	Organo-metallic compounds of analytical importance	N.C. Sojani	1956	Ph.D.
	7.	Kinetics of chemical Reactions and Solubilities of Weak Acids in Salts of weak acids	S.G. Harmalkar	1956	Ph.D.

1	2	3	4	5	6
	8.	Applications of Refractive Index in Chemical Constitution	D.P. Joshi	1956	Ph.D.
	9.	Behaviour of Halogenated Nitro Benzenes with reactive methylene compounds	I.R. Gambhir	1957	Ph.D.
	10.	Effect of Induced Hypothyroidism on Metabolism and Enzyme Activity	J.S. Rawat	1957	Ph.D.
	11.	Physico-chemical studies on the Interaction of Proteins with large and small organic molecules and concomitant phenomenon of Denaturation.	R. Nath	1957	Ph.D.
	12.	Humification of Organic matter in relation to the Physico-chemical properties of soils	B.R. Nagar	1958	Ph.D.
	13.	Kinetics of chemical Reactions	V.M. Bhale	1958	Ph.D.
	14.	Role of Phytic Acid Phosphorus in Ruminant Metabolism	P.N. Johri	1958	Ph.D.
	15.	Studies on Antiseptic preparations of Organo-Mercury compounds and study of their bactericidal properties	H.L. Rohatgi	1958	Ph.D.

1	2	3	4	5	6
	16.	Studies on the Bio-chemical changes with special reference to Vitamin C in conditions of stress (Fracture) and the Enzymic make up of Salmonella typhosa	S.N. Ghatak	1958	Ph.D.
	17.	Studies in the preparation of Chalkones and their derivatives.	D.N. Dhar	1959	Ph.D.
	18.	Studies in Aromatic Hydroxy Ketones and some Cyclizations of their derivatives.	H. Singh	1959	Ph.D.
	19.	Studies in Ion Exchange Chromatography and Allied Problems	R.P. Bhatnagar	1959	Ph.D.
	20.	Physico-Chemical Studies on some aspects of Chromatography	D.R. Gupta	1959	Ph.D.
	21.	Studies on Alternating Current Polarography and Caramelisation of Sugars	K.D. Agarwal	1959	Ph.D.
	22.	Physico-chemical studies on Polycomponent Saccharine systems	Vishnu	1959	Ph.D.
	23.	Studies on the Humic Fractions and their Hydrolysates in Agra Soil and Microbiological studies at different seasons of the year 1952-53.	N. Ram	1959	Ph.D.

1	2	3	4	5	6
	24.	Chemical studies on Indian Essential Oils	N.L. Zutshi	1959	Ph.D.
	25.	Reactive Methylene Compounds—A systematic study	H G. Garg	1960	Ph.D.
2. *Aligarh*	1.	Saponins from Indigenous Plants	I.P. Varshney	1955	Ph.D.
	2.	(a) Some aspects of action between Acids and Urea (b) Hoffman Reaction.	Aziz-ur-Rahman	1955	Ph.D.
	3.	Chemical Investigations of Satare-Farsi-Essential Oils	Gopi Shankar Gupta	1956	Ph.D.
	4.	The study of Glycosides of some of the members of the family Unbelliferae—Apium graveolens and Apium petresolinum	Wasi-ur-Rahman	1958	Ph.D.
	5.	Physical Studies on the stability of Cr. (II) and Co (II) and Their Complexes	K.M. Abubacker	1959	Ph.D.
	6.	Chemical Investigations of Saponins from Indigenous plants	Hameedul Hasan	1960	Ph.D.
	7.	Chemical Investigations of the seed oils of some of the members of Umbelliferae family	S.M. Osman	1960	Ph.D.

1	2	3	4	5	6
3.	*Allahabad*	1. Nitrogen Transformation in soil with Saw Dust and Leaves	K.L. Nangpal	1955	Ph.D.
		2. Nitrogen transformation in soil with cloves	Pritam Singh	1955	Ph.D.
		3. Reclamation of user soil (Alkaline and Barren)	S.K. Pal	1955	Ph.D.
		4. Some important problems of Qualitative Analysis with special reference to precipitation	G.B.S. Salaria	1955	Ph.D.
		5. Chemical Kinetics of the Reduction of Fehlings Solution.	M.P. Singh	1955	Ph.D.
		6. Influence of Phosphonates	B. Bose	1955	Ph.D.
		7. Bio-chemistry of Yeast	(Smt.) Ranganayaki	1955	Ph.D.
		8. Catalytic activity of Hydrous Oxides	M.A. Beg	1955	Ph.D.
		9. Chemical Kinetics in Solution.	A.K. Sinha	1955	Ph.D.
		10. Studies in the growth of Yeast	K. Bahadur	1956	D.Sc.
		11. Studies on Colloidal Silicates and Gels.	K.L. Yadava	1956	Ph.D.
		12. The stability of Colloidal Solutions	R.S. Rai	1956	Ph.D.
		13. Nitrogen Transformation	T.N. Chojar	1956	Ph.D.

1	2	3	4	5	6
	14.	Studies in Alkali Soils	Hari Shankar	1956	Ph.D.
	15.	Studies on Periodic Precipitations	P.B. Mathur	1956	Ph.D.
	16.	Studies on Colloids	R.S. Singh	1956	Ph.D.
	17.	Studies in Plant Chemistry	B.C. Joshi	1956	Ph.D.
	18.	Studies on Hydrous Oxides	N.K. Kulshrestha	1956	Ph.D.
	19.	Base Exchange and other Physico-Chemical properties of Minerals	D. Prakash	1956	Ph.D.
	20.	Studies on Reactions of ·Sulphydryl and disulphide groups	R.C. Kapoor	1957	D.Sc.
	21.	Studies in Chemical Constitution of Holarrhena Alkaloids and some other Plant Constituents	V.N. Sharma	1957	D.Sc.
	22.	Studies in some Chelate Compounds	Satish Chandra Tripati	1957	D.Sc.
	23.	Nitrogen Fixation and Nitrogen Loss in Soil	Maya Shankar Lal	1957	Ph.D.
	24.	Studies in Nitrogen Transformations	Madhuri Mohan Rai	1957	Ph.D.
	25.	Studies in Soils and Gels of some Insoluble succinates	Salil Kumar Bose	1957	Ph.D.
	26.	Studies in Yeast	Krishna Wadalkar	1957	Ph.D.
	27.	Studies in Yeast	Narendra Kumar Garg	1957	Ph.D.

1	2	3	4	5	6
	28.	Study of Reactions in Aqueous Solution	Dhirendra Nath Chakra-varti	1957	Ph.D.
	29.	Studies on Plant Chemistry	Rajkumar Gupta	1957	Ph.D.
	30.	Some Aspects of Red-Ox- Kinetics in solution.	Bajrang Prasad Sinha	1957	Ph.D.
	31.	Studies in Chemical Reaction and High Frequencies	Satish Chandra Srivastava	1957	Ph.D.
	32.	Studies on Plant Chemistry	Divoan Singh Bhavuni	1957	Ph.D.
	33.	Studies in Alkali Soils	Raghubir Singh	1957	Ph.D.
	34.	Studies in Titanium & other Phosphates	Krishna Mohan Varma	1957	Ph.D.
	35.	Synthesis of some Phthalein Dye-Stuffs & Study of their Structures	Srinath Das Loiwal	1957	Ph.D.
	36.	Studies on Comp-lexes	Anil Kumar Mukerji	1957	Ph.D.
	37.	Studies in Synthetic Dyes	Lal Bihari Lal	1957	Ph.D.
	38.	Studies in Compost-ing	Amar Chand Garg	1957	Ph.D.
	39.	Studies on Colloids and Ultrasonic Re-actions	Ashim Kumar Ghosh	1958	Ph.D.
	40.	Studies in Aluminium & other Phosphates	Dharmendra Sharma	1958	Ph.D.

1	2	3	4	5	6
	41.	Studies on Colour & Constitution on Dyes obtained from Substituted Succinic Acid	Jagdish Singh Chauhan	1958	Ph.D.
	42.	Some important problems of qualitative and quantitative chemical analysis	Gur Bachan Singh Salaria	1958	D.Sc.
	43.	Properties of soils and Fertilizers	Kailash Narain Goel	1958	Ph.D.
	44.	Dipole Moment, Dielectric Constant & Molecular Structure	Krishna Kumar Srivastava	1958	Ph.D.
	45.	Estimation as Sulphides	Mauttaram Nath Srivastava	1958	Ph.D.
	46.	Cerate Oxidimetry	Narendra Nath Sharma	1958	Ph.D.
	47.	Studies on Hydrous Oxides	Rajesh Behari Hajela	1958	Ph.D.
	48.	Studies on Enzyme Reaction of Papain	Ramesh Chandra Sinha	1958	Ph.D.
	49.	Plant Chemistry	Sat Guru Saran Khanna	1958	Ph.D.
	50.	Kinetics of Oxidation-Reduction Reaction in Solution	Yugal Kishore Gupta	1958	Ph.D.
	51.	Studies in Complex Formation	Krishna Chandra Mathur	1959	Ph.D.
	52.	On the Composition of the Arrhenius Factor in the Reaction Rates	Nirmal Kumar Shastri	1959	Ph.D.
	53.	Plant Chemistry	Shekhar Pande	1959	Ph. D.

1	2	3	4	5	6
	54.	Preparation of Hydrous Oxides Gels with Pyridine Bases and their Ultrasonic Studies	Yogendra Nath Chaturvedi	1959	Ph.D.
	55.	Influence of Light on Nitrogen Fixation & Loss	Riazul Husain	1959	Ph.D.
	56.	Studies in Reaction Kinetics in Solutions	Krishna Chandra Tewari	1959	Ph.D.
	57.	Studies on Hydrous Thorium Oxides	Rameshwar Prasad	1959	Ph.D.
	58.	Detection and Estimation of Acid and Mixtures	Manohar Lal	1959	Ph.D.
	59.	Study of Mineral Intake of the Yeast Cells	Harish Chandra Verma	1959	Ph.D.
	60.	Studies in the behaviour of Insoluble substances	Ishwar Singh Ahuja	1959	Ph.D.
	61.	Studies in Metal Chelate Compounds	Samir Kumar Banerjee	1959	Ph.D.
	62.	The Study of Colloidal solutions	Dilwar Singh Jaiswar	1959	Ph.D.
	63.	Studies in Complex Compounds of Phosphoric and other acids and their Salts	Guru Prasad Ghosh	1959	Ph.D.
4. *Annamalai*	1.	Synthesis of β-amino, α,β unsaturated and bis-(aminoaryl) Sulphones	M. Balasubramanian	1955	Ph.D.

1	2	3	4	5	6
	2.	Preparation of sulphones by the Fries and Friedel—Crafts reactions and a study of internal hydrogen bond in o-hydroxy sulphones	Aley Kutty	1957	Ph.D.
	3.	A Physico-Chemical Study of the sulphur-oxygen bond and conjugation in sulphones	S.P. Shanmuganathan	1957	Ph.D.
	4.	Dielectric contribution to liquid miscibility	K.M.Somasundaram	1958	Ph.D.
	5.	Ultraviolet absorption spectra of thiophenes and aryl sulphides	T.S.Govindarajan	1958	Ph.D.
	6.	Synthesis and Ultra-Violet absorption spectra of Sulphoxides and Sulphones	R.Varadachari	1959	Ph.D.
	7.	Activating influence of the sulphonyl group and steric effects in sulphones	T.Rangarajan	1960	Ph.D.
	8.	A Physico-Chemical study of the Cis-Trans-isomerism in unsaturated sulphones	M.S.R. Naidu	1960	Ph.D.

1	2	3	4	5	6
5.	*Banaras*	1. Studies in the analytical aspects of the chemistry	Joshi, M.K.	1955	Ph.D.
		2. Oils and Fats	Dey, L.M.	1955	Ph.D.
		3. Kinetic investigations of certain Redox Reactions and Analytical aspects of the chemistry of Hydrazine Thiocyanate and some rare elements	Bai, B.S.	1956	Ph.D.
		4. Studies on the surface dependence of the Joshi effect	Shukla, B.M.	1956	Ph.D.
		5. Chemical and pharmacological studies of Ortho siphen polliders Royle	Singh, H.	1956	Ph.D.
		6. Studies of some redox reactions of Ascorbic Acid, Vanadium, Thallium....Hydrazine	Bapat, M.G.	1957	Ph.D.
		7. Stereo-chemistry of Camphor, Study of Rotatory and refractive dispersion	Kapoor, N.S.	1957	Ph.D.
		8. Studies of the positive and negative Joshi effects in Halogens	Venugopalan, M.	1957	Ph.D.
		9. Studies in Indian animal and vegetable fats	Trivedi, B.N.	1957	Ph.D.
6.	*Baroda*	1. Studies on the Chemotherapy of Mycobacterial Infections and of Filariasis	Wadia, P.S.	1958	Ph.D.

1	2	3	4	5	6
	2.	Studies on Chelates and Chelation	Talati, A.M.	1959	Ph.D.
7. *Bombay*	1.	I-Chemical Investigation of Indigenous Medicinal Plants Swertia decussatea and Swertia chirata	S.R. Dalal	1955	Ph.D.
		II. Synthetic Experiments in the Lanthone Series			
	2.	Dyes and Dye-Intermediates from Benzanthrone	A.B. Dias	1955	Ph.D.
	3.	Studies on the Chemotherapy of Tuberculosis	P.R.J. Gangadharan	1955	Ph.D.
	4.	Studies in Neera and Palm Gur	B.V.Hatwalne	1955	Ph.D.
	5.	The regeneration of Blood and Tissues	L.S. Kale	1955	Ph.D.
	6.	Formation of Coumarins-Attempts at the synthesis of Pimpinellin Substitution in the resorcinol nucleus	R.M. Naik	1955	Ph.D.
		Investigations into factors affecting the nutritive value of paddy straw as a cattle food	S.S. Negi	1955	Ph.D.
	7.	Synthesis of amino acids and related products	P.B.Mahajani	1955	Ph.D.

1	2	3	4	5	6
	8.	Studies in Synthetic drugs	M. Raghavan	1955	Ph.D.
	9.	Some metabolic studies of B-Complex Vitamins in Cereals and Pulses.	V.S. Raut	1955	Ph.D.
	10.	Enzymic studies on the synthesis and degradation of Oligo and Polysaccharides	K. Saroja	1955	Ph.D.
	11.	Substituted Diphenyl-sulphides, sulphoxides, Sulphones	R.D. Shingte	1955	Ph.D.
	12.	Studies on the metabolism of the mould Aspergillus flavus	K.S.Srinivasan	1955	Ph.D.
	13.	Synthetical Anthelmintics-Synthesis of Chloro-Phenyl Butyro-Lactones	V.A. Vyas	1955	Ph.D.
	14.	Crystalline Trypsin Inhabitors from bean field bean and Potato	Ambe, K.S.	1956	Ph.D.
	15.	Studies in the nature of lead oxides	V.V.Deshpande	1956	Ph.D.
	16.	Investigation on the Constitution of the Alkaloids of Cassia absus Seeds	S.K. Guha	1956	Ph.D.
	17.	Component fatty acids and glycerides in Shark Liver Oil	G.G. Kamath	1956	Ph.D.

1	2	3	4	5	6
	18.	A synthesis of munin-gin and other isofla-vones	S.S. Karmar-kar	1956	Ph.D.
	19.	Studies in Oxidations of some organic com-pounds with sodium perborate	N.S. Kunte	1956	Ph.D.
	20.	Preservation of shell Eggs	T.D.Mahade-van	1956	Ph.D.
	21.	Studies on nitrogenous compounds and nitro-gen metabolism in plants with special reference to chromato-graphic methods	A.N. Radha-krishnan	1956	Ph.D.
	22.	Studies on Cracking and Aromotisation of High boiling petro-leum hydrocarbons	M.Ramachar-yulu	1956	Ph.D.
	23.	Studies on the inter-action of proteins and carbohydrates and its bearing on the nutritive value	P.B.Rama Rao	1956	Ph.D.
	24.	Studies in Sulphur Compounds	R.N.Urgaonkar	1955	Ph.D.
	25.	The Study of Proteins of some edible varie-ties of Bombay fishes	N.N.Valanju	1956	Ph.D.
	26.	Studies on synthesis of α,β-unsaturated Aldehydes	M.C. Chaco	1956	Ph.D.
		Constituents of the heartwood of Artocar-pus integrifolia	K.G. Dave	1957	Ph.D.

1	2	3	4	5	6
	27.	Studies in the reactivity of Imidochlorides.	Usha N. Hirwe	1956	Ph.D.
	28.	A study of some N-p-Phenethylamidines	N.N. Katrak	1956	Ph.D.
	29.	The Magnetic study of some Coumarins and Silicones	R.M. Mathur	1956	Ph.D.
	30.	Nutritive requirements and Synthetic abilities of the Lactic Acid Bacteria	V.K.N. Nambudripad	1956	Ph.D.
	31.	Studies on Tocopherol and Vitamin A in milk and milk products	K.M.Narayan	1956	Ph.D.
	32.	Biosynthesis of Carbo-hydrates by Enzymes from Aspergillus flavus, liver and green gram (Phaseolus radiatus)	V.N. Nigam	1956	Ph.D.
	33.	Glycolic Enzymes in Green gram (Phaseolus radiatus)	T. Ramasarma	1956	Ph.D.
	34.	Studies in Sesquiterpenes	C.S. Krishna Rao	1956	Ph.D.
	35.	Studies in Serine Metabolism	G.B. Nadkarni	1957	Ph.D.
	36.	Experiments on the synthesis of Cyanomaclurin and related substances	R.B. Desai	1957	Ph.D.

1	2	3	4	5	6
	37.	Studies on water pollution and purification with special reference to sewage	C.A. Sastry	1957	Ph.D.
	38.	Studies on Nutritional aspects of some lesser known food grains and studies on some aspects of utilisation of proteinand or nonprotein nitrogen in animals, albinorats	N. Seetha Ganapathy	1957	Ph.D.
	39.	Biochemical Studies in Nepalea cochineleifera	R.W.P.Master	1957	Ph.D.
	40.	Investigations on the Fat requirements of Ruminants	Kedar Nath	1957	Ph.D.
	41.	Synthesis in Thiophene Series	D.S. Rao	1957	Ph.D.
	42.	Anti-infective agents from plants and synthetics	S.R. Shah	1957	Ph.D.
	43.	Metabolic Interrelationship between Vitamin E and Molybdenum	P.P. Nair	1957	Ph.D.
	44.	Biochemical studies on the formation and germination of bacterial spores	Kerala Varma	1957	Ph.D.
	45.	Studies in some Metal-oxine Chelates	K.A. Venkatachalam	1957	Ph.D.

1	2	3	4	5	6
	46.	Physico-chemical relationship in Fat Metabolism	R.K. Anjaria	1958	Ph.D.
	47.	Studies in Chemistry and Carcinogenicity of chewing Tobacco	V.D. Divakar	1958	Ph.D.
	48.	Nutritive value of palm Gur	M.R. Joshi	1958	Ph.D.
	49.	Some studies on Metabolic aspects in pregnancy and Gynaec disorder	K.R. Juvale	1958	Ph.D.
	50.	Studies in Proteins of Vegetables	S.H. Kamath	1958	Ph.D.
	51.	Synthetic investigations on the degradation products of bile acids	T.R. Kasturi	1958	Ph.D.
	52.	Some metabolic aspects of vitamin B_{12}	B.D. Punekar	1958	Ph.D.
	53.	Studies on Sewage Protozoa and activated sludge	A.V.S. Prabhakara Rao	1958	Ph.D.
	54.	Study on Mowrah Flowers (Bassia latifolia)	P.B. Sutaria	1958	Ph.D.
	55.	Experimental Studies in Absorption of gases to elucidate the nature of catalyst surfaces	V. Srinivasan	1958	Ph.D.

1	2	3	4	5	6
	56.	Studies in Human Milk	P.V. Gaitonde	1958	Ph.D.
	57.	Part I :-(a) Studies in Nitrification of four common oil cakes in the main soils of the Bombay State (b) The effect of deoiling of ordinary oil cakes on nitrification Part II : Studies in the loss of Nitrogen from oil cakes during nitrification-factors affecting the loss and possible forms in which the nitrogen may be lost	V.S. Kulkarni	1958	Ph.D.
	58.	Studies on Blood Coagulation	N.C. Pillai	1958	Ph.D.
	59.	Amino-Acid Decarboxylases in some plants	L.K. Ambe	1959	Ph.D.
	60.	A study of Indigenous drugs and pharmaceuticals	R.H. Bhatt	1959	Ph.D.
	61.	Studies in the Trypsin Inhabitors of green gram Phaseolus aurens R	P.M. Honavar	1959	Ph.D.
	62.	Studies in the behaviour of brass towards alkaline liquids	B.G. Joshi	1959	Ph.D.

1	2	3	4	5	6
	63.	Studies on the Carbonates of Transition Elements-Nickel Carbonates	R.M. Mallya	1959	Ph.D.
	64.	Studies in Fish Proteins	B.N. Mashalkar	1959	Ph.D.
	65.	Studies in Folic Acid	J.M. Naronha	1959	Ph.D.
	66.	Studies in Lipids	V.S. Patil	1959	Ph.D.
	67.	Terpenoids-some synthetic studies	A. Paul	1959	Ph.D.
	68.	Study of Prawns	R.S. Shaikhmahmud	1959	Ph.D.
	69.	Studies on the Metabolism of Aspergillus niger	J.R. Vakil	1959	Ph.D.
8. *Calcutta*	1.	Studies on the active principles of Kopsia fruticosa, Kopsia albflora and Skimmia laureola	A.K. Bhattacharya	1958	D.Sc.
	2.	Investigations on the role of essential fatty acids in Phrynoderma	S. Choudhary	1958	D.Sc.
	3.	Transport properties of gases	S.C. Saxena	1958	D.Sc.
	4.	Synthesis of alicyclic compounds related to natural products	U.R. Ghatak	1958	Ph.D.
	5.	A study of Alicyclic compounds	N.R. Ghosh	1958	Ph.D.

1	2	3	4	5	6
	6.	Studies on mechanical behaviours of some cellulose fibres including Jute	B.L. Banerjee	1958	Ph.D.
	7.	On the free Amino acids, related products and some B-vitamin contents of a few Leguminous seeds during germination	D.L. Nandi	1958	Ph.D.
	8.	Ion-exchange studies with the help of membrane electrodes	S.K. Basu	1958	Ph.D.
	9.	Studies on Carbocyclic compounds	K. Sen	1958	Ph.D.
	10.	Synthesis of Alicyclic compounds	U. Rakshit	1958	Ph.D.
	11.	Synthesis and the mechanism of action of Vitamin A with special reference to Vitaminosis A in the body	A.K. Ray	1958	Ph.D.
	12.	Studies in solubilization of water in non-polar solvents	V.A. Moghe	1958	Ph.D.
	13.	Studies on coagulation and electrokinetic potential of colloids	K.C. Ray	1958	Ph.D.
	14.	Action of some common bleaching agents and alkalies on jute	S.K. Majumdar	1958	Ph.D.
	15.	Studies on the chemical constituents of Alstonia scholaris	R. Ghosh	1958	Ph.D.

1	2	3	4	5	6
	16.	Applications of co-ordination complexes of organic thio-compounds in analytical chemistry	J. Xavier	1958	Ph.D.
	17.	Studies on the electro-Kinetic potential of colloids and pyrex glass	A.K. Ghosh	1958	Ph.D.
	18.	studies on properties of blast furnace slag available in India	S.K. Chatterjee	1958	Ph.D.
	19.	Role of liver in the synthesis of Nicotinic acid from tryptophan	D. Prasad	1958	Ph.D.
	20.	Studies in non-aqueous acid-base titration	M.N. Das	1959	D.Sc.
	21.	Complex formation in Analytical Separation	S. Banerjee	1959	D.Sc.
	22.	Studies on experimental head Anaemia	D.C. Dhar	1959	D.Sc.
	23.	Some aspects of quantum chemistry	R. Bhattacharya	1959	D.Sc.
	24.	Studies of clay minerals as constituents of some West Bengal Soils	M. Adhikari	1959	D.Sc.
	25.	The Chemistry of Plant products	P.C. Maiti	1959	D.Sc.
	26.	Some darivatives of Tetralin and of Indane	D.N. Mukerjee	1959	D.Sc.
	27.	A study of metal Biguanide Co-ordination complexes and their stability	M.M. Ray	1959	D.Sc.
	28.	Studies in Vinyl Polymerisation	A.K. Chaudhary	1959	D.Sc.

1	2	3	4	5	6
	29.	Investigations on the Ion-exchange properties of some carbonaceous materials	D. Datta	1959	D.Sc.
	30.	The reclamation of rancid fats and an improved method for the estimation of unsaturated fatty acids	S.K. Chakrabarti	1959	D.Sc.
	31.	Physico-chemical properties of Coal and Coke and Mechanism of coke formation	S. Ghosh	1959	D.Sc.
	32.	Organic reagents in Inorganic analysis and their sundry problems related to analytical chemistry	M.M. Chakrabarti	1959	D.Sc.
	33.	Chemical Investigation of Natural Pro-products	A.K Banerjee	1959	D.Sc.
	34.	Ultraviolet absorption spectra of organic compounds in different states	S. Banerjee	1959	D.Sc.
	35.	Studies on the effect of heated fats and oils on certain aspects of nutrition	D. Sinha	1959	D.Sc.
9. *Delhi*	1.	Base exchange properties of Indian Soils in relation to their mineralogical composition	A.K. Das	1955	Ph.D.

1	2	3	4	5	6
	2.	Synthetic approach to the constitution of the naturally occurring Isoflavones of the Irigenin group	M. Krishnamurti	1955	Ph.D.
	3.	Study of the structure and synthesis of oxygen ring compounds present in Lichens other plant sources	O.P. Mittal	1955	Ph.D.
	4.	Chemical investigation of Indian Lichens and a new synthesis of Allowogonin and Alizarin-I-methyl ether	S. Neelakantan	1955	Ph.D.
	5.	Synthesis of some isoflavone partial methyl ethers and chemical investigation of Indian Lichens	M.L. Dhar	1956	Ph.D.
	6.	Studies of (a) the special components of woods, (b) some reactions involving active methylene groups	V.N. Gupta	1956	Ph.D.
	7.	Synthetic experiments in Benzopyrone series and special chemical components of some commercial woods	I. Dass	1956	Ph.D.
	8.	Some aspects of the photo-sensitive low frequency electric discharge	B.D. Khosla	1957	Ph.D.

1	2	3	4	5	6
	9.	Chemistry of plant products.	D.B. Parihar	1957	Ph.D.
	10.	Study of fungal and Lichen Anthraquinones	T.R. Rajagopalan	1957	Ph.D.
	11.	In vitro studies on the Chemotherapy of tuberculosis	K.R. Rao	1957	Ph.D.
	12.	Chemical Investigation of Indian Medicinal Plants and synthesis of Dihydrowogonin	S.N. Aiyar	1959	Ph.D.
	13.	Synthesis of Benzofuran derivatives following a possible path of Biogenesis	R. Aneja	1959	Ph.D.
	14.	Synthetic experiments in the Benzopyrone series and a study of flavonoids as antioxidants	A.C. Mehta	1959	Ph.D.
	15.	Chemical Examination of some Indian Medicinal plants	G.R. Chaudhary	1959	Ph.D.
	16.	A study of naturally occurring Leucoanthocyanidins	A.K. Ganguly	1959	Ph.D.
	17.	A chemical study of naturally occurring flavanones and 3-hydroxy flavanones	R.N. Goel	1959	Ph.D.
	18.	A study of the compounds of Pulvinic Acid Series	P.K. Grover	1959	Ph.D.

1	2	3	4	5	6
	19.	Coupling of Aryl Diazonium salts with reactive unsaturated compounds	H.S. Mehra	1959	Ph.D.
	20.	Synthesis of some naturally occurring flavone and isoflavone derivatives	S. Ramanujam	1959	Ph.D.
	21.	Analytical and synthetic studies of naturally occurring flavonoid derivatives	P.S. Sarin	1959	Ph.D.
	22.	Electrochemical properties of some layer-lattice silicates in relation to their structure with a special reference to the role of structural hydroxyl groups	B.K. Sharma	1959	Ph.D.
	23.	Synthesis of some Lichen depsides and mould toluquinones	G.B. Venkatasubramanian	1959	Ph.D.
	24.	Electrochemical properties of some condensation polymers in relation to their structure	S.C. Dube	1959	Ph.D.
	25.	Studies on the component acids and gyceride structure of natural fats	R. Narayanan	1959	Ph.D.
	26.	A study of natural and synthetic leucoanthocyanidins	K.R. Laumas	1959	Ph.D.

1	2	3	4	5	6
	27.	Investigations on organic compounds in inorganic analysis	S.D.V. Paul	1959	Ph.D.
	28.	Some aspects of the structural chemistry of clay minerals	H. Singh	1960	Ph.D.
10. *Gujarat*	1.	Studies in the synthesis of 4 hydroxy quinoline and Bromination of Ethyl β-Arylamino α, β-Unsaturated esters	K.R. Mapata	1955	Ph.D.
	2.	Some reactions of Hyponitrites and nitrites	V.T. Oza	1955	Ph.D.
	3.	Studies in Chalkones	C.C. Patel	1955	Ph.D.
	4.	Some reactions in Hyponitrites and Nitrites	R.H. Thaker	1955	Ph.D.
	5.	Studies in Heterocyclic compounds	J. J. Setalvad	1956	Ph.D.
	6.	Studies of Alkali soils in North Gujarat	R.K. Shah	1956	Ph.D.
	7.	Synthesis of thioureas and Thiobarbiturates	P.J. Trivedi	1958	Ph.D.
	8.	Studies in corrosion of brass	M.M. Desai	1958	Ph.D.
	9.	Studies in Orthohydroxy acyl coumarones	P.M. Shah	1958	Ph.D.
	10.	Chalkones and related compounds	S.R. Parikh	1959	Ph.D.

1	2	3	4	5	6
	11.	Ortho-hydroxy carbonyl compounds and related products	A.K. Raval	1959	Ph.D.
	12.	Studies on chalkones and related compounds	N.B. Mulchandani	1959	Ph.D.
	13.	Synthesis of 2-hydroxy chalkones and related compounds and studies in Fries rearrangements	C.M. Christian	1959	Ph.D.
	14.	Synthetic anthelmintics and anticonvulsants	D.K. George	1960	Ph.D.
	15.	Studies in Alkali soil in (Bhalnal-Area) Gujarat	J.C.P. Vora	1960	Ph.D.
	16.	Studies in Corrosion of Brass	J.D. Talati	1960	Ph.D.
11. *Jabalpur*	1.	Studies on some organic reactions	S. Bose	1960	Ph.D.
12. *Jadavpur*	1.	Synthesis of Fused Ring Systems	S.K. Sen Gupta	1959	Ph.D.
	2.	Correlation of physical properties : Force constant, Atomic size, Boiling point, etc.	G.R. Somayajulu	1960	Ph.D.
13. *Karnatak*	1.	Synthesis of compounds of Pharmacological interest	V.N. Deshpande	1956	Ph.D.

1	2	3	4	5	6
	2.	Friedel & Crafts condensation of phenyl ethyl sulphides and related compounds	V.R. Dane	1957	Ph.D.
	3.	Some analogues of papavarine	S.K. Kulkarni	1957	Ph.D.
	4.	Synthesis of Isoquinolines; Chlorine analogues of papavarins	P.B. Sattur	1957	Ph.D.
	5.	Synthetic investigation in Steroids and Terpenoids	V.V. Devas	1959	Ph.D.
	6.	Studies in Antibacterials	P.K. Nargund	1959	Ph.D.
14. *Kerala*	1.	Studies on plant Antibiotics:pterygospermin-the antibiotic principle of Moringa pterigosperma	P.A. Kurup	1955	Ph.D.
	2.	Studies on Indigenous Drugs	K.G. Das	1955	Ph.D.
	3.	Studies on the catalytic oxidation of organic compounds in the vapour phase	K. Venkitaraman	1955	Ph.D.
	4.	Physiological and Biochemical Investigations on Marine Algae	V. Krishna Pillai	1956	Ph.D.
	5.	Studies on Haxachloro ceric Acid and Hydrated Ceric oxide	S.M. Subramanyan	1956	Ph.D.

1	2	3	4	5	6
	6.	Studies in the Chemistry of some new naturally occurring Triterpenoids	K.S. Madhavan Pillai	1956	Ph.D.
	7.	Chemical and Microbiological studies on the Acid soils of Kerala	N. Subramania Iyer	1958	Ph.D.
	8.	Studies on some aspects of Metabolism of Vitamin A and carotenoids in the Rat and Chicken	S. Krishnamoorthy Ayyar	1959	Ph.D.
	9.	Natural Products—their structure and synthesis	G. Valayudhan Nair	1959	Ph.D.
	10.	Electrodeposition of Metals and Alloys from the Pyrophosphate Bath	C.R. Sankaran Kutty Panikkar	1960	Ph.D.
	11.	Studies on Nitrogen Metabolism with special reference to amino acids	G. Yegnanarayana Ayyar	1959	Ph.D.
15. *Lucknow*	1.	Mechanism of chromic acid oxidations	Antony Verkey	1955	Ph.D.
	2.	Formation of complex compounds between potassium chloride and alkaline earth chlorides	P.C. Bose	1955	Ph.D.
	3.	Pedo-chemical studies on the soils of Banaras district in U.P.	R.N. Gupta	1955	Ph.D.

1	2	3	4	5	6
	4.	Potential synthetic analysis	I.K. Kacker	1955	Ph.D.
	5.	Studies on the physical properties of the systems	J. Misra	1955	Ph.D.
	6.	Studies on paper chromatography	V.K.M. Rao	1955	Ph.D.
	7.	Studies on Fries rearrangement	B.N. Tripathi	1955	Ph.D.
	8.	Search for possible anti-tubercular compounds	M.P. Khare	1956	Ph.D.
	9.	Studies in Cynoethylation	R.S. Asthana	1957	Ph.D.
	10.	Search for new Amoebicides	Y.D. Kulkarni	1957	Ph.D.
	11.	Compounds of Aluminium and Titanium with fatty acids	K.C. Pandey	1957	Ph.D.
	12.	Complex compounds of mercuric chloride with potassium chloride and some similar halides	K.V. Nair	1957	Ph.D.
	13.	Thermodynamic properties of mixtures in the condensed phases	K.K. Rama Verma	1957	Ph.D.
	14.	The solubility and light-fastness of Azo-Dyes and studies on Chemotherapeutics	R.C. Sharma	1957	Ph.D.
	15.	Specific refractivity as a new method of detection of adulteration in fats (Ghee) and Oils.	U. Chandra	1957	Ph.D.

1	2	3	4	5	6
	16.	A study on the formation of complex compounds between bivalent and univalent salts in solution	S.R.C. Agarwal	1958	Ph.D.
	17.	Organic compounds of Zirconium	R.N. Kapoor	1958	Ph.D.
	18.	Studies in addition polymerization	R.N. Chadha	1958	Ph.D.
	19.	Studies on Kolbe's Electrosynthesis	G. S. Pande	1958	Ph.D.
	20.	Studies in paper chromatography (Precipitation chromatography and rhythmic precipitation)	H. Bhagwan	1958	Ph.D.
	21.	Studies on oxidation of organic compounds (Kinetics and mechanism of chromic acid oxidations)	S. K. Mukerjee	1958	Ph.D.
	22.	Formation of complex compounds between Urea land Alkaline Earth Halides	M.P. Bhatnagar	1958	Ph.D.
	23.	Studies on stability of Lyophobic colloids : effect of non-electrolytes	P. Tewari	1959	Ph.D.
	24.	Mixed Emulsifying Agents	J.P. Barthwal	1959	Ph.D.

1	2	3	4	5	6
	25.	Studies on the solubilisation and physical properties of non-aqueous soap solutions	V.K. Dixit	1959	Ph.D.
	26.	Search from new Amoebicides	S.L. Arora	1959	Ph.D.
	27.	Studies on Inorganic Poly-electrolytes with special reference to Polyphosphates	H.N. Bhargava	1959	Ph.D.
	28.	Part I : Studies in Antimetabolites & Part II : Chemical investigation of Indian Medicinal plants	S.K. Chatterjee	1959	Ph.D.
	29.	Studies on the phenomenon of solubilisation	K.N. Mehrotra	1959	Ph.D.
	30.	Complex compounds of some organic carboxylic acids with polyvalent metalions	S.P. Agarwal	1959	Ph.D.
	31.	Studies on the Fries rearrangement	A. Singh	1959	Ph.D.
16. *Madras*	1.	Chemistry of phenanthridine compounds	N. Arumugam	1955	Ph.D.
	2.	Part I : Synthetical Experiments in the Aporphine series. Part II : Chemical Investigation of Tylophora asthmatica	K. Nagarajan	1955	Ph.D.

1	2	3	4	5	6
	3.	Experiments towards the synthesis of carpeins, carpanic acid and their analogues	N.S. Narasimhan	1955	Ph.D.
	4.	Studies in Dielectrics	P.T. Narasimhan	1955	Ph.D.
	5.	A study of the chemical structure of the main phenolic constituents of Indian Cashewnut liquid : Anacardic Acid and Cardol	V.J. Paul	1955	Ph.D.
	6.	The influence of certain Vitamins on Nitrogen Metabolism	V.M. Sivarama Krishnan	1955	Ph.D.
	7.	Dielectrics—Dipole Moments and Molecular Structure of Organic compounds	S. Soundara Rajan	1955	Ph.D.
	8.	Essential Amino Acids in Milk and Milk products	R. Venkateswara Rao	1955	Ph.D.
	9.	Absorption of Gases on Catalyst surfaces	T.S. Viswanathan	1955	Ph.D.
	10.	Investigation on Raman and Infrared spectra	D. Krishnamurti	1955	Ph.D.
	11.	Studies on Fungal Enzymes	K. Lakshminarayanan	1955	Ph.D.
	12.	Studies on the interrelationships among Vitamins of B group	R. Radhakrishna Murti	1955	Ph.D.

1	2	3	4	5	6
	13.	Studies on the dephosphorylation of phosphoproteins	T.A. Sundararajan	1956	Ph.D.
	14.	Studies on the Antibiotics of Fusaria and their mode of action	M.O. Tirunarayanan	1956	Ph.D.
	15.	Studies on Nitrogen Heterocyclic compounds	K.W. Gopinath	1957	Ph.D.
	16.	Synthetic investigations of Azulenes	T.M. Jacob	1957	Ph.D.
	17.	Biochemistry of Thyroid Hormone	N.R. Moudgal	1957	Ph.D.
	18.	Chemistry of Cryptopine type Alkaloids—studies on the structure of a carpeine	M.S. Rajadurai	1957	Ph.D.
	19.	Metabolic studies with Thyroxine and some Vitamins of the B Group	K.V. Rajagopalan	1957	Ph.D.
	20.	Studies on Casein Phosphopeptone	B.V. Ramachandran	1957	Ph.D.
	21.	Some aspects of Nitrogen Utilisation by Soil Fungi	K.V. Srinivasa Pai	1957	Ph.D.
	22.	Studies on fats with special reference to iso-oleic acids	M.R. Subbaram	1957	Ph.D.
	23.	Studies on the electro-deposition and estimation of Germanium	P.R. Subbaraman	1957	Ph.D.

1	2	3	4	5	6
	24.	Free radical polymerisation of Vinyl Monomers in solution	R.V. Subrahmanyan	1957	Ph.D.
	25.	The chemistry of Natural Products from plants of the families Asclepiadaceae and Rutacea	B.S. Tyagarajan	1957	Ph.D.
	26.	Studies on the structure of Tylophorine	M.V. Lakshmi Kantham	1958	Ph.D.
	27.	Kinetics of the Decomposition of metal Alkyls (Thermal decomposition of gaseous zinc dimethyl)	R. Ganesan	1959	Ph.D.
	28.	Reaction between Bromine and Ethylene Derivatives	I.M. Mathai	1959	Ph.D.
	29.	Studies in nitrogen rings—Studies on the constituents of some natural fats	P.S. Raman	1959	Ph.D.
	30.	Phospho-Proteins	K.S. Sampath Kumaran	1959	Ph.D.
	31.	Studies on Ascorbic Acid	A. Thangamani	1959	Ph.D.
	32.	Kinetics of phenol and substituted phenols with formaldehyde	V.P.V. Gopala Krishna	1959	Ph.D.
	33.	The carbohydrate constituents and sugar metabolism of Penicillium chrysogenum	R. Irani	1959	Ph.D.

1	2	3	4	5	6
	34.	Biochemical studies on Iodoamino acids, iodoproteins and iodopeptides	E. Raghupathi	1959	Ph.D.
	35.	Studies on condensed Furan Derivatives	P.C. Parthasarthi	1959	Ph.D.
	36.	Hetrocyclic Nitrogen compounds	N. Viswa-nathan	1959	Ph.D.
	37.	Kinetics and mecha-nism of Bromination of Aromatic compo-unds by Bromine and by Iodine Bromide	N.S. Gnanapragasam	1959	Ph.D.
	38.	Chemistry of Hetero-cyclic compounds; synthesis of analogues of natural products	M. Krishnan	1959	Ph.D.
	39.	Heterocyclic nitro-gen compounds	C.V. Ramadass	1959	Ph.D.
	40.	Kinetics of Vinyl polymerisation in aqueous solution by photo-chemical methods	V. Mahadeva Ayyar	1959	Ph.D.
	41.	Studies in Oxidation	N.V. Subra-manian	1959	Ph.D.
	42.	Chemisorption— Hydrogen on Nickel dispersed in magnesia Catalysts	N.R. Subra-manyan	1959	Ph.D.
	43.	Studies in the syn-thesis of Heterocyclic compounds : Nitrogen Ring Compounds	P. Shanmugam	1959	Ph.D.

1	2	3	4	5	6
	44.	Study on the optical properties (Birefringence) of collogen and tanned fibers	S.B.C. Basu	1960	Ph.D.
	45.	Structural and solvent influences of some hydrolytic reactions	P.S. Radha Krishna Murti	1960	Ph.D.
17. *Nagpur*	1.	Electro-deposition of Metals from Fluoride solution	F.R. Talaty	1955	Ph.D.
	2.	The mechanism of the Mutual Coagulation of hydrophobic sols	N.V. Kalbelkar	1957	Ph.D.
18. *Osmania*	1.	Studies on complex formation, determination and co-deposition of cobalt and nickel	V.S. Subramaniam	1955	Ph.D.
	2.	Synthesis of some substituted 1:4 Naphthoquinones as potential fungicides	K.B. Rao	1957	Ph.D.
	3.	Photochemical reaction involving the compounds of nickel & chromium	K. Veeriah	1957	Ph.D.
	4.	Studies in the Thermal Decarboxylation of Chlorobenzoic acids	A. Mirza	1957	Ph.D.
	5.	Use of Mercuric salts in the preparation of organo mercurials and in the oxidation of alcohols	B.T. Khan	1957	Ph.D.

1	2	3	4	5	6
	6.	Search for physiologically active compounds : synthesis of some halogenated & Nitro coumarins	V.S. Murty	1958	Ph.D.
	7.	Studies on ground-nut-shell hemicelluloses	B. Radhakrishna Murty	1958	Ph.D.
	8.	Studies in the formation of heterocyclic rings from o-phenylene diamines and aromatic aldehydes	C.V. Ratnam	1958	Ph.D.
	9.	Search for new insecticides : Synthesis of some substituted Xanthones and commarones and chemical investigation of the pods of Tephroria purpurea var maxima	R. Kurdukar	1959	Ph.D.
	10.	A kinetic study of the chain photolysis of hydrogen peroxide in aqueous solution	Navaneeth Rao	1959	Ph.D.
	11.	Synthesis of some 4-Arylthio-semicarbazones and related cyclic products as potential anti-tubercular Agents	G. Ramachander	1960	Ph.D.
19. *Panjab*	1.	Studies in the terpenoid constituents of oil of Pinus longifolia and products obtained thereof	J. Verghese	1955	Ph.D.

1	2	3	4	5	6
	2.	Studies in local anaesthetics and quinazoline derivatives	I.S. Gupta	1956	Ph.D.
	3.	Synthetic investigations in Terpenoids and Aromatic hydrocarbons	O.P. Vig	1956	Ph.D.
	4.	Synthetic experiments in polynuclear aromatic hydrocarbons and potential gonadogens	V.S. Gaind	1956	Ph.D.
	5.	Physico-chemical studies on Catalytic vapour phase oxidation of organic compounds	I.B. Gulati	1956	Ph.D.
	6.	A study of potassium metaperiodate and chloramine B as Volumetric Reagents	A. Singh	1956	Ph.D.
	7.	Glycolytic reactions in the formation of Citric acid by Aspergillus niger	K. Singh	1957	Ph.D.
	8.	Studies on the chemical and biochemical changes in foods under different processing and storage conditions, including characterisation of tannins with a supplement on stereo-chemistry of comphor derivatives	N.S. Kapoor	1957	Ph.D.
	9.	Studies on the effect of antibacterial agents on enzymes in relation to their mode of action	K.L. Arora	1958	Ph.D.

1	2	3	4	5	6
	10.	Studies on the cyclo-heptane series	B.R. Sharma	1958	Ph.D.
	11.	Crystal growth in solid gas reactions	Y. Trehan	1958	Ph.D.
	12.	Acetyl chloride as a polar solvent	S.S. Sandhu	1958	Ph.D.
	13.	Reduction of permanganates by dioxides of sulphur and selenium and oxidation of hydrogen sulphide by manganese dioxide and potassium metaperiodate	K. Lal	1958	Ph.D.
	14.	Studies in surface oxygen complexes of charcoal and their influence on its surface behaviour	L. Raj	1959	Ph.D.
	15.	Potassium fixation in Indian Soils and clay minerals	I. Das	1959	Ph.D.
	16.	Electrodeposition of metals and alloys for pyrophosphate bath	J.L. Vaid	1959	Ph.D.
	17.	Studies in tryptophan and its peptides	M. Ram	1959	Ph.D.
	18.	Studies in terpenoids and polycyclic hydrocarbons	R.P. Gandhi	1959	Ph.D.

1	2	3	4	5	6
	19.	Studies in Thiopegans and related compounds including their intermediates.	H.S. Sachdeva	1959	Ph.D.
	20.	Behaviour of metals under explosive attack with special reference to explosives with metal lines cavities	S. Singh	1959	Ph.D.
	21.	Studies in Benzoyl chloride and Thiophosphoryl chloride as non-aqueous solvents	G.S. Saini	1960	Ph.D.
	22.	Surface complexes and surface reactions of charcoal	D.D.S. Saroia	1960	Ph.D.
20. *Poona*	1.	Absorption and Fluorescence of organic compounds	B.N. Mattoo	1955	Ph.D.
	2.	Dielectric constant and molecular structure	V.K. Phansalkar	1955	Ph.D.
	3.	Potentiometric studies of metal ammines, double salts and metallic soaps	K.A. Khargiwala	1955	Ph.D.
	4.	Lithium Aluminium Hydride as a reducing agent for anthoxanthins	C.G. Joshi	1956	Ph.D.
	5.	Ultrasonic velocity in gases and liquids	D.D. Deshpande	1956	Ph.D.
	6.	Studies in naturally occurring carbohydrates	T.R. Ingle	1956	Ph.D.

1	2	3	4	5	6
	7.	Biochemical studies on Edible muscles	J. Barnabas	1956	Ph.D.
	8.	Studies in essential oils	B. Ghatgey	1956	Ph.D.
	9.	The theory and mechanism of solid reactions	K.P. Sinha	1956	Ph.D.
	10.	A study of the interaction of metal ions with Bovine serum Albumin	M.S.N. Rao	1956	Ph.D.
	11.	Physico-Chemical studies on polymer solutions	H.L. Bhatnagar	1957	Ph.D.
	12.	Dipole moment and the nature of the chemical bond	C.M. Deshpande	1957	Ph.D.
	13.	Spectrophotometric studies of Ferric phenol complexes	K.G. Divakar	1957	Ph.D.
	14.	Investigation on some indigenous medicinal oils	C. Mitra	1957	Ph.D.
	15.	Ionic Equilibria in Aqueous Solution	B.M. Mattoo	1959	D.Sc.
	16.	Structural transformation in spincles	K.S. Irani	1959	Ph.D.
	17.	Studies in optical activity	A.S. Mukhedkar	1959	Ph.D.
	18.	Studies in some aspects of blood Coagulation	N.R. Kale	1959	Ph.D.
	19.	Potentiometric studies of strong Electrolytes	V.D. Jogal	1960	Ph.D.

1	2	3	4	5	6
	20.	Studies in Double Salts	S.S. Katti	1958	Ph.D.
	21.	Diffusion and Evaporation of trace impurities from the matrix of a host lattice	K.D. Gupta	1958	Ph.D.
	22.	Experiments in Benzopyrones	K.G. Gore	1958	Ph.D.
	23.	Synthesis of Nitroflavonols	V.G. Naik	1958	Ph.D.
	24.	Study in the fatty oils of Sterculia foetida Linn, and Momordica charantia Linn	Joyti Prasad Varma	1958	Ph.D.
	25.	A study on the structure of vapour deposits	Prem sarup Agarwal	1958	Ph.D.
	26.	A study in thermal polymerisation of dehydrated castor oil	Vasant Rangnath Keskar	1958	Ph.D.
	27.	The studies in Isomerisation and conjugation of some drying oils	Venkatesh Anantharao Saraf	1959	Ph.D.
	28.	Diffusion of Ions in solution	D.N.Sitharama Rao	1959	Ph.D.
	29.	Ultrasonic Velocity in Liquids and liquid mixtures	Murlidhar Venkatesh Kaulgud	1959	Ph.D.
	30.	Alcoholysis of oils & Fats	Mandakini Vishwanath Natekar	1959	Ph.D.
	31.	Problems connected with the preservation of timber	Mohan Chandra Tiwari	1959	Ph.D.

1	2	3	4	5	6
21. *Rajasthan*	1.	Synthetic drugs (Anti-malarials)	K.S. Srinivasan	1955	Ph.D.
	2.	Studies on the composition of natural and synthetic aluminium silicates and their behaviour in relation to ion exchange phenomena	Kamla Zutshi	1956	Ph.D.
	3.	Studies on diamagnetism of ions in crystals	Raniji Lal Mittal	1956	Ph.D.
	4.	Diamagnetic behaviour of some organic molecules	S.N. Mukerjee	1958	Ph.D.
	5.	Lipotropic factors and experimental liver injury	K. Dakshina Murti	1958	Ph.D.
	6.	Physico-chemical studies on the composition of ferrocyanide, Ferricyanide and Thiosulphate complexes of metals	Ram Sahai Saxena	1958	Ph.D.
	7.	Studies on Skin & Hide proteins	K. Thomas Joseph	1959	Ph.D.
22. *Saugar*	1.	Studies on the decomposition of nitrogenous substances	P.N. Awasthi	1955	Ph.D.
	2.	Up-gradation and utilisation of titanium ores	D.P. Kheskar	1955	Ph.D.
	3.	Studies in light absorption	N.R. Subratam	1955	Ph.D.

1	2	3	4	5	6
	4.	Chemical investigation of vegetable oils	M.L. Murty	1956	Ph.D.
	5.	Study of physical properties of colloids	T.G. Kher	1956	Ph.D.
	6.	Studies in the effect of fertilisers and energy materials in Sagar Oils	O.N. Tripati	1956	Ph.D.
	7.	Synthesis of compounds which may possess amoebicidal activity	C.N. Kechru	1957	Ph.D.
	8.	Studies in optical activity and chemical constitution	S.P. Banerjee	1957	Ph.D.
	9.	Studies in Hydrous oxides and complex salts	K. Govind Kamal	1957	Ph.D.
	10.	Effect of Ammonium Phosphate, Energy Rich Meterials on Physico-chemical properties of soil and plant growth	S.S. Sharma	1959	Ph.D.
23. *Utkal*	1.	Preparation and useful applications of some thiazolidone derivatives	Hrishikesh Pujari	1956	Ph.D.
	2.	Studies on the behaviour of some Unibevalent, Bi-Univalent and Bi-Bivalent salts in aqueous solution	S.C. Sircar	1956	Ph.D.

1	2	3	4	5	6
	3.	Studies on the behaviour of some Bi-Univalent, Uni-bivalent and Bi-bivalent salts in aqueous solution	Prafulla Kumar Jena	1956	Ph.D.
	4.	Synthetic investigations in Terpenes	Shiba N. Mahapatra	1957	Ph.D.
	5.	Chemical and biological investigations of some Thiazole derivatives	Gokulananda Mahapatra	1958	Ph.D.
	6.	Studies on Heterocyclic compounds	M.K. Raut	1959	Ph.D.
	7.	Studies on Heterocyclicsulphur compounds	B.K. Patnaik	1960	Ph.D.