

# **CURRICULUM OF CHEMISTRY**

(Revised 2005)



**HIGHER EDUCATION COMMISSION  
ISLAMABAD**

## **CURRICULUM DIVISION, HEC**

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## PREFACE

Curriculum of a subject is said to be the throbbing pulse of a nation. By looking at the curriculum one can judge the state of intellectual development and the state of progress of the nation. The world has turned into a global village; new ideas and information are pouring in like a stream. It is, therefore, imperative to update our curricula regularly by introducing the recent developments in the relevant fields of knowledge.

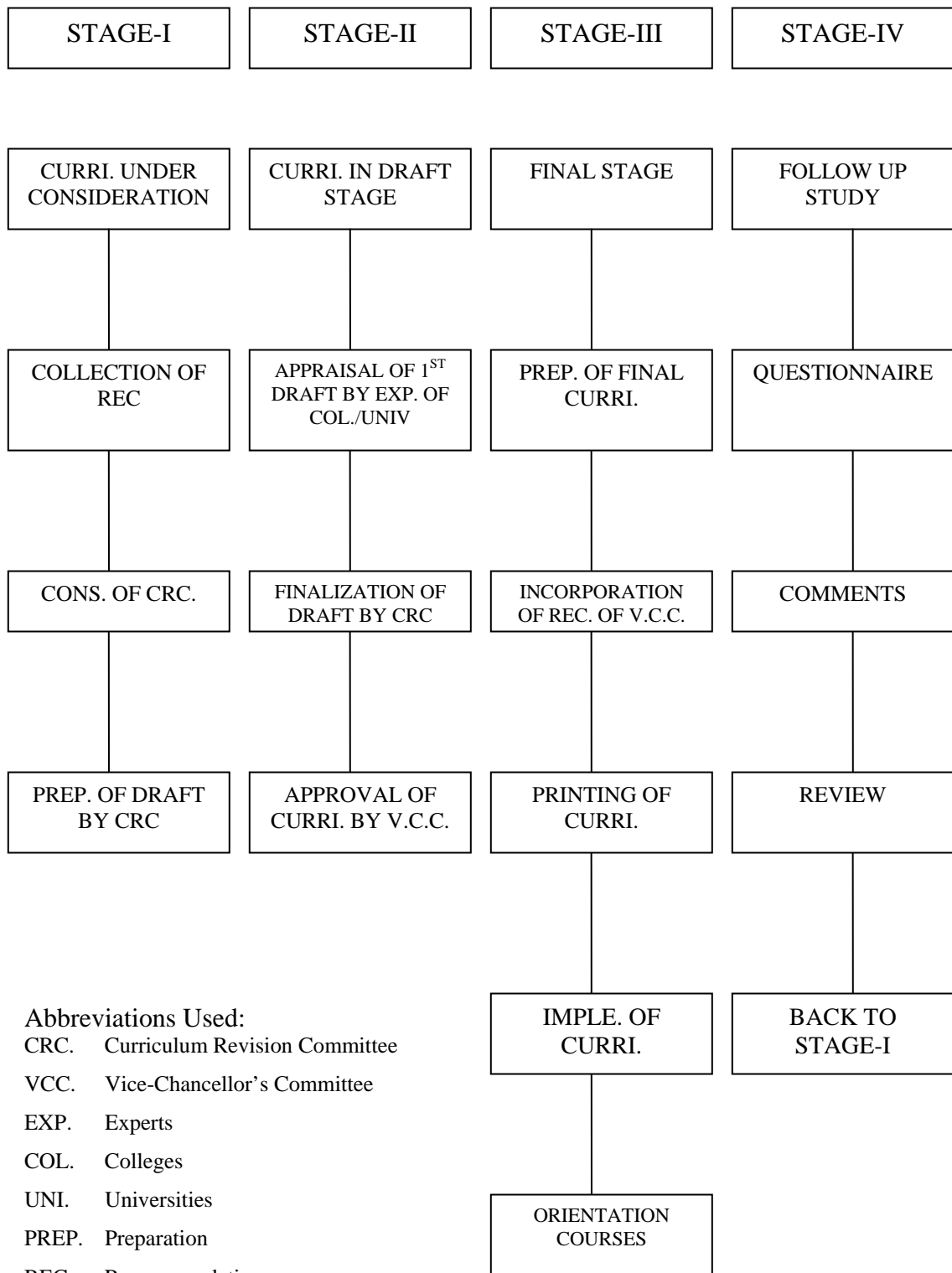
In exercise of the powers conferred by sub-section (1) of section 3 of the Federal Supervision of Curricula Textbooks and Maintenance of Standards of Education Act 1976, the Federal Government vide notification no. D773/76-JEA (Cur.), dated December 4, 1976, appointed University Grants Commission as the competent authority to look after the curriculum revision work beyond class XII at bachelor level and onwards to all degrees, certificates and diplomas awarded by degree colleges, universities and other institutions of higher education.

In pursuance of the above decisions and directives, the Higher Education Commission (HEC) is continually performing curriculum revision in collaboration with universities. According to the decision of the special meeting of Vice-Chancellors' Committee, curriculum of a subject must be reviewed after every 3 years. For the purpose, various committees are constituted at the national level comprising senior teachers nominated by universities. Teachers from local degree colleges and experts from user organizations, where required, are also included in these committees. The National Curriculum Revision Committee for Rural Sociology in its meeting held in **April 19-21, 2005** at the HEC Regional Centre, Karachi revised the curriculum after due consideration of the comments and suggestions received from universities and colleges where the subject under consideration is taught. The final draft prepared by the National Curriculum Revision Committee duly approved by the Competent Authority is being circulated for implementation by architectural institutions.

**(PROF. DR. ALTAF ALI G. SHAIKH)**  
**Adviser (Acad/R&D)**

July 2005

# CURRICULUM DEVELOPMENT





## INTRODUCTION

A National Curriculum Revision Committee (NCRC) meeting to prepare the final revised curriculum of Chemistry and for the introduction of 4-years, B.S Program in Chemistry at various Institutions was held from April 19-21, 2005 at the HEC, Regional Centre, Karachi. The following were the experts.

1. Dr. G. A. Miana, Convener  
Dean / Director,  
Riphah Institute of Pharmaceutical Sciences,  
7<sup>th</sup> Avenue, G-7/4,  
Islamabad
2. Prof. Dr. Muhammad Shahid Ansari, Member  
Professor,  
Deptt. of Chemistry,  
Quaid-i-Azam University, Islamabad
3. Dr. Bushra Khan, Member  
Associate Professor,  
Deptt. of Chemistry,  
Lahore College for Women,  
Jail Road, Lahore
4. Prof. Dr. Mazhar Maqsood Qureshi, Member  
Dean Academics,  
Superior College, New Garden Town,  
Near Kalma Chowk, Lahore
5. Prof. Dr. Saeed A. K. Lodhi, Member  
Dean,  
Faculty of Engineering & Technologies,  
Institute of Business Technology,  
Korangi Creek, Karachi
6. Prof. Dr. Abdus Sattar Khan, Member  
Dean,  
Kohat University of Science & Technology,  
Bannu Road, Kohat
7. Dr. Nikhat Saba, Member  
Associate Professor,  
Jinnah University for Women,  
5-C, Nazimabad, Karachi

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| 8.  | Prof. Dr. Muhammad Hanif Noomrio,<br>Chairman,<br>Deptt. of Chemistry,<br>Shah Abdul Latif University, Khairpur                                | Member |
| 9.  | Prof. Dr. Jamil Anwar,<br>Director,<br>Institute of Chemistry,<br>University of the Punjab, Lahore   | Member |
| 10. | Dr. Sher Khan Sadozai,<br>Chairman,<br>Deptt. of Chemistry,<br>Gomal University, D.I.Khan  | Member |
| 11. | Prof. Dr. Muhammad Ali,<br>Chairman,<br>Deptt. of Chemistry,<br>University of Sargodha, Sargodha   | Member |
| 12. | Dr. Athar Yaseen Khan,<br>Professor<br>Deptt. of Chemistry,<br>Allama Iqbal Open University,<br>Islamabad                                      | Member |
| 13. | Prof. Dr. Muhammad Javed Iqbal,<br>Chairman,<br>Deptt. of Chemistry,<br>Newport University, Islamabad  | Member |
| 14. | Dr. Muhammad Ibrahim Rajoka,<br>Chief Scientific Officer,<br>National Institute of Bio-Technology and Genetic Engg.,<br>Jhang Road, Faisalabad | Member |
| 15. | Dr. Mian Muhammad Izhar-ul-Haq,<br>Director,<br>Science & Technology Division<br>University of Education, Lahore.                              | Member |
| 16. | Dr. Abdul Mateen Farid,<br>Senior Fellow, Deptt. of Chemistry,<br>Institute of Business Management,<br>Korangi Creek, Karachi                  | Member |



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| 17. | Dr. Rakhshanda Nawaz,<br>Dean,<br>Faculty of Sciences,<br>University of Agriculture, Faisalabad                | Member |
| 18. | Dr. Abdul Jabbar,<br>Assistant Professor,<br>Deptt. of Chemistry,<br>Government College University, Faisalabad | Member |
| 19. | Prof. Dr. Zahur Ahmad Malik,<br>Chairman,<br>Deptt. of Chemistry,<br>GC University, Faisalabad                 | Member |
| 20. | Prof. Dr. Atta-ur-Rehman,<br>Institute of Chemistry,<br>University of Sindh, Jamshoro                          | Member |
| 21. | Prof. Dr. Shahida B. Niazi,<br>Chairperson,<br>Deptt. of Chemistry,<br>Bahauddin Zakria University, Multan     | Member |
| 22. | Prof. Dr. Shahnaz Malik,<br>Chairperson,<br>Deptt. of Chemistry,<br>Hazara University, Mansehra, NWFP          | Member |
| 23. | Prof. Dr. Muhammad Ashfaq,<br>Assistant Professor,<br>Deptt. of Chemistry,<br>Islamia University, Bahalpur     | Member |
| 24. | Engr. Shahid Akhter Baig,<br>Itehad Chemical Ltd, Lahore   | Member |
| 25. | Dr. Bushra Mateen,<br>Vice Chancellor,<br>Lahore University for Women,<br>Jail Road, Lahore.                   | Member |
| 26. | Prof. Dr. Pervez Khalid Butt,<br>Professor,<br>Deptt. of Pharmacy,<br>University of Lahore, Lahore             | Member |

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| 27. | Dr. Dur-e-Shawar,<br>Assistant Professor,<br>Deptt. of Chemistry,<br>GC University, Katchery Road, Lahore       | Member    |
| 28. | Prof. Dr. Fazeelat Tahira,<br>Chairperson,<br>Deptt. of Chemistry,<br>University of Engg. & Technology, Lahore. | Member    |
| 29. | Prof. Dr. Mumtaz Ali Qureshi,<br>Chairman,<br>Deptt. of Chemistry,<br>Shah Abdul Latif University, Khairpur     | Member    |
| 30. | Prof. Dr. Ahmed Saeed,<br>Dean,<br>Faculty of Sciences,<br>Gomal University, D.I.Khan                           | Member    |
| 31. | Dr. Jamil Ahmed,<br>Air University, E-9, Islamabad  | Member    |
| 32. | Dr. Iftikhar Imam Naqvi,<br>Professor & Chairman,<br>Deptt. of Chemistry,<br>University of Karachi, Karachi     | Secretary |

The meeting started with the recitation of the Holy Quran by Dr. Altaf Ali G. Shaikh, Advisor, Acad/R&D. Dr. Altaf welcomed the participants on behalf of the Chairman, Higher Education Commission. He discussed at length the need for updating the curriculum and the development of curriculum for the modern day needs. He emphasized that the participants should concentrate on development of a curriculum which could cater for a trained manpower of young people ready to meet the academic and development challenges faced by the nation. He was of the view that four years BS degree program be compatible to train the human resource in hi-tech areas and that emphasis be given towards incorporation of research activity in the curriculum as it is considered vital for admissions in the higher education institutions of the world.

Dr. Altaf advised to have the curriculum in its final shape before June 30, 2005. He informed the participants that the exercise is being undertaken in other disciplines of science and humanities as well. The members of the committee have been drawn from all segments of the society imparting academic training in chemistry. The members of the NCRC Committee

decided to appoint Dr. G.A Miana as its Convener and Dr. Iftikhar Imam Naqvi as the Secretary.

