FOREWORD

Renewing and updating of the Curriculum is the essential ingredient of any vibrant university academic system. There ought to be a dynamic Curriculum with necessary additions and changes introduced in it from time to time by the respective university with a prime objective to maintain updated Curriculum and also providing therein inputs to take care of fast paced development in the knowledge of the subject concerned. Revising the Curriculum should be a continuous process to provide an updated education to the students at large.

Leaving a few, there have been many universities where this exercise has not been done for years together and it is not uncommon to find universities maintaining, practicing and teaching still on the Curriculum as old as few years or even more than a decade. Not going through the reasons for this inertia, the University Grants Commission, realising the need in this context and in relevance to its mandate of coordinating and maintaining standard of higher education, decided to adopt a pro-active role to facilitate this change and to ensure that the university Curriculum are soon updated to provide a standard education all over the country.

Curriculum Development Committee for each subject was constituted with the respective Convenor as its nodal person. The Committee besides having five subject experts drawn from the university system, was given a wider representation of various sub subject experts attending meetings of the Committee as the esteemed co-opted members which kept on changing from time to time as the need arose. The Committees, therefore, had representations from a large number of experts and had many meetings before final updated Model Curricula were presented to UGC.

The University Grants Commission and I as its Chairman are grateful to the nodal persons, a large number of permanent and co-opted members in different subjects and their sub disciplines for having worked seriously with committed devotion to have produced a UGC Model Curriculum in 32 subjects within a record period of 18 months.

The exercise would not have been possible without the support of our entire academic community. We can only hope that the results will fulfil their expectations and also those of university community and Indian society.

The UGC Model Curriculum has been produced to take care of the lacuna, defects/shortcomings in the existing Curricula in certain universities, to develop a new Model Curriculum aiming to produce the one which is compatible in tune with recent development in the subject, to introduce innovative concepts, to provide a multi disciplinary profile and to allow a flexible cafeteria like approach including initiating new papers to cater to frontier development in the concerned subject.

The recommendations have been compiled by panels of experts drawn from across the country. They have attempted to combine the practical requirements of teaching in the Indian academic context with the need to observe high standards to provide knowledge in the frontier areas of their disciplines. It has also been aimed to combine the goals and parameters of global knowledge with pride in the Indian heritage and Indian contribution in this context.
Today all knowledge is interdisciplinary. This has been duly considered. Flexible and interactive models have been presented for the universities to extend them further as they would like. Each institution may have to work out certain uniform structures for courses at the same level, so that effective interaction between subjects and faculties is possible. The tendency across the country is now to move from the annual to the semester system, and from award of marks to award of credits. There is perceptible growing interest in modular framing as well.

The recommendations while taking all these features into account, have also made provisions for institutions who may not be in a position to undertake radical structural reform immediately. In any country, especially one as large and varied as India, academic institutions must be allowed enough autonomy and freedom of action to frame courses according to specific needs. The recommendations of the Curriculum Development Committees are meant to reinforce this. The purpose of our exercise has been to provide a broad common framework for exchange, mobility and free dialogue across the entire Indian academic community. These recommendations are made in a spirit of openness and continuous improvement.

To meet the need and requirement of the society and in order to enhance the quality and standards of education, updating and restructuring of the curriculum must continue as a perpetual process. Accordingly, the University Grants Commission constituted the Curriculum Development Committees. If you need to seek any clarification, you may contact Dr. (Mrs.) Renu Batra, UGC Deputy Secretary and Coordinator of CDC who shall accordingly respond to you after due consultation with the respective nodal person of the concerned subject.

The University Grants Commission feels immense pleasure in forwarding this Model Curriculum to the Hon'ble Registrars of all Universities with a request to get its copies made to be forwarded also to the concerned Deans and Heads of Departments requesting them to initiate an early action to get their Curriculum updated. The University Grants Commission Model Curricula is being presented to the Registrar of the university with options either to adopt it in toto or adopt it after making necessary amendments or to adopt it after necessary deletion/addition or to adopt it after making any change whatsoever which the university may consider right. This UGC Model Curriculum has been provided to the universities only to serve as a base and to facilitate the whole exercise of updating the Curriculum soon.

May I request Hon'ble Vice Chancellor and the Hon'ble Registrar including the esteemed Deans, Heads of Departments, Members of the Faculty, Board of Studies and Academic Council of the Universities to kindly update their Curriculum in each of the 32 subjects in consultation with Model Curriculum provided here. This has to be done and must be done soon. May I request the Academic administration of the universities to kindly process it immediately so that an updated Curriculum is adopted by the university latest by July, 2002.

The University Grants Commission requests the Hon'ble Registrars to confirm that this time bound exercise has been done and send a copy of the university's updated Curriculum in each subject to UGC by July 31, 2002. It is a must. It has to be done timely, failing which, the UGC may be forced to take an appropriate unpleasant action against the concerned university.

The UGC looks forward for your active participation in this joint venture to improve the standards to achieve excellence in higher education.

December 2001

HARI GAUTAM
MS (SURGERY) FRCS (EDIN) FRCS (ENG)
FAMS FACS FICS FIACS DSc (HON CAUSA)
CHAIRMAN, UGC
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td>i</td>
</tr>
<tr>
<td>Members of the UGC Chemistry Panel</td>
<td>1</td>
</tr>
<tr>
<td>Members of the CDC for Chemistry</td>
<td>2</td>
</tr>
<tr>
<td>About the Report</td>
<td>3</td>
</tr>
<tr>
<td>Scheme of Academic Programme</td>
<td>6</td>
</tr>
<tr>
<td>Course Structure</td>
<td>8</td>
</tr>
<tr>
<td>Syllabus</td>
<td>23</td>
</tr>
<tr>
<td>Elective Papers</td>
<td>89</td>
</tr>
<tr>
<td>Recommendations</td>
<td>125</td>
</tr>
</tbody>
</table>
PREFACE

All the background information and objectives for constituting the UGC Curriculum Development Committee (CDC) for Chemistry has already been given in the Report of the Curriculum Development Centre in Chemistry published in 1989. The present exercise may be considered as the continuation of the earlier Report.

The CDC for Chemistry was constituted in September 2000 and was asked specifically to “consider various issues like developing multi-disciplinary skills, linking the general studies with professional courses, introduction of bridge courses, allowing both the vertical and horizontal academic mobility etc. while framing/re-framing the curriculum.” The members of the CDC have tried to address many of these issues through brain-storming sessions in the two meetings held in Delhi on Dec. 18th-19th, 2000 and Jan. 29-31, 2001.

Before the task of framing and re-framing of the Chemistry syllabuses was entrusted to the CDC, the Chemistry Panel constituted by the UGC in 1997 was already seized with this work from the date of its inception. The Panel held three meetings as per the details given below.

In addition to deliberating on a large number of issues pertaining to chemical education, the panel in its first meeting held at Kurukshetra on 21-22 December, 1997 considered and discussed the Report of the Curriculum Development Centre (1989). The members were of the opinion that this is an excellent document prepared with great care and effort. But since this was more than a decade old, it needed revision. For this purpose four sub-committees were constituted with the following coordinators.

1. Prof. B.N. Achar  Mysore University
2. Prof. S.N. Bhat  NEHU, Shillong
3. Prof. V.D. Gupta  BHU, Varanasi
4. Prof. (Mrs.) Bani Talapatra  Calcutta University

The coordinators of these sub-committees were requested to prepare the outlines of the proposed syllabuses for the next meeting of the Panel.

The Panel also felt that the UGC should give top priority to up-gradation of laboratory teaching through introduction of electronics and computer-based approaches. A specific suggestion made by the Panel was that where feasible, Refresher Courses in chemistry should include a component of chemical instrumentation.

In the second meeting of the Panel held at I.I.Sc., Bangalore (6-8 August, 1998), the members considered the introductory remarks of Prof. Goverdhan Mehta, Director of the
Institute regarding the thrust to be provided by the Panel in up-gradation of the chemical education.

The Panel members prepared the draft of the syllabus for undergraduate courses and laid down a broad framework for postgraduate courses in the Bangalore meeting. The members undertook the task of expanding various topics for consideration and finalization at the next meeting of the Panel.

In the last meeting of the Panel held at Goa University (11-13 January, 1999), the preliminary drafts of the undergraduate and postgraduate syllabuses were considered. It was decided that once these syllabuses were finalized, they had to be circulated to all the universities for feedback. It was emphasized that there was a need to introduce cost-effective and eco-friendly micro-scale experiments, both at the undergraduate and postgraduate levels. The Convener of the Panel invited Dr. S.L. Kelkar of the University of Pune and the Panel had a demonstration lecture by him on the micro-scale experiments. In view of the viability of these experiments, the Panel strongly recommended that the Academic Staff Colleges may involve Dr. Kelkar for training the teachers in this innovative programme.

The Panel was supposed to have another meeting for further discussion. However, in spite of the best efforts of the Convener the fourth meeting of the Panel could not be held. The present CDC for chemistry picked the thread left by the Chemistry Panel in Sep., 2000.

The first meeting of the CDC for Chemistry was held on 18-19 Dec. 2000 in the UGC office, New Delhi. The Panel members (The Convener, Prof. S.N. Bhat and Prof. V.D. Gupta) appraised the new members (Prof. Ramesh Chandra, Prof. S.C. Gupta, Prof. N.K. Sharma and Prof. P.S. Zacharias) of the existing status of the syllabuses. In view of the shortage of time, it was decided to carry out most of the task assigned to it through correspondence.

The second meeting of the CDC for Chemistry was held on 29-31 January, 2001 in the UGC office, New Delhi. As a result of the efforts of the members, details regarding the contents of the syllabuses, time allocation, academic programme etc. could be finalized in the meeting itself.

Since different persons framed different papers of the syllabus, an important task was to bring uniformity in contents and presentation. This stupendous task required perseverance and lot of fine-tuning of the matter to create unity out of diversity. Prof. S.C. Gupta, member of the CDC performed this task with dedication at Kurukshetra. In the editing of the present document Dr R.C Kamboj, Reader in the Department of Chemistry at Kurukshetra provided Prof. Gupta the much needed help. Both these colleagues worked for long hours for several months to give final shape to this Report. I am also thankful to many other colleagues of the Department who offered their valued opinion in suggesting some changes that went a long way in improving the contents.
In conclusion, I must express my gratefulness to the UGC for giving us an opportunity to develop and updating the curricula and to all members of the Chemistry Panel and the CDC, who put in their best efforts in preparing these syllabuses.

I also take this opportunity of thanking Dr. M.V. Krishnaswamy, Deputy Secretary, UGC and Dr. S.P. Dasthakur, Joint Secretary, UGC for their assistance in co-ordination and arranging the meetings at various places.

S.P. Singh
Professor Emeritus
Convener, Chemistry Panel &
Nodal Person CDC for Chemistry

Kurukshetra
June, 2001

1. Prof. S.P. Singh  
   Kurukshetra University  
   Convener

2. Prof. B.N. Achar  
   Mysore University  
   Analytical Chemistry

3. Prof. S.N. Bhat  
   NEHU, Shillong  
   Physical Chemistry

4. Prof. S. Chandrasekaran  
   I.I.Sc., Bangalore  
   Organic Chemistry

5. Prof. S.K. Dogra  
   I.I.T., Kanpur  
   Physical Chemistry

6. Prof. S.R. Gadre  
   University of Pune  
   Physical Chemistry

7. Prof. R.R. Gupta  
   University of Rajasthan  
   Organic Chemistry

8. Prof. V.D. Gupta  
   BHU, Varanasi  
   Inorganic Chemistry

9. Prof. (Mrs.) A. Khare  
   University of Lucknow  
   Organic Chemistry

10. Prof. S.V. Kessar  
    Panjab University  
    Organic Chemistry

11. Prof. V.M. Kulkarni  
    Bombay University  
    Medicinal Chemistry

12. Prof. P. Ananthakrishna Nadar  
    Annamalai University  
    Physical Chemistry

13. Prof. P. Rabindra Reddy  
    Osmania University  
    Inorganic Chemistry

14. Prof. K.V. Sane  
    Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore  
    Physical Chemistry

15. Prof. (Mrs.) Bani Talapatra  
    Calcutta University  
    Organic Chemistry

Dr. M.V. Krishnaswamy  
Deputy Secretary  
U.G.C., New Delhi  
Secretary to the Panel
MEMBERS OF THE CDC FOR CHEMISTRY (2000-2001)

1. Prof. S.P. Singh  
   Kurukshestra University  
   Nodal Person

2. Prof. B.N. Achar  
   Mysore University  
   Analytical Chemistry

3. Prof. S.N. Bhat  
   NEHU, Shillong  
   Physical Chemistry

4. Prof. Ramesh Chandra  
   Vice-Chancellor  
   Bio-inorganic Chemistry  
   Bundelkhand University

5. Prof. S.C. Gupta  
   Kurukshestra University  
   Organic Chemistry

6. Prof. V.D. Gupta  
   BHU, Varanasi  
   Inorganic Chemistry

7. Prof. N.K. Sharma  
   Jammu University  
   Physical Chemistry

8. Prof. P.S. Zacharias  
   University of Hyderabad  
   Inorganic Chemistry

Dr. S.P. Dastakhur  
Joint Secretary  
U.G.C., New Delhi  
Secretary to the Committee
ABOUT THE REPORT

With increasing awareness of the importance of learning process in chemical education, more learner-oriented or enquiry-oriented teaching methods should be introduced in the instructional system. Accordingly, efforts must be made with an aim at shifting emphasis from teaching to learning. Students need to be encouraged to study some part of the syllabus themselves and be given assignments so as to make them use the library or laboratory.

More specifically, lectures should be supplemented with tutorials, problem-solving sessions and periodical assessments so that a student derives maximum benefit from his programme of study. Hence, in the proposed syllabuses adequate time has been provided for tutorials, problem-solving exercises, seminars and project work. It is expected that a teacher will make a productive use of this in-built time which is available in every paper.

A few salient features of this Report are as follows:

1. We have freely drawn from the Report of the Curriculum Development Centre in Chemistry (1989) which is an excellent and exhaustive document.

2. There has been a general feeling in academic circles that the programme of studies in Chemistry at many universities in the country has not kept pace with the fast changing needs and demands of the society. Thus an urgent need for upgradation and modernization of the existing curricula was felt. The present exercise may be considered timely to meet the demands of the changes in chemical education and societal aspirations in general.

3. An important feature of the Report is the amalgamation between the factual knowledge and skill to generate new ideas. Every effort has been made to minimize the compartmentalization of Chemistry into the conventional three branches – Inorganic, Organic and Physical at the postgraduate level. The papers have been split into topics with the suggested number of lectures which may be adequate not only for classroom teaching but also for activities such as periodical evaluation.

4. It would have been desirable that CDC for Chemistry should have interacted with the other CDC’s of experimental sciences, particularly those of Physics, Botany, Zoology and Biochemistry as the time table of undergraduate classes is usually prepared taking into consideration the requirements of all the three subjects having equal weightage. However, such a meeting could not be arranged despite our best efforts.

5. The CDC for Chemistry has no idea about the academic programme being offered by the other CDC’s of science subjects for Hons. Courses. After prolonged deliberations, it is suggested that at the I yr. and II yr. levels, the course content should be the same for both, B.Sc. and B.Sc. (Hons.) classes. At the III yr. level, while the B.Sc. students will study all
the three subjects, the Hons. students shall study only Chemistry with minor variations depending upon the regional requirements.
The course content of two subsidiary subjects which a student majoring in Chemistry should study may be suitably designed by other CDC’s of the related subjects so as to present a compact and complete module retaining all the basic features of the subject. The proposed Chemistry syllabus for B.Sc. I yr. and II yr. has taken care of this requirement and a student majoring in Physics, for instance, will have sufficient exposure to Chemistry for a professional career. There should not be a feeling of “incomplete studies” as all the core topics of Chemistry are covered in the first two years. Such an arrangement will also facilitate in combining I yr. and II yr. classes of B.Sc. (three year course) and Hons. Course, in case it is required.

6 Important thrust areas such as organo-metallics, bioinorganic chemistry and polymers based on inorganic skeleton have been introduced in the undergraduate syllabus of Inorganic Chemistry. Similarly, in the undergraduate syllabus of Organic Chemistry, major thrust has been to explain the chemical transformations based on mechanistic pathways. Spectroscopic techniques for the characterization of organic compounds have been introduced at an early stage. Another noteworthy feature of Organic Chemistry syllabus is the inclusion of topics of applied nature in the III yr. course of B.Sc.

In the undergraduate syllabus of Physical Chemistry, a topic on Mathematics and application of Computers in Chemistry has been introduced in the first year. An attempt has been made to bring relevant and related topics together. Special care has been taken for carrying out Physical Chemistry experiments only after the theory involved in the exercises has been covered in the lectures.

7 A number of avenues have opened up for employment of Chemistry graduates in the industrial sector. Some of the areas that offer opportunities to chemists are: drugs, food, polymers, textile and agro-based industries. An effort has been made in the curricula to provide background material for these topics to the students for taking up jobs in this sector.

8. Realizing that boundaries between different sub-disciplines – Inorganic, Organic and Physical – are rapidly diminishing, the postgraduate syllabus has been so designed that three fourth of it shall be common for all the students. And for the rest, a basket of several papers has been offered out of which a student may select any four papers of his interest. This provision has been made to generate flair for a particular profession. For instance, a student opting for a career in pharmaceutical industry should be encouraged to go for electives such as medicinal chemistry, heterocyclic chemistry and organic synthesis. In order to provide sufficient flexibility and diversity to the students, lab courses for this duration will be either experiments of advanced nature or preferably project work/industrial training.
Also, the students coming out of such an academic programme will not experience any difficulty in teaching undergraduate courses.

The Report has several novel features at the postgraduate level. Some of these are:

(i) Compulsory teaching of Group Theory and Spectroscopy.
(ii) Selective teaching of Mathematics/Biology for chemists depending upon the background of the student.
(iii) A well-defined course of 60 hrs. on application of computers for chemists with a laboratory component.
(iv) Introduction of a compulsory, unified paper comprising elements of bioinorganic, bioorganic and biophysical chemistry.
(v) A compulsory paper consisting of applications of spectroscopy, photochemistry and solid state chemistry.
(vi) A compulsory paper on Environmental Chemistry.
(vii) Availability of a basket of elective papers in M.Sc. II yr.
(viii) Introduction of eco-friendly and micro-scale experiments in the laboratory with particular emphasis on instrumental methods of analysis. The experiments have been coordinated to a great extent with theory courses for better appreciation.
(ix) At the end of syllabus for each paper, a number of books have been suggested for ready reference of both the teachers and students. Although publishers and authors of these books have been mentioned but the year of publication has been omitted to facilitate the use of latest editions.
SCHEME OF ACADEMIC PROGRAMME

As per guidelines issued by the UGC, the effective teaching days in an Institution should not be less than 180 days. The undergraduate and postgraduate syllabuses given in this Report have been framed accordingly. Based on the assumption that there will be 6-days teaching in a week, the expected working days for effective teaching are

Per year = 30 weeks
Per semester = 15 weeks

The syllabuses are, however, designed on annual basis with an in-built provision to be divided into two semesters.

UNDERGRADUATE PROGRAMME

B.Sc. (Three-year Degree Course)

In most Universities, there are three compulsory subjects with equal weightage in terms of time allotment and marks. Each subject is normally allotted 12 periods per week (including lab course) of 45-50 min. It is now felt that the period should be of 60 min. (1 hr.). The schedule for Chemistry teaching suggested by the CDC is as follows:

<table>
<thead>
<tr>
<th></th>
<th>Theory</th>
<th>Lab Course</th>
<th>Total Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I yr.</td>
<td>6 Hrs/week</td>
<td>6 Hrs/week</td>
<td>12 Hrs/week.</td>
</tr>
<tr>
<td></td>
<td>180 Hrs/year**</td>
<td>180 Hrs/year</td>
<td>360 Hrs/year</td>
</tr>
<tr>
<td>II yr.</td>
<td>As above</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>III yr.</td>
<td>As above</td>
<td>As above</td>
<td>As above</td>
</tr>
</tbody>
</table>

* These can be arranged as 2 lab sessions of 3 Hrs. each
** 60 Hrs. theory each for Inorganic, Organic and Physical Chemistry

B.Sc. (Hons.) Course

For framing the B.Sc. (Hons.) Course, the CDC felt the need to have interaction with other science disciplines regarding the nature, pattern and duration of various subsidiaries, however, it could not be done. After detailed deliberations at various levels, the CDC suggests the following pattern for teaching Chemistry at Hons. level.

At the I yr. and II yr. levels, the curriculum in Chemistry should be the same for B.Sc. three-year degree course and Hons. Course with equal weightage for all the three subjects. At
the III yr. level, there should be an exclusive teaching of Chemistry. Based on this model, the following academic programme can be suggested for the teaching of Chemistry at Hons. level.

<table>
<thead>
<tr>
<th></th>
<th>Theory</th>
<th>Lab Course</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I yr.</td>
<td>6 Hrs/week</td>
<td>6 Hrs /week(^a)</td>
<td>12 Hrs /week</td>
</tr>
<tr>
<td></td>
<td>180 Hrs /year(^b)</td>
<td>180 Hrs /year</td>
<td>360 Hrs /year</td>
</tr>
<tr>
<td>II yr.</td>
<td>As above</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>III yr.</td>
<td>18 Hrs /week</td>
<td>18 Hrs /week(^c)</td>
<td>36 Hrs /week</td>
</tr>
<tr>
<td></td>
<td>540 Hrs /year(^d)</td>
<td>540 Hrs /year</td>
<td>1080 Hrs /year</td>
</tr>
</tbody>
</table>

\(^a\) These can be arranged as 2 lab. sessions of 3 Hrs. each
\(^b\) 60 Hrs. theory each for Inorganic, Organic and Physical Chemistry
\(^c\) There should be a lab course of 3 Hrs. per day.
\(^d\) 180 Hrs. theory each for Inorganic, Organic and Physical Chemistry

The list of a few suggested titles for the topics to be included in Hons. syllabus has been prepared and it is expected that depending upon the requirement and expertise available, these topics will be expanded by the Boards of Studies for inclusion in the III yr. of B.Sc. Hons. Course.

**POSTGRADUATE PROGRAMME**

A common programme of teaching has been suggested for three-fourth of the curriculum. For the rest, the students shall have the option of selecting the papers of their choice and specific interest. The students will be offered a large number of elective papers from which they can select four papers of 60 hrs. each. Such an arrangement is expected to provide sufficient flexibility as regards to the utilization of the expertise available in the existing faculty as well as bringing uniformity in the instructions to a great extent. Based on this model, the following teaching programme has been framed for M.Sc. course.

<table>
<thead>
<tr>
<th></th>
<th>Theory</th>
<th>Lab Course</th>
<th>Total Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.Sc. I yr.</td>
<td>18 Hrs/week</td>
<td>18 Hrs /week</td>
<td>36 Hrs /week</td>
</tr>
<tr>
<td></td>
<td>540 Hrs/year</td>
<td>540 Hrs /year</td>
<td>1080 Hrs /year</td>
</tr>
<tr>
<td>M.Sc. II yr.</td>
<td>18 Hrs/week.</td>
<td>18 Hrs/week.</td>
<td>36 Hrs/week.</td>
</tr>
<tr>
<td></td>
<td>540 Hrs./year</td>
<td>540 Hrs./year</td>
<td>1080 Hrs/year</td>
</tr>
</tbody>
</table>
COURSE STRUCTURE

B. Sc. CHEMISTRY
(Three Year Degree Course)

<table>
<thead>
<tr>
<th>Year</th>
<th>Paper</th>
<th>Course No.</th>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>I</td>
<td>CH-101</td>
<td>Inorganic Chemistry-I</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>CH-102</td>
<td>Organic Chemistry-I</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>CH-103</td>
<td>Physical Chemistry-I</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>CH-104</td>
<td>Laboratory Course-I</td>
<td>180</td>
</tr>
<tr>
<td>II</td>
<td>V</td>
<td>CH-201</td>
<td>Inorganic Chemistry-II</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>VI</td>
<td>CH-202</td>
<td>Organic Chemistry-II</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>CH-203</td>
<td>Physical Chemistry-II</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>VIII</td>
<td>CH-204</td>
<td>Laboratory Course-II</td>
<td>180</td>
</tr>
<tr>
<td>III</td>
<td>IX</td>
<td>CH-301</td>
<td>Inorganic Chemistry-III</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>CH-302</td>
<td>Organic Chemistry-III</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>XI</td>
<td>CH-303</td>
<td>Physical Chemistry-III</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>XII</td>
<td>CH-304</td>
<td>Laboratory Course-III</td>
<td>180</td>
</tr>
</tbody>
</table>

The ratio of marks between lab. course and theory may be kept between 1:2 to 1:3.
# M.Sc. CHEMISTRY
## (TWO YEAR COURSE)

### I Year

<table>
<thead>
<tr>
<th>Paper</th>
<th>Course No.</th>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper I</td>
<td>CH-401</td>
<td>Inorganic Chemistry</td>
<td>120</td>
</tr>
<tr>
<td>Paper II</td>
<td>CH-402</td>
<td>Organic Chemistry</td>
<td>120</td>
</tr>
<tr>
<td>Paper III</td>
<td>CH-403</td>
<td>Physical Chemistry</td>
<td>120</td>
</tr>
<tr>
<td>Paper IV</td>
<td>CH-404</td>
<td>Group Theory and Spectroscopy</td>
<td>90</td>
</tr>
<tr>
<td>Paper V</td>
<td>CH-405</td>
<td>a) Mathematics for Chemists*</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) Biology for Chemists**</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Computers for Chemists</td>
<td>60</td>
</tr>
<tr>
<td>Paper VI</td>
<td>CH-406</td>
<td>Laboratory Course in Chemistry</td>
<td>270</td>
</tr>
<tr>
<td>Paper VII</td>
<td>CH-407</td>
<td>Laboratory Course in Chemistry-II</td>
<td>270</td>
</tr>
</tbody>
</table>

Papers with 120 Hrs will be taught for 4 Hrs/week, with 90 Hrs for 3 Hrs/week, with 60 Hrs for 2 Hrs/week and with 30 Hrs for 1 Hr/week.

* For students without Mathematics in B.Sc.

** For students without Biology in B.Sc.

The ratio of marks between laboratory course and theory may be 1:3.

### II Year

<table>
<thead>
<tr>
<th>Paper</th>
<th>Course No.</th>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper VIII</td>
<td>CH-501</td>
<td>a) Applications of Spectroscopy</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Photochemistry</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Solid State Chemistry</td>
<td>30</td>
</tr>
<tr>
<td>Paper IX</td>
<td>CH-502</td>
<td>a) Bioinorganic Chemistry</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Bioorganic Chemistry</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Biophysical Chemistry</td>
<td>30</td>
</tr>
<tr>
<td>Paper X</td>
<td>CH-503</td>
<td>Environmental Chemistry</td>
<td>60</td>
</tr>
<tr>
<td>Paper XI</td>
<td>CH-504</td>
<td>Elective Papers 1-15*</td>
<td>60</td>
</tr>
<tr>
<td>Paper XII</td>
<td>CH-505</td>
<td>-do-</td>
<td>60</td>
</tr>
<tr>
<td>Paper XIII</td>
<td>CH-506</td>
<td>-do-</td>
<td>60</td>
</tr>
<tr>
<td>Paper XIV</td>
<td>CH-507</td>
<td>-do-</td>
<td>60</td>
</tr>
<tr>
<td>Seminars</td>
<td></td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Paper XV</td>
<td>CH-508</td>
<td>Laboratory Course in Chemistry III</td>
<td>270</td>
</tr>
<tr>
<td>Paper XVI</td>
<td>CH-509</td>
<td>Laboratory Course in Chemistry IV*</td>
<td>270</td>
</tr>
</tbody>
</table>

Papers with 120 Hrs will be taught for 4 Hrs/week, with 90 Hrs for 3 Hrs/week, with 60 Hrs for 2 Hrs/week and with 30 Hrs for 1 Hr/week.

Seminars have been assigned 1 Hr/week.

* From the elective papers 1 to 15, students are required to select any four papers.

# Laboratory course may be advanced practical and/or Project work/Industrial training

The ratio of marks between laboratory course and theory may be 1:3.
# B.Sc. CHEMISTRY
(Three Year Degree Course)

## I Year

<table>
<thead>
<tr>
<th>Paper I</th>
<th>CH-101 Inorganic Chemistry – I</th>
<th>60 Hrs (2 Hrs/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Atomic Structure</td>
<td>6 Hrs</td>
</tr>
<tr>
<td>II</td>
<td>Periodic Properties</td>
<td>5 Hrs</td>
</tr>
<tr>
<td>III</td>
<td>Chemical Bonding</td>
<td>20 Hrs</td>
</tr>
<tr>
<td>IV</td>
<td>s-Block Elements</td>
<td>6 Hrs</td>
</tr>
<tr>
<td>V</td>
<td>p-Block Elements</td>
<td>20 Hrs</td>
</tr>
<tr>
<td>VI</td>
<td>Chemistry of Noble Gases</td>
<td>3 Hrs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Paper II</th>
<th>CH-102 Organic Chemistry – I</th>
<th>60 Hrs (2 Hrs/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Structure and Bonding</td>
<td>5 Hrs</td>
</tr>
<tr>
<td>II</td>
<td>Mechanism of Organic Reactions</td>
<td>8 Hrs</td>
</tr>
<tr>
<td>III</td>
<td>Stereochemistry of Organic Compounds</td>
<td>12 Hrs</td>
</tr>
<tr>
<td>IV</td>
<td>Alkanes and Cycloalkanes</td>
<td>7 Hrs</td>
</tr>
<tr>
<td>V</td>
<td>Alkenes, Cycloalkenes, Dienes and Alkynes</td>
<td>12 Hrs</td>
</tr>
<tr>
<td>VI</td>
<td>Arenes and Aromaticity</td>
<td>8 Hrs</td>
</tr>
<tr>
<td>VII</td>
<td>Alkyl and Aryl halides</td>
<td>8 Hrs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Paper III</th>
<th>CH-103 Physical Chemistry -I</th>
<th>60 Hrs (2 Hrs/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Mathematical Concepts and Computers</td>
<td>16 Hrs</td>
</tr>
<tr>
<td>II</td>
<td>Gaseous States</td>
<td>8 Hrs</td>
</tr>
<tr>
<td>III</td>
<td>Liquid State</td>
<td>6 Hrs</td>
</tr>
<tr>
<td>IV</td>
<td>Solid State</td>
<td>11 Hrs</td>
</tr>
<tr>
<td>V</td>
<td>Colloidal State</td>
<td>6 Hrs</td>
</tr>
<tr>
<td>VI</td>
<td>Chemical Kinetics and Catalysis</td>
<td>13 Hrs</td>
</tr>
</tbody>
</table>

## Paper IV CH –104 Laboratory Course I
(Inorganic, Organic, Physical) 180 Hrs (6 Hrs/week)
### II Year

**Paper V CH-201 Inorganic Chemistry – II**

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Chemistry of Elements of First Transition Series</td>
<td>10</td>
</tr>
<tr>
<td>II</td>
<td>Chemistry of Elements of Second and Third Transition Series</td>
<td>10</td>
</tr>
<tr>
<td>III</td>
<td>Oxidation and Reduction</td>
<td>8</td>
</tr>
<tr>
<td>IV</td>
<td>Coordination Compounds</td>
<td>10</td>
</tr>
<tr>
<td>V</td>
<td>Chemistry of Lanthanide Elements</td>
<td>6</td>
</tr>
<tr>
<td>VI</td>
<td>Chemistry of Actinides</td>
<td>4</td>
</tr>
<tr>
<td>VII</td>
<td>Acids and Bases</td>
<td>6</td>
</tr>
<tr>
<td>VIII</td>
<td>Non-aqueous Solvents</td>
<td>6</td>
</tr>
</tbody>
</table>

**Paper VI CH-202 Organic Chemistry – II**

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Electromagnetic Spectrum: Absorption Spectra</td>
<td>10</td>
</tr>
<tr>
<td>II</td>
<td>Alcohols</td>
<td>6</td>
</tr>
<tr>
<td>III</td>
<td>Phenols</td>
<td>6</td>
</tr>
<tr>
<td>IV</td>
<td>Ethers and Epoxides</td>
<td>3</td>
</tr>
<tr>
<td>V</td>
<td>Aldehydes and Ketones</td>
<td>14</td>
</tr>
<tr>
<td>VI</td>
<td>Carboxylic Acids</td>
<td>6</td>
</tr>
<tr>
<td>VII</td>
<td>Carboxylic Acid Derivatives</td>
<td>3</td>
</tr>
<tr>
<td>VIII</td>
<td>Organic Compounds of Nitrogen</td>
<td>12</td>
</tr>
</tbody>
</table>

**Paper VII CH-203 Physical Chemistry - II**

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Thermodynamics – I</td>
<td>12</td>
</tr>
<tr>
<td>II</td>
<td>Thermodynamics – II</td>
<td>13</td>
</tr>
<tr>
<td>III</td>
<td>Chemical Equilibrium</td>
<td>5</td>
</tr>
<tr>
<td>IV</td>
<td>Phase Equilibrium</td>
<td>10</td>
</tr>
<tr>
<td>V</td>
<td>Electrochemistry - I</td>
<td>10</td>
</tr>
<tr>
<td>VI</td>
<td>Electrochemistry – II</td>
<td>10</td>
</tr>
</tbody>
</table>

**Paper VIII CH – 204 Laboratory Course II**

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Inorganic, Organic, Physical)</td>
<td>180</td>
</tr>
</tbody>
</table>
### III Year

<table>
<thead>
<tr>
<th>Paper IX CH – 301 Inorganic Chemistry – III</th>
<th>60 Hrs (2 Hrs/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I  Hard and Soft Acids and Bases (HSAB)</td>
<td>7 Hrs</td>
</tr>
<tr>
<td>II Metal-ligand Bonding in Transition Metal Complexes</td>
<td>10 Hrs</td>
</tr>
<tr>
<td>III Magnetic Properties of Transition Metal-Complexes</td>
<td>7 Hrs</td>
</tr>
<tr>
<td>IV Electron Spectra of Transition Metal-Complexes</td>
<td>7 Hrs</td>
</tr>
<tr>
<td>V  Thermodynamic and Kinetic Aspects of Metal-Complexes</td>
<td>5 Hrs</td>
</tr>
<tr>
<td>VI Organometallic Chemistry</td>
<td>10 Hrs</td>
</tr>
<tr>
<td>VII Bioinorganic Chemistry</td>
<td>10 Hrs</td>
</tr>
<tr>
<td>VIII Silicones and phosphazenes</td>
<td>4 Hrs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Paper X CH - 302 Organic Chemistry – III</th>
<th>60 Hrs (2 Hrs/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I  Spectroscopy</td>
<td>10 Hrs</td>
</tr>
<tr>
<td>II Organometallic Compounds</td>
<td>4 Hrs</td>
</tr>
<tr>
<td>III Organosulphur Compounds</td>
<td>4 Hrs</td>
</tr>
<tr>
<td>IV Heterocyclic Compounds</td>
<td>8 Hrs</td>
</tr>
<tr>
<td>V  Organic Synthesis via Enolates</td>
<td>6 Hrs</td>
</tr>
<tr>
<td>VI Carbohydrates</td>
<td>8 Hrs</td>
</tr>
<tr>
<td>VII Amino Acids, Peptides, Proteins and Nucleic Acids</td>
<td>6 Hrs</td>
</tr>
<tr>
<td>VIII Fats, Oils and Detergents</td>
<td>2 Hrs</td>
</tr>
<tr>
<td>IX Synthetic Polymers</td>
<td>4 Hrs</td>
</tr>
<tr>
<td>X  Synthetic Dyes</td>
<td>8 Hrs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Paper XI CH - 303 Physical Chemistry – II</th>
<th>60 Hrs (2 Hrs/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I  Elementary Quantum Mechanics</td>
<td>20 Hrs</td>
</tr>
<tr>
<td>II Spectroscopy</td>
<td>20 Hrs</td>
</tr>
<tr>
<td>III Photochemistry</td>
<td>8 Hrs</td>
</tr>
<tr>
<td>IV Physical Properties and Molecular Structure</td>
<td>5 Hrs</td>
</tr>
<tr>
<td>V  Solutions, Dilute Solutions and Colligative Properties</td>
<td>7 Hrs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Paper XII CH – 304 Laboratory Course III</th>
<th>180 Hrs (6 Hrs/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Inorganic, Organic, Physical)</td>
<td></td>
</tr>
</tbody>
</table>
# M.Sc. CHEMISTRY

## I Year

<table>
<thead>
<tr>
<th>Paper I</th>
<th>CH-401 Inorganic Chemistry</th>
<th>120 Hrs (4 Hrs/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Stereochemistry and Bonding in Main</td>
<td>12 Hrs</td>
</tr>
<tr>
<td></td>
<td>Group Compounds</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Metal-Ligand Equilibria in Solution</td>
<td>8 Hrs</td>
</tr>
<tr>
<td>III</td>
<td>Reaction Mechanism of Transition Metal Complexes</td>
<td>24 Hrs</td>
</tr>
<tr>
<td>IV</td>
<td>Metal-Ligand Bonding</td>
<td>15 Hrs</td>
</tr>
<tr>
<td>V</td>
<td>Electronic Spectra and Magnetic Properties of Transition Metal Complexes</td>
<td>24 Hrs</td>
</tr>
<tr>
<td>VI</td>
<td>Metal π-Complexes</td>
<td>18 Hrs</td>
</tr>
<tr>
<td>VII</td>
<td>Metal Clusters</td>
<td>15 Hrs</td>
</tr>
<tr>
<td>VIII</td>
<td>Isopoly and Heteropoly Acids and Salts</td>
<td>4 Hrs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Paper II</th>
<th>CH-402 Organic Chemistry</th>
<th>120 Hrs (4 Hrs/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Nature of Bonding in Organic Molecules</td>
<td>10 Hrs</td>
</tr>
<tr>
<td>II</td>
<td>Stereochemistry</td>
<td>15 Hrs</td>
</tr>
<tr>
<td>III</td>
<td>Reaction Mechanism: Structure and Reactivity</td>
<td>12 Hrs</td>
</tr>
<tr>
<td>IV</td>
<td>Aliphatic Nucleophilic Substitution</td>
<td>15 Hrs</td>
</tr>
<tr>
<td>V</td>
<td>Aliphatic Electrophilic Substitution</td>
<td>5 Hrs</td>
</tr>
<tr>
<td>VI</td>
<td>Aromatic Electrophilic Substitution</td>
<td>6 Hrs</td>
</tr>
<tr>
<td>VII</td>
<td>Aromatic Nucleophilic Substitution</td>
<td>5 Hrs</td>
</tr>
<tr>
<td>VIII</td>
<td>Free Radical Reactions</td>
<td>8 Hrs</td>
</tr>
<tr>
<td>IX</td>
<td>Addition to Carbon-Carbon Multiple Bonds</td>
<td>7 Hrs</td>
</tr>
<tr>
<td>X</td>
<td>Addition to Carbon-Hetero Multiple Bonds</td>
<td>12 Hrs</td>
</tr>
<tr>
<td>XI</td>
<td>Elimination Reactions</td>
<td>5 Hrs</td>
</tr>
<tr>
<td>XII</td>
<td>Pericyclic Reactions</td>
<td>20 Hrs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Paper III</th>
<th>CH-403 Physical Chemistry</th>
<th>120 Hrs (4 Hrs/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Quantum Chemistry</td>
<td>30 Hrs</td>
</tr>
<tr>
<td>II</td>
<td>Thermodynamics</td>
<td>30 Hrs</td>
</tr>
<tr>
<td>III</td>
<td>Chemical Dynamics</td>
<td>20 Hrs</td>
</tr>
<tr>
<td>IV</td>
<td>Surface Chemistry</td>
<td>20 Hrs</td>
</tr>
<tr>
<td>V</td>
<td>Electrochemistry</td>
<td>20 Hrs</td>
</tr>
</tbody>
</table>
### Paper IV  CH-404 Group Theory, Spectroscopy and Diffraction Methods

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Symmetry and Group Theory in Chemistry</td>
</tr>
<tr>
<td>II</td>
<td>Unifying Principles</td>
</tr>
<tr>
<td>III</td>
<td>Microwave Spectroscopy</td>
</tr>
<tr>
<td>IV</td>
<td>Vibrational Spectroscopy</td>
</tr>
<tr>
<td>V</td>
<td>Electronic Spectroscopy</td>
</tr>
<tr>
<td>VI</td>
<td>Magnetic Resonance Spectroscopy</td>
</tr>
<tr>
<td>VII</td>
<td>Photoacoustic Spectroscopy</td>
</tr>
<tr>
<td>VIII</td>
<td>X-ray Diffraction</td>
</tr>
<tr>
<td>IX</td>
<td>Electron Diffraction</td>
</tr>
<tr>
<td>X</td>
<td>Neutron Diffraction</td>
</tr>
</tbody>
</table>

**90 Hrs (3 Hrs/week)**

### Paper V  CH-405 (a) Mathematics for Chemists

*For students without Mathematics in B.Sc.*

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Vectors and Matrix Algebra</td>
</tr>
<tr>
<td>II</td>
<td>Differential Calculus</td>
</tr>
<tr>
<td>III</td>
<td>Elementary Differential Equations</td>
</tr>
<tr>
<td>IV</td>
<td>Permutation and Probability</td>
</tr>
</tbody>
</table>

**30 Hrs (1 Hr/week)**

### Paper V  CH-405 (a) Biology for Chemists

*For students without Biology in B.Sc.*

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Cell Structure and Functions</td>
</tr>
<tr>
<td>II</td>
<td>Carbohydrates</td>
</tr>
<tr>
<td>III</td>
<td>Lipids</td>
</tr>
<tr>
<td>IV</td>
<td>Amino Acids, Peptides and Proteins</td>
</tr>
<tr>
<td>V</td>
<td>Nucleic Acids</td>
</tr>
</tbody>
</table>

**30 Hrs (1 Hr/week)**

### Paper V  CH-405 (b) Computers for Chemists

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Introduction to Computers and Computing</td>
</tr>
<tr>
<td>II</td>
<td>Computer Programming in FORTRAN/C/BASIC</td>
</tr>
<tr>
<td>III</td>
<td>Programming in Chemistry</td>
</tr>
<tr>
<td>IV</td>
<td>Use of Computer Programmes</td>
</tr>
</tbody>
</table>

**60 Hrs (2 Hrs/week)**

### Paper VI & VII  CH-406 & 407 Laboratory Course-I & II

**540 Hrs (18 Hrs/week)**
Inorganic Chemistry

- Qualitative and Quantitative Analysis
- Chromatography
- Preparations

Organic Chemistry

- Qualitative Analysis
- Organic Synthesis
- Quantitative Analysis

Physical Chemistry

- Error Analysis and Statistical Data Analysis
- Adsorption
- Phase Equilibria
- Chemical Kinetics
- Electrochemistry
- Polarimetry
II Year

Paper VIII CH-501 (a) Applications of Spectroscopy

Inorganic Chemistry

I  Vibrational Spectroscopy  5 Hrs
II  Electron Spin Resonance Spectroscopy  8 Hrs
III  Nuclear Magnetic Resonance of Paramagnetic Substances in Solution  7 Hrs
IV  Mössbauer Spectroscopy  6 Hrs

Organic Chemistry

I  Ultraviolet and Visible Spectroscopy  3 Hrs
II  Infrared Spectroscopy  5 Hrs
III  Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD)  3 Hrs
IV  Nuclear Magnetic Resonance Spectroscopy  10 Hrs
V  Carbon-13 NMR Spectroscopy  5 Hrs
VI  Mass Spectrometry  8 Hrs

Paper VIII CH-501 (b) Photochemistry

1  Photochemical Reactions  4 Hrs
II  Determination of Reaction Mechanism  4 Hrs
III  Photochemistry of Alkenes  6 Hrs
IV  Photochemistry of Carbonyl Compounds  8 Hrs
V  Photochemistry of Aromatic Compounds  4 Hrs
VI  Miscellaneous Photochemical Reactions  4 Hrs

Paper VIII CH-501 (c) Solid State Chemistry

I  Solid State Reactions  4 Hrs
II  Crystal Defects and Non-Stoichiometry  6 Hrs
III  Electronic Properties and Band Theory  15 Hrs
IV  Organic Solids  5 Hrs

Paper IX  CH-502 (a) Bioinorganic Chemistry

I  Metal Ions in Biological Systems  2 Hrs
II  Na⁺/K⁺ Pump  3 Hrs
III  Bioenergetics and ATP Cycle  6 Hrs
IV  Transport and Storage of Dioxygen  8 Hrs
<table>
<thead>
<tr>
<th>Paper IX</th>
<th>CH-502 (b) Bioorganic Chemistry</th>
<th>30 Hrs (1 Hr/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Introduction</td>
<td>2 Hrs</td>
</tr>
<tr>
<td>II</td>
<td>Enzymes</td>
<td>6 Hrs</td>
</tr>
<tr>
<td>III</td>
<td>Mechanism of Enzyme Action</td>
<td>3 Hrs</td>
</tr>
<tr>
<td>IV</td>
<td>Kinds of Reactions Catalysed by Enzymes</td>
<td>6 Hrs</td>
</tr>
<tr>
<td>V</td>
<td>Co-Enzyme Chemistry</td>
<td>4 Hrs</td>
</tr>
<tr>
<td>VI</td>
<td>Enzyme Models</td>
<td>4 Hrs</td>
</tr>
<tr>
<td>VII</td>
<td>Biotechnological Applications of Enzymes</td>
<td>5 Hrs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Paper IX</th>
<th>CH-502 (c) Biophysical Chemistry</th>
<th>30 Hrs (1 Hr/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Biological Cell and its Constituents</td>
<td>2 Hrs</td>
</tr>
<tr>
<td>II</td>
<td>Bioenergetics</td>
<td>3 Hrs</td>
</tr>
<tr>
<td>III</td>
<td>Statistical Mechanics in Biopolymers</td>
<td>5 Hrs</td>
</tr>
<tr>
<td>IV</td>
<td>Biopolymer Interactions</td>
<td>5 Hrs</td>
</tr>
<tr>
<td>V</td>
<td>Thermodynamics of Biopolymer Solutions</td>
<td>4 Hrs</td>
</tr>
<tr>
<td>VI</td>
<td>Cell Membrane and Transport of Ions</td>
<td>3 Hrs</td>
</tr>
<tr>
<td>VII</td>
<td>Biopolymers and their Molecular Weights</td>
<td>5 Hrs</td>
</tr>
<tr>
<td>VIII</td>
<td>Diffraction Methods</td>
<td>3 Hrs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Paper X</th>
<th>CH-503 Environmental Chemistry</th>
<th>60 Hrs (2 Hrs/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Environment</td>
<td>8 Hrs</td>
</tr>
<tr>
<td>II</td>
<td>Hydrosphere</td>
<td>12 Hrs</td>
</tr>
<tr>
<td>III</td>
<td>Soils</td>
<td>6 Hrs</td>
</tr>
<tr>
<td>IV</td>
<td>Atmosphere</td>
<td>8 Hrs</td>
</tr>
<tr>
<td>V</td>
<td>Industrial Pollution</td>
<td>12 Hrs</td>
</tr>
<tr>
<td>VI</td>
<td>Environmental Toxicology</td>
<td>14 Hrs</td>
</tr>
</tbody>
</table>
ELECTIVE PAPERS

Elective Paper 1  Organotransition Metal Chemistry  60  Hrs (2 Hrs/week)
I  Alkyls and Aryls of Transition Metals  5  Hrs
II  Compounds of Transition Metal-Carbon  12  Hrs
      Multiple Bonds
III  Transition Metal π- Complexes  18  Hrs
IV  Transition Metal Compounds with  3  Hrs
      Bonds to Hydrogen
V  Homogeneous Catalysis  14  Hrs
VI  Fluxional Organometallic Compounds  8  Hrs

Elective Paper 2  Bioinorganic and  60  Hrs (2 Hrs/week)
      Supramolecular Chemistry
I  Metal Storage Transport and Biomineralization  5  Hrs
II  Calcium in Biology  6  Hrs
III  Metalloenzymes  20  Hrs
IV  Metal–Nucleic Acid Interactions  6  Hrs
V  Metals in Medicine  5  Hrs
VI  Supramolecular Chemistry  18  Hrs

Elective Paper 3  Photoinorganic Chemistry  60  Hrs (2 Hrs/week)
I  Basics of Photochemistry  10  Hrs
II  Properties of Excited States  10  Hrs
III  Excited States of Metal Complexes  8  Hrs
IV  Ligand Field Photochemistry  8  Hrs
V  Redox Reactions by Excited Metal Complexes  16  Hrs
VI  Metal Complex Sensitizers  8  Hrs

Elective Paper 4  Analytical Chemistry  60  Hrs (2 Hrs/week)
I  Introduction  12  Hrs
II  Errors and Evaluation  7  Hrs
III  Food Analysis  12  Hrs
IV  Analysis of Water Pollution  12  Hrs
V  Analysis of Soil, Fuel, Body Fluids and Drugs  17  Hrs
### Elective Paper 5  Organic Synthesis I
- **I** Organometallic Reagents 25 Hrs
- **II** Oxidation 7 Hrs
- **III** Reduction 7 Hrs
- **IV** Rearrangements 12 Hrs
- **V** Metalloenes, Nonbenzenoid Aromatics and Polycyclic Aromatic Compounds 9 Hrs

### Elective Paper 6  Organic Synthesis II
- **I** Disconnection Approach 18 Hrs
- **II** Protecting Groups 5 Hrs
- **III** One Group C-C Disconnections 7 Hrs
- **IV** Two Group C-C Disconnections 10 Hrs
- **V** Ring Synthesis 8 Hrs
- **VI** Synthesis of Some Complex Molecules 12 Hrs

### Elective Paper 7  Heterocyclic Chemistry
- **I** Nomenclature of Heterocycles 4 Hrs
- **II** Aromatic Heterocycles 5 Hrs
- **III** Non-aromatic Heterocycles 6 Hrs
- **IV** Heterocyclic Synthesis 4 Hrs
- **V** Small Ring Heterocycles 5 Hrs
- **VI** Benzo-Fused Five-Membered Heterocycles 5 Hrs
- **VII** Meso-ionic Heterocycles 5 Hrs
- **VIII** Six-Membered Heterocycles with one Heteroatom 6 Hrs
- **IX** Six-Membered Heterocycles with Two or More Heteroatoms 5 Hrs
- **X** Seven- and Large-Membered Heterocycles 5 Hrs
- **XI** Heterocyclic Systems Containing P, As, Sb and B 10 Hrs

### Elective Paper 8  Chemistry of Natural Products
- **I** Terpenoids and Carotenoids 15 Hrs
- **II** Alkaloids 15 Hrs
- **III** Steroids 15 Hrs
- **IV** Plant Pigments 7 Hrs
- **V** Porphyrrins 3 Hrs
- **VI** Prostaglandins 3 Hrs
- **VII** Pyrethroids and Rotenones 2 Hrs
### Elective Paper 9  Medicinal Chemistry

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Drug Design</td>
<td>15</td>
</tr>
<tr>
<td>II</td>
<td>Pharmacokinetics</td>
<td>5</td>
</tr>
<tr>
<td>III</td>
<td>Pharmacodynamics</td>
<td>5</td>
</tr>
<tr>
<td>IV</td>
<td>Antineoplastic Agents</td>
<td>5</td>
</tr>
<tr>
<td>V</td>
<td>Cardiovascular Drugs</td>
<td>5</td>
</tr>
<tr>
<td>VI</td>
<td>Local Antiinfective Drugs</td>
<td>10</td>
</tr>
<tr>
<td>VII</td>
<td>Psychoactive Drugs - The Chemotherapy of Mind</td>
<td>7</td>
</tr>
<tr>
<td>VIII</td>
<td>Antibiotics</td>
<td>8</td>
</tr>
</tbody>
</table>

60 Hrs (2 Hrs/week)

### Elective Paper 10  Physical Organic Chemistry

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Concepts in Molecular Orbital (MO) and Valence Bond (VB) Theory</td>
<td>10</td>
</tr>
<tr>
<td>II</td>
<td>Principles of Reactivity</td>
<td>5</td>
</tr>
<tr>
<td>III</td>
<td>Kinetic Isotope Effect</td>
<td>4</td>
</tr>
<tr>
<td>IV</td>
<td>Structural Effects on Reactivity</td>
<td>6</td>
</tr>
<tr>
<td>V</td>
<td>Solvation and Solvent Effects</td>
<td>6</td>
</tr>
<tr>
<td>VI</td>
<td>Acids, Bases, Electrophiles, Nucleophiles and Catalysis</td>
<td>6</td>
</tr>
<tr>
<td>VII</td>
<td>Steric and Conformational Properties</td>
<td>6</td>
</tr>
<tr>
<td>VIII</td>
<td>Nucleophilic and Electrophilic Reactivity</td>
<td>6</td>
</tr>
<tr>
<td>IX</td>
<td>Radical and Pericyclic Reactivity</td>
<td>6</td>
</tr>
<tr>
<td>X</td>
<td>Supramolecular Chemistry</td>
<td>5</td>
</tr>
</tbody>
</table>

60 Hrs (2 Hrs/week)

### Elective Paper 11  Chemistry of Materials

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Multiphase Materials</td>
<td>5</td>
</tr>
<tr>
<td>II</td>
<td>Glasses, Ceramics, Composites, Nanomaterials</td>
<td>5</td>
</tr>
<tr>
<td>IV</td>
<td>Liquid Crystals</td>
<td>10</td>
</tr>
<tr>
<td>V</td>
<td>Polymeric Materials</td>
<td>5</td>
</tr>
<tr>
<td>VI</td>
<td>Ionic Conductors</td>
<td>8</td>
</tr>
<tr>
<td>VII</td>
<td>High Tc Materials</td>
<td>10</td>
</tr>
<tr>
<td>VIII</td>
<td>Materials for Solid State Devices</td>
<td>3</td>
</tr>
<tr>
<td>IX</td>
<td>Organic Solids, Fullerenes, Molecular Devices</td>
<td>9</td>
</tr>
</tbody>
</table>

60 Hrs (2 Hrs/week)

### Elective Paper 12  Computational Chemistry

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Fortran/C Programming and Numerical Methods</td>
<td>15</td>
</tr>
<tr>
<td>II</td>
<td>Running of Advanced Scientific Packages</td>
<td>15</td>
</tr>
<tr>
<td>III</td>
<td>Introduction to Networking and Search using Internet</td>
<td>10</td>
</tr>
<tr>
<td>IV</td>
<td>Project</td>
<td>20</td>
</tr>
</tbody>
</table>

60 Hrs (2 Hrs/week)
Elective Paper 13  Advanced Quantum Chemistry  60 Hrs (2 Hrs/week)
I  Theoretical and Computational Treatment of Atoms  12 Hrs
and Molecules Hartree-Fock Theory
II  Configuration Interaction and MC-SCF  12 Hrs
III  Semi-empirical Theories  12 Hrs
IV  Density Functional Theory  12 Hrs
V  Computer Experiments  12 Hrs

Elective Paper 14  Liquid State  60 Hrs (2 Hrs/week)
I  General Properties of Liquids  13 Hrs
II  Theory of Liquids  9 Hrs
III  Distribution Function and Related Equations  14 Hrs
IV  Methods for Structure Determination  12 Hrs
and Computational Techniques
V  Supercooled and Ionic Liquids  12 Hrs

Elective Paper 15  Polymers  60 Hrs (2 Hrs/week)
I  Basics  8 Hrs
II  Polymer Characterization  14 Hrs
III  Structure and Properties  14 Hrs
IV  Polymer Processing  12 Hrs
V  Properties of Commercial Polymers  12 Hrs

Paper XV & XVI CH-508 & 509  540 Hrs (18 Hrs/week)

Inorganic Chemistry
Preparations
Spectrophotometric Determinations
Flame Photometric Determinations
Chromatographic Separations

Organic Chemistry
Qualitative Analysis
Multi-Step Synthesis of Organic Compounds
Extraction of Organic Compounds from Natural Sources
Paper Chromatography
Spectroscopy
Spectrophotometric (UV/VIS) Estimations

Physical Chemistry
Thermodynamics
Spectroscopy
Polarography
Electronics: Basic Electronics, Active Components, Operational Amplifier
SYLLABUS
B.Sc. FIRST YEAR

Paper I CH-101 Inorganic Chemistry – I 60 Hrs (2 Hrs/week)

I Atomic Structure 6 Hrs

Idea of de Broglie matter waves, Heisenberg uncertainty principle, atomic orbitals, Schrodinger wave equation, significance of $\psi$ and $\psi^2$, quantum numbers, radial and angular wave functions and probability distribution curves, shapes of s, p, d orbitals. Aufbau and Pauli exclusion principles, Hund's multiplicity rule. Electronic configurations of the elements, effective nuclear charge

II Periodic Properties 5 Hrs

Atomic and ionic radii, ionization energy, electron affinity and electronegativity – definition, methods of determination or evaluation, trends in periodic table and applications in predicting and explaining the chemical behaviour.

III Chemical Bonding 20 Hrs

(A) Covalent Bond – Valence bond theory and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions. Valence shell electron pair repulsion (VSEPR) theory to $\text{NH}_3$, $\text{H}_2\text{O}^+$, $\text{SF}_4$, $\text{ClF}_3$, $\text{ICl}_5^-$ and $\text{H}_2\text{O}$. MO theory, homonuclear and heteronuclear (CO and NO) diatomic molecules, multicenter bonding in electron deficient molecules, bond strength and bond energy, percentage ionic character from dipole moment and electronegativity difference.

(B) Ionic Solids – Ionic structures, radius ratio effect and coordination number, limitation of radius ratio rule, lattice defects, semiconductors, lattice energy and Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarisability of ions, Fajan's rule. Metallic bond-free electron, valence bond and band theories.

(C) Weak Interactions – Hydrogen bonding, van der Waals forces

IV s-Block Elements 6 Hrs

Comparative study, diagonal relationships, salient features of hydrides, solvation and complexation tendencies including their function in biosystems, an introduction to alkyls and aryls.

V p-Block Elements 20 Hrs

Comparative study (including diagonal relationship) of groups 13-17 elements, compounds like hydrides, oxides, oxyacids and halides of groups 13-16, hydrides of boron-diborane
and higher boranes, borazine, borohydrides, fullerenes, carbides, fluorocarbons, silicates (structural principle), tetrathiafulvalene, basic properties of halogens, interhalogens and polyhalides.

VI Chemistry of Noble Gases 3 Hrs

Chemical properties of the noble gases, chemistry of xenon, structure and bonding in xenon compounds.
PAPER II

CH-102 Organic Chemistry – I 60 Hrs (2 Hrs/week)

I Structure and Bonding 5 Hrs

Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bond, van der Waals interactions, inclusion compounds, clathrates, charge transfer complexes, resonance, hyperconjugation, aromaticity, inductive and field effects, hydrogen bonding.

II Mechanism of Organic Reactions 8 Hrs

Curved arrow notation, drawing electron movements with arrows, half-headed and double-headed arrows, homolytic and heterolytic bond breaking. Types of reagents — electrophiles and nucleophiles. Types of organic reactions. Energy considerations. Reactive intermediates — carboxations, carbanions, free radicals, carbenes, arynes and nitrenes (with examples). Assigning formal charges on intermediates and other ionic species.
Methods of determination of reaction mechanism (product analysis, intermediates, isotope effects, kinetic and stereochemical studies).

III Stereochemistry of Organic Compounds 12 Hrs

Concept of isomerism. Types of isomerism.
Optical isomerism — elements of symmetry, molecular chirality, enantiomers, stereogenic centre, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centres, diastereomers, threo and erythro diastereomers, meso compounds, resolution of enantiomers, inversion, retention and racemization.
Relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclature.
Geometric isomerism — determination of configuration of geometric isomers. E & Z system of nomenclature, geometric isomerism in oximes and alicyclic compounds.
Difference between configuration and conformation.

IV Alkanes and Cycloalkanes 7 Hrs

IUPAC nomenclature of branched and unbranched alkanes, the alkyl group, classification of carbon atoms in alkanes. Isomerism in alkanes, sources, methods of formation (with
special reference to Wurtz reaction, Kolbe reaction, Corey-House reaction and
decarboxylation of carboxylic acids), physical properties and chemical reactions of
alkanes.
Mechanism of free radical halogenation of alkanes: orientation, reactivity and selectivity.
Cycloalkanes — nomenclature, methods of formation, chemical reactions, Baeyer’s strain
theory and its limitations. Ring strain in small rings (cyclopropane and cyclobutane), theory
of strainless rings. The case of cyclopropane ring: banana bonds.

V Alkenes, Cycloalkenes, Dienes and Alkynes 12 Hrs

Nomenclature of alkenes, methods of formation, mechanisms of dehydration of alcohols
and dehydrohalogenation of alkyl halides, regioselectivity in alcohol dehydration. The
Saytzeff rule, Hofmann elimination, physical properties and relative stabilities of alkenes.
Chemical reactions of alkenes — mechanisms involved in hydrogenation, electrophilic and
free radical additions, Markownikoff’s rule, hydroboration—oxidation,
oxymercuration-reduction. Epoxidation, ozonolysis, hydration, hydroxylation and oxidation
with K\text{MnO}_4. Polymerization of alkenes. Substitution at the allylic and vinylic positions of
alkenes. Industrial applications of ethylene and propene.
Methods of formation, conformation and chemical reactions of cycloalkenes.
Nomenclature and classification of dienes: isolated, conjugated and cumulated dienes.
Structure of allenes and butadiene, methods of formation, polymerization. Chemical
reactions — 1,2 and 1,4 additions, Diels-Alder reaction.
Nomenclature, structure and bonding in alkynes. Methods of formation. Chemical
reactions of alkynes, acidity of alkynes. Mechanism of electrophilic and nucleophilic
addition reactions, hydroboration-oxidation, metal-ammonia reductions, oxidation and
polymerization.

VI Arenes and Aromaticity 8 Hrs

Nomenclature of benzene derivatives. The aryl group. Aromatic nucleus and side chain.
Structure of benzene: molecular formula and Kekule structure. Stability and carbon-carbon
bond lengths of benzene, resonance structure, MO picture.
Aromaticity: the Huckel rule, aromatic ions.
Aromatic electrophilic substitution — general pattern of the mechanism, role of \(\sigma\)- and \(\pi\)-
complexes. Mechanism of nitration, halogenation, sulphonation, mercuration and Friedel-
Crafts reaction. Energy profile diagrams. Activating and deactivating substituents,
orientation and ortho/para ratio. Side chain reactions of benzene derivatives. Birch
reduction.
Methods of formation and chemical reactions of alkylbenzenes, alkylnylbenzenes and
biphenyl.
VII Alkyl and Aryl Halides

Nomenclature and classes of alkyl halides, methods of formation, chemical reactions. Mechanisms of nucleophilic substitution reactions of alkyl halides, $S_N2$ and $S_N1$ reactions with energy profile diagrams.

Polyhalogen compounds: chloroform, carbon tetrachloride.

Methods of formation of aryl halides, nuclear and side chain reactions. The addition-elimination and the elimination-addition mechanisms of nucleophilic aromatic substitution reactions.

Relative reactivities of alkyl halides vs allyl, vinyl and aryl halides. Synthesis and uses of DDT and BHC.
PAPER III

CH-103 Physical Chemistry – I 60 Hrs (2 Hrs/week)

I Mathematical Concepts and Computers 16 Hrs

(A) Mathematical Concepts

Logarithmic relations, curve sketching, linear graphs and calculation of slopes, differentiation of functions like $k_x$, $e^x$, $x^n$, $\sin x$, $\log x$; maxima and minima, partial differentiation and reciprocity relations. Integration of some useful/relevant functions; permutations and combinations. Factorials. Probability.

(B) Computers

General introduction to computers, different components of a computer, hardware and software, input-output devices; binary numbers and arithmetic; introduction to computer languages. Programming, operating systems.

II Gaseous States 8 Hrs

Postulates of kinetic theory of gases, deviation from ideal behavior, van der Waals equation of state.

Critical Phenomena: PV isotherms of real gases, continuity of states, the isotherms of van der Waals equation, relationship between critical constants and van der Waals constants, the law of corresponding states, reduced equation of state.

Molecular velocities: Root mean square, average and most probable velocities. Qualitative discussion of the Maxwell’s distribution of molecular velocities, collision number, mean free path and collision diameter. Liquification of gases (based on Joule-Thomson effect).

III Liquid State 6 Hrs

Intermolecular forces, structure of liquids (a qualitative description).

Structural differences between solids, liquids and gases.

Liquid crystals: Difference between liquid crystal, solid and liquid. Classification, structure of nematic and cholesteric phases. Thermography and seven segment cell.

IV Solid State 11 Hrs

Definition of space lattice, unit cell.


X-ray diffraction by crystals. Derivation of Bragg equation. Determination of crystal structure of NaCl, KCl and CsCl (Laue’s method and powder method).
V Colloidal State 6 Hrs

Definition of colloids, classification of colloids.
Solids in liquids (sols): properties – kinetic, optical and electrical; stability of colloids, protective action, Hardy-Schulze law, gold number.
Liquids in solids (gels): classification, preparation and properties, inhibition, general applications of colloids.

VI Chemical Kinetics and Catalysis 13 Hrs

Chemical kinetics and its scope, rate of a reaction, factors influencing the rate of a reaction – concentration, temperature, pressure, solvent, light, catalyst. Concentration dependence of rates, mathematical characteristics of simple chemical reactions – zero order, first order, second order, pseudo order, half life and mean life. Determination of the order of reaction – differential method, method of integration, method of half life period and isolation method.
Radioactive decay as a first order phenomenon.
Experimental methods of chemical kinetics: conductometric, potentiometric, optical methods, polarimetry and spectrophotometer.
Theories of chemical kinetics: effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy,
Simple collision theory based on hard sphere model, transition state theory (equilibrium hypothesis). Expression for the rate constant based on equilibrium constant and thermodynamic aspects.
Catalysis, characteristics of catalysed reactions, classification of catalysis, miscellaneous examples.
PAPER IV

CH –104 Laboratory Course I 180 Hrs (6 Hrs/week)

Inorganic Chemistry
Semimicro Analysis – cation analysis, separation and identification of ions from Groups I, II, III, IV, V and VI. Anion analysis.

Organic Chemistry
Laboratory techniques

Calibration of Thermometer
80-82° (Naphthalene), 113.5-114° (Acetanilide), 132.5-133° (Urea), 100° (Distilled Water)

Determination of melting point
Naphthalene 80 -82°, Benzoic acid 121.5-122°
Urea 132.5-133°, Succinic acid 184.5-185°
Cinnamic acid 132.5-133°, Salicylic acid 157.5-158°
Acetanilide 113.5-114°, m-Dinitrobenzene 90°
p-Dichlorobenzene 52°, Aspirin 135°

Determination of boiling points
Ethanol 78°, Cyclohexane 81.4°, Toluene 110.6°, Benzene 80°

Mixed melting point determination
Urea-Cinnamic acid mixture of various compositions (1:4, 1:1, 4:1)

Distillation
Simple distillation of ethanol-water mixture using water condenser
Distillation of nitrobenzene and aniline using air condenser

Crystallization
Concept of induction of crystallization
Phthalic acid from hot water (using fluted filter paper and stemless funnel)
Acetanilide from boiling water
Naphthalene from ethanol
Benzoic acid from water
Decolorisation and crystallization using charcoal

Decolorisation of brown sugar (sucrose) with animal charcoal using gravity filtration. Crystallization and decolorisation of impure naphthalene (100g of naphthalene mixed with 0.3 g of Congo Red using 1g decolorising carbon) from ethanol.

Sublimation (Simple and Vacuum)

Camphor, Naphthalene, Phthalic acid and Succinic acid.

Qualitative Analysis

Detection of extra elements (N, S and halogens) and functional groups (phenolic, carboxylic, carbonyl, esters, carbohydrates, amines, amides, nitro and anilide) in simple organic compounds.

PHYSICAL CHEMISTRY

Chemical Kinetics

1. To determine the specific reaction rate of the hydrolysis of methyl acetate/ethyl acetate catalyzed by hydrogen ions at room temperature.
2. To study the effect of acid strength on the hydrolysis of an ester.
3. To compare the strengths of HCl and H₂SO₄ by studying the kinetics of hydrolysis of ethyl acetate.
4. To study kinetically the reaction rate of decomposition of iodide by H₂O₂.

Distribution Law

1. To study the distribution of iodine between water and CCl₄.
2. To study the distribution of benzoic acid between benzene and water.

Colloids

1. To prepare arsenious sulphide sol and compare the precipitating power of mono-, bi- and trivalent anions.

Viscosity, Surface Tension

1. To determine the percentage composition of a given mixture (non interacting systems) by viscosity method.
2. To determine the viscosity of amyl alcohol in water at different concentrations and calculate the excess viscosity of these solutions.
3. To determine the percentage composition of a given binary mixture by surface tension method (acetone & ethyl methyl ketone).
SECOND YEAR

PAPER V

CH-201 Inorganic Chemistry – II 60 Hrs (2 Hrs/week)

I Chemistry of Elements of First Transition Series 10 Hrs
Characteristic properties of d-block elements.
Properties of the elements of the first transition series, their binary compounds and complexes illustrating relative stability of their oxidation states, coordination number and geometry.

II Chemistry of Elements of Second and Third Transition Series 10 Hrs
General characteristics, comparative treatment with their 3d-analogues in respect of ionic radii, oxidation states, magnetic behaviour, spectral properties and stereochemistry

III Oxidation and Reduction 8 Hrs

IV Coordination Compounds 10 Hrs
Werner's coordination theory and its experimental verification, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complexes.

V Chemistry of Lanthanide Elements 6 Hrs
Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, lanthanide compounds.

VI Chemistry of Actinides 4 Hrs
General features and chemistry of actinides, chemistry of separation of Np, Pu and Am from U, similarities between the later actinides and the later lanthanides.

VII Acids and Bases 6 Hrs
Arrhenius, Bronsted-Lowry, the Lux-Flood, solvent system and Lewis concepts of acids and bases.
VIII Non-aqueous Solvents  

Physical properties of a solvent, types of solvents and their general characteristics, reactions in non-aqueous solvents with reference to liquid NH₃ and liquid SO₂.
PAPER VI

CH-202 Organic Chemistry – II  

60 Hrs (2 Hrs/week)

I Electromagnetic Spectrum: Absorption Spectra  

10 Hrs

Ultraviolet (UV) absorption spectroscopy — absorption laws (Beer-Lambert law), molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of conjugation. Concept of chromophore and auxochrome. Bathochromic, hypsochromic, hyperchromic and hypochromic shifts. UV spectra of conjugated enes and enones.

Infrared (IR) absorption spectroscopy — molecular vibrations, Hooke's law, selection rules, intensity and position of IR bands, measurement of IR spectrum, fingerprint region, characteristic absorptions of various functional groups and interpretation of IR spectra of simple organic compounds.

II Alcohols  

6 Hrs

Classification and nomenclature.


Dihydric alcohols — nomenclature, methods of formation, chemical reactions of vicinal glycols, oxidative cleavage [Pb(OAc)$_4$ and HIO$_4$] and pinacol-pinacolone rearrangement.

Trihydric alcohols — nomenclature and methods of formation, chemical reactions of glycerol.

III Phenols  

6 Hrs


IV Ethers and Epoxides  

3 Hrs

Nomenclature of ethers and methods of their formation, physical properties. Chemical reactions — cleavage and autoxidation, Ziesel's method.

Synthesis of epoxides. Acid and base-catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organolithium reagents with epoxides.
V Aldehydes and Ketones


An introduction to α,β unsaturated aldehydes and ketones.

VI Carboxylic Acids


Methods of formation and chemical reactions of halo acids. Hydroxy acids: malic, tartaric and citric acids.

Methods of formation and chemical reactions of unsaturated monocarboxylic acids.

Dicarboxylic acids: methods of formation and effect of heat and dehydrating agents.

VII Carboxylic Acid Derivatives

Structure and nomenclature of acid chlorides, esters, amides (urea) and acid anhydrides.

Relative stability of acyl derivatives. Physical properties, interconversion of acid derivatives by nucleophilic acyl substitution.

Preparation of carboxylic acid derivatives, chemical reactions. Mechanisms of esterification and hydrolysis (acidic and basic).

VIII Organic Compounds of Nitrogen


Reactions of amines, electrophilic aromatic substitution in aryl amines, reactions of amines with nitrous acid. Synthetic transformations of aryl diazonium salts, azo coupling.
PAPER VII

CH-203 Physical Chemistry – II

I  Thermodynamics – I  12 Hrs

Definition of thermodynamic terms: system, surroundings etc. Types of systems, intensive and extensive properties. State and path functions and their differentials. Thermodynamic process. Concept of heat and work.


II  Thermodynamics -II  13 Hrs


Concept of entropy: entropy as a state function, entropy as a function of V & T, entropy as a function of P & T, entropy change in physical change, Clausius inequality, entropy as a criteria of spontaneity and equilibrium. Entropy change in ideal gases and mixing of gases.

Third law of thermodynamics: Nernst heat theorem, statement and concept of residual entropy, evaluation of absolute entropy from heat capacity data. Gibbs and Helmholtz functions; Gibbs function (G) and Helmholtz function (A) as thermodynamic quantities, A & G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change. Variation of G and A with P, V and T.

III  Chemical Equilibrium  5 Hrs

Equilibrium constant and free energy. Thermodynamic derivation of law of mass action. Le Chatelier’s principle.

Reaction isotherm and reaction isochore – Clapeyron equation and Clausius -Clapeyron equation, applications.

IV  Phase Equilibrium  10 Hrs

Statement and meaning of the terms – phase, component and degree of freedom, derivation of Gibbs phase rule, phase equilibria of one component system – water, \( \text{CO}_2 \) and S systems.
Phase equilibria of two component system – solid-liquid equilibria, simple eutectic – Bi-Cd, Pb-Ag systems, desilverisation of lead.

Solid solutions – compound formation with congruent melting point (Mg-Zn) and incongruent melting point, (NaCl-H₂O), (FeCl₃-H₂O) and CuSO₄-H₂O system. Freezing mixtures, acetone -dry ice.


Partially miscible liquids – Phenol-water, trimethylamine-water, nicotine-water systems.

Lower and upper consolute temperature. Effect of impurity on consolute temperature.

Immiscible liquids, steam distillation.

Nernst distribution law – thermodynamic derivation, applications.

V Electrochemistry – I 10 Hrs

Electrical transport -conduction in metals and in electrolyte solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution.

Migration of ions and Kohlrausch law, Arrhenius theory of electrolyte dissociation and its limitations, weak and strong electrolytes, Ostwald's dilution law its uses and limitations. Debye-Hückel-Onsager's equation for strong electrolytes (elementary treatment only).

Transport number, definition and determination by Hittorf method and moving boundary method.

Applications of conductivity measurements: determination of degree of dissociation, determination of $K_a$ of acids, determination of solubility product of a sparingly soluble salt, conductometric titrations.

VI Electrochemistry - II 10 Hrs


Electrolytic and Galvanic cells – reversible and irreversible cells, conventional representation of electrochemical cells.


Concentration cell with and without transport, liquid junction potential, application of concentration cells, valency of ions, solubility product and activity coefficient, potentiometric titrations.
Definition of pH and pKₐ determination of pH using hydrogen, quinhydrone and glass electrodes, by potentiometric methods.
Corrosion – types, theories and methods of combating it.
PAPER VIII

CH – 204 Laboratory Course – II 180 Hrs (6 Hrs/week)

Inorganic Chemistry

Calibration of fractional weights, pipettes and burettes. Preparation of standard solutions. Dilution- 0.1 M to 0.001 M solutions.

Quantitative Analysis

Volumetric Analysis

(a) Determination of acetic acid in commercial vinegar using NaOH
(b) Determination of alkali content – antacid tablet using HCl.
(c) Estimation of calcium content in chalk as calcium oxalate by permanganometry.
(d) Estimation of hardness of water by EDTA.
(e) Estimation of ferrous and ferric by dichromate method.
(f) Estimation of copper using thiosulphate.

Gravimetric Analysis

Analysis of Cu as CuSCN and Ni as Ni (dimethylglyoxime).

Organic Chemistry

Laboratory Techniques

A. Thin Layer Chromatography

Determination of Rf values and identification of organic compounds.

(a) Separation of green leaf pigments (spinach leaves may be used).
(b) Preparation and separation of 2,4-dinitrophenylhydrazones of acetone, 2-butanone, hexan-2- and 3-one using toluene and light petroleum (40:60).
(c) Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5).

B. Paper Chromatography: Ascending and Circular

Determination of Rf values and identification of organic compounds.

(a) Separation of a mixture of phenylalanine and glycine. Alanine and aspartic acid. Leucine and glutamic acid. Spray reagent – ninhydrin.

**Qualitative Analysis**

Identification of an organic compound through the functional group analysis, determination of melting point and preparation of suitable derivatives.

**Physical Chemistry**

**Transition Temperature**

1. Determination of the transition temperature of the given substance by thermometric/dialometric method (e.g. MnCl₂·4H₂O/SrBr₂·2H₂O).

**Phase Equilibrium**

1. To study the effect of a solute (e.g. NaCl, succinic acid) on the critical solution temperature of two partially miscible liquids (e.g. phenol-water system) and to determine the concentration of that solute in the given phenol-water system.

2. To construct the phase diagram of two component (e.g. diphenylamine -benzophenone) system by cooling curve method.

**Thermochemistry**

1. To determine the solubility of benzoic acid at different temperatures and to determine ΔH of the dissolution process.

2. To determine the enthalpy of neutralisation of a weak acid/weak base versus strong base/strong acid and determine the enthalpy of ionisation of the weak acid/weak base.

3. To determine the enthalpy of solution of solid calcium chloride and calculate the lattice energy of calcium chloride from its enthalpy data using Born Haber cycle.
THIRD YEAR

PAPER IX

CH – 301 Inorganic Chemistry – III  60 Hrs (2 Hrs/week)

I  Hard and Soft Acids and Bases (HSAB)  7 Hrs
   Classification of acids and bases as hard and soft. Pearson's HSAB concept, acid-base
   strength and hardness and softness. Symbiosis, theoretical basis of hardness and
   softness, electronegativity and hardness and softness.

II  Metal-ligand Bonding in Transition Metal Complexes  10 Hrs
   Limitations of valence bond theory, an elementary idea of crystal-field theory, crystal field
   splitting in octahedral, tetrahedral and square planar complexes, factors affecting the
   crystal-field parameters.

III Magnetic Properties of Transition Metal Complexes  7 Hrs
   Types of magnetic behaviour, methods of determining magnetic susceptibility, spin-only
   formula. L-S coupling, correlation of $\mu_s$ and $\mu_{\text{eff}}$ values, orbital contribution to magnetic
   moments, application of magnetic moment data for 3d-metal complexes.

IV  Electron Spectra of Transition Metal Complexes  7 Hrs
   Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground
   states, spectrochemical series. Orgel-energy level diagram for $d^1$ and $d^6$ states, discussion
   of the electronic spectrum of [Ti(H$_2$O)$_6$]$^{3+}$ complex ion.

V  Thermodynamic and Kinetic Aspects of Metal Complexes  5 Hrs
   A brief outline of thermodynamic stability of metal complexes and factors affecting the
   stability, substitution reactions of square planar complexes.

VI  Organometallic Chemistry  10 Hrs
   Definition, nomenclature and classification of organometallic compounds. Preparation,
   properties, bonding and applications of alkyls and aryls of Li, Al, Hg, Sn and Ti, a brief
   account of metal-ethylenic complexes and homogeneous hydrogenation, mononuclear
   carbonyls and the nature of bonding in metal carbonyls.
VII  Bioinorganic Chemistry  10 Hrs


VIII  Silicones and Phosphazenes  4 Hrs

Silicones and phosphazenes as examples of inorganic polymers, nature of bonding in triphosphazenes.
PAPER X

CH – 302 Organic Chemistry – III 60 Hrs (2 Hrs/week)

I Spectroscopy 10 Hrs

Nuclear magnetic resonance (NMR) spectroscopy.
Proton magnetic resonance (1H NMR) spectroscopy, nuclear shielding and deshielding,
chemical shift and molecular structure, spin-spin splitting and coupling constants, areas of
signals, interpretation of PMR spectra of simple organic molecules such as ethyl bromide,
ethanol, acetaldehyde, 1,1,2-tribromoethane, ethyl acetate, toluene and acetophenone.
Problems pertaining to the structure elucidation of simple organic compounds using UV,
IR and PMR spectroscopic techniques.

II Organometallic Compounds 4 Hrs

Organomagnesium compounds: the Grignard reagents-formation, structure and chemical
reactions.
Organozinc compounds: formation and chemical reactions.
Organoaluminium compounds: formation and chemical reactions.

III Organosulphur Compounds 4 Hrs

Nomenclature, structural features, Methods of formation and chemical reactions of thiols,
thioethers, sulphonic acids, sulphonamides and sulphaguanidine.

IV Heterocyclic Compounds 8 Hrs

Introduction: Molecular orbital picture and aromatic characteristics of pyrrole, furan,
thiophene and pyridine. Methods of synthesis and chemical reactions with particular
emphasis on the mechanism of electrophilic substitution. Mechanism of nucleophilic
substitution reactions in pyridine derivatives. Comparison of basicity of pyridine, piperidine
and pyrrole.
Introduction to condensed five and six-membered heterocycles. Preparation and
reactions of indole, quinoline and isoquinoline with special reference to Fisher indole
synthesis, Skraup synthesis and Bischler-Napieralski synthesis. Mechanism of
electrophilic substitution reactions of indole, quinoline and isoquinoline.

V Organic Synthesis via Enolates 6 Hrs

Acidity of α-hydrogens, alkylation of diethyl malonate and ethyl acetoacetate. Synthesis of
ethyl acetoacetate: the Claisen condensation. Keto-enol tautomerism of ethyl
aceetoacetate.
Alkylation of 1,3-dithianes. Alkylation and acylation of enamines
VI **Carbohydrates**  
8 Hrs


Structures of ribose and deoxyribose.

An introduction to disaccharides (maltose, sucrose and lactose) and polysaccharides (starch and cellulose) without involving structure determination.

VII **Amino Acids, Peptides, Proteins and Nucleic Acids**  
6 Hrs

Classification, structure and stereochemistry of amino acids. Acid-base behavior, isoelectric point and electrophoresis. Preparation and reactions of \( \alpha \)-amino acids.


Levels of protein structure. Protein denaturation/renaturation.


VIII **Fats, Oils and Detergents**  
2 Hrs

Natural fats, edible and industrial oils of vegetable origin, common fatty acids, glycerides, hydrogenation of unsaturated oils. Saponification value, iodine value, acid value. Soaps, synthetic detergents, alkyl and aryl sulphonates.

IX **Synthetic Polymers**  
4 Hrs

Addition or chain-growth polymerization. Free radical vinyl polymerization, ionic vinyl polymerization, Ziegler-Natta polymerization and vinyl polymers.

Condensation or step growth polymerization. Polyesters, polyamides, phenol formaldehyde resins, urea formaldehyde resins, epoxy resins and polyurethanes.

Natural and synthetic rubbers.

X **Synthetic Dyes**  
8 Hrs

Colour and constitution (electronic concept). Classification of dyes. Chemistry and synthesis of Methyl orange, Congo red, Malachite green, Crystal violet, Phenolphthalein, Fluorescein, Alizarin and Indigo
PAPER XI

CH 303 Physical Chemistry – III

I  Elementary Quantum Mechanics  20 Hrs

Black-body radiation, Planck’s radiation law, photoelectric effect, heat capacity of solids, Bohr’s model of hydrogen atom (no derivation) and its defects, Compton effect.
De Broglie hypothesis, the Heisenberg’s uncertainty principle, Sinusoidal wave equation, Hamiltonian operator, Schrödinger wave equation and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in a one dimensional box.
Schrödinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance, hydrogen like wave functions, radial wave functions, angular wave functions.
Molecular orbital theory, basic ideas – criteria for forming M.O from A.O, construction of M.O’s by LCAO - H₂⁺ ion, calculation of energy levels from wave functions, physical picture of bonding and antibonding wave functions, concept of σ, σ*, π, π* orbitals and their characteristics. Hybrid orbitals – sp, sp², sp³; calculation of coefficients of A.O.’s used in these hybrid orbitals.
Introduction to valence bond model of H₂, comparison of M.O. and V.B. models.

II  Spectroscopy  20 Hrs

Introduction: electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born-Oppenheimer approximation, degrees of freedom.

Rotational Spectrum


Vibrational Spectrum

Infrared spectrum: Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different functional groups.
Raman Spectrum: concept of polarizability, pure rotational and pure vibrational Raman spectra of diatomic molecules, selection rules.
Electronic Spectrum

Concept of potential energy curves for bonding and antibonding molecular orbitals, qualitative description of selection rules and Franck-Condon principle.
Qualitative description of $\sigma$, $\pi$- and $n$ M.O., their energy levels and the respective transitions.

III  Photochemistry  8 Hrs

Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry: Grothus – Drapper law, Stark – Einstein law, Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions - energy transfer processes (simple examples).

IV  Physical Properties and Molecular Structure  5 Hrs

Optical activity, polarization – (Clausius – Mossotti equation), orientation of dipoles in an electric field, dipole moment, induced dipole moment, measurement of dipole moment-temperature method and refractivity method, dipole moment and structure of molecules, magnetic properties –paramagnetism, diamagnetism and ferromagnetics.

V  Solutions, Dilute Solutions and Colligative Properties  7 Hrs

Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient.
Dilute solution, colligative properties, Raoult’s law, relative lowering of vapour pressure, molecular weight determination. Osmosis, law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure. Elevation of boiling point and depression of freezing point, Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. Experimental methods for determining various colligative properties.
Abnormal molar mass, degree of dissociation and association of solutes.
PAPER XII

CH – 304 Laboratory Course – III 180 Hrs (6 Hrs/week)

INORGANIC CHEMISTRY

Synthesis and Analysis

(a) Preparation of sodium trioxalato ferrate (III), \( \text{Na}_3[\text{Fe(C}_2\text{O}_4)_3] \) and determination of its composition by permaganometry.
(b) Preparation of Ni-DMG complex, \([\text{Ni(DMG)}_2] \).
(c) Preparation of copper tetraammine complex, \([\text{Cu(NH}_3)_4]\text{SO}_4 \).
(d) Preparation of \textit{cis-} and \textit{trans-} bisoxalato diaqua chromate(III) ion.

Instrumentation

\textit{Colorimetry}

(a) Job's method (b) Mole-ratio method

Adulteration – Food stuffs.

Effluent analysis, water analysis.

\textit{Solvent Extraction}

Separation and estimation of Mg(II) and Fe(II))

\textit{Ion Exchange Method}

Separation and estimation of Mg(II) and Zn(II).

ORGANIC CHEMISTRY

Laboratory Techniques

\textit{Steam Distillation}

Naphthalene from its suspension in water
Clove oil from cloves
Separation of \textit{o-} and \textit{p-} nitrophenols

\textit{Column Chromatography}

Separation of fluorescein and methylene blue
Separation of leaf pigments from spinach leaves
Resolution of racemic mixture of (\(\pm\)) mandelic acid
Qualitative Analysis

Analysis of an organic mixture containing two solid components using water, NaHCO₃, NaOH for separation and preparation of suitable derivatives.

Synthesis of Organic Compounds

(a) Acetylation of salicylic acid, aniline, glucose and hydroquinone. Benzoylation of aniline and phenol
(b) Aliphatic electrophilic substitution
   Preparation of iodoform from ethanol and acetone
(c) Aromatic electrophilic substitution
   Nitration
   Preparation of m-dinitrobenzene
   Preparation of p-nitroacetanilide
   Halogenation
   Preparation of p-bromoacetanilide
   Preparation of 2,4,6-tribromophenol
(d) Diazotizatoin/coupling
   Preparation of methyl orange and methyl red
(e) Oxidation
   Preparation of benzoic acid from toluene
(f) Reduction
   Preparation of aniline from nitrobenzene
   Preparation of m-nitroaniline from m-dinitrobenzene.

Stereochemical Study of Organic Compounds via Models

R and S configuration of optical isomers.
E, Z configuration of geometrical isomers.
Conformational analysis of cyclohexanes and substituted cyclohexanes.

PHYSICAL CHEMISTRY

Electrochemistry

(a) To determine the strength of the given acid conductometrically using standard alkali solution.
(b) To determine the solubility and solubility product of a sparingly soluble electrolyte conductometrically.
(c) To study the saponification of ethyl acetate conductometrically.
(d) To determine the ionisation constant of a weak acid conductometrically.
(e) To titrate potentiometrically the given ferrous ammonium sulphate solution using
KMnO₄/K₂Cr₂O₇ as titrant and calculate the redox potential of Fe⁺⁺⁺/Fe⁴⁺⁺ system on the hydrogen scale.

**Refractometry, Polarimetry**

(a) To verify law of refraction of mixtures (e.g., of glycerol and water) using Abbe’s refractometer.

(b) To determine the specific rotation of a given optically active compound.

**Molecular Weight Determination**

(a) Determination of molecular weight of a non-volatile solute by Rast method/Beckmann freezing point method.

(b) Determination of the apparent degree of dissociation of an electrolyte (e.g., NaCl) in aqueous solution at different concentrations by ebullioscopy.

**Colorimetry**

To verify Beer – Lambert law for KMnO₄/K₂Cr₂O₇ and determine the concentration of the given solution of the substance.

**Books Suggested (Theory Courses)**

2. Concise Inorganic Chemistry, J.D. Lee, ELBS.
6. Inorganic Chemistry, A.G. Sharpe, ELBS.
Books Suggested (Laboratory Courses)

1. Vogel's Qualitative Inorganic Analysis, revised, Svehla, Orient Longman.
SOME SUGGESTED TOPICS FOR B.Sc. HONS. COURSE

- Nuclear Chemistry and Radiochemistry
- Instrumental Methods of Analysis
- Separation Techniques
- Environmental Chemistry
- Industrial Chemistry
- Chemistry of Some Transition Elements
- Inorganic Ring Structures
- Organometallics in Organic Synthesis
- Inorganic Polymers
- Coal, Petroleum and Petrochemicals
- Fermentation
- Polynuclear Aromatic Hydrocarbons
- Synthetic Dyes
- Pesticides
- Topics in Medicinal Chemistry
- Natural and Synthetic Pesticides
- Natural Products—Terpenoids, Alkaloids and Steroids
- Hormones
- Topics in Biological Chemistry
- Orbital Symmetry and Pericyclic Reactions
- Organic Photochemistry
- Planning Organic Syntheses
- Computers and its Applications in Chemistry
- Electronics for Chemists
- Classical Mechanics
- Statistical Thermodynamics
- Micelles
- Thermodynamics of Living Systems
M.Sc. I YEAR

Paper I CH-401 Inorganic Chemistry 120 Hrs (4 Hrs/week)

I Stereochemistry and Bonding in Main Group Compounds 12 Hrs

VSEPR, Walsh diagrams (tri- and penta- atomic molecules), dπ-pπ bonds, Bent rule and energetics of hybridization, some simple reactions of covalently bonded molecules

II Metal-Ligand Equilibria in Solution 8 Hrs

Stepwise and overall formation constants and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by pH-metry and spectrophotometry.

III Reaction Mechanism of Transition Metal Complexes 24 Hrs

Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism, anation reactions, reactions without metal ligand bond cleavage. Substitution reactions in square planar complexes, the trans effect, mechanism of the substitution reaction. Redox reactions, electron transfer reactions, mechanism of one electron transfer reactions, outer-sphere type reactions, cross reactions and Marcus-Hush theory, inner sphere type reactions

IV Metal-Ligand Bonding 15 Hrs

Limitation of crystal field theory, molecular orbital theory, octahedral, tetrahedral and square planar complexes, π-bonding and molecular orbital theory.

V Electronic Spectra and Magnetic Properties of Transition Metal Complexes 24 Hrs

Spectroscopic ground states, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^4-d^9 states), calculations of Dq, B and β parameters, charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information, anomalous magnetic moments, magnetic exchange coupling and spin crossover

VI Metal π-Complexes 18 Hrs

Metal carbonyls, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls; preparation, bonding,
structure and important reactions of transition metal nitrosyl, dinitrogen and dioxygen complexes; tertiary phosphine as ligand

VII Metal Clusters 15 Hrs

Higher boranes, carboranes, metalloboranes and metallocarboranes. Metal carbonyl and halide clusters, compounds with metal-metal multiple bonds.

VIII Isopoly and Heteropoly Acids and Salts 4 Hrs

Books Suggested
2. Inorganic Chemistry, J.E. Huheey, Harpes & Row.
PAPER II

CH-402 Organic Chemistry 120 Hrs(4 Hrs/week)

I Nature of Bonding in Organic Molecules 10 Hrs
Delocalized chemical bonding-conjugation, cross conjugation, resonance, hyperconjugation, bonding in fullerenes, tautomerism.
Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Huckel's rule, energy level of $\pi$-molecular orbitals, annulenes, anti-aromaticity, $\psi$-aromaticity, homo-aromaticity, PMO approach.
Bonds weaker than covalent- addition compounds, crown ether complexes and cryptands, inclusion compounds, cyclodextrins, catenanes and rotaxanes.

II Stereochemistry 15 Hrs
Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity, conformation of sugars, steric strain due to unavoidable crowding.
Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Asymmetric synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape.
Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

III Reaction Mechanism: Structure and Reactivity 12 Hrs
Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes.
Effect of structure on reactivity — resonance and field effects, steric effect, quantitative treatment. The Hammett equation and linear free energy relationship, substituent and reaction constants. Taft equation.

IV Aliphatic Nucleophilic Substitution 15 Hrs
The $S_N2$, $S_N1$, mixed $S_N1$ and $S_N2$ and SET mechanisms.
The neighbouring group mechanism, neighbouring group participation by $\pi$ and $\sigma$ bonds, anchimeric assistance.
Classical and nonclassical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements. Application of NMR spectroscopy in the detection of carbocations.
The $S_{E1}$ mechanism.
Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon.
Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity.

V Aliphatic Electrophilic Substitution 5 Hrs
Bimolecular mechanisms- $S_{E2}$ and $S_{E1}$. The $S_{E1}$ mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.

VI Aromatic Electrophilic Substitution 6 Hrs
The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction.

VII Aromatic Nucleophilic Substitution 5 Hrs
The $S_{N}Ar$, $S_{N}1$, benzyne and $S_{RN}1$ mechanisms. Reactivity - effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser, and Smiles rearrangements.

VIII Free Radical Reactions 8 Hrs
Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents on reactivity.

IX Addition to Carbon-Carbon Multiple Bonds 7 Hrs

X Addition to Carbon-Hetero Multiple Bonds 12 Hrs
Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds,

XI Elimination Reactions  5 Hrs

The E2, E1 and E1cB mechanisms and their spectrum. Orientation of the double bond. Reactivity - effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.

XII Pericyclic Reactions  20 Hrs

Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3- butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reactions — conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems. Cycloadditions — antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloadditions and cheleotropic reactions. Sigmatropic rearrangements — suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3- and 5,5- sigmatropic rearrangements. Claisen, Cope and aza-Cope rearrangements. Fluxional tautomerism. Ene reaction.

Books Suggested

PAPER III

CH-403 Physical Chemistry

120 Hrs (4Hrs/week)

I  Quantum Chemistry

30 Hrs

A  Introduction to Exact Quantum Mechanical Results

The Schrödinger equation and the postulates of quantum mechanics. Discussion of solutions of the Schrödinger equation to some model systems viz., particle in a box, the harmonic oscillator, the rigid rotor, the hydrogen atom.

B  Approximate Methods


C  Angular Momentum

Ordinary angular momentum, generalized angular momentum, eigenfunctions for angular momentum, eigenvalues of angular momentum, operator using ladder operators, addition of angular momenta, spin, antisymmetry and Pauli exclusion principle.

D  Electronic Structure of Atoms

Electronic configuration, Russell-Saunders terms and coupling schemes, Slater-Condon parameters, term separation energies of the pⁿ configuration, term separation energies for the dⁿ configurations, magnetic effects: spin-orbit coupling and Zeeman splitting, introduction to the methods of self-consistent field, the virial theorem.

E  Molecular Orbital Theory

Hückel theory of conjugated systems, bond order and charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical, cyclobutadiene etc. Introduction to extended Hückel theory.

II  Thermodynamics

30 Hrs

A.  Classical Thermodynamics

Brief resume of concepts of laws of thermodynamics, free energy, chemical potential and entropies. Partial molar properties; partial molar free energy, partial molar volume and partial molar heat content and their significances. Determinations of these quantities. Concept of fugacity and determination of fugacity.

Non-ideal systems: Excess functions for non-ideal solutions. Activity, activity coefficient,
Debye-Hückel theory for activity coefficient of electrolytic solutions; determination of activity and activity coefficients; ionic strength.
Application of phase rule to three component systems; second order phase transitions.

B Statistical Thermodynamics
Concept of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical, grand canonical and microcanonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers).
Partition functions – translational, rotational, vibrational and electronic partition functions, calculation of thermodynamic properties in terms of partition functions. Applications of partition functions.
Heat capacity behaviour of solids – chemical equilibria and equilibrium constant in terms of partition functions, Fermi-Dirac statistics, distribution law and applications to metal. Bose-Einstein statistics – distribution law and application to helium.

C Non Equilibrium Thermodynamics
Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow, entropy balance equations for different irreversible processes (e.g., heat flow, chemical reaction etc.) transformations of the generalized fluxes and forces, non equilibrium stationary states, phenomenological equations, microscopic reversibility and Onsager's reciprocity relations, electrokinetic phenomena, diffusion, electric conduction, irreversible thermodynamics for biological systems, coupled reactions.

III Chemical Dynamics 20 Hrs
Methods of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory, Arrhenius equation and the activated complex theory; ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, treatment of unimolecular reactions.
Dynamic chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogen-bromine and hydrogen-chlorine reactions) and oscillatory reactions (Belousov-Zhabotinsky reaction), homogeneous catalysis, kinetics of enzyme reactions, general features of fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis and the nuclear magnetic resonance method. Dynamics of molecular motions, probing the transition state, dynamics of barrierless chemical reactions in solution, dynamics of unimolecular reactions (Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus [RRKM] theories of unimolecular reactions).
IV Surface Chemistry 20 Hrs

A. Adsorption

Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation of surface area (BET equation), surface films on liquids (Electro-kinetic phenomenon), catalytic activity at surfaces.

B Micelles

Surface active agents, classification of surface active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization - phase separation and mass action models, solubilization, micro emulsion, reverse micelles.

C Macromolecules

Polymer – definition, types of polymers, electrically conducting, fire resistant, liquid crystal polymers, kinetics of polymerization, mechanism of polymerization.
Molecular mass, number and mass average molecular mass, molecular mass determination (osmometry, viscometry, diffusion and light scattering methods), sedimentation, chain configuration of macromolecules, calculation of average dimensions of various chain structures.

V Electrochemistry 20 Hrs

Over potentials, exchange current density, derivation of Butler-Volmer equation, Tafel plot.
Quantum aspects of charge transfer at electrodes-solution interfaces, quantization of charge transfer, tunneling.
Semiconductor interfaces – theory of double layer at semiconductor, electrolyte solution interfaces, structure of double layer interfaces. Effect of light at semiconductor solution interface.
Electrocatalysis – influence of various parameters. Hydrogen electrode.
Bioelectrochemistry, threshold membrane phenomena, Nernst-Planck equation, Hodges-Huxley equations, core conductor models, electrocardiography.
Polarography theory, Ilkovic equation; half wave potential and its significance.
Introduction to corrosion, homogenous theory, forms of corrosion, corrosion monitoring and prevention methods.
Books Suggested

1. Physical Chemistry, P.W. Atkins, ELBS.
4. Coulson's Valence, R. McWeeny, ELBS.
5. Chemical Kinetics, K. J. Laidler, Mcgraw-Hill.
7. Micelles, Theoretical and Applied Aspects, V. Moroi, Plenum
PAPER IV

CH-404

Group Theory, Spectroscopy and Diffraction Methods 90 Hrs (3 Hrs/week)

I Symmetry and Group Theory in Chemistry 12 Hrs

Symmetry elements and symmetry operation, definitions of group, subgroup, relation between orders of a finite group and its subgroup. Conjugacy relation and classes. Point symmetry group. Schönflies symbols, representations of groups by matrices (representation for the C_n, C_nv, C_nh, D_nh etc. groups to be worked out explicitly). Character of a representation. The great orthogonality theorem (without proof) and its importance. Character tables and their use; spectroscopy.

II Unifying Principles 10 Hrs

Electromagnetic radiation, interaction of electromagnetic radiation with matter—absorption, emission, transmission, reflection, refraction, dispersion, polarisation and scattering. Uncertainty relation and natural line width and natural line broadening, transition probability, results of the time dependent perturbation theory, transition moment, selection rules, intensity of spectral lines, Born-Oppenheimer approximation, rotational, vibrational and electronic energy levels.

III Microwave Spectroscopy 3 Hrs

Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities, non-rigid rotor. Stark effect, nuclear and electron spin interaction and effect of external field. Applications.

IV Vibrational Spectroscopy 12 Hrs

A. Infrared Spectroscopy

Review of linear harmonic oscillator, vibrational energies of diatomic molecules, zero point energy, force constant and bond strengths; anharmonicity, Morse potential energy diagram, vibration-rotation spectroscopy, P,Q,R branches. Breakdown of Oppenheimer approximation; vibrations of polyatomic molecules. Selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the band positions and intensities, far IR region, metal-ligand vibrations, normal co-ordinate analysis.

B. Raman Spectroscopy

Classical and quantum theories of Raman effect. Pure rotational, vibrational and
vibrational-rotational Raman spectra, selection rules, mutual exclusion principle. Resonance Raman spectroscopy, coherent anti Stokes Raman spectroscopy (CARS).

V  Electronic Spectroscopy  12 Hrs

A.  Atomic Spectroscopy

Energies of atomic orbitals, vector representation of momenta and vector coupling, spectra of hydrogen atom and alkali metal atoms.

B.  Molecular Spectroscopy

Energy levels, molecular orbitals, vibronic transitions, vibrational progressions and geometry of the excited states, Franck-Condon principle, electronic spectra of polyatomic molecules. Emission spectra; radiative and non-radiative decay, internal conversion, spectra of transition metal complexes, charge-transfer spectra.

C.  Photoelectron Spectroscopy

Basic principles; photo-electric effect, ionization process, Koopman’s theorem. Photoelectron spectra of simple molecules, ESCA, chemical information from ESCA. Auger electron spectroscopy – basic idea.

VI  Magnetic Resonance Spectroscopy  20 Hrs

A.  Nuclear Magnetic Resonance Spectroscopy

Nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements, factors influencing chemical shift, deshielding, spin-spin interactions, factors influencing coupling constant ‘J’. Classification (ABX, AMX, ABC, A_2B_2 etc.), spin decoupling; basic ideas about instrument, NMR studies of nuclei other than proton - ^13C, ^19F and ^31P. FT NMR, advantages of FT NMR, use of NMR in medical diagnostics.

B  Electron Spin Resonance Spectroscopy

Basic principles, zero field splitting and Kramer’s degeneracy, factors affecting the ‘g’ value. Isotropic and anisotropic hyperfine coupling constants, spin Hamiltonian, spin densities and McConnell relationship, measurement techniques, applications.

C  Nuclear Quadrupole Resonance Spectroscopy

Quadrupole nuclei, quadrupole moments, electric field gradient, coupling constant, splittings. Applications.
VII  Photoacoustic Spectroscopy  

Basic principles of photoacoustic spectroscopy (PAS), PAS-gases and condensed systems, chemical and surface applications.

VIII  X-ray Diffraction  12 Hrs


IX  Electron Diffraction  

Scattering intensity vs. scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules. Low energy electron diffraction and structure of surfaces.

X  Neutron Diffraction  

Scattering of neutrons by solids and liquids, magnetic scattering, measurement techniques. Elucidation of structure of magnetically ordered unit cell.

Books Suggested

PAPER V

CH-405 (a) Mathematics for Chemists 30 Hrs (1 Hr/week)
(For students without Mathematics in B.Sc.)

Note: This paper should be taught before teaching papers 403 and 404

I  Vectors and Matrix Algebra 10 Hrs

A  Vectors

Vectors, dot, cross and triple products etc. The gradient, divergence and curl. Vector calculus, Gauss' theorem, divergence theorem etc.

B. Matrix Algebra

Addition and multiplication; inverse, adjoint and transpose of matrices, special matrices (Symmetric, skew-symmetric, Hermitian, skew-Hermitian, unit, diagonal, unitary etc.) and their properties. Matrix equations: Homogeneous, non-homogeneous linear equations and conditions for the solution, linear dependence and independence.

Introduction to vector spaces, matrix eigenvalues and eigenvectors, diagonalization, determinants (examples from Hückel theory).

Introduction to tensors; polarizability and magnetic susceptibility as examples.

II  Differential Calculus 10 Hrs

Functions, continuity and differentiability, rules for differentiation, applications of differential calculus including maxima and minima (examples related to maximally populated rotational energy levels, Bohr's radius and most probable velocity from Maxwell's distribution etc), exact and inexact differentials with their applications to thermodynamic properties.

Integral calculus, basic rules for integration, integration by parts, partial fraction and substitution. Reduction formulae, applications of integral calculus.

Functions of several variables, partial differentiation, co-ordinate transformations (e.g. cartesian to spherical polar), curve sketching.

III  Elementary Differential Equations 7 Hrs

Variables-separable and exact first-order differential equations, homogeneous, exact and linear equations. Applications to chemical kinetics, secular equilibria, quantum chemistry etc. Solutions of differential equations by the power series method, Fourier series, solutions of harmonic oscillator and Legendre equation etc., spherical harmonics, second order differential equations and their solutions.
IV Permutation and Probability

Permutations and combinations, probability and probability theorems, probability curves, average, root mean square and most probable errors, examples from the kinetic theory of gases etc., curve fitting (including least squares fit etc.) with a general polynomial fit.

Books Suggested

PAPER V

CH-405 Biology for Chemists
(For students without Biology in B. Sc.)

I Cell Structure and Functions 5 Hrs

II Carbohydrates 8 Hrs

III Lipids 6 Hrs

IV Amino-acids, Peptides and Proteins 6 Hrs
V  Nucleic Acids       |  5 Hrs

Purine and pyrimidine bases of nucleic acids, base pairing via H-bonding. Structure of ribonucleic acids (RNA) and deoxyribonucleic acids (DNA), double helix model of DNA and forces responsible for holding it. Chemical and enzymatic hydrolysis of nucleic acids. The chemical basis for heredity, an overview of replication of DNA, transcription, translation and genetic code. Chemical synthesis of mono and trinucleoside.

Books Suggested

PAPER V

CH-405 (b) Computers for Chemists 60 Hrs (2 Hrs/week)

This is a theory-cum-laboratory course with more emphasis on laboratory work.

I Introduction to Computers and Computing 8 Hrs


II Computer Programming in FORTRAN/C/BASIC 12 Hrs

(The language features are listed here with reference to FORTRAN. The instructor may choose another language such as BASIC or C and the features may be replaced appropriately). Elements of the computer language. Constants and variables. Operations and symbols. Expressions. Arithmatic assignment statement. Input and Output. Format statement. Termination statements. Branching statements such as IF or GO TO statement. LOGICAL variables. Double precision variables. Subscripted variables and DIMENSION. DO statement. FUNCTION and SUBROUTINE. COMMON and DATA statements. (Students learn the programming logic and these language features by ‘hands on’ experience on a personal computer from the very beginning of this topic).

III Programming in Chemistry 15 Hrs

Development of small computer codes involving simple formulae in chemistry, such as van der Waals equation, pH titration, kinetics, radioactive decay. Evaluation of lattice energy and ionic radii from experimental data. Linear simultaneous equations to solve secular equations within the Hückel theory. Elementary structural features such as bond lengths, bond angles, dihedral angles etc. of molecules extracted from a database such as Cambridge data base.

IV Use of Computer Programmes 25 Hrs

The students will learn how to operate a PC and how to run standard programmes and packages. Execution of linear regression, X-Y plot, numerical integration and differentiation as well as differential equation solution programmes. Monte Carlo and Molecular dynamics. Programmes with data preferably from physical chemistry laboratory. Further, the students will operate one or two or the packages such as MATLAB, EASYPLOT, LOTUS, FOXPRO and Word Processing software such as WORDSTAR/MS-WORD.
Books Suggested

2. Computational Chemistry, A.C. Norris.
PAPER VI & VII

CH-406 & 407 Laboratory Course-I
Laboratory Course-II

540 Hrs (18 Hrs/week)

Inorganic Chemistry

Qualitative and Quantitative Analysis

(a) Less common metal ions – Tl, Mo, W, Ti, Zr, Th, V, U (two metal ions in cationic/anionic forms)
(b) Insolubles - oxides, sulphates and halides
(c) Separation and determination of two metal ions Cu-Ni, Ni-Zn, Cu-Fe etc. involving volumetric and gravimetric methods

Chromatography

Separation of cations and anions by
(a) Paper Chromatography
(b) Column Chromatography – Ion exchange.

Preparations

Preparation of selected inorganic compounds and their studies by I.R., electronic spectra, Mössbauer, E.S.R. and magnetic susceptibility measurements. Handling of air and moisture sensitive compounds

1. VO(acac)₂
2. TiO(C₅H₆NO)₂.2H₂O
3. cis-K[Cr(C₂O₄)₂(H₂O)₂]
4. Na[Cr(NH₃)₂(SCN)₄]
5. Mn(acac)₃
6. K₃[Fe(C₂O₄)₃]
7. Prussian Blue, Turnbull’s Blue.
8. Co(NH₃)₆][Co(NO₂)₆]
9. cis-[Co(trien)(NO₂)₂]Cl·H₂O
10. Hg[Co(SCN)₄]
11. [Co(Py)₂Cl₂]
12. [Ni(NH₃)₆]Cl₂
13. Ni(dmg)₂
14. [Cu(NH₃)₄]SO₄·H₂O
Organic Chemistry

Qualitative Analysis

Separation, purification and identification of compounds of binary mixture (one liquid and one solid) using TLC and column chromatography, chemical tests. IR spectra to be used for functional group identification.

Organic Synthesis

Acetylation: Acetylation of cholesterol and separation of cholestereryl acetate by column chromatography
Oxidation: Adipic acid by chromic acid oxidation of cyclohexanol
Grignard reaction: Synthesis of triphenylmethanol from benzoic acid
Aldol condensation: Dibenzal acetone from benzaldehyde
Sandmeyer reaction: p-Chlorotoluene from p-toluidine
Acetoacetic ester Condensation: Synthesis of ethyl-n-butyrlacetioacetate by A.E.E. condensation.
Cannizzaro reaction: 4-Chlorobenzaldehyde as substrate
Friedel Crafts Reaction: β-Benzoyl propionic acid from succinic anhydride and benzene
Aromatic electrophilic substitutions: Synthesis of p-nitroaniline and p-bromoaniline

The Products may be Characterized by Spectral Techniques

Quantitative Analysis

Determination of the percentage or number of hydroxyl groups in an organic compound by acetylation method
Estimation of amines/phenols using bromate bromide solution/or acetylation method
Determination of Iodine and Saponification values of an oil sample.
Determination of DO, COD and BOD of water sample

Physical Chemistry

Number of hours for each experiment: 3-4 hours
A list of experiments under different headings is given below. Typical experiments are to be selected from each type. Students are required to perform at least 30 experiments.

Error Analysis and Statistical Data Analysis

Errors, types of errors, minimization of errors, error distribution curves, precision, accuracy and combination; statistical treatment for error analysis, student ‘t’ test, null hypothesis, rejection criteria, F & Q test; linear regression analysis, curve fitting.
Calibration of volumetric apparatus, burette, pipette and standard flask.

**Adsorption**

To study surface tension - concentration relationship for solutions (Gibbs equation).

**Phase Equilibria**

(i) Determination of congruent composition and temperature of a binary system (e.g., diphenylamine-benzophenone system)

(ii) Determination of glass transition temperature of a given salt (e.g., CaCl₂) conductometrically.

(iii) To construct the phase diagram for three component system (e.g., chloroform–acetic acid–water).

**Chemical Kinetics**

(i) Determination of the effect of (a) Change of temperature (b) Change of concentration of reactants and catalyst and (c) ionic strength of the media on the velocity constant of hydrolysis of an ester/ionic reactions.

(ii) Determination of the velocity constant of hydrolysis of an ester/ionic reaction in micellar media.

(iii) Determination of the rate constant for the oxidation of iodide ions by hydrogen peroxide studying the kinetics as an iodine clock reaction.

(iv) Flowing clock reactions (Ref: Experiments in Physical Chemistry by Showmaker)

(v) Determination of the primary salt effect on the kinetics of ionic reactions and testing of the Brønsted relationship (iodide ion is oxidised by persulphate ion)

(vi) Oscillatory reaction.

**Solutions**

(i) Determination of molecular weight of non-volatile and non-electrolyte/electrolyte by cryoscopic method and to determine the activity coefficient of an electrolyte.

(ii) Determination of the degree of dissociation of weak electrolyte and to study the deviation from ideal behaviour that occurs with a strong electrolyte.

**Electrochemistry**

**A. Conductometry**

(i) Determination of the velocity constant, order of the reaction and energy of activation for saponification of ethyl acetate by sodium hydroxide conductometrically.

(ii) Determination of solubility and solubility product of sparingly soluble salts (e.g., PbSO₄, BaSO₄) conductometrically.
(iii) Determination of the strength of strong and weak acids in a given mixture conductometrically.

(iv) To study the effect of solvent on the conductance of AgNO₃/acetic acid and to determine the degree of dissociation and equilibrium constant in different solvents and in their mixtures (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Hückel-Onsager theory.

(v) Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Hückel’s limiting law.

B. Potentiometry/pH metry

(i) Determination of strengths of halides in a mixture potentiometrically.

(ii) Determination of the valency of mercurous ions potentiometrically.

(iii) Determination of the strength of strong and weak acids in a given mixture using a potentiometer/pH meter.

(iv) Determination of temperature dependence of EMF of a cell.

(v) Determination of the formation constant of silver-ammonia complex and stoichiometry of the complex potentiometrically.

(vi) Acid-base titration in a non-aqueous media using a pH meter.

(vii) Determination of activity and activity coefficient of electrolytes.

(viii) Determination of the dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by titrating it with KOH.

(ix) Determination of the dissociation constant of monobasic/dibasic acid by Albert-Serjeant method.

(x) Determination of thermodynamic constants, ΔG, ΔS and ΔH for the reaction by e.m.f. method.

\[
\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + 2\text{H}
\]

Polarimetry

(i) Determination of rate constant for hydrolysis/inversion of sugar using a polarimeter.

(ii) Enzyme kinetics - inversion of sucrose

Books Suggested

5. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
8. Practical Physical Chemistry, A. M. James and F. E. Prichard, Longman
9. Findey's Practical Physical Chemistry, B. P. Levitt, Longman
PAPER VIII

CH-501 (a) Applications of Spectroscopy 60 Hrs (2 Hrs/week)

Inorganic Chemistry

I Vibrational Spectroscopy 5 Hrs
Symmetry and shapes of AB$_2$, AB$_3$, AB$_4$, AB$_5$ and AB$_6$, mode of bonding of ambidentate ligands, ethylenediamine and diketonato complexes, application of resonance Raman spectroscopy particularly for the study of active sites of metalloproteins.

II Electron Spin Resonance Spectroscopy 8 Hrs
Hyperfine coupling, spin polarization for atoms and transition metal ions, spin-orbit coupling and significance of g-tensors, application to transition metal complexes (having one unpaired electron) including biological systems and to inorganic free radicals such as PH$_4$, F$_2$ and [BH$_3$].

III Nuclear Magnetic Resonance of Paramagnetic Substances in Solution 7 Hrs
The contact and pseudo contact shifts, factors affecting nuclear relaxation, some applications including biochemical systems, an overview of NMR of metal nuclides with emphasis on $^{195}$Pt and $^{119}$Sn NMR.

IV Mössbauer Spectroscopy 6 Hrs
Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (1) bonding and structures of Fe$^{+2}$ and Fe$^{+3}$ compounds including those of intermediate spin, (2) Sn$^{+2}$ and Sn$^{+4}$ compounds – nature of M-L bond, coordination number, structure and (3) detection of oxidation state and inequivalent MB atoms.

Organic Chemistry

I Ultraviolet and Visible Spectroscopy 3 Hrs
Various electronic transitions (185-800 nm), Beer–Lambert law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds. Steric effect in biphenyls.

II Infrared Spectroscopy 5 Hrs
Instrumentation and sample handling.
Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance. FT IR. IR of gaseous, solids and polymeric materials.

III Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD)

Definition, deduction of absolute configuration, octant rule for ketones.

IV Nuclear Magnetic Resonance Spectroscopy

General introduction and definition, chemical shift, spin-spin interaction, shielding mechanism, mechanism of measurement, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), chemical exchange, effect of deuteration, complex spin-spin interaction between two, three, four and five nuclei (first order spectra), virtual coupling. Stereochemistry, hindered rotation, Karplus curve-variation of coupling constant with dihedral angle. Simplification of complex spectra-nuclear magnetic double resonance, contact shift reagents, solvent effects. Fourier transform technique, nuclear Overhauser effect (NOE). Resonance of other nuclei-F, P.

V Carbon-13 NMR Spectroscopy

General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants.
Two dimension NMR spectroscopy - COSY, NOESY, DEPT, INEPT, APT and INADEQUATE techniques.

VI Mass Spectrometry

Introduction, ion production - EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule. High resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

Books Suggested

5. Transition Metal Chemistry ed. R.L. Carlin vol. 3, Dekker
PAPER VIII

CH-501 (b) Photochemistry  

30 Hrs (1 Hr/week)

I Photochemical Reactions  
4 Hrs

Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry.

II Determination of Reaction Mechanism  
4 Hrs

Classification, rate constants and life times of reactive energy states - determination of rate constants of reactions. Effect of light intensity on the rate of photochemical reactions. Types of photochemical reactions - photo-dissociation, gas-phase photolysis.

III Photochemistry of Alkenes  
6 Hrs

Intramolecular reactions of the olefinic bond - geometrical isomerism, cyclisation reactions, rearrangement of 1,4- and 1,5- dienes,

IV Photochemistry of Carbonyl Compounds  
8 Hrs

Intramolecular reactions of carbonyl compounds - saturated, cyclic and acyclic, β,γ-unsaturated and α,β-unsaturated compounds. Cyclohexadienones. 
Intermolecular cycloaddition reactions - dimerisations and oxetane formation.

V Photochemistry of Aromatic Compounds  
4 Hrs

Isomerisations, additions and substitutions.

VI Miscellaneous Photochemical Reactions  
4 Hrs

Photo-Fries reactions of anilides. Photo-Fries rearrangement. 
Barton reaction. Singlet molecular oxygen reactions. Photochemical formation of smog. 

Books Suggested

PAPER VIII

CH-501 (c) Solid State Chemistry
30 Hrs (1 Hr/week)

I Solid State Reactions 4 Hrs
General principles, experimental procedures, co-precipitation as a precursor to solid state reactions, kinetics of solid state reactions.

II Crystal Defects and Non-Stoichiometry 6 Hrs
Perfect and imperfect crystals, intrinsic and extrinsic defects - point defects, line and plane defects, vacancies-Schottky defects and Frenkel defects. Thermodynamics of Schottky and Frenkel defect formation, colour centres, non-stoichiometry and defects.

III Electronic Properties and Band Theory 15 Hrs
Metals, insulators and semiconductors, electronic structure of solids- band theory, band structure of metals, insulators and semiconductors. Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junctions, super conductors.
Optical properties - Optical reflectance, photoconduction-photoelectric effects.

IV Organic Solids 5 Hrs
Electrically conducting solids, organic charge transfer complex, organic metals, new superconductors.

Books Suggested
1 Solid State Chemistry and its Applications, A.R. West, Plenum.
3 Solid State Chemistry, N.B. Hannay.
PAPER IX

CH-502 (a) Bioinorganic Chemistry 30 Hrs (1 Hr/week)

I Metal Ions in Biological Systems 2 Hrs
   Essential and trace metals.

II Na+/K+ Pump 3 Hrs
   Role of metals ions in biological processes.

III Bioenergetics and ATP Cycle 6 Hrs
   DNA polymerisation, glucose storage, metal complexes in transmission of energy; chlorophylls, photosystem I and photosystem II in cleavage of water. Model systems.

IV Transport and Storage of Dioxygen 8 Hrs
   Heme proteins and oxygen uptake, structure and function of hemoglobin, myoglobin, hemocyanins and hemerythrin, model synthetic complexes of iron, cobalt and copper.

V Electron Transfer in Biology 6 Hrs
   Structure and function of metalloproteins in electron transport processes – cytochromes and ion-sulphur proteins, synthetic models

VI Nitrogenase 5 Hrs
   Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenases model systems.

Books Suggested
PAPER IX

CH-502 (b) Bioorganic Chemistry 30 Hrs (1 Hr/week)

I Introduction 2 Hrs
Basic considerations. Proximity effects and molecular adaptation.

II Enzymes 6 Hrs
Introduction and historical perspective, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Nomenclature and classification, extraction and purification. Fischer's lock and key and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed mutagenesis. Enzyme kinetics, Michaelis-Menten and Lineweaver-Burk plots, reversible and irreversible inhibition.

III Mechanism of Enzyme Action 3 Hrs
Transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Examples of some typical enzyme mechanisms for chymotrypsin, ribonuclease, lysozyme and carboxypeptidase A.

IV Kinds of Reactions Catalysed by Enzymes 6 Hrs
Nucleophilic displacement on a phosphorus atom, multiple displacement reactions and the coupling of ATP cleavage to endergonic processes. Transfer of sulphate, addition and elimination reactions, enolic intermediates in isomerization reactions, β-cleavage and condensation, some isomerization and rearrangement reactions. Enzyme catalyzed carboxylation and decarboxylation.

V Co-Enzyme Chemistry 4 Hrs
Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological functions of coenzyme A, thiamine pyrophosphate, pyridoxal phosphate, NAD^+, NADP^+, FMN, FAD, lipoic acid, vitamin B_{12}. Mechanisms of reactions catalyzed by the above cofactors.

VI Enzyme Models 4 Hrs
Host-guest chemistry, chiral recognition and catalysis, molecular recognition, molecular asymmetry and prochirality. Biomimetic chemistry, crown ethers, cryptates. Cyclodextrins, cyclodextrin-based enzyme models, calixarenes, ionophores, micelles, synthetic enzymes or synzymes.
VII  Biotechnological Applications of Enzymes  5 Hrs

Large-scale production and purification of enzymes, techniques and methods of immobilization of enzymes, effect of immobilization on enzyme activity, application of immobilized enzymes, use of enzymes in food and drink industry-brewing and cheese-making, syrups from corn starch, enzymes as targets for drug design. Clinical uses of enzymes, enzyme therapy, enzymes and recombinant DNA technology.

Books Suggested

2.  Understanding Enzymes, Trevor Palmer, Prentice Hall.
PAPER IX

CH-502 (c) Biophysical Chemistry 30 Hrs (1 Hr/week)

I Biological Cell and its Constituents 2 Hrs
Biological cell, structure and functions of proteins, enzymes, DNA and RNA in living systems. Helix coil transition.

II Bioenergetics 3 Hrs
Standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP.

III Statistical Mechanics in Biopolymers 5 Hrs
Chain configuration of macromolecules, statistical distribution end to end dimensions, calculation of average dimensions for various chain structures. Polypeptide and protein structures, introduction to protein folding problem.

IV Biopolymer Interactions 5 Hrs
Forces involved in biopolymer interactions. Electrostatic charges and molecular expansion, hydrophobic forces, dispersion force interactions. Multiple equilibria and various types of binding processes in biological systems. Hydrogen ion titration curves.

V Thermodynamics of Biopolymer Solutions 4 Hrs
Thermodynamics of biopolymer solutions, osmotic pressure, membrane equilibrium, muscular contraction and energy generation in mechanochemical system.

VI Cell Membrane and Transport of Ions 3 Hrs

VII Biopolymers and their Molecular Weights 5 Hrs
Evaluation of size, shape, molecular weight and extent of hydration of biopolymers by various experimental techniques. Sedimentation equilibrium, hydrodynamic methods, diffusion, sedimentation velocity, viscosity, electrophoresis and rotational motions.

VIII Diffraction Methods 3 Hrs
Light scattering, low angle X-ray scattering, X-ray diffraction and photo correlation spectroscopy. ORD.
Books Suggested

PAPER X

CH-503 Environmental Chemistry 60 Hrs (2 Hrs/week)

I Environment 8 Hrs

II Hydrosphere 12 Hrs
Chemical composition of water bodies-lakes, streams, rivers and wet lands etc. Hydrological cycle.
Analytical methods for measuring BOD, DO, COD, F, Oils, metals (As, Cd, Cr, Hg, Pb, Se etc.), residual chloride and chlorine demand.
Purification and treatment of water.

III Soils 6 Hrs
Composition, micro and macro nutrients, Pollution – fertilizers, pesticides, plastics and metals. Waste treatment.

IV Atmosphere 8 Hrs
Chemical composition of atmosphere – particles, ions and radicals and their formation.
Chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, O and their effect, pollution by chemicals, petroleum, minerals, chlorofluorohydrocarbons.
Green house effect, acid rain, air pollution controls and their chemistry.
Analytical methods for measuring air pollutants. Continuous monitoring instruments.

V Industrial Pollution 12 Hrs
Cement, sugar, distillery, drug, paper and pulp, thermal power plants, nuclear power plants, metallurgy. Polymers, drugs etc. Radionuclide analysis. Disposal of wastes and their management.

VI Environmental Toxicology 14 Hrs
Chemical solutions to environmental problems, biodegradability, principles of decomposition, better industrial processes.
Bhopal gas tragedy, Chernobyl, Three mile island, Sewozo and Minamata disasters.

Books Suggested

Environmental Chemistry, S. E. Manahan, Lewis Publishers.
Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern
Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
ELECTIVE PAPERS

Paper XI CH-504
Paper XII CH-505
Paper XIII CH-506
Paper XIV CH-507
Students are required to select any four of the following elective papers. Each paper will carry 60 marks.

1. Organotransition Metal Chemistry  
2. Bioinorganic and Supramolecular Chemistry  
3. Photoinorganic Chemistry  
4. Analytical Chemistry  
5. Organic Synthesis-I  
6. Organic Synthesis-II  
7. Heterocyclic Chemistry  
8. Chemistry of Natural Products  
9. Medicinal Chemistry  
10. Physical Organic Chemistry  
11. Chemistry of Materials  
12. Computational Chemistry  
13. Advanced Quantum Chemistry  
14. Liquid State  
15. Polymers

Depending on the feasibility/availability of local expertise, more elective courses may be introduced. Some of the suggested topics are mentioned below.

1. Organic Semiconductors  
2. Chemical Dynamics  
3. Surfactants  
4. Electrochemistry  
5. Irreversible Thermodynamics  
6. Statistical Thermodynamics  
7. Physical Chemistry of Supramolecules  
8. Nuclear and Radiochemistry
# ELECTIVE PAPER 1

## Organotransition Metal Chemistry

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Alkyls and Aryls of Transition Metals</td>
<td>5 Hrs</td>
</tr>
<tr>
<td></td>
<td>Types, routes of synthesis, stability and decomposition pathways, organocopper in organic synthesis</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Compounds of Transition Metal-Carbon Multiple Bonds</td>
<td>12 Hrs</td>
</tr>
<tr>
<td></td>
<td>Alkylidenes, alkyldynes, low valent carbenes and carbynes- synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligands, role in organic synthesis</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Transition Metal π-Complexes</td>
<td>18 Hrs</td>
</tr>
<tr>
<td></td>
<td>Transition metal π-complexes with unsaturated organic molecules, alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes, preparations, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligands and to organic synthesis</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>Transition Metal Compounds with Bonds to Hydrogen</td>
<td>3 Hrs</td>
</tr>
<tr>
<td></td>
<td>Transition metal compounds with bonds to hydrogen.</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Homogeneous Catalysis</td>
<td>14 Hrs</td>
</tr>
<tr>
<td></td>
<td>Stoichiometric reactions for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction), oxopalladation reactions, activation of C-H bond.</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>Fluxional Organometallic Compounds</td>
<td>8 Hrs</td>
</tr>
<tr>
<td></td>
<td>Fluxionality and dynamic equilibria in compounds such as η²- olefin, η³- allyl and dienyl complexes</td>
<td></td>
</tr>
</tbody>
</table>

## Books Suggested

2. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, John Wiley
4. Organometallic Chemistry, R.C. Mehrotra and A. Singh, New Age International
Bioinorganic and Supramolecular Chemistry 60 Hrs (2 Hrs/week)

I Metal Storage Transport and Biomineralization 5 Hrs
Ferritin, transferrin, and siderophores

II Calcium in Biology 6 Hrs
Calcium in living cells, transport and regulation, molecular aspects of intramolecular processes, extracellular binding proteins

III Metalloenzymes 20 Hrs

IV Metal–Nucleic Acid Interactions 6 Hrs
Metal ions and metal complex interactions. Metal complexes - nucleic acids

V Metals in Medicine 5 Hrs
Metal deficiency and disease, toxic effects of metals, metals used for diagnosis and chemotherapy with particular reference to anticancer drugs

VI Supramolecular Chemistry 18 Hrs
Concepts and language.
(A) Molecular recognition: Molecular receptors for different types of molecules including arisonic substrates, design and synthesis of coreceptor molecules and multiple recognition.
(B) Supramolecular reactivity and catalysis.
(C) Transport processes and carrier design.
(D) Supramolecular devices. Supramolecular photochemistry, supramolecular electronic, ionic and switching devices.
Some example of self-assembly in supramolecular chemistry

Books Suggested
5. Supramolecular Chemistry, J.M. Lehn, VCH.
ELECTIVE PAPER 3

Photoinorganic Chemistry 60 Hrs (2 Hrs/week)

I Basics of Photochemistry 10 Hrs

II Properties of Excited States 10 Hrs

III Excited States of Metal Complexes 8 Hrs
Excited states of metal complexes: comparison with organic compounds, electronically excited states of metal complexes, charge-transfer spectra, charge transfer excitations, methods for obtaining charge-transfer spectra.

IV Ligand Field Photochemistry 8 Hrs
Photosubstitution, photooxidation and photoreduction, lability and selectivity, zero vibrational levels of ground state and excited state, energy content of excited state, zero-zero spectroscopic energy, development of the equations for redox potentials of the excited states.

V Redox Reactions by Excited Metal Complexes 16 Hrs
Energy transfer under conditions of weak interaction and strong interaction-exciplex formation; conditions of the excited states to be useful as redox reactants, excited electron transfer, metal complexes as attractive candidates (2,2'-bipyridine and 1,10-phenanthroline complexes), illustration of reducing and oxidising character of Ruthenium^{2+}(bipyridal complex, comparision with Fe(bipy)_3; role of spin-orbit coupling-life time of these complexes. Application of redox processes of electronically excited states for catalytic purposes, transformation of low energy reactants into high energy products, chemical energy into light

VI Metal Complex Sensitizers 8 Hrs
Metal complex sensitizer, electron relay, metal colloid systems, semiconductor supported metal or oxide systems, water photolysis, nitrogen fixation and carbon dioxide reduction
Books Suggested

ELECTIVE PAPER 4

Analytical Chemistry 60 Hrs (2 Hrs/week)

I  Introduction 12 Hrs

II  Errors and Evaluation 7 Hrs
Definition of terms in mean and median. Precision-standard deviation, relative standard deviation. Accuracy-absolute error, relative error. Types of error in experimental data-determinate (systematic), indeterminate (or random) and gross. Sources of errors and the effects upon the analytical results. Methods for reporting analytical data. Statistical evaluation of data-indeterminate errors. The uses of statistics.

III  Food Analysis 12 Hrs

IV  Analysis of Water Pollution 12 Hrs
V Analysis of Soil, Fuel, Body Fluids and Drugs

(a) Analysis of soil: moisture, pH, total nitrogen, phosphorus, silica, lime, magnesia, manganese, sulphur and alkali salts.


(c) Clinical chemistry: Composition of blood-collection and preservation of samples. Clinical analysis. Serum electrolytes, blood glucose, blood urea nitrogen, uric acid, albumin, globulins, barbiturates, acid and alkaline phosphatases. Immunoassay: principles of radio immunoassay (RIA) and applications. The blood gas analysis-trace elements in the body.

(d) Drug analysis: Narcotics and dangerous drugs. Classification of drugs. Screening by gas and thin-layer chromatography and spectrophotometric measurements.

Books Suggested

6. Principles of Instrumental Analysis, D.A. Skoog, W. B. Saunders.
8. Environmental Solution Analysis, S.M. Khopkar, Wiley Eastern
ELECTIVE PAPER 5

Organic Synthesis I  

I  Organometallic Reagents  25 Hrs

Principle, preparations, properties and applications of the following in organic synthesis with mechanistic details

Group I and II metal organic compounds

Li, Mg, Hg, Cd, Zn and Ce compounds.

Transition metals

Cu, Pd, Ni, Fe, Co, Rh, Cr and Ti compounds.

Other elements

S, Si, B and I compounds.

II  Oxidation  7 Hrs

Introduction. Different oxidative processes.

Hydrocarbons- alkenes, aromatic rings, saturated C-H groups (activated and unactivated).

Alcohols, diols, aldehydes, ketones, ketals and carboxylic acids.

Amines, hydrazines, and sulphides.

Oxidations with ruthenium tetroxide, iodobenzene diacetate and thallium (III) nitrate.

III  Reduction  7 Hrs

Introduction. Different reductive processes.

Hydrocarbons– alkanes, alkenes, alkynes and aromatic rings.


Nitro, nitroso, azo and oxime groups.

Hydrogenolysis.

IV  Rearrangements  12 Hrs

General mechanistic considerations - nature of migration, migratory aptitude, memory effects.

A detailed study of the following rearrangements

V  Metalocenes, Nonbenzenoid Aromatics and Polycyclic Aromatic Compounds

General considerations, synthesis and reactions of some representative compounds

Books Suggested
ELECTIVE PAPER 6

Organic Synthesis II 60 Hrs (2 Hrs/week)

I Disconnection Approach 18 Hrs

An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, the importance of the order of events in organic synthesis, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclisation reactions, amine synthesis

II Protecting Groups 5 Hrs

Principle of protection of alcohol, amine, carbonyl and carboxyl groups.

III One Group C-C Disconnections 7 Hrs

Alcohols and carbonyl compounds, regioselectivity. Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis

IV Two Group C-C Disconnections 10 Hrs

Diels-Alder reaction, 1,3-difunctionalised compounds, α,β-unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds. Micheal addition and Robinson annelation.

V Ring Synthesis 8 Hrs

Saturated heterocycles, synthesis of 3-, 4-, 5- and 6-membered rings, aromatic heterocycles in organic synthesis.

VI Synthesis of Some Complex Molecules 12 Hrs

Application of the above in the synthesis of following compounds: Camphor, Longifoline, Cortisone, Reserpine, Vitamin D, Juvabione, Aphidicolin and Fredericamycin A.

Books Suggested

2. Organic Synthesis- Concept, Methods and Starting Materials, J.Fuhrhop and G. Penzilin, Verlage VCH.
4. Modern Synthetic Reactions, H.O.House, W. A. Benjamin,
ELECTIVE PAPER 7

Heterocyclic Chemistry 60 Hrs (2 Hrs/week)

I Nomenclature of Heterocycles 4 Hrs
Replacement and systematic nomenclature (Hantzsch-Widman system) for monocyclic, fused and bridged heterocycles.

II Aromatic Heterocycles 5 Hrs
General chemical behaviour of aromatic heterocycles, classification (structural type), criteria of aromaticity (bond lengths, ring current and chemical shifts in $^1$H NMR-spectra, empirical resonance energy, delocalization energy and Dewar resonance energy, diamagnetic susceptibility exaltations).
Heteroaromatic reactivity and tautomerism in aromatic heterocycles

III Non-aromatic Heterocycles 6 Hrs
Strain -bond angle and torsional strains and their consequences in small ring heterocycles.
Conformation of six-membered heterocycles with reference to molecular geometry, barrier to ring inversion, pyramidal inversion and 1,3-diaxial interaction.
Stereo-electronic effects - anomeric and related effects. Attractive interactions - hydrogen bonding and intermolecular nucleophilic- electrophilic interactions

IV Heterocyclic Synthesis 4 Hrs
Principles of heterocyclic synthesis involving cyclization reactions and cycloaddition reactions

V Small Ring Heterocycles 5 Hrs
Three-membered and four-membered heterocycles-synthesis and reactions of aziridines, oxiranes, thiiranes, azetidines, oxetanes and thietanes

VI Benzo-Fused Five-Membered Heterocycles 5 Hrs
Synthesis and reactions including medicinal applications of benzopyrroles, benzofurans and benzothiophenes

VII Meso-ionic Heterocycles 5 Hrs
General classification, chemistry of some important meso-ionic heterocycles of type-A and B and their applications.
VIII Six-Membered Heterocycles with One Heteroatom

6 Hrs

Synthesis and reactions of pyrylium salts and pyrones and their comparison with pyridinium & thiopyrylium salts and pyridones.

Synthesis and reactions of quinolizinium and benzopyrylium salts, coumarins and chromones.

IX Six-Membered Heterocycles with Two or More Heteroatoms

5 Hrs

Synthesis and reactions of diazines, triazines, tetrazines and thiazines.

X Seven- and Large-Membered Heterocycles

5 Hrs

Synthesis and reactions of azepines, oxepines, thiepines, diazepines thiazepines, azocines, diazocines, dioxocines and dithiocines.

XI Heterocyclic Systems Containing P, As, Sb and B

10 Hrs

Heterocyclic rings containing phosphorus: introduction, nomenclature, synthesis and characteristics of 5- and 6-membered ring systems-phosphorinanes, phosphorines, phospholanes and phospholes.

Heterocyclic rings containing As and Sb: introduction, synthesis and characteristics of 5- and 6- membered ring systems.

Heterocyclic rings containing B: introduction, synthesis, reactivity and spectral characteristics of 3-, 5- and 6- membered ring systems.

Books Suggested

2. The Chemistry of Heterocycles, T. Eicher and S. Hauptmann, Thieme.
# ELECTIVE PAPER 8

## Chemistry of Natural Products 60 Hrs (2 Hrs/week)

### I Terpenoids and Carotenoids 15 Hrs
Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule.
Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules: Citral, Geraniol, α-Terpeneol, Menthol, Farnesol, Zingiberene, Santonin, Phytol, Abietic acid and β-Carotene.

### II Alkaloids 15 Hrs
Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants.
Structure, stereochemistry, synthesis and biosynthesis of the following: Ephedrine, (+)-Coniine, Nicotine, Atropine, Quinine and Morphine.

### III Steroids 15 Hrs
Occurrence, nomenclature, basic skeleton, Diel’s hydrocarbon and stereochemistry.
Isolation, structure determination and synthesis of Cholesterol, Bile acids, Androsterone, Testosterone, Estrone, Progestrone, Aldosterone.
Biosynthesis of steroids

### IV Plant Pigments 7 Hrs
Occurrence, nomenclature and general methods of structure determination. Isolation and synthesis of Apigenin, Luteolin, Quercetin, Myrcetin, Quercetin-3-glucoside, Vitexin, Diadzein, Butein, Aureusin, Cyanidin-7-arabinoside, Cyanidin, Hirsutidin.
Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway.

### V Porphyrins 3 Hrs
Structure and synthesis of Haemoglobin and Chlorophyll.

### VI Prostaglandins 3 Hrs
Occurrence, nomenclature, classification, biogenesis and physiological effects.
Synthesis of PGE$_2$ and PGF$_{2α}$.
VII Pyrethroids and Rotenones

Synthesis and reactions of Pyrethroids and Rotenones.
(For structure elucidation, emphasis is to be placed on the use of spectral parameters wherever possible).

Books Suggested

ELECTIVE PAPER 9

Medicinal Chemistry 60 Hrs (2 Hrs/week)

1 Drug Design 15 Hrs


II Pharmacokinetics 5 Hrs

Introduction to drug absorption, disposition, elimination using pharmacokinetics, important pharmacokinetic parameters in defining drug disposition and in therapeutics. Mention of uses of pharmacokinetics in drug development process.

III Pharmacodynamics 5 Hrs

Introduction, elementary treatment of enzyme stimulation, enzyme inhibition, sulphonamides, membrane active drugs, drug metabolism, xenobiotics, biotransformation, significance of drug metabolism in medicinal chemistry.

IV Antineoplastic Agents 5 Hrs

Introduction, cancer chemotherapy, special problems, role of alkylating agents and antimetabolites in treatment of cancer. Mention of carcinolytic antibiotics and mitotic inhibitors.

Synthesis of mechlorethamine, cyclophosphamide, melphalan, uracil, mustards, and 6-mercaptopurine. Recent development in cancer chemotherapy. Hormone and natural products.

V Cardiovascular Drugs 5 Hrs


Synthesis of amyl nitrate, sorbitrate, diltiazem, quinidine, verapamil, methyldopa, atenolol, oxyprenolol.
VI Local Antiinfective Drugs 10 Hrs

Introduction and general mode of action.
Synthesis of sulphonamides, furazolidone, nalidixic acid, ciprofloxacin, norfloxacin, dapsone, amino salicylic acid, isoniazid, ethionamide, ethambutal, fluconazole, econazole, griseofulvin, chloroquin and primaquin.

VII Psychoactive Drugs - The Chemotherapy of Mind 7 Hrs

Introduction, neurotransmitters, CNS depressants, general anaesthetics, mode of action of hypnotics, sedatives, anti-anxiety drugs, benzodiazepines, buspiron, neurochemistry of mental diseases. Antipsychotic drugs - the neuroleptics, antidepressants, butyrophenones, serendipity and drug development, stereochemical aspects of psychotropic drugs.
Synthesis of diazepam, oxazepam, chlorazepam, alprazolam, phenityn, ethosuximde, trimethadione, barbiturates, thiopental sodium, glutethimide

VIII Antibiotics 8 Hrs

Cell wall biosynthesis, inhibitors, β-lactam rings, antibiotics inhibiting protein synthesis.
Synthesis of penicillin G, penicillin V, ampicillin, amoxycillin, chloramphenicol, cephalosporin, tetracyclin and streptomycin.

Books Suggested

1. Introduction to Medicinal Chemistry, A Gringuage, Wiley-VCH.
5. Goodman and Gilman's Pharmacological Basis of Therapeutics, McGraw-Hill.
ELECTIVE PAPER 10

Physical Organic Chemistry

I Concepts in Molecular Orbital (MO) and Valence Bond (VB) Theory

Introduction to Huckel molecular orbital (MO) method as a means to explain modern theoretical methods. Advanced techniques in PMO and FMO theory. Molecular mechanics, semi empirical methods and \textit{ab initio} and density functional methods. Scope and limitations of several computational programmes.

II Principles of Reactivity


III Kinetic Isotope Effect

Theory of isotope effects. Primary and secondary kinetic isotope effects. Heavy atom isotope effects. Tunneling effect. Solvent effects.

IV Structural Effects on Reactivity

Linear free energy relationships (LFER). The Hammett equation, substituent constants, theories of substituent effects. Interpretation of \( \sigma \)-values. Reaction constant \( \rho \). Deviations from Hammett equation. Dual-parameter correlations, inductive substituent constant. The Taft model, \( \sigma_i \) and \( \sigma_R \)-scales.

V Solvation and Solvent Effects

Qualitative understanding of solvent-solute effects on reactivity. Thermodynamic measure of solvation. Effects of solvation on reaction rates and equilibria. Various empirical indexes
of solvation based on physical properties, solvent-sensitive reaction rates, spectroscopic properties and scales for specific solvation. Use of solvation scales in mechanistic studies. Solvent effects from the curve-crossing model.

VI Acids, Bases, Electrophiles, Nucleophiles and Catalysis 6 Hrs


VII Steric and Conformational Properties 6 Hrs


VIII Nucleophilic and Electrophilic Reactivity 6 Hrs

Structural and electronic effects on \( S_N1 \) and \( S_N2 \) reactivity. Solvent effects. Kinetic isotope effects. Intramolecular assistance. Electron transfer nature of \( S_N2 \) reaction. Nucleophilicity and \( S_N2 \) reactivity based on curve-crossing model. Relationship between polar and electron transfer reactions. \( S_{RN}1 \) mechanism. Electrophilic reactivity, general mechanism. Kinetic of \( S_{E2} \)-Ar reaction. Structural effects on rates and selectivity. Curve-crossing approach to electrophilic reactivity.

IX Radical and Pericyclic Reactivity 6 Hrs

Radical stability, polar influences, solvent and steric effects. A curve crossing approach to radical addition, factors effecting barrier heights in additions, regioselectivity in radical reactions, Reactivity, specificity and periselectivity in pericyclic reactions.

X Supramolecular Chemistry 5 Hrs

Properties of covalent bonds - bond length, inter-bond angles, force constant, bond and molecular dipole moments. Molecular and bond polarizability, bond dissociation enthalpy, entropy. Intermolecular forces, hydrophobic effects. Electrostatic, induction, dispersion and resonance energy, magnetic interactions, magnitude of interaction energy, forces between macroscopic bodies, medium effects. Hydrogen bond. Principles of molecular association and organization as exemplified in biological macromolecules like enzymes, nucleic acids, membranes and model systems like micelles and vesicles. Molecular receptors and design principles. Cryptands, cyclophanes,

Books Suggested

4. Introduction to Theoretical Organic Chemistry and Molecular Modeling, W. B. Smith, VCH, Weinheim.
6. Supramolecular Chemistry; Concepts and Perspectives, J. M. Lehn, VCH.
ELECTIVE PAPER 11

Chemistry of Materials

I Multiphase Materials

Ferrous alloys; Fe-C phase transformations in ferrous alloys; stainless steels, non-ferrous alloys, properties of ferrous and non-ferrous alloys and their applications.

II Glasses, Ceramics, Composites and Nanomaterials

Glassy state, glass formers and glass modifiers, applications. Ceramic structures, mechanical properties, clay products. Refractories, characterizations, properties and applications.
Microscopic composites; dispersion-strengthened and particle-reinforced, fibre-reinforced composites, macroscopic composites. Nanocrystalline phase, preparation procedures, special properties, applications.

III Thin Films and Langmuir -Blodgett Films

Preparation techniques; evaporation/sputtering, chemical processes, MOCVD, sol-gel etc.
Langmuir-Blodgett (LB) film, growth techniques, photolithography, properties and applications of thin and LB films.

IV Liquid Crystals

Mesomorphic behaviour, thermotropic liquid crystals, positional order, bond orientational order, nematic and smectic mesophases; smectic - nematic transition and clearing temperature- homotropic, planar and schlieren textures, twisted nematics, chiral nematics, molecular arrangement in smectic A and smectic C phases, optical properties of liquid crystals.Dielectric susceptibility and dielectric constants. Lyotropic phases and their description of ordering in liquid crystals.

V Polymeric Materials

Molecular shape, structure and configuration, crystallinity, stress-strain behaviour, thermal behaviour, polymer types and their applications, conducting and ferro-electric polymers.

VI Ionic Conductors

Types of ionic conductors, mechanism of ionic conduction, interstitial jumps (Frenkel); vacancy mechanism, diffusion superionic conductors; phase transitions and mechanism of conduction in superionic conductors, examples and applications of ionic conductors.
VII  High Tc Materials  10 Hrs

Defect perovskites, high Tc superconductivity in cuprates, preparation and characterization of 1-2-3 and 2-1-4 materials, normal state properties; anisotropy; temperature dependence of electrical resistance; optical phonon modes, superconducting state; heat capacity; coherence length, elastic constants, position lifetimes, microwave absorption-pairing and multigap structure in high Tc materials, applications of high Tc materials.

VIII  Materials for Solid State Devices  3 Hrs

Rectifiers, transistors, capacitors -IV-V compounds, low-dimensional quantum structures; optical properties.

IX  Organic Solids, Fullerenes, Molecular Devices  9 Hrs

Conducting organics, organic superconductors, magnetism in organic materials.
Fullerenes –doped, fullerenes as superconductors.
Molecular rectifiers and transistors, artificial photosynthetic devices, optical storage memory and switches -sensors.
Nonlinear optical materials: nonlinear optical effects, second and third order - molecular hyperpolarisability and second order electric susceptibility - materials for second and third harmonic generation.

Books Suggested

ELECTIVE PAPER 12

Computational Chemistry 60 Hrs (2 Hrs/week)

I  Fortran/C Programming and Numerical Methods 15 Hrs

Advanced programming features of FORTRAN/C. Basic theory, discussion of algorithms and errors for the following numerical methods. Examples from chemistry should be selected for illustrating the methods. The teacher may select ANY THREE of the following subtopics considering the background of students, available time etc.

a.  Solution of Equations


b.  Linear Simultaneous Equations


c.  Eigenvalues and Matrix Diagonalization

Jacobi and Householder methods, analysis or errors.

d.  Interpolation


e.  Numerical Differentiation

Solution of simple differential equations by Taylor series and Runge-Kutta methods.

f.  Numerical Integration

Newton-Cotes formulae, Romberg integration, errors in integration formulae.

The students should develop computer programs for some of the above numerical methods.

II  Running of Advanced Scientific Packages 15 Hrs

The students are expected to get hands on experience of running a few selected advanced level scientific software packages after a brief introduction to the basic theory and methodology. ab initio quantum chemical packages such as GAUSSIAN/GAMES with carefully designed exercises for illustrating various features of the packages. Semi-
empirical/Dynamics/Simulation packages such as MOPAC, CHARM, AMBER, QUANTA etc. Basic ideas on structure activity relation, drug and catalysis design etc.

III Introduction to Networking and Search using Internet 10 Hrs

IV Project 20 Hrs

The students will develop utilities such as analysis of spectra, simulation programmes which will supplement laboratory or theory exercises in physical, organic, inorganic chemistry or biochemistry. This list is only indicative and a variety of small projects designed by the teacher based on the interest of the student and capabilities should be worked out.

Books Suggested

ELECTIVE PAPER 13

Advanced Quantum Chemistry 60 Hrs (2 Hrs/week)

(Pre-requisite: Mathematics at least up to First Year B.Sc. level is necessary. At least one PC among 4 students should be available)

I Theoretical and Computational Treatment of Atoms and Molecules, Hartree-Fock Theory 12 Hrs

Review of the principles of quantum mechanics, Born-Oppenheimer approximation. Slater-Condon rules, Hartree-Fock equation, Koopmans and Brillouin theories, Roothan equation, Gaussian basis sets

II Configuration Interaction and MC-SCF 12 Hrs

Introduction to CI; full and truncated CI theories, size consistency. Introductory treatment of coupled cluster and MC-SCF methods.

III Semi-Empirical Theories 12 Hrs


IV Density Functional Theory 12 Hrs

Derivation of Hohenberg-Kohn theorem, Kohn-Sham formulation, N- and V-representabilities; review of the performance of the existing local (e.g. Slater Xa and other methods) and non-local functionals, treatment of chemical concepts with the density functional theory.

V Computer Experiments 12 Hrs

Computer experiments using quantum chemistry - software packages such as GAUSSIAN/GAMESS/MOPAC and modeling software e.g. MM2/ AMBER/CHARM etc.

Books Suggested

1 Modern Quantum Chemistry, N.S. Ostlund and A. Szabo, McGraw Hill.
2 Methods of Molecular Quantum Mechanics, R. McWeeny and B.T. Sutcliffe, Academic Press.
4 Exploring Chemistry with Electron Structure Methods, J. B. Foresman and E. Frish, Goussian Inc.
ELECTIVE PAPER 14

Liquid State 60 Hrs (2 Hrs/week)

I General Properties of Liquids 13 Hrs

a) Liquids as dense gases, liquids as disordered solids, some thermodynamic relations, internal pressure and its significance in liquids. Equations of state, critical constants. Different types of intermolecular forces in liquids, different potential functions for liquids, additivity of pair potential approximation.

b) A classical partition function for liquids, correspondence principle, configuration integral, configuration properties.

II Theory of Liquids 9 Hrs

Theory of liquids, partition function method or model approach; single cell models, communal energy and entropy, LTD model, significant structure model.

III Distribution Function and Related Equations 14 Hrs

Radial distribution function method, equation of state in terms of RDF. Molecular distribution functions, pair distribution function. Relationship between pair distribution function and pair potential function. The IBG equation, the HNC equation, the PY equation, cluster expansion.

IV Methods for Structure Determination and Computational Techniques 12 Hrs

Spectroscopic techniques for liquid dynamic structure studies, Neutron and X-ray scattering spectroscopy.

Computation Techniques—Monte Carlo and molecular dynamics methods.

V Supercooled and Ionic Liquids 12 Hrs

Supercooled and ionic liquids, theories of transport properties; non Arrhenius behaviour of transport properties, Cohen-Turnbull free volume model, configurational entropy model, Macedo-Litovitz hybrid model, glass transition in supercooled liquids.

Books Suggested

2. The Dynamic Liquid State, A.F.M. Barton, Longman.
4. The Liquid State, J.A. Pryde.
ELECTIVE PAPER 15

Polymers

60 Hrs (2 Hrs/week)

I Basics

II Polymer Characterization

III Structure and Properties
Morphology and order in crystalline polymers-configurations of polymer chains. Crystal structures of polymers. Morphology of crystalline polymers, strain-induced morphology, crystallization and melting. Polymer structure and physical properties-crystalline melting point Tm - melting points of homogeneous series, effect of chain flexibility and other steric factors, entropy and heat of fusion. The glass transition temperature, Tg-Relationship between Tm and Tg, effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking. Property requirements and polymer utilization.

IV Polymer Processing
Plastics, elastomers and fibres. Compounding. Processing techniques: Calendering, die casting, rotational casting, film casting, injection moulding, blow moulding, extrusion moulding, thermoforming, foaming, reinforcing and fibre spinning.

V Properties of Commercial Polymers
Polyethylene, polyvinyl chloride, polyamides, polyesters, phenolic resins, epoxy resins and silicone polymers. Functional polymers - Fire retarding polymers and electrically
conducting polymers. Biomedical polymers - contact lens, dental polymers, artificial heart, kidney, skin and blood cells.

Books Suggested

PAPER XV & XVI

CH-508 & 509  540 Hrs (18 Hrs/week)

Inorganic Chemistry

Preparation

Preparation of selected inorganic compounds and their study by IR, electronic spectra, Mossbauer, ESR and magnetic susceptibility measurements. Handling of air and moisture sensitive compounds involving vacuum lines.

Selection can be made from the following:

3. Atomic absorption analysis of Mg and Ca.
4. Trialkoxyboranes – Preparation, IR and NMR spectra.
7. Relative stability of Tin(IV) and Pb(IV). Preparation of ammonium hexachlorostannate (NH₄)₂SnCl₆, ammonium hexachloroplumbate (NH₄)₂PbCl₆.
8. Hexa-bis (4-nitrophenoxy) cyclotriphosphazene.
10. Sodium tetrathionate Na₂S₄O₆.
14. Magnetic moment of Cu(acac)₂H₂O.
15. Cis and Trans [Co(en)₂Cl₂]⁺.
18. Determination of Cr(III) complexes.
   [Cr(H₂O)₆]NO₃₃H₂O, [Cr(H₂O)₄Cl₂ ]Cl₂H₂O, [Cr(en)₃]Cl₃, Cr(acac)₃. Inorg. Synth., 1972, 13, 184.
19. Preparation of N,N bis(salicyldehyde)ethylenediamine, salen H₂, Co(salen)  
   Determination of O₂ absorption by Co(salen)  
   Reaction of oxygen adduct with CHCl₃ (deoxygenation).
21. Reaction of Cr(III) with a multidentate ligand: a kinetics experiment (visible spectra  
   Cr-EDTA complex.)  
   J. A. C. S., 1953, 75, 5670.
22. Preparation of [Co(phenanthroline-5,6-quinone].  
23. Preparation and use of Ferrocene.  
24. Preparation of copper glycine complex-cis and trans bis (glycinato Copper(II). J.  
26. Any other experiment such as conversion of p-xylene to terephthalic acid catalyzed  
   by CoBr₂ (homogeneous catalysis)

**Spectrophotometric Determinations**

(a) Manganese/Chromium/Vanadium in steel sample  
(b) Nickel/molybdenum/tungsten/vanadium/uranium by extractive spectrophotometric  
    method.  
(c) Fluoride/nitrite/phosphate  
(d) Iron-phenanthroline complex: Job's Method of continuous variations.  
(e) Zirconium-Alizarin Red-S complex: Mole-ratio method.  
(f) Copper-Ethylene diamine complex: Slope-ratio method.

**Flame Photometric Determinations**

(a) Sodium and potassium when present together  
(b) Lithium/calcium/barium/strontium  
(c) Cadmium and magnesium in tap water.

**Nephelometric determinations**

(a) Sulphate  
(b) Phosphate  
(c) Silver

**Chromatographic Separations**

(a) Cadmium and zinc
(b) Zinc and magnesium
(c) Thin-layer chromatography-separation of nickel, manganese, cobalt and zinc. Determination of Rf values.
(d) Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of Rf values.

**Organic Chemistry**

**Qualitative Analysis**

Separation, purification and identification of the components of a mixture of three organic compounds (three solids or two liquids and one solid, two solids and one liquid), using tlc for checking the purity of the separated compounds, chemical analysis, IR, PMR and mass spectral data.

**Multi-step Synthesis of Organic Compounds**

The exercises should illustrate the use of organic reagents and may involve purification of the products by chromatographic techniques.

Photochemical reaction

Benzophenone $\rightarrow$ Benzpinacol $\rightarrow$ Benzpinacolone

Beckmann rearrangement: Benzanilide from benzene

Benzene $\rightarrow$ Benzophenone $\rightarrow$ Benzophenone oxime $\rightarrow$

Benzanilide

Benzillic acid rearrangement: Benzillic acid from benzoin

Benzoin $\rightarrow$ Benzil $\rightarrow$ Benzillic acid

Synthesis of heterocyclic compounds


Enzymatic synthesis

Enzymatic reduction: Reduction of ethyl acetoacetate using Bakers' yeast to yield enantiomeric excess of S (+) ethyl-3-hydroxybutanoate and determine its optical purity.

Biosynthesis of ethanol from sucrose

Synthesis using microwaves

Alkylation of diethyl malonate with benzyl chloride.

Synthesis using phase transfer catalyst

Alkylation of diethyl malonate or ethyl acetoacetate with an alkyl halide

**Extraction of Organic Compounds from Natural Sources**

1. Isolation of caffeine from tea leaves.
2. Isolation of casein from milk (the students are required to try some typical colour reactions of proteins).
3. Isolation of lactose from milk (purity of sugar should be checked by TLC and PC and Rf value reported).
4. Isolation of nicotine dipicrate from tobacco.
5. Isolation of cinchonine from cinchona bark.
6. Isolation of piperine from black pepper.
7. Isolation of lycopene from tomatoes.
8. Isolation of β-carotene from carrots.
9. Isolation of oleic acid from olive oil (involving the preparation of complex with urea and separation of linoleic acid).
10. Isolation of eugenol from cloves.
11. Isolation of (+) limonine from citrus rinds

**Paper Chromatography**

Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of Rf values.

**Spectroscopy**

Identification of organic compounds by the analysis of their spectral data (UV, IR, PMR, CMR & MS)

**Spectrophotometric (UV/VIS) Estimations**

1. Amino acids
2. Proteins
3. Carbohydrates
4. Cholesterol
5. Ascorbic acid
6. Aspirin
7. Caffeine

**Physical Chemistry**

Number of hours for each experiment: 3-4 hours

A list of experiments under different headings are given below. Typical experiments are to be selected from each type.

**Thermodynamics**

(i) Determination of partial molar volume of solute (e.g., KCl) and solvent in a binary mixture.
(ii) Determination of the temperature dependence of the solubility of a compound in two
solvents having similar intermolecular interactions (benzoic acid in water and in DMSO-water mixture) and calculate the partial molar heat of solution.

**Spectroscopy**

(i) Determination of pKa of an indicator (e.g., methyl red) in (a) aqueous and (b) micellar media.

(ii) Determination of stoichiometry and stability constant of inorganic (e.g. ferric - salicylic acid) and organic (e.g. amine-iodine) complexes.

(iii) Characterization of the complexes by electronic and IR spectral data.

**Polarography**

(i) Estimation of Pb^{2+} and Cd^{2+}/Zn^{+} and Ni^{2+} ions in a mixture of Pb^{2+} and Cd^{2+}/Zn^{+} and Ni^{2+} by polarography.

(ii) Determination of dissolved oxygen in aqueous solution of organic solvents.

**Electronics**

This lab course will have theory as well as practicals and the lectures shall be delivered during lab hours.

**Basic Electronics**

Notations used in an electric circuit, study of electronic components and colour codes, conversion of chemical quantities into electrical quantities. Transducer, illustration with electrodes, thermocouples and thermistors.

Passive components: Resistors, capacitors and inductors with some emphasis on solid state properties of materials. Net works of resistors. Thévenin's theorem, superposition theorem, loop analysis, R C circuits, L R circuits, LCR circuits. Illustration of the use of the circuits in NQR spectroscopy, Mössbauer spectroscopy, cyclic voltametry and in power supplies as filter circuits.

**Active Components**

Introduction to ordinary diodes and Zener diodes with some emphasis on p-n junction as a solid state property. Use of diodes as rectifiers, clipping and clamping circuits. Power supplies.

Transistors: An extension of p-n junction to p-n-p and n-p-n transistors. Characteristics of transistors, hybrid parameters; transistor circuits as amplifiers, high impedance (preamplifier) circuits. Darlington pairs, differential amplifiers.

**Operational Amplifiers**

Ideal characteristics; inverter, summer, integrator, differentiator, voltage follower, illustrative use of operational amplifiers.
Introduction to Fourier transform in instrumentation.

List of Experiments in Electronics
- Measurements of resistance with multimeter
- To measure the resistance of the given ammeter
- Voltage measurement with CRO
- Familiarising with CRO
- Use of a Wheatstone Bridge for accurate measurement of resistance
- Capacitor as a charge storage device
- To study the behaviour of parallel charged capacitors in series charged capacitors placed in parallel
- The use of LCR Bridge
- Response characteristics of RC network
- Response characteristics of LR network
- Response characteristics of LCR network
- Verification of Kirchhoff's laws
- To study the Lissajou's figures
- Measurement of e.m.f. with thermocouple
- To plot the characteristic curve of a diode
- Half-wave and full-wave rectifier
- Clipping and clamping circuits
- Capacitor filter for full-wave rectifier
- Voltage doubler, Zener stabilized bipolar power supply
- Transistor characteristics
- Differential amplifier
- Transistor amplifier
- Introduction of an operational amplifier as a voltage follower
- Op-Amp as non-inverting and inverting amplifier
- Simple integration differentiation with Op-Amp 741
- Op-Amp as comparator
- Designing and fabrication of a printed circuit board
- Setting up of a thermostat: Constant temperature bath
- Four-probe method for resistivity measurement

Books Suggested
1. Inorganic Experiments, J. Derek Woollins, VCH.
5  Semimicro Qualitative Organic Analysis, N. D. Cheronis, J. B. Entrikin and E. M. Hodnett
6  Experimental Organic Chemistry, M. P. Doyle and W. S. Mungall
7  Small Scale Organic Preparations, P. J. Hill.
8  Organometallic Synthesis, J J. Fisch and R B. King, Academic.
10 Findlay’s Practical Physical Chemistry, revised B.P. Levitt, Longman.
RECOMMENDATIONS

1. In the proposed undergraduate and postgraduate programmes of teaching in Chemistry, considerable time has been allotted both in theory as well as in laboratory courses, for problem-solving sessions, tutorials, continuous evaluation and preparation and instructions for laboratory work. The focus is to give an opportunity to the student to learn on his/her own or through discussions. It is strongly recommended that this in-built time should be utilized properly so as to generate a sense of curiosity and creativity among the students. Further, the students may be encouraged to prepare topics from the textual material and present them before their class fellows in the presence of the teacher concerned.

2. Application of computers in Chemistry has been introduced both at undergraduate and postgraduate levels as essential components of the teaching. There is a provision of separate computer laboratory for the postgraduate students. It is recommended that the institutions should take advantage of the UGC scheme of special assistance for setting up of computer laboratory comprising several departments.

3. Improvement of laboratory courses requires tremendous effort and resources. Most of the ‘wet’ experiments need to be performed at semi-micro level. Such exercises are needed not only to provide better training to the students, but also these are eco-friendly and less expensive. More attention should be focused on safety measures and disposal of the laboratory ‘waste’.

   It is recommended that the experiments should be scheduled in such a manner so as to illustrate the principles dealt within the theory classes. The process of continuous evaluation with transparency is relatively more effective in the laboratory than the conventional system of evaluation. It is recommended that there should be at least 50% internal assessment based on the marks after the report of an experiment is submitted by the student.

   It was felt that the UGC may constitute a Committee of Experts to design laboratory set-up essentially required for undergraduate and postgraduate laboratory courses so that a uniform norm is strictly adhered to at the national level.

4. Question papers for both undergraduate and postgraduate examinations should have at least five units and each question be divided into several components in order to limit ‘choice’ for the students. Objective type questions as well as the practice of internal evaluation should be encouraged depending upon regional conditions.

5. An important area which requires greater focus is the training of the teachers for effective implementation of the new syllabuses. At the moment, such an exercise is being carried
out through Academic Staff Colleges who periodically arrange Refresher Courses primarily designed to update the knowledge of undergraduate teachers. These courses are usually of 3 weeks duration and address the teachers belonging to all branches of Chemistry. Most of the participants and resource persons are drawn on regional basis. It has often been seen that many participants commute from nearby places and the time schedule of the Refresher Course is set accordingly. For better utilization of these Refresher Courses, it is recommended that:

(a) At least 50% of the participants should come from outside the region. Such an arrangement will expose participants to interact with resource persons from other regions thus widening their horizons.

(b) The participants should stay together in the accommodation to be provided by the host institution. This will provide an opportunity to know and appreciate the methodology of teaching of Chemistry being followed in different parts of the country. Informal discussions outside the lecture rooms will go a long way in generating a ‘feeling’ for Chemistry teaching.

(c) A list of resource persons should be prepared by the UGC and supplied to the Directors of the Refresher Courses. This pool should consist of teachers of proven ability.

(d) A Refresher Course of 2 weeks on an advanced topic of Chemistry will be more useful than a conventional 3-weeks course of general nature.

It is also expected that after the submission of this Report, many institutions will orient the teaching of Chemistry accordingly. The CDC strongly recommends that the UGC should provide adequate infrastructural support for the upgradation of the laboratories.

6. The CDC is of the opinion that admission to postgraduate classes should be made on the basis of an entrance test.

7. It was felt that talented students are not opting for a career in science. To arrest this declining trend, there is an urgent need for a debate at national level.