The NCRC had a detailed discussion on various aspects pertaining to knowledge related to chemistry. After detailed discussion, the committee agreed to constitute the subcommittees for the following branches of chemistry to prepare details of courses of their respective group.

1. **Physical Chemistry**
2. **Inorganic Chemistry /Analytical Chemistry**
3. **Organic/Biochemistry**
4. **Applied/Environmental Chemistry**

The subcommittees held separate meetings and submitted their recommendations. These recommendations were later discussed in a joint meeting of the NCRC. It was agreed upon that a total of 128 credit hours will be required for a 4 years B.S Chemistry programme. It was also decided that apart from 80 credit hours. The NCRC decided that all the three science subjects would be given equal weightage for the first two years. It was also recommended that functional English and communication skills be taught instead of English literature.

The contents of the proposed curriculum were discussed and approved for circulation to the respective institutions to seek general opinion prior to coming to conclusion for the final draft. The meeting ended with a vote of thanks from the convener.

The participants acknowledged the efforts of Dr. G.A Miana for his contribution to the success of the meeting.

The second follow up meeting started with the recitation of the Holy Quran. The Director of the regional centre, Prof. S. M. Iqbal, welcomed the participants from all over Pakistan. The meeting after some discussion and opening remarks from Dr. G.A. Miana got divided into two groups. One committee headed by Dr. G. A. Miana was assigned to prepare the proposal for BS (4 years) course and the second committee headed by Dr. Iftikhar Imam Naqvi was formed to finalize the draft of MS (2 years) course in Chemistry.

### **Sub Committee for 4 Years BS Program**

1. Dr. G. A. Miana, Convener
2. Prof. Dr. Muhammad Shahid Ansari
3. Prof. Dr. Shahnaz Malik
4. Prof. Dr. Abdus Sattar Khan
5. Prof. Dr. Zahur Ahmed Malik
6. Prof. Dr. Atta-ur-Rehman,

7. Prof. Dr. Muhammad Javed Iqbal,
8. Prof. Dr. Muhammad Ashfaq,
9. Dr. Sher Khan Sadozai
10. Dr. Mian Muhammad Izhar-ul-Haq
11. Dr. Nikhat Saba
12. Dr. Abdul Mateen Farid,
13. Dr. Abdul Jabbar

### **Sub Committee for 2 Years MS Program**

1. Dr. Iftikhar Imam Naqvi Co-Convener
2. Prof. Dr. Mazhar Maqsood Qureshi
3. Prof. Dr. Saeed A. K. Lodhi
4. Prof. Dr. Muhammad Ali
5. Prof. Dr. Jamil Ahmed
6. Prof. Dr. Shahida B. Niazi
7. Prof. Dr. Muhammad Hanif Noomrio
8. Dr. Bushra Khan
9. Dr. Athar Yaseen Khan
10. Dr. Muhammad Ibrahim Rajoka
11. Dr. Rakhshanda Nawaz
12. Engr. Shahid Akhter Baig

In order to finalize the two drafts, on the concluding day of the session, a joint session of the two sub committees was held, presided over by Dr. Iftikhar Imam Naqvi. Following long discussions, suggestions and amendments the proposals were approved with consensus. During the final discussion, Dr. Altaf Ali G. Shaikh, Adviser (HRD) was also present and he appreciated the efforts of all the participants.

The participants acknowledged the efforts of Dr. G.A.Miana, the Convener, Dr. Iftikhar Imam Naqvi, the Secretary and Dr. Muhammad Shahid Ansari, the additional Secretary of the committee. The participants also thanked Ms. Ghayyur Fatima and HEC staff for facilitating the efforts of the committee.

## MISSION STATEMENT

1. The common purpose is to achieve the highest possible standards of scholarship, teaching and research in chemistry and chemistry related disciplines.
2. The aim in teaching is:
  - i) to encourage intellectual development and scholarship in and through chemistry;
  - ii) to impart a sound knowledge of chemistry to students and to help them to use this knowledge creatively and analytically;
  - iii) to develop in students an awareness of the applications of chemistry including its practical, social and economic aspects such as health, agriculture, industry and defense.
  - iv) to develop and improve students' practical, written and oral communication, information retrieval, computer and problem solving skills.
  - v) to encourage students to become effective independent learners.
  - vi) to develop the curriculum which is need based and its continuous developments shall be made considering the changing global and national requirements.
  - vii) to develop in students the ability to work in groups so as to acquire respect for human values.
  - vii) to encourage students to broaden their knowledge, to develop their own capabilities and self confidence, to respect learning and to participate in continuing education.

## CURRICULUM FOR 4-Year BS (Hons) Program

The students who have passed F.Sc. /A-level examinations with chemistry shall be eligible for BS chemistry program. A student may choose chemistry as a major subject along with two other subjects out of different possible combinations as given below. These may be offered at the colleges / university campuses:

1. <b>Chemistry</b> Physics Mathematics	2. <b>Chemistry</b> Biochemistry Botany	3. <b>Chemistry</b> Microbiology Biochemistry	4. <b>Chemistry</b> Physics Botany
5. <b>Chemistry</b> Physics Computer Science	6. <b>Chemistry</b> Botany Geography	7. <b>Chemistry</b> Botany Zoology	8. <b>Chemistry</b> Botany Statistics
9. <b>Chemistry</b> Botany Computer Science	10. <b>Chemistry</b> Zoology Statistics	11. <b>Chemistry</b> Zoology Computer Science	13. <b>Chemistry and</b> two other science subjects (any combination)

### **Note: Suggestions for Annual System**

*The institutions continuing with the existing annual examination system may have the provision that two semester courses e.g. of semesters I, II and III & IV, be merged to constitute the course for one academic year. Thus the students shall appear in five papers in the annual examination of each of the academic year of the BS Program.*

## **SCHEME OF STUDIES**

A student choosing a combination of major subjects, for example, chemistry - physics - mathematics shall have the following scheme of studies:

### **1<sup>st</sup> Year**

<b>Semester-I</b>	<b>Credits</b>	<b>Semester-II</b>	<b>Credits</b>
<b>Chemistry</b> (Physical)	3+1*	<b>Chemistry</b> (Inorganic)	3+1*
Physics	3+1	Physics	3+1
Mathematics	4	Mathematics	4
English (Functional)	<u>2</u>	English (Functional)	2
<b>Total</b>	14 Cr	Islamic Studies	<u>2</u>
		<b>Total</b>	16 Cr

### **2<sup>nd</sup> Year**

<b>Semester-III</b>	<b>Credits</b>	<b>Semester-IV</b>	<b>Credits</b>
<b>Chemistry</b> (Organic)	3+1*	<b>Chemistry</b> (Special Topics)	3+1*
Physics	3+1	Physics	3+1
Mathematics	4	Mathematics	4
English (Functional)	<u>2</u>	English (Functional)	2
<b>Total</b>	14 Cr	Pak. Studies	<u>2</u>
		<b>Total</b>	16 Cr

**Total Credits: 14+16+14+16 = 60**

**Note:** At college or university level, a student may discontinue the studies at this stage to become eligible for a B.Sc. (Pass) degree. Those who continue their studies (for BS program) shall read the following courses:

### **3<sup>rd</sup> Year**

<b>Semester-V</b>	<b>Credits</b>	<b>Semester-VI</b>	<b>Credits</b>
Inorganic Chemistry	3+1*	Inorganic Chemistry	3+1*
Organic Chemistry	3+1	Organic Chemistry	3+1
Physical Chemistry	3+1	Physical Chemistry	3+1
Analytical/Environmental Chemistry	3+1	Applied/Bio-Chemistry	3+1
Mathematics for Chemists	<u>2</u>	Computer Applications in Chemistry	<u>2</u>
<b>Total</b>	18 Cr	<b>Total</b>	18 Cr

\* 3+1 means 3 theory lectures and 1 practical (3 hours) per week.

## **4<sup>th</sup> Year**

### **Specialization**

<b>Semester-VII</b>	<b>Credits</b>	<b>Semester-VIII</b>	<b>Credits</b>
Paper-I	4	Paper-IV	4
Paper-II	4	Paper-V	4
Paper-III	4	Paper-VI	4
Practicals	4	Advanced Practicals/ Research	4
<b>Total</b>	<u>16 Cr</u>	<b>Total</b>	<u>16 Cr</u>

### **Total: 128 Credit Hours**

Students should be encouraged to complete 4-6 weeks of non-credit **internship** at industries during the last year of BS program. A successful completion of the internship shall be mentioned in the transcript.



# **DETAIL OF COURSES**

## **BS: 1<sup>st</sup> Year**

### **Semester-I**

#### **Physical Chemistry (3 + 1)**

##### **Physical States of Matter**

Ideal and real gases, equations of state, critical phenomenon and critical constants. Molecules in motion: collision diameter and mean free path. Physical properties of liquids: surface tension, viscosity, refractive index etc. and their applications. Brief account of interactions among the molecules in liquids. Packing of atoms. Unit cells and crystal systems. Methods of crystal structure analysis. Brief account of polymers and composite materials with special emphasis on superconductors, semi-conductors etc. Introduction to plasma.

##### **Chemical Thermodynamics**

Laws of thermodynamics and their applications. Thermodynamic functions: internal energy, enthalpy, entropy and free energy. Relations between thermodynamic functions. van't Hoff's equation. Heat capacities, concept of entropy and probability.

##### **Chemical Kinetics**

Rate of reaction. Rate law, order and molecularity of the reactions. Zero, first and second order reactions. Determination of reaction order and its rate constant. Effect of temperature on the reaction rate. Concepts of chemical equilibrium. Law of mass action, equilibrium constant, Le-Chatelier principle and its applications. Elementary concepts underlying complex and fast reactions. Theories of elementary reactions: collision theory, transition state theory.

##### **Solution Chemistry**

Ideal and non-ideal solutions. Raoult's law and its applications. Molecular interactions in solutions. Colligative properties. Distillation and concept of azeotropic mixture. Phase rule and its applications.

##### **Surface Chemistry**

Concept of interfaces. Adsorption and adsorption isotherms: Freundlich and Langmuir adsorption isotherms. Catalysis, colloids, emulsion and their industrial applications.

##### **Physical Chemistry Practicals**

- Determination of viscosity and para-ochor values of liquids.
- Determination of percent composition of liquid solutions viscometrically.
- Determination of refractive index and molar refractivity.

- Determination of percent composition of liquid solutions by refractive index measurements.
- Determination of molecular weight of a compound by elevation of boiling point (ebullioscopic method).
- Determination of molecular weight of a compound by lowering of freezing point (cryoscopic method).
- Determination of heat of solution by solubility method.
- Determination of heat of neutralization of an acid with a base.
- Kinetic study of acid catalyzed hydrolysis of ethyl acetate.
- Determination of partition coefficient of a substance in two immiscible liquids.

## **Books Recommended**

### **Theory**

1. Alberty, R. "Physical Chemistry" 17<sup>th</sup> Ed., John Wiley and Sons (1987).
2. Atkins P.W. "Physical Chemistry" 6<sup>th</sup> edition, W. H. Freeman and co. New York (1998).
3. Laidler, K. J., "The World of Physical Chemistry" 1st Ed., Oxford University Press, pp. 488 (1993).
4. Laidler, K.J., John H. M. and Bryan C. S., "Physical Chemistry" 4th Ed., Houghton Mifflin Publishing Company Inc. (2003 ).
5. Peter, P.A., "Chemical Thermodynamics", Oxford University Press (1983).
6. Brain, S. E., "Basic Chemical Thermodynamics" 4<sup>th</sup> Ed., E. L. B. S. Publishers (1990).
7. Barrow, M.G., "Physical Chemistry" 5<sup>th</sup> Ed., Mc Graw Hill (1992).

### **Practicals**

1. Jaffar, M., "Experimental Physical Chemistry" University Grants Commission (1989).
2. Levitt B.P., "Findlay's Practical Physical Chemistry", 9<sup>th</sup> Ed., Longman Group Limited.
3. Shoemaker, D., "Experiments in Physical Chemistry" 5<sup>th</sup> Ed., McGraw Hill Publishing Company
4. Limited (1989).

## **Semester-II**

### **Inorganic Chemistry (3 + 1)**

#### **The Periodic Law and Periodicity**

Development of periodic table; Classification of elements based on s, p, d, and f orbitals, group trends and periodic properties in s, p, d and f block elements i.e., atomic radii, ionic radii, ionization potentials. Electron affinities, electronegativities and redox potential.

#### **Chemical Bonding in Main Block Elements**

Nature and types of chemical bonding, Lewis concepts, ionic, covalent, coordinate covalent bond; Valence Bond Theory (VBT), Molecular Orbital Theory (MOT). Interpretation of shapes of inorganic molecules on the basis of valence shell electron pair repulsion (VSEPR) theory and hybridization.

#### **Acid and Bases**

Concepts of acids and bases including soft and hard acid base concepts. Relative strengths of acids and bases, significance of pH,  $pK_a$ ,  $pK_b$  and buffers solutions. Theories of indicators: (acid base, redox, adsorption). Solubility, solubility product, common ion effect and their industrial applications

#### **Chemistry of the p-block Elements**

General characteristics of the following group of p-block elements with reference to the aspects given against each:

##### ***Boron and Aluminum***

Group anomalies: Boron and aluminium hydrides: Structures, properties and industrial applications.

##### ***Carbon and Silicon***

Group anomalies. Allotropic forms of carbon, fullerenes and their applications. Production of pure silicon for solar energy and silicon chips, silicates and silicones and industrial applications.

##### ***Nitrogen and Phosphorus***

Group anomalies. Preparation, structures, properties and the environmental role of oxides of nitrogen. Industrial preparation of nitric acid, urea and superphosphate fertilizers. Causes of fog and smog.

##### ***Oxygen and Sulfur***

Group anomalies. Preparation, structures, properties and environmental role of oxides and oxyacids of sulphur, manufacturing of sulphuric acid and its reactions. Thionic acids and use of 'hypo' in industry.

### ***The Halogens***

Anomalous behaviour of fluorine. Industrial preparation of chlorine. Preparation, structures, properties and uses of oxides, oxyacids of chlorine, interhalogens and pseudohalogens.

### ***The Noble Gases***

Preparation, properties, structures and uses of xenon fluorides; Commercial uses of noble gases.

## **Practicals**

- 1. Laboratory Ethics and Safety Measures**  
Awareness about the toxic nature of chemicals and their handling, cleaning of glassware, safe laboratory operations
- 2. Qualitative Analysis**  
Analysis of four ions (two cations and two anions) from mixture of salts.
- 3. Preparation and standardization of normal and molar solutions of HCl, NaOH and  $\text{KMnO}_4$**
- 4. Quantitative Analysis**  
Determination of total hardness of water using EDTA.  
Estimation of magnesium using EDTA  
Estimation of copper (iodometrically).  
Determination of ferricyanide using KI solution  
Determination of chloride by Volhard and Mohr methods.  
Estimation of chloride/bromide ions using adsorption (fluorescein) indicator.  
Percentage determination of ferric ions in ferric alum using  $\text{KMnO}_4$  solution.  
Determination of purity of commercial potassium oxalate using  $\text{KMnO}_4$  solution.  
Estimation of ferrous /ferric ions using  $\text{K}_2\text{Cr}_2\text{O}_7$  solution.  
Percentage determination of barium in barium nitrate by gravimetric method.  
Gravimetric determination of nickel.

## **Recommended Books:**

1. Badar-ud-Din and Ali S. M. "Inorganic Chemistry" Ferozsons Pvt. Ltd.
2. Cartmell E. and Fowles G. W. A. "Valency and Molecular Structure" Adlard and Sons Limited .3rd Edition (1966)

3. Cotton, F. A., Wilkinson G., Murillo C.A. and Bockhmann, M. "Basic Inorganic Chemistry" John Wiley & Sons, Inc. 2<sup>nd</sup> Edition (1987)
4. Douglas B., McDaniel D. and Alexander J. "Concepts and Models of Inorganic Chemistry" John Wiley & Sons, Inc. 3rd Edition (1994)
5. Harvey K. B. and Porter G. B. "Introduction to Inorganic Physical Chemistry" Addison-Wesley Publishing Company, Inc. (1963)
6. Hill J. W. and Petrucci R. H. "General Chemistry" Prentice-Hall, Inc. (1996)
7. Huheey J. E. "Inorganic Chemistry Principles of Structure and Reactivity" Harper and Row Publishers 2nd Edition (1978)
8. Huheey J. E. "Inorganic Chemistry Principles of Structure and Reactivity" Harper and Row Publishers. SI Unit Edition (1975)
9. Lee J. D. "Concise Inorganic Chemistry" Chapman and Hall. 5th Edition (1996)
10. Marr G. and Rockett B. W. "Practical Inorganic Chemistry" Van Nostrand Reinhold Company. (1972)
11. Miessler G. L. and Tarr Donald A. "Inorganic Chemistry" Prentice-Hall International, Inc. Prentice-Hall International Edition (1991)
12. Moody B. "Comparative Inorganic Chemistry" Routledge, Chapman and Hall, Inc. 3rd Edition (1991)
13. Shriver, D.F., Atkins P.W. and Langford C. H. "Inorganic Chemistry" Oxford University Press 2nd Edition (1994)

## Practicals

- Baig M. M. "Inorganic Chemical Analysis" Kifayat Academy (1974)
- Bassette J., Denney C., Jeffery G. H. and Mendham J. "Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis" English Language Book Society. 4th Edition (1978)
- Harris W. E., Kratochvil B. "An Introduction to Chemical Analysis" Saunders College Publishing. Holt-Saunders International Edition (1981)
- Vogel, A.I. "A Text Book of Micro and Semimicro Qualitative Inorganic Analysis" Longman Green & Co. (1995)

## **BS: 2<sup>nd</sup> Year**

### **Semester-III**

#### **Organic Chemistry (3+1)**

##### **Basic Concepts in Chemical Bonding**

Localized and delocalized bonding; concept of hybridization leading to bond angles, bond energies and geometry of simple organic molecules; dipole moment; inductive effect; resonance, resonance energy, rules of resonance, resonance effect, steric inhibition of resonance; hyperconjugation; tautomerism; hydrogen bonding.

##### **Nomenclature of Organic Compounds**

Common and trivial names of organic compounds; an introduction to the systematic nomenclature of mono- and bi-functional organic compounds by IUPAC rules.

##### **Hydrocarbons**

***Open Chain:*** Preparation, properties and reactions of alkanes, alkenes and alkynes.

***Closed Chain:*** Synthesis, reactions and relative stability of small and medium sized cycloalkanes.

***Aromatic Compounds:*** Structure of benzene, aromaticity, electrophilic substitution including orientation and reactivity, addition and oxidation reactions, preparation and reactivity of naphthalene.

##### **Isomerism**

***Geometrical isomerism:*** Determination of configuration of geometrical isomers, Z, E convention and cis- and trans- isomerism in compounds containing two double bonds;

***Optical isomerism:*** Optical activity, chirality and optical activity, racemisation and resolution of racemic mixtures, R, S notation, diastereoisomers.

***Conformational isomerism:*** A brief introduction to conformation of ethane, n-butane and cyclohexane.

##### **Alkyl Halides**

Preparation and reactions of alkyl halides with special reference to nucleophilic substitution and eliminations reactions, factors effecting nucleophilic substitution

and elimination reactions. Grignard's reagent: Preparation, structure and applications in the synthesis of alcohols and carboxylic acids.

### **Chemistry of the Hydroxyl Group and Ethers**

Brief review of the physical properties, preparation and reactions of alcohols. Phenols: Acidity, preparation and reactions, Ethers: Preparation, properties and reactions.

### **Chemistry of Carbonyl Compounds**

Structure and reactivity of the carbonyl group; preparation and reactions of aldehydes and ketones.

### **Chemistry of Carboxylic Acids and Their Derivatives**

Physical properties of carboxylic acids, effect of substitution and structure on the strengths of acidity of carboxylic acids. Preparation, properties and reactions of carboxylic acids and their derivatives i.e. esters, amides, acid halides and acid anhydrides.

### **Chemistry of Amino Group**

The structure of aliphatic and aromatic primary, secondary and tertiary amines. Physical and chemical properties of amines, basicity and nucleophilicity of amines. Synthesis and reactions of amines. Diazonium salts: Preparation and their synthetic applications.

## **Practicals**

Sixteen experiments shall be conducted based on the following:

- a. **Techniques**  
Melting and boiling point determination  
Distillation, solvent extraction, crystallization,
- b. **Qualitative Organic Analysis**  
Systematic identification of organic compounds (10 Compounds)
- c. **Preparation of Organic Compounds**  
Preparation of simple organic compounds like iodoform, aspirin, acetanilide etc (10 Preparation)

## **Recommended Books**

### **Theory**

1. Bansal.R.K, "A Text book of Organic Chemistry" Wiley Eastern Ltd; Second Edition (1990).
2. Carrey.F.A, "Organic Chemistry" The McGraw-Hill Companies, Inc; Fourth Edition (2000).

3. Finar.I.L, "Fundamental Principles of Organic Chemistry" Longman, Third Edition, Vol.1 (1959).
4. March.J, "Advanced Organic Chemistry Reactions, Mechanisms and Structure" John Wiley & Sons (latest edition available).
5. McMurry.J, "Organic Chemistry" Thomson Asia Ltd; Singapore, Fifth Edition (2000).
6. Morrison.R.T, Boyd.R.N; "Organic Chemistry" Prentice-Hall, Inc; Sixth Edition (1992).
7. Pine.S.H, Hendrickson.J.B Hammond.G.S, "Organic Chemistry" McGraw-Hill, Inc; Fourth Sons.Inc; Fourth Edition (1992).

## **Practicals**

- Furniss.B.S, Hannaford.A.J, Rogers.V, Smith.P.W.G, Tatchell.A.R, "Vogel's Text book of Practical Organic Chemistry Including Qualitative Organic Analysis" Longman Group Ltd; Fourth Edition (1986).
- I.Gosney.J.T.S, Rowley.A.G, "Practical Organic Chemistry" Chapman and Hall (1990).
- Mann.F.G, Saunders.B.C, "Practical Organic Chemistry" Lowe and Brydone (Printers) Ltd; Thetford, Norfolk (1975).
- Shriner.R.L, Fuson.R.C, Curtin.D.Y and Morrill.T.C, "The Systematic Identification of Organic Compounds (a laboratory manual)" John Wiley & Sons, Inc; Sixth Edition (1980).
- Vogel, A., I., "Practical Organic Chemistry", Longman Green & Co, (1995).

## **Semester-IV**

### **Chemistry (Special Topics) (3+1)**

#### **Electrochemistry**

Ions in solution. Measurement of conductance and Kohlrausch's law. Debye-Hückel theory and activity coefficient. Application of conductance measurement. Electrode potential. Electrochemical cell. Application of electrode potential.

#### **Quantum Theory**

Limitations of classical mechanics, Wave and particle nature of matter, de Broglie equation, Heisenberg uncertainty principle. Schrödinger wave equation and its solution for particle in 1-dimensional and 3-dimensional boxes. Concept of quantization of energy and an introduction to spectroscopy: spectra of hydrogen and hydrogen-like atoms.



### **Chemistry of d-block Elements**

Electronic configuration. General characteristics of d-block elements. Werner's concepts of co-ordination compounds; nomenclature. nature of coordinate covalent bond. Valence Bond, Molecular Orbital and Crystal Field theories to explain the structures of polymers coordination compounds. Introduction to chelates. Industrial applications of transition metals.

### **Introduction to Nuclear Chemistry**

Natural and artificial radioactivity; Nuclear reactions, fission and fusion. Uses of radioisotopes in various fields. Nuclear hazards and safety measures.

### **Chromatography**

Classification and introduction to paper, column and thin layer chromatography.

### **Heterocyclic Compounds**

Nomenclature of simple heterocyclic structures containing oxygen, nitrogen and sulfur in five and six membered rings. The chemistry of furan, pyrrole, pyridine and thiophene and their aromatic character.

### **An Introduction to Spectroscopy**

Spectroscopic Methods: Infrared & ultraviolet spectroscopy, structure elucidation of different organic compounds by spectroscopic techniques

### **Biomolecules**

A brief introduction to the chemical nature of carbohydrates, proteins, lipids, nucleic acids and their importance in living systems

### **Practicals**

More experiments should be included according to the facilities available to the teaching institution.

- Eight experiments in chromatography (TLC, column and paper) using cations, mixture of inks and organic compounds.
- Determination of dipole moment of organic compounds.
- Determination of specific and molar conductivities of strong and weak electrolytes

### **Recommended Books**

1. Banwell, C.N., "Fundamentals of Molecular Spectroscopy", 1978.
2. Berry, R. S., Stuart A. R., and Ross J., "Physical Chemistry" 2nd Ed. Oxford University Press (2 000) 1080 pp.
3. Cotton, F. Albert, Geoffrey Wilkinson and Paul L.Gaus, "Advanced Inorganic Chemistry", John Wiley & Sons, Inc. 3rd Edition (1995).
4. Ernest, H. and Lyons, Jr., "Introduction to Electrochemistry" D. C. Heath and Company (1967).

5. Finar, I.L., "Organic Chemistry" Vol-II, Longman Group Limited, London.
6. Kennedy, Friedlander, "Nuclear and Radiochemistry" (latest edition).
7. Mortimer, G. R., "Physical Chemistry" 2nd Ed., Academic Press (2000)
8. Rastogi R.P., Srivastava V. K., "An Introduction to Quantum Mechanics of Chemical Systems", Mohan Pramlani for Oxford and IBH Publishing Co, New Dehli India (1986).
9. Silverstein, R. M., G.C. Basseler and T.C. Morill "Spectrometric Identification of Organic Compounds" John Wiley and Sons, Inc. New York.
10. Skoog A., Donald, M., "Analytical Chemistry" Saunder Publishers, London (2000).
11. Steitweisser, A., Heathcock, C., "Introduction to Organic Chemistry", Maxwell McMillan International New York.
12. W.L. Jolly "The Principles of Inorganic Chemistry". McGraw-Hill Inc. pp376 (1976).
13. Warren, S. W., "The Physical Basis of Chemistry" 2nd Ed., Elsevier-Academic Press (2000) 211 pp.
14. Griffiths, D. J., "Introduction to Quantum Mechanics" 2nd Ed., Prentice Hall (2004) .
15. Chandra, A.K., "Introductory Quantum Chemistry" Mc Graw Hill, New Delhi, India (1969).

## **BS: 3<sup>rd</sup>Year**

<b>Semester-V</b>	<b>Credits</b>
Inorganic Chemistry	3+1*
Organic Chemistry	3+1
Physical Chemistry	3+1
Analytical/Environmental Chemistry	3+1
Mathematics for Chemists	2

\* 3+1 means 3 theory lectures and 1 practical (3 hours) per week

### **Inorganic Chemistry**

#### **Theory**

##### **Principles of Chemical Bonding**

Types of chemical bonding. The localized bond approach: V.B. theory, hybridization and resonance, The delocalized approach to bonding, molecular orbital theory (MOT) as applied to diatomic and polyatomic molecules. Band theory of metallic bonding (conductors, insulators and semiconductors). Bonding in electron deficient compounds. Hydrogen bonding.

##### **Chemistry of Coordination Compounds**

Introduction to d-block elements, nomenclature, Werner's theory, valence bond theory, molecular orbital theory, crystal field and ligand-field theory. Jahn-Teller theorem; magnetic properties, The spectrochemical series and color of metal complexes, Isomerism and stereochemistry, geometry of complexes having coordination number 2 to 9. Techniques for studying complexes, stability constant, applications of coordination compounds.

##### **$\pi$ Acceptor Ligands**

Mononuclear and polynuclear metal carbonyls, The eighteen electrons as applied to metal carbonyls, rationalization of molecular structure, evaluation of structure based on spectroscopic evidence, Chemistry of metal carbonyls and their derivatives (nitrosyls, halides and hydrides)

#### **Practicals**

- Semi-micro analysis and paper chromatographic techniques for confirmation of anions.  
Preparation of at least four Inorganic compounds in pure state.

- Complexometric titration using EDTA:  
Ni (II)  
Ca (II) and Mg (II) in mixture.  
Mg (II), Mn (II) and Zn (II) in a mixture.

### Recommended Books

1. Atkins, P., Jones, L. "Chemical Principles" Freeman and Company (2002)
2. Basolo F., and Johnson R. C. "Coordination Chemistry: The Chemistry of Metal Complexes" W. A. Benjamin, Inc. (1964)
3. Brady, J.E., Holum, J.R. "Chemistry-The Study of Matter and Its Changes" John Wiley and Sons, Inc. (1996)
4. Cartmell E. and Fowles G. W. A. "Valency and Molecular Structure". 3rd Ed. Adlard and Sons Limited. (1966).
5. Douglas B., McDaniel D. and Alexander J. "Concepts and Models of Inorganic Chemistry" John Wiley & Sons, Inc. 3rd Edition (1994)
6. Ebbing, D.D., "General Chemistry" Houghton Mifflin Company (1996)
7. Kettle S. F. A. "Coordination Compounds" Thomas Nelson & Sons Ltd. (1969)
8. Larsen E. M. "Transitional Elements". W. A. Benjamin, Inc. (1995)
9. Miessler G. L. and Tarr Donald A. "Inorganic Chemistry" Prentice-Hall International, Inc. Prentice-Hall International Ed (1991)
10. Mortimer C. E. "Chemistry: A Conceptual Approach" D. Van Nostrand Company. 3rd Edition (1975)
11. Purcell, K.F., Kortz, J.C., "An Introduction to Inorganic Chemistry" Saunders College Publishing (1980)
12. Shriver D. F., Atkins P. W. and Langford C. H. "Inorganic Chemistry". Oxford University Press. (1994).
13. Sultana N. and Arayne M. S. "A Text Book of Coordination Chemistry:" B. C. C. & T Press, University of Karachi. (1996)

### Practicals:

- Bassette J., Denney C., Jeffery G. H. and Mendham J. "Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis" English Language Book Society. 4th Edition (1978)
- Fritz J. S., Schenk G. H. "Quantitative Analytical Chemistry" Allyn and Bacon, Inc. 4th Edition (1979).
- Marr G., Rockett B. W. "Practical Inorganic Chemistry". Van Nostrand Reinhold Company. (1972)
- Pass G. and Sutcliffe H. "Practical Inorganic Chemistry: Preparations, Reactions and Instrumental Methods" Chapman and Hall. 2<sup>nd</sup> Edition (1974)

## **Organic Chemistry**

### **Acids and Bases**

Concepts of acids and bases; scale of acidity and basicity;  $pK_a$  values; predicting acid/base reactions from  $pK_a$  values; the effect of structure on the strengths of acids and bases, field effects, resonance effects, steric effects, hydrogen bonding effects and hybridization effects; the effect of the medium on the strengths of acids and bases; the Hammett and Taft's equations- applications and limitations.

### **Stereochemistry**

Introduction; Optical isomerism: optical activity, chirality, symmetry elements and optical inactivity, relative and absolute configuration, R, S notation, methods of determining configuration, racemic mixtures and their resolution, asymmetric synthesis, optical activity in biphenyls, allenes and spiro compounds, stereospecific and stereoselective reactions; Geometrical isomerism: Determination of configuration of geometrical isomers, Z, E convention cis- and trans- isomerism in cyclic systems; Conformational isomerism: Conformational analysis of monosubstituted cyclohexanes, disubstituted cyclohexanes and decalin systems.

### **Spectroscopy**

Introduction to UV, IR,  $^1\text{H-NMR}$  and Mass Spectrometry; structure elucidation of different organic compounds by these techniques

### **Practicals**

- **Purification Techniques:** Fractional distillation, fractional distillation under reduced pressure and fractional crystallization
- **Mixture Analysis:** Analysis of two component mixtures.

### **Books Recommended**

(Latest available editions of the following books are recommended)

1. Finar, I.L; "Organic Chemistry", Vol-II, Longman Group Limited, London.
2. Fleming, I; "Frontier Orbitals and Organic Chemical Reactions", John Wiley & Sons, New York.
3. Kemp, W; "Organic Spectroscopy", Macmillan Publishers Ltd. London.
4. Klaus, Peter, and Zeller, "NMR and Mass Spectroscopy for Organic Chemist, Vol.2, University Grants Commission, Islamabad.
5. March, J; "Advanced Organic Chemistry", John Wiley & Sons, New York.
6. Morrison, R.T. and R.N. Boyd, "Organic Chemistry", Allyn & Bacon Inc.
7. Pine, S.H; "Organic Chemistry", McGraw Hill, Inc; New York.

8. Silverstein, R.M., G.C. Bassler and T.C. Morrill, "Spectrometric Identification of Organic Compounds", John Wiley & Sons, Inc. New York.
9. Solomon, T.W.G; "Organic Chemistry", John Wiley & Sons, New York.
10. Steitwieser, A.C. Heathcock and E.M. Kosower, "Introduction to Organic Chemistry", Maxwell Macmillan International, New York.
11. Younas, M, "Organic Spectroscopy", A. H. Publisher, Lahore.

## **Physical Chemistry**

### **Kinetic Theory of Gases**

Virial equations. Maxwell's law of molecular velocities. Calculation of molecular velocities and binary collisions. Maxwell-Boltzmann's law of energy distribution.

### **Chemical Thermodynamics**

Relation of entropy and energy with equilibrium constant and their dependence on temperature. Clausius-Clapeyron equation. Chemical potential. Partial molar quantities.

### **Chemical Kinetics**

Integrated rate laws: second and third order reactions with same and different initial concentrations of reactants. Elementary and complex reactions: opposing, parallel and consecutive reactions. Steady state approximation, Lindemann theory of unimolecular reactions. chain reactions, kinetics of thermal and photochemical reactions

### **Practicals**

- Equilibrium constant of the  $KI + I_2 = KI_3$  reaction
- Kinetics of saponification of ethyl acetate
- Acid catalyzed hydrolysis of sucrose
- Study of the adsorption isotherms of acetic acid-charcoal system
- Study of the charge transfer complex formation between iodine and benzene
- Determination of activation energy for the acid catalyzed hydrolysis of ethyl acetate
- Determination of partial molar volumes

### **Books Recommended**

1. Alberty, R. A., Robert J. S. and Mounji G. B. "Physical Chemistry". 4th Edition, John Wiley and Sons, 960 pp (2004).
2. Ball, D.W., "Physical Chemistry" 1st Ed., Brooks/Cole Co. Inc., pp. 880 (2003).
3. Engel, Thomas and Reid P., "Thermodynamics, Statistical Thermodynamics, and Kinetics" 1st Ed., Benjamin Cummings, 2006.

4. James K. and Wothers, P., "Why Chemical Reactions Happen". Oxford University Press, (2003).
5. Smith, E. Brian, "Basic Chemical Thermodynamics" 5<sup>th</sup> Edition. Imperial College Press., (2004).
6. Stephen B. R., Rice S. A., and Ross J., "Physical Chemistry" 2nd Ed., Oxford University Press, 1080 (2000).
7. Jurg, W., "Basic Chemical Thermodynamics" W. A. Benjamin (1969).
8. Chorkendorff, I. and Niemantsverdriet, J. W. "Concepts of Modern Catalysis and Kinetics" 1st Edition John Wiley and Sons (2003).
9. Espenson, J. H. "Chemical Kinetics and Reaction Mechanism" 2nd Edition McGraw Hill (2002) .
10. Berry, R. S., Stuart A. R., and John Ross "Physical and Chemical Kinetics" 2nd Ed., Oxford University Press (2000)

### **Practical:**

- Halpern, Arthur M., " Experimental Physical Chemistry: A Laboratory Textbook" 2nd Ed., Prentice Hall. pp 610 (1997)
- Bassette J., Denney C., Jeffery G. H. and Mendham J. "Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis" English Language Book Society. 4th Edition (1978)
- Daniel, F., "Experimental Physical Chemistry" Mc Graw Hill (1962).
- Shoemaker, D., "Experimental Physical Chemistry" Mc Graw Hill (1989).

## **Analytical Chemistry**

### **Chemical Analysis and Data Handling**

Accuracy of analytical processes such as sampling, weighing, volume measurements, precipitation, washing, filtration and ignition

Recent developments in the sampling techniques, Statistical analysis; random and systematic errors, rounding off the data, arithmetic mean, median, mode, standard deviation, relative standard deviation, Student t-test, F-test etc., quality control and quality assurance Constructing and interpreting quality control plots. The use of computers in data handling

### **Ionic Equilibria in Solutions**

Activity and activity coefficients, Hydrogen ion activity and pH for weak acids and bases, Determination of  $pK_a$  and  $pK_b$  value, common ion effect and its industrial applications. Buffer its composition and mechanism and buffer capacity. Stability and formation constants of complexes, methods for their determination

## **Separation Techniques**

**Solvent extraction:** Principle, factors affecting the extraction systems, Distribution law, Coefficient and ratio, multiple batch extraction, Practical applications in chemical analysis.

**Chromatographic methods:** General theory of chromatography, classification of chromatographic methods, column, paper, thin-layer, and ion-exchange chromatography and their applications.

## **Practicals**

- Use of double pan balance, long swing and short swing methods by use of riders
- Calibration of weights.
- Conductometric determination of solubility product of AgCl / PbSO<sub>4</sub>.
- Effect of common ions on solubility of sparingly soluble salts (AgCl / PbSO<sub>4</sub>).
- Verification of Beer Lambert law by using KMnO<sub>4</sub> solution.
- Determination of  $\lambda_{\max}$  of KMnO<sub>4</sub> and K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> solutions.
- Construction of voltaic cell and electrochemical cells.
- Electrogravimetric determination of copper in given samples.

## **Books Recommended:**

1. Blackburn, Thomas, R., "Equilibrium- A Chemistry of Solutions", Holt, Rinehart and
2. Winston, Inc., 1969.
3. Christian, G.D., "Analytical Chemistry" 6th ed., John Wiley & Sons, New York, 2003.
4. Harris D.C., "Quantitative Chemical Analysis" 4<sup>th</sup> Ed., Freeman (1995).
5. Miller J.C., and Miller J.N., "Statistics for Analytical Chemists"
6. Skoog D.A., West D.D., and Holler F.J., "Fundamentals of Analytical Chemistry" 6<sup>th</sup> Ed., Saunders College Publishing, 1992.

## **Environmental Chemistry**

Environmental degradation. Impact of modern life-style on environmental quality; resource depletion; poverty and environment degradation; environmental education. Nature and composition of atmosphere; temperature and pressure profiles. Environmental aspects related to chemistry, classification of environmental pollutants. Major sources of pollutants including industry and vehicular emissions. Introduction to air-pollution, water-pollution, soil-pollution and food-pollution. Basics of green house effect and global warming. Impacts of chemical pollutants on biological systems in the lithosphere and hydrosphere. Role of chemistry in abatement of environmental pollution. Heavy metals and



inorganic anions as pollutants. Oxides of non-metals (C, N, and S). Significance of oxygen level in water bodies. Biodiversity in aquatic systems.

### **Practicals:**

- Determination of dissolved oxygen in water sample.
- Determination of lead in soil sample.
- Estimation of lead, zinc and tin in canned food.
- Collection of air samples from various industries.
- Collection and analyze of industrial effects.
- Determination of chromium in leather samples.
- Estimation of particulate matter from collected air samples.
- Estimation of volatile formaldehyde from press wood samples.
- Detection and determination of toxic anions ( $S^{2-}$ ,  $NO_2^-$ ,  $CN^-$ ) in water samples.
- Recycling of polystyrene samples.

### **Recommended Books**

( Latest available editions of the following books)

1. A. Kumar, Environmental Chemistry, Wiley Eastern, New Delhi.
2. Baird, C. Environmental Chemistry, Freeman, New York.
3. J. W. Moore & E.M. Moore, Environmental Chemistry, Academic Press, New York.
4. Neil, P.O. Environmental Chemistry, Chapman, London.
5. Pakistan Environmental Pollution Act 1997.
6. S. K. Banerji, Environmental Chemistry, Prentice Hall, Delhi.
7. S. K. Banerji, Environmental Chemistry, Tata Publisher, Delhi.
8. Staneley E. Manahan, Environmental Chemistry, Brooks, California.

### **Mathematics for Chemists**

Review of basic algebra, trigonometry and graphical methods; differentiation, simple and multiple variable problem, concept of maxima and minima; integration and partial differentiation, differential equations (linear, homogenous and exact); determinants, matrices and vectors-their use in chemical problems; coordinate systems: Cartesian and polar coordinates and their transformation. Probability and errors. Data handling variable correlations; t-test linear regression and line fitting. Solution of linear and quadratic equations. Binomial theorem.

### **Recommended Books:**

1. Scott, S., "Beginning Mathematics for Chemistry". Oxford University press New York (1995).
2. Stephen, K. S., "Beginning Mathematics for Chemistry" Oxford University Press (2005).

## BS 3<sup>rd</sup> Year

Semester-VI	Credits
Inorganic Chemistry	3+1
Organic Chemistry	3+1
Physical Chemistry	3+1
Applied/Bio-Chemistry	3+1
Computer Applications in Chemistry	<u>2</u>

**Total** 18 Cr

### Inorganic Chemistry

#### The Lanthanide Series

Electronic structure and position in the periodic table, Lanthanide's contraction, oxidation states, Spectral and magnetic properties, occurrence and preparations, complexes and uses.

#### The Actinide Series

Electronic structure and position in periodic table, Oxidation states, Occurrence and preparation with reference to Uranium complexes, uses of actinides

#### Non-aqueous Solvents

Introduction, Classification of solvents, Types of reactions in solvents, Effect of physical and chemical properties of solvents, Study of reactions in liquid  $\text{NH}_3$ ,  $\text{SO}_2$ ,  $\text{HF}$ ,  $\text{H}_2\text{SO}_4$  and  $\text{BrF}_3$ . Reactions in molten salts systems.

#### **Practicals**

- Semi micro analysis and paper chromatographic confirmation of cations containing interfering anions
- Redox titration:  $\text{Cu(II)}$  by potassium iodate,  $\text{Fe(II)}$  by ceric sulfate.
- Estimation of at least two halides by adsorption indicator.
- Gravimetric estimation of barium and oxalate ions.

### **Books Recommended**

#### **Theory**

1. Huheey J. E. "Inorganic Chemistry Principles of Structure and Reactivity" 2<sup>nd</sup> Ed. Harper and Row Publishers. 1978
2. Lee J. D. "Concise Inorganic Chemistry" 5<sup>th</sup> Ed. Chapman and Hall. 1996
3. Mackay K. M., Mackay R. A. and Henderson W. "Introduction to Modern Inorganic Chemistry". 5<sup>th</sup> Ed. Stanley Thornes (Publishers) Ltd. (1996)

4. Miessler G. L. and Tarr Donald A. "Inorganic Chemistry". Prentice-Hall International Ed. Prentice-Hall International, Inc. (1991)

## **Practical**

- Bassette J., Denney C., Jeffery G. H. and Mendham J. "Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis" English Language Book Society. 4th Edition (1978)
- Fritz J. S., Schenk G. H. "Quantitative Analytical Chemistry" Allyn and Bacon, Inc. 4<sup>th</sup> Edition (1979)
- Harris W. E., Kratochvil B. "An Introduction to Chemical Analysis" Saunders College Publishing. Holt-Saunders International Edition (1981)

## **Organic Chemistry**

### **Aliphatic Nucleophilic Substitution and Elimination Reactions**

***Aliphatic Nucleophilic Substitution Reactions:*** Mechanisms and study of  $S_{N1}$ ,  $S_{N2}$ ,  $S_{N1'}$ ,  $S_{N2'}$ , mechanisms; Neighbouring group participation: Intramolecular displacement by neighbouring oxygen, nitrogen, sulphur and halogen; The effects of the substrate structure, entering group, leaving group and reaction medium on the mechanisms and rates of substitution reactions.

***Elimination Reactions:*** Mechanisms-Study of E1, E1cB and E2 mechanisms; Orientation: Saytzeff and Hofmann Rules; The effects of the substrate structure, attacking base, leaving group and the reaction medium on the rates and mechanisms of elimination reactions; competition between elimination and substitution reactions.

### **Aromatic Substitution Reactions**

***Electrophilic Substitution:*** Aromaticity; mechanisms of substitution; orientation and reactivity; electrophilic substitution reactions, i.e. nitration, halogenation, sulfonation, Friedel-Crafts reactions, diazo-coupling, formylation and carboxylation.

***Nucleophilic Substitution:*** Mechanisms-Study of  $S_{NAr}$ ,  $S_{N1}$  and benzyne mechanisms; The effects of substrate structure, leaving group and the attacking nucleophile on the rates of substitution reactions.

## **Named Organic Reactions**

Cannizzaro reaction, Perkin reaction, Michael reaction, Claisen-Schmidt reaction, Darzens Glycidic Ester reaction, Stobbe reaction, Mannich reaction, Wittig reaction, Ene reaction and Reformatsky reaction, Diels-Alder reaction.

## **Practicals**

- Organic Synthesis: At least four experiments involving two step Synthesis
- Estimation of Amide and Carboxyl groups, Phenol and other functional groups.
- Determination of Saponification value and acid value in oil

## **Recommended Books:**

1. Carey. F.A, Sundberg. R.J, "Advanced Organic Chemistry (Part B: Reactions and Synthesis)", Plenum Press, New York, Third Edition (1990).
2. Carpenter. B.K, "Determination of Organic Reaction Mechanisms, "John Wiley & Sons, Inc. (1984).
3. Chatwal. G.R, "Reaction Mechanism and Reagents in Organic Chemistry", Himalaya Publishing House (1987).
4. Fieser.L.F, Williamson.K.L, "Organic Experiments", D.C.Heath and Company (1975).
5. Fuhrhop.J, Penzlin.G, "Organic Synthesis Concepts, Methods, Starting Materials", Weinheim (1983).
6. Gould.E.S, "Mechanism and Structure of Organic Chemistry", Holt, Rinehart and Winston, Inc (1959).
7. Harris.J.M, Wamser.C.C, "Fundamental of Organic Reaction Mechanisms, "John Wiley & Sons, Inc (1976).
8. Knipe.A.C, Watts.W.E, "Organic Reaction Mechanisms", John Wiley & Sons, Inc. (1980).
9. Lowry.T.H, Richardson.K.S, "Mechanism and theory in Organic Chemistry", Harper and Row (1976).
10. Mackie.R.K, Smith.D.M, "Guide book to Organic Synthesis", Longman Group Ltd. (1982).
11. March.J, "Advanced Organic Chemistry Reactions, Mechanisms and Structure", John Wiley & Sons, Inc; Fourth Edition (1992).
12. Streitwieser.A, Heath Cock.C.H, "Introduction to Organic Chemistry", Macmillan Publishing Company, Third Edition (1989).
13. Sykes.P, "A Guide Book to Mechanism in Organic Chemistry", Longman Group Ltd. (1986).
14. Vogel.A.I, "Elementary Practical Organic Chemistry Part III: Quantitative Organic Analysis", Longman Group Ltd (1958).

## **Physical Chemistry**

### **Electrochemistry**

Theory of metallic conduction, electrode potential, electrochemical cell, electrolysis and related issues, liquid junction potential electron transfer reactions, rate of charge transfer reaction and Butler-Volmer equation. Latimer Diagram, Frost Diagram, cell Potential and thermodynamics, and Nernst Equation. Voltammetry, fuel cells. Corrosion and its prevention. Ion in aqueous solution, ionic activity and Debye Hückel Theory.

### **Quantum Chemistry and Spectroscopy**

Simple harmonic oscillator. Rigid rotor, Hydrogen atom. Quantum numbers, rotational, vibrational and rotational-vibrational spectra of diatomic and polyatomic molecules.

### **Group Theory**

Symmetry operations. properties of groups, matrices, transformation of matrices, character tables.

### **Practicals**

- Determination of molecular weight of a polymer by viscosity method
- Precipitation value of electrolytes
- Measurement of IR spectra of simple compound and their interpretation
- Measurement of cyclic voltammogram of an organic compound and its interpretation
- Determination of dipole moment of an organic liquid
- Determination of percentage composition of  $\text{KMnO}_4$  /  $\text{K}_2\text{Cr}_2\text{O}_7$  in a given solution by spectrophotometry.
- Stoichiometry of a complex in solution by Job's method
- Evaluation of  $\text{pK}_a$  value of an indicator by spectrometric method

### **Recommended Books**

#### **Theory**

1. Cotton, F. Albert "Chemical Applications of Groups Theory", Interscience Publishers (1963).
2. G. W. King, "Spectroscopy and Molecular Structure", Rinehart and Winston (1964)
3. J. Albery, "Electrode Kinetics", Clarendon, Oxford, 1975
4. Bockris J. OM. and Reddy A.K.N., "Modern Electrochemistry" Vol. I and 2, Plenum Press, New York, (1970).
5. Micheal, D. F., "Elements of Quantum Mechanics" Oxford University Press (2005).

6. Lowell, Hall H., "Group Theory and Symmetry in Chemistry" McGraw Hill Book Company (1969).
7. Whiffen, D. H. "Spectroscopy" Longmans Green and Co.: London, (1966).
8. Bockris, J., "Modern Electrochemistry", Rosseta Publishing Co., Vol: 1,2 (1970).
9. Barrow, G., "Molecular Spectroscopy" McGraw Hill (1962)

### **Practical:**

- Bassette J., Denney C., Jeffery G. H. and Mendham J. "Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis" English Language Book Society. 4th Edition (1978)
- Hatch R. C. "Experimental Chemistry" Van Nostrand Reinhold Company (1972).
- Halpern, Arthur M., "Experimental Physical Chemistry: A Laboratory Textbook" 2nd Ed., Prentice Hall. pp 610 (1997)
- Daniel, F., "Experimental Physical Chemistry" Mc Graw Hill (1962).
- Shoemaker, D., "Experimental Physical Chemistry" Mc Graw Hill (1989).

## **BIOCHEMISTRY**

### **Introduction to Biochemistry**

Brief introduction to the scope and history of biochemistry. The molecular logic of living organism. Cell structure and their functions. Origin and nature of biomolecules.

### **Physical aspects of Biochemistry**

Weak interaction in aqueous system. Ionization of water. Weak acids and weak bases. Buffers. Buffering against pH changes. Diffusion, osmosis and osmotic pressure.

### **Proteins**

Amino acids, classification and properties. Proteins, classification and properties. Primary, secondary, tertiary and quaternary structures of proteins. Amino acid sequence. Biological functions of proteins and peptides

### **Lipids**

Classification, fatty acids and their properties. Biological significance of glycerides, phospholipids, non phospholipids and steroids. Structure of biological membrane.

### **Carbohydrates**

Classification of carbohydrates, chemistry and properties of monosaccharide, disaccharides and polysaccharides. Glycolipids and glycoproteins.

## **Digestion and Absorption Utilization**

Carbohydrates, Lipids and Proteins

## **Nucleic Acids**

Purines and pyrimidines, nucleosides and nucleotides. Structures and functions of RNA and DNA.

## **Enzymes**

Chemical nature, nomenclature and classification. Enzyme activity. Effect of different factors on enzyme activity. Coenzymes and immobilized enzymes.

## **Vitamins**

Introduction, classification, chemistry and biological significances of vitamins A, D, E, K, B, complex and C.

## **Practicals**

- Hydrolysis of protein
- Qualitative tests for amino acids/paper chromatography
- Estimation of protein by Kjeldahl, Lowery methods
- Titration curve of amino acids
- Qualitative tests for carbohydrates (pentoses, hexoses, reducing and non reducing sugar)
- Estimation of glucose, Sucrose (polarimeter)
- Enzymatic Hydrolysis of glycogen
- Qualitative tests for fats, sterols and phospholipids
- Saponification and iodine values of fat
- Isolation and assay of enzymes, effects of various physical and chemical factors on enzyme activity e.g. ALP, LDH
- Enzyme inhibition, enzymes kinetics, enzyme immobilization, identification of enzymes using zymogen techniques.

## **Recommended Books:**

1. Lehninger, A. L., "Principles of Biochemistry" Worth Publisher, New York (2001)
2. Murray, R. K., P. A. Mayes, D. K. Granner and V. W. Rodwell, "Harper's Biochemistry", Appleton and Lange(2000).
3. Robert, "Harper's Biochemistry", 25th Edition. (2000)
4. Stryer, L. "Biochemistry", Freeman & Co.( 1994)
5. Voet, D. and Voet J.G. "Biochemistry" John Wiley & Sons, New York (2000)
6. West, "Text Book of Biochemistry" 4th Edition. (2000)
7. Zubay, G. "Biochemistry", 4th Edition Macmillan Publishing Co.(1999)

## **Applied Chemistry**

### **Common Industrial Unit Operations**

Elementary treatment of general unit operations commonly used in industries such as size reduction, screening, enrichment, filtration, distillation and crystallization Chemical unit processes like nitration, halogenation, sulfonation, oxidation and hydrolysis with appropriate technical examples.

### **Basic Chemical Industries**

Raw materials, chemical processes involved: flow sheet diagrams with all the important parameters concerning the manufacture of sulfuric acid, hydrochloric acid, caustic soda, washing soda, phthalic anhydride.

### **Cement Industry**

Raw materials used for cement manufacturing used, dry process, wet process, chemistry involved in hydration of cement, setting of cement, setting time.

### **Glass Industry**

Raw materials used for glass, methods of manufacturing, method of manufacturing glass. Special types of glass and their properties.

### **Soap Industry**

Processes involved in soap manufacturing, methods used for manufacturing laundry detergents. Recovery of glycerin. Detergent or surface active agents, cationic anionic and non-ionic agents.

### **Water Softening and Scale Removing**

Water hardness, its measurement and removal, methods used for water softening including ion-exchange, distillation and precipitation.

### **Practicals:**

- Titrimetry: Water hardness by complexometry, determination of magnesium and aluminum by EDTA titrations, analysis of caustic soda and soda ash in mixtures.
- Flame Photometry: Lithium in industrial effluents, barium in ores, potassium by in soil samples
- Spectrophotometry: Iron in pharmaceuticals, chromium in steel, phosphate in fertilizers.
- Preparations: Calcium gluconate, detergents, cosmetics and vanishing creams, formic acid.

### **Books Recommended**

1. Arovan Singh "Industrial Chemistry" Vol. I & II, Anmd. Publishers. New Dehli



2. Buchel, Moretto & Wodith , Industrial Inorganic Chemistry, John Wiley & Sons.
3. Crogsins “ Unit Operation in Oganic Synthesis” McGraw Hill.
4. Pandey Vikas, “Text Book of Chemical Technology, Vol. 1 & II” Publishing Co. New Dehli
5. Streven & Brink “Chemical Process Industries, McGraw Hill
6. Weissermel & Ape “Industrial Organic Chemistry” Verlag Chemie.

## **Semester-VI**

### **Computer Applications in Chemistry**

Introduction to computer, computer's functioning; programming, understanding computer aided numerical methods test square curve fitting, numerical integration, errors, molecular modeling understanding MS Word, understanding Power Point, Internet Searching.

### **Books Recommended:**

1. Grants G.H., and Richards W.G., “Computational Chemistry”, Oxford Science Publication (1995).
2. Richard G., “Computer Simulate with Mathematics” and Spring-Verlag. Germany (2000)

## **BS 4<sup>th</sup> Year**

In the fourth year the student would take specialized courses in one of the following fields: Analytical/Biochemistry/Inorganic/ Organic/Physical Chemistry

<b>Semester-VII</b>	<b>Credits</b>	<b>Semester-VIII</b>	<b>Credits</b>
Paper-I	4	Paper-IV	4
Paper-II	4	Paper-V	4
Paper-III	4	Paper-VI	4
Practicals	4	Advanced Practicals/ Research	4
<b>Total</b>	<b>16 Cr</b>	<b>Total</b>	<b>16 Cr</b>

## **SPECIALIZATION IN ANALYTICAL CHEMISTRY**

### **Semester-VII**

#### **Paper - I**

##### **Electro Analytical Techniques**

**Theoretical Principles:** Faraday's laws of electrolytes, Nernst equation and its application for determination of electrode potential, redox potential, Voltaic cells (lead storage battery, dry cells), introduction to corrosion and its prevention.

**Potentiometry:** Principles, instrumentation, potentiometric titrations, reference, indicator and ion-selective electrodes used in chemical analysis.

**Conductometry:** Principle, measurement of conductance, applications.

#### **Paper-II**

##### **Polarography**

Basic concept of polarography and interpretation of various polarographic curves, measurement of decomposition potential, diffusion and limiting currents, derivation of Ilkovic equation, logarithmic analysis of polarographic wave, advantages and limitation of dropping mercury electrode.

##### **Voltammetry**

Polarizable and non-polarizable electrodes, solid electrodes, their scope and limitations

### **Coulometry**

Principle, instrumentation and applications of coulometry

### **Advanced Chromatography**

Principle and instrumentation of gas chromatography, HPLC, and applications

## **Paper-III**

### **UV-Visible Spectroscopy**

Brief Introduction, instrumentation and sample handling, chromophore, absorption by conjugated systems. Woodward Fieser rules, absorption of UV-Vis light by organic compounds . Beer-Lambert law, theory, instrumentation and analytical applications of UV-Visible spectrophotometry.

### **Infra red Spectroscopy**

Brief introduction, instrumentation and sample handling, interpretation of IR spectra, characteristic and absorption frequency of common functional groups, applications in clinical, food and forensic analysis

### **Mass Spectrometry:**

Brief introduction, instrumentation and sample handling, mass spectra and its interpretation, applications in related to determination of molecular weight.

### **NMR Spectroscopy**

Brief introduction, principles, instrumentation and sample handling, spin relaxation, chemical shift, coupling constant, Factors effecting the chemical shift and applications

### **Flame Spectrometry**

Basic Principles of FES & AAS, instrumentation, interferences and applications

### **Practicals:**

- The experiments may be set making use of the following instruments depending upon their
- availability, special experiments may also be designed for which a specimen list of instruments is
- given below. For the innovative designing of experiments the Journal of Chemical Education
- may be consulted.

### **Instruments:**

UV/Visible spectrophotometers

Flame photometers

pH-meters  
Conductivity bridge  
Gas chromatography  
HPLC chromatography  
Electrogravimetric apparatus  
Atomic absorption spectrophotometer  
Infrared spectrophotometers

**Experiments:**

- Determination of iron in soil by spectrophotometry.
- Spectrophotometric determination of molybdate ion.
- Separation of dyes using column/paper/thin layer chromatography.
- Separation of sugars using paper chromatography.
- Separation of amino acids using paper/thin layer chromatography.
- Separation of hydrocarbons using GC/HPLC.
- Determination of iron in foods products spectrophotometrically.
- Determination of phosphate content in commercial fertilizers by spectrophotometry.
- Determination of nickel in vegetable ghee by spectrophotometry involving solvent extraction.
- Identification and spectrophotometric determination of aspirin, phenacetine and caffeine in pharmaceutical samples.
- IR analysis and identification of human body stones
- Mass spectrometry of mineral oil samples.
- To determine pKa Values for the given samples of weak acids by potentiometric method
- To determine the quality parameters i.e. pH, conductance and concentration of anions & cations.
- To determine Ni (II) in steel using DMG reagent by spectrophotometric method.
- To determine vitamin-C concentration in the given samples.
- To determine calcium and zinc in milk by atomic absorption spectrophotometer.
- To determine lead in sewage sludge by atomic absorption spectrophotometer.
- To determine Mn and Cr in stainless steel spectrophotometrically.
- To record and characterization of IR spectra of at least 10 organic compounds

## **Semester-VIII**

### **Paper-IV**

#### **X ray Spectroscopy**

Introduction, lattice and unit cell, dimensional relationship, Bragg's equation, reciprocal lattice, single and multocrystal (powder) analysis, diffraction and diffractometer, identification and applications.

#### **Thermal Methods of Analysis**

Introduction to thermal methods, TGA, TG, DTA and DSC, analytical applications

### **Paper-V**

#### **Electrophoresis:**

Introduction, Principle, instrumentation and application

#### **Emission Spectroscopy with Plasma & Electrical Discharge Sources**

Introduction, Principle, instrumentation and application

### **Paper VI**

Basic Electronic in Instrumentation

Process Instruments and Automation Chemical Analysis:

Practicals / Research

#### **Recommended Books:**

1. A. Pople, W. G. Schneider and H. J. Bernstein, "High Resolution Nuclear Magnetic Resonance," McGraw-Hill Book Co., New York, 1959.  
(AD/591/P6)
2. A.J. Bard and L.R. Faulkner, "Electrochemical Methods, Fundamentals and Applications", 2nd. Ed., Wiley, N.Y., 2001.
3. Alkemade, C.Th.J., Herrmann, R., Fundamentals of Analytical Flame Spectroscopy, Hilger, Bristol, UK.
4. Ault and G. Dudek, "An Introduction to Proton NMR Spectroscopy," Holden Day, San Francisco, 1976.
5. B.B. Kebbekus, S. Mitra "Environmental Chemical Analysis", Blackie Academic & Professional, New York, NY, 1998.
6. Banwell, C. N. "Fundamentals of Molecular Spectroscopy" 2nd ed.; McGraw-Hill Book Company (U.K.): Maidenhead, U.K., 1972
7. Bernhard Welz "Atomic Absorption Spectroscopy" 2<sup>nd</sup> Ed (1985).
8. Bertin, EP. "Principles and Pracyti of X-ray Spectrometric Analysis", Plenum Press (1975).

9. BH Vassos and GW Ewing, "Electroanalytical Chemistry", Wiley, New York 1983
10. D. H. Williams and I. Fleming, "Spectroscopic Methods in Organic Chemistry," 4th ed., 1988.
11. D. L. Pavia, G. M. Lampman, G. S. Kriz, Jr., "Introduction to Spectroscopy," W. B. Saunders, 1979.
12. D. W. Mathieson, "Nuclear Magnetic Resonance for Organic Chemistry," Academic Press, London, 1967. L. M. Jackman and S. Sternhell, "Applications of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry," Pergamon Press, Oxford, 1969.
13. D.T. Sawyer, J. L. Roberts, Jr., "Experimental Electrochemistry for Chemists" J. Wiley, New York, 1974.
14. Dahmen EAMF "Electroanalysis" Elsevier, Amsterdam 1986
15. Douglas A. Skoog, F. James Holler, Timothy A. Nieman "Principles of Instrumental Analysis", 5th Edition, , Saunders College Publishing, New York, 1997.
16. E. A. V. Ebsworth, D. W. H. Rankin, S. Cradock, "Structural Methods in Inorganic Chemistry," Blackwell, 1987.
17. Ebdon, E.H. Evans (ed.), A. Fisher and S.J. Hill "An Introduction to Analytical Atomic Spectrometry" Wiley, Chichester, 1998.
18. Edmond De Hoffmann, Vincent Stroobant (Editors) "Mass Spectrometry: Principles and Applications" John Wiley & Sons; 2nd edition 2001.
19. G.D. Christian and J.E. O'Reilley, Allyn and Bacon, "Instrumental Analysis," 2nd edition, Boston 1986.
20. G.W. Ewing "Instrumental Methods of Chemical Analysis, 5th edition, McGraw-Hill, New York 1985.
21. G.W.C. Milner, G. Phillip, "Coulometry in Analytical Chemistry" Pergamon Press, 1967.
22. R.P.W. Scott, Techniques and Practices of Chromatography, Marcel Dekker, 1995.
23. H. A. Liebhafsky, H. G. Pfeiffer, E. H. Winslow, and P. D. Zeman, "X-Rays, Electrons, and Analytical Chemistry -- Spectrochemical Analysis with X-Rays", Wiley-Interscience, N. Y., (1972)
24. H. Budzikewitz, C. Djerassi, and D. H. Williams, "Mass Spectrometry of Organic Compounds," Holden-Day.  
J. R. Chapman, "Practical Organic Mass Spectrometry," Wiley, 1985
25. H. Gunther, "NMR Spectroscopy - An Introduction," John Wiley, 1980.
26. H. H. Jaffé and M. Orchin, "Theory and Applications of Ultraviolet Spectroscopy," Wiley, 1962
27. H. Strobel and W. Heineman, "Chemical Instrumentation: A Systematic Approach", 3rd edition, Wiley, New York 1989.
28. H. Willard, L. Merritt, J. Dean, and F. Settle, "Instrumental Methods of Analysis", 7th edition van Nostrand Co., New York 1992.

29. Harold Gomes Cassidy "Fundamentals of Chromatography" New York, Interscience Publishers, 1957.
30. J. Akitt, "NMR and Chemistry; An Introduction to Nuclear Magnetic Resonance Spectroscopy," Chapman and Hall, London, 1973.
31. J. Heyrovsky and J. Kuta, "Principles of Polarography", Academic Press, 1966.
32. J. R. Dyer, "Applications of Absorption Spectroscopy to Organic Compounds," Prentice-Hall, 1965.
33. J.D. Ingle and S.R. Crouch "Spectrochemical Methods of Analysis" Prentice-Hall, New Jersey 1988
34. J.P.Glusker and K.N.Trueblood , "Crystal Structure Analysis: a primer" , 2nd Ed, Oxford University Press, New York, 1985.
35. L. Ebdon, E.H. Evans (ed.), A. Fisher and S.J. Hill "An Introduction to Analytical Atomic Spectrometry" Wiley, Chichester, 1998.
36. L.H.J. Lajunen "Spectrochemical Analysis by Atomic Absorption and Emission" Royal Society of Chemistry, Cambridge, 1992.
37. Lingane,J.J "Electroanalytical Chemistry", 2 Ed., Interscience, 1970.
38. McLafferty, F. W. "Interpretation of Mass Spectra," 1980.
39. Melvin and Kelvin "Electrophoresis" Analytical Chemistry by Open Learning, Published by John Wiley and Sons.
40. N. Levine, "Molecular Spectroscopy", Wiley (1975).
41. R.M. Silverstein, G.C. Bassler and T.C. Morrill "Spectrometric Identification of Organic Compounds," John Wiley & Sons, New York, 5th Ed. 1991.
42. Reiger, P.H. "Electrochemistry", Prentice Hall N.J, 1987
43. Schomburg, Gerhard "Gas Chromatography-A Practical Course" VCH(1990).
44. Snyder and J. J. Kirkland," Introduction to Modern Liquid Chromatography", Wiley, New York, 2nd ed., 1979.
45. Stock and Rice, Chromatographic methods, Chapman and Hall, 1967
46. Thomspon K.C. Reynold R.J. "Atomic Absorption, Fluorescence and Flame Emission Spectroscopy" 2<sup>nd</sup> Ed. John Wiley and Sons (1978).
47. Wendlandt, Wesley Wm, "Thermal Analysis" Third Edition, Wiley (1986).

# 4<sup>th</sup> Year- SPECIALIZATION IN BIOCHEMISTRY

## Semester-VII

### Paper I

#### Biological oxidation and reduction

Biological oxidation and reduction, cell bioenergetics, phosphorylation and mechanism of energy transfer through energy carriers ATP, NADH, NADPH, FADH<sub>2</sub>,

#### Carbohydrate metabolism

Carbohydrate metabolism, pentose phosphate pathway, uronic acid pathway, gluconeogenesis, glycogenesis and glycogenolysis. Regulation of carbohydrate metabolism. Photosynthesis.

#### Lipid metabolism

Lipid metabolism, biosynthesis of fatty acids, glycerides, phospholipids and ketone bodies. Degradation and biosynthesis of sterols and bile acids. Regulations of lipid metabolism.

#### Protein metabolism

Protein metabolism and biosynthesis of amino acids. deamination and transamination, urea cycle, metabolic disorders, creatine & creatinine synthesis.

#### Metabolism of Nucleic acids

Metabolism of nucleic acids biosynthesis and degradation of purines, pyrimidines, nucleosides and nucleotides.

### Paper-II

#### Physical techniques in biochemistry

Physical techniques in biochemistry, gel filtration, ion-exchange and affinity chromatography, isoelectric focussing, centrifugation, ultrafiltration Isotopic labelling, Immunoblotting, ELISA and spectrometry.

#### Chemotherapy

Chemotherapy antimalarials, sulfonamides and some commonly used antibiotics. Mechanism of drug resistance



## **Paper-III**

### **Immunology**

Immunology, chemistry of immunoglobulins, myeloma and hybridoma immunoglobulins. Immune system and its abnormalities, allergy and inflammation, complement system, peripheral leucocytes and macrophages.

### **Molecular biology**

Molecular biology Replication, transcription and translation. Regulation of gene expression. DNA synthesis and sequencing. Genetic code. plasmids, bacteriophages and cosmids. Mutagenesis, Methods and applications of recombinant DNA.

### **Microbiology**

Microbiology microbial cultivation, metabolism and genetics. Bacteria, fungi, protozoa and algae. Medical and industrial microbiology.

## **Semester-VIII**

## **Paper-IV**

### **Composition of blood**

Composition of blood blood plasma, serum proteins, red blood cells, white blood cells, plateletes, structure and function of haemoglobin. Coagulation and its mechanism.

### **Body Fluids**

Biochemistry of urine and lymphatic fluids.

### **Physiological Chemistry**

Structure and functions of liver lungs, muscle, connective tissue, kidney, heart, nerve conduction and sensory systems.

## **Paper-V**

### **Hormones**

Chemistry, functions and metabolism of thyroid, adrenal, pancreatic, steroid and growth hormones, hormonal regulation of metabolism.

### **Enzymes Kinetics**

Kinetic of single substrate reactions, substrate specify enzyme inhibition, multi-substrate reactions, multi-enzyme systems.

## Paper-VI

### Vitamins:

structure, physiological functions, deficiency diseases and recommended dietary allowances of vitamin A, D, E, K, B complex and C.

### Nutrition

Nutritional importance of carbohydrates, fats and proteins. Balance diet. micro-nutrients and their functions. Role of nutrition in growth, development and disease.

## Research / Project Report

### Practicals

- Analysis of normal and abnormal constituents in urine.
- Analysis of organic and inorganic constituents of blood.
- Estimation of different vitamins.
- Separation of sub-cellular fractions in cells.
- Gel filtration, ion-exchange chromatography and HPLC.
- Enzymes: Purification and kinetic studies of invertase, lactic dehydrogenase and peroxidase.
- Electrophoresis of plasma proteins, polyacrylamide gel electrophoresis. Agarose electrophoresis of DNA.
- Dialysis, ultra filtration and lyophilization.
- Cultivation of microorganisms in laboratory using solid and liquid culture media, test tube, petri plate and shake flask cultures, isolation of pure culture, study of physical characteristics of microorganism, bacterial growth curve, preservation of microbial strains

### Recommended Books

1. Lehninger, A. L. *Principles of Biochemistry*, Worth Publisher, New York (2001).
2. Voet, D. and J. G. Voet, *Biochemistry*, John Wiley & Sons, New York. (2000)
3. Murray, R. K., P. A. Mayes, D. K. Granner and V. W. Rodwell, *Harper's Biochemistry*, Appleton and Lange (2000).
4. Robert, *Harper's Biochemistry*, 25th Edition. (2000)
5. West, *Text Book of Biochemistry* 4th Edition. (2000)
6. Zubay, G. *Biochemistry*, 4th Edition Macmillan Publishing Co. (1999)
7. Stryer, L. *Biochemistry*, Freeman & Co. (1994)
8. Alberts, B., D. Bray, J. Lewis, M. Raff, K. Roberts and J. D. Watson, *Molecular Biology of Cell*, McGraw Hill Book Co., New York.

9. Watson, J. D., N. H. Hopkins, J. W. Roberts, J. A. Steitz and A. M. Weiner, *Molecular Biology of the Gene*, Benjamin/Cummins.
10. Darnell Jr., J., H. Lodish and D. Baltimore, *Molecular Cell Biology*, Scientific American Books.
11. Dawis, B. D., R. Dulbecco, H. N. Eisen and H. S. Ginsberg, *Microbiology*, Harper & Row.
12. Bryce, C. F. A., *Microcomputers in Biochemistry: A practical approach*, Oxford University Press.
13. Passmore, R. and M. A. Eastwood, *Human Nutrition & Dietetics*, Churchill Livingstone/ELBS
14. Watson, J. D., J. Tooze and D. T. Kurtz, *Recombinant DNA*, Scientific American Books

### **Practicals**

- Wilson, A. Practical Biochemistry: Principle and techniques (2000).
- Swotzer, Experimental Biochemistry theory and exercises in fundamental method (2000)
- Dryer, R. L. and G. F. Lata, *Experimental Biochemistry*, Oxford University Press.
- Plummer, D. T., *Introduction to Practical Biochemistry*, McGraw Hill Book Co., New York (1986).
- Alexander, R. R., J. M. Griggiths and M. L. Wilkinson, *Basic Biochemical Methods*, John Wiley & Sons
- Wooton, I. D. P., *Microanalysis in Medical Biochemistry*, J&A Churchill
- Gowenlock, A.H., Varley's Practical Clinical Biochemistry, 6th ed., Heinemann Professional Publishing, Oxford (1988).
- T. N. Pattabiraman. Laboratory Manual in biochemistry. All India Publishers(1998)
- Gosling, J. P. Immunoassay: Laboratory Analysis and Clinical application (1994).
- Sauhney, Introductory Practical Biochemistry (1998)

# 4<sup>th</sup> Year: SPECIALIZATION IN INORGANIC CHEMISTRY

## Semester-VII

### Paper-I: Advanced Inorganic Chemistry

#### Periodicity

First and second row anomalies, The use of p-orbital in pi bonding , The uses (or not) of d Orbital by non-metals, Reactivity and orbital participation, Periodic Anomalies of the non-metals and post-transition metals

#### Kinetics and Reaction Mechanisms of Inorganic Reactions

Classification (D-I<sub>d</sub>, I<sub>a</sub> and A mechanisms, rate law, stationary state approximation, inner and labile complexes

**Octahedral Complexes:** Acid hydrolysis, acid catalyzed, aquation, and anation reactions,

**Square planar complexes:** Nucleophilic reactivity, trans-effect, cis-effect, effect of leaving group; Mechanism of substitution Recimization reactions. Electron transfer processes (outer and inner sphere reactions)

#### **Recommended Books**

1. Jordan R. B. "Reaction Mechanisms of Inorganic and Organometallic Systems: 2<sup>nd</sup> Ed. Oxford University Press, Inc. 1998
2. Purcell, K.F. and Kortz, J.C. "Inorganic Chemistry" W. B. Saunders Company. Holt-Saunders International Editions (1977)
3. Purcell, K.F., Kortz, J.C., "An Introduction to Inorganic Chemistry" Saunders College Publishing (1980)
4. Shriver D. F., Atkins P. W. and Langford C. H. "Inorganic Chemistry" Oxford University Press. (1990)
5. Wilkins R. G. "Kinetics and Mechanism of Reactions of Transition Metal Complexes" VCH Publishers, Inc. 2<sup>nd</sup> Thoroughly Revised Edition (1991)

### Paper-II: Spectroscopic Methods of Analysis

Physical Methods in Inorganic Chemistry, NMR, IR, UV Spectroscopy, Mass Spectrometry, Flame Spectrometry (AAS & FES), Basic, principles, instrumentation and applications.

## Recommended Books

1. Bassette J., Denney C., Jeffery G. H. and Mendham J. "Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis" English Language Book Society. 4th Edition (1978)
2. Braun R. D. "Introduction to Chemical Analysis" Mc Graw-Hill, Inc. (1982)
3. Drago R. S. "Physical Methods in Inorganic Chemistry" W. B. Saunders Company. (1997)
4. Kemp W. "NMR in Chemistry: A Multinuclear Introduction" Macmillan Press Ltd. (1986)
5. Pavia D. L., Lampman G. M. and Kriz G. S. "Introduction to Spectroscopy" Saunders College Publishing. (1979)

## Paper-III

### Organometallic Chemistry

Introduction, Compounds of transition metals, Single, double and triple bonds to carbon, Acyls, Alkylidene complexes and Alkylidyne complexes, Delocalized hydrocarbon system: alkenes, olefins, allyl and butadienes: alkyne complexes, Cyclic complexes: four-five-six members rings

### Oxidative- Addition and Reductive Elimination

Oxidative Addition: One-electron Oxidative Addition, Addition of Oxygen, Addition of bimetallic species, Hydrogen addition, HX addition, Organic halides, Reductive Elimination reactions

## Recommended Books

1. Douglas B. E., McDaniel D. H. and Alexander J. J. "Concepts and Models of Inorganic Chemistry" John Wiley & Sons, Inc. 2nd Edition (1983)
2. Douglas B., McDaniel D. and Alexander J. "Concepts and Models of Inorganic Chemistry" John Wiley & Sons, Inc. 3rd Edition (1994)
3. Huheey J. E. "Inorganic Chemistry Principles of Structure and Reactivity" 2<sup>nd</sup> Ed. Harper and Row Publishers. 1978
4. Huheey J. E. "Inorganic Chemistry Principles of Structure and Reactivity" SI Unit Ed.. Harper and Row Publishers. (1975)
5. Mackay K. M., Mackay R. A. and Henderson W. "Introduction to Modern Inorganic Chemistry". 5<sup>th</sup> Ed. Stanley Thornes (Publishers) Ltd. (1996)
6. Miessler G. L. and Tarr Donald A. "Inorganic Chemistry". Prentice-Hall International Ed. Prentice-Hall International, Inc. (1991)
7. Purcell, K.F. and Kortz, J.C. "Inorganic Chemistry" W. B. Saunders Company. Holt-Saunders International Editions (1977)
8. Purcell, K.F., Kortz, J.C., "An Introduction to Inorganic Chemistry" Saunders College Publishing (1980)

## Practicals

- Practical to be designed based on the following:
- Chromatographic Techniques: Chromatographic techniques for the separation of inorganic compounds.
- Spectroscopic and Complexometric Methods: Use of organic reagents for the estimation of various elements using spectroscopic and complexometric methods.
- Instrumental Methods of Analysis: Conductometric and potentiometric titrations, spectrophotometric determination of metal ions.
- Preparation and characterization of coordination and organometallic compounds
- The experiments may be set making use of the following instruments depending upon their availability, special experiments may also be designed for which a specimen list of instruments is given below. For the innovative designing of experiments the Journal of Chemical Education may be consulted.

### Instruments:

UV/Visible spectrophotometers

Flame photometers

pH-meters

Gouy balance

Conductivity bridge

Atomic absorption spectrophotometer

Infrared spectrophotometers (for the characterization of complexes)

Simple NMR experiments depending upon the availability of the instrument.

## Practical Inorganic Chemistry-I

### 1. Conductometry

- (i) Titration of strong acid and weak acid with a strong base.
- (ii) Precipitation titration involving  $\text{AgNO}_3$  and  $\text{KCl}$ .
- (iii) Determination of dissociation constant  $K_a$  for acetic acid

### 2. Potentiometry

Determination of  $K_1$ ,  $K_2$  and  $K_3$  for  $\text{H}_3\text{PO}_4$

Determination of chloride in the presence of iodide and evaluation of  $K_{sp}$  of  $\text{AgI}$  and  $\text{AgCl}$

## Practical Inorganic Chemistry-II

### Use of some Organic Reagents for Gravimetric Estimation.

- (a) 8-Hydroxyquinoline Al (III) and Fe (III)
- (b) Nitron

### Use of Some Organic Reagents for The Estimation of Various Elements

- (a) Salicylaldoxime: Ni (II) in the presence of Cu (II)
- (b) Anthranilic acid: Co(II) and Zn(II)

### Inorganic Synthesis:

Preparation of at least six inorganic compounds / complexes in a pure state and determination of their state of purity.

### **Recommended Books:**

1. Bassette J., Denney C., Jeffery G. H. and Mendham J. "Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis" English Language Book Society. 4th Edition (1978)
2. Fritz J. S., Schenk G. H. "Quantitative Analytical Chemistry" Allyn and Bacon, Inc. 4th Edition (1979)
3. Harris W. E., Kratochvil B. "An Introduction to Chemical Analysis" Saunders College Publishing. Holt-Saunders International Edition (1981)
4. Hatch R. C. "Experimental Chemistry" Van Nostrand Reinhold Company (1972)
5. Jefferey, G.H., J. Bassett, J. Mendham and R. C. Denney, 'Vogel's Textbook of Quantitative Analysis'
6. Marr G., Rockett B. W. "Practical Inorganic Chemistry". Van Nostrand Reinhold Company. (1972)
7. Pass G. and Sutcliffe H. "Practical Inorganic Chemistry: Preparations, Reactions and Instrumental Methods" Chapman and Hall. 2<sup>nd</sup> Edition (1974)
8. Vogel, A.I. "A Text Book of Micro and Semimicro Qualitative Inorganic Analysis" Longmans Green & Co. 4th Edition (1954)
9. Vogel, A.I. "A Text Book of Micro and Semimicro Qualitative Inorganic Analysis" Longman Green & Co. (1995)

## Practical Inorgainc Chemistry-III

1-Credit Hours

### ▪ Spectrophotometry:

Micro determination of Cr(III) by Di-phenylecarbazide.  
Determination of Fe (II) by 1-10 Phenanthroline.

Determination of nitrites.

Determination of Fe (III) by 8-hydroxyquinoline.

- **Atomic absorption spectrometry: (subject to the availability of equipment )**

Estimation of Na, K, Ca, Mg, Co, Ni, and Zn. in various materials (e.g. food , tap water and brass etc.)

- **Spectroscopy:**

Recording and characterization of at least five organic or organometallic compounds by IR, and UV and NMR spectrophotometer to the subject of availability of facilities

### **Recommended Books**

1. Bassette J., Denney C., Jeffery G. H. and Mendham J. “Vogel’s Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis” English Language Book Society. 4th Edition (1978)
2. Fritz J. S., Schenk G. H. “Quantitative Analytical Chemistry” Allyn and Bacon, Inc. 4th Edition (1979)
3. Harris W. E., Kratochvil B. “An Introduction to Chemical Analysis” Saunders College Publishing. Holt-Saunders International Edition (1981)
4. Hatch R. C. “Experimental Chemistry” Van Nostrand Reinhold Company (1972)
5. Jefferey, G.H., J. Bassett, J. Mendham and R. C. Denney, ‘Vogel’s Textbook of Quantitative Analysis’
6. Marr G., Rockett B. W. “Practical Inorganic Chemistry”. Van Nostrand Reinhold Company. (1972)
7. Pass G. and Sutcliffe H. “Practical Inorganic Chemistry: Preparations, Reactions and Instrumental Methods” Chapman and Hall. 2<sup>nd</sup> Edition (1974)
8. Vogel, A.I. “A Text Book of Micro and Semimicro Qualitative Inorganic Analysis” Longmans Green & Co. 4th Edition (1954)
9. Vogel, A.I. “A Text Book of Micro and Semimicro Qualitative Inorganic Analysis” Longman Green & Co. (1995)



## Semester-VIII

### Advanced Inorganic Chemistry

#### Organic reagents in Inorganic Analysis

Type of reagents, their specific nature and methods of applications with specific examples, Complexometric and gravimetric methods involving various reagents, chelates and chelate effect

#### Homogenous Catalysis by Transition Metal Complexes

**Reaction of CO and hydrogen:** Hydroformylation, reductive carbonylation, reduction of CO by hydrogen, synthesis of water gas and shift reaction.

**Carbonylation reaction:** Synthesis of methanol and methyl acetate, adipic ester, other carbonylation and decarbonylation reactions.

**Catalytic addition of molecules to C-C multiple bonds:** Homogeneous hydrogenation, and hydrocylation and hydrocyanation.

#### Polymer Chemistry

**Molecular species:** Polymeric sulfur and nitrogen compounds, borazines, phosphazines, carboranes and silicones.

**Polyionic species:** Isopoly and heteropoly anions of transition elements, poly silicates and poly phosphates.

**Metal cluster compounds.**

#### Magnetochemistry

Theory of magnetism, paramagnetism, diamagnetism, ferro-, ferri- & anti-magnetism, Magnetic susceptibility, magnetic moments, Faraday's & Gouy's methods, orbital contribution to magnetic moment, The Russell-Sunders coupling scheme, microstates derivation of terms chambers for p1 to p6 and d1 to d10 system

#### Nuclear Chemistry

Introduction, Structure of nucleus, radioactivity and radioactive series, artificial radioactivity, Determination of half life, nuclear fission and fusion reaction, energetic nuclear reactions, Particle accelerators and reactors, Application of radioisotopes.

## **Practicals / Research**

### **Recommended Books:**

1. Choppin G. R. and Rydberg J. "Nuclear Chemistry, Theory and Applications" Pergamon. (1980)
2. Elton L. R. B. "Introductory Nuclear Theory" The English Language Book Society and Sir ISAAC Pitman & Sons, Ltd. (1959)
3. Friedlander G., Kennedy J. W. and Macias E. S. "Nuclear and Radiochemistry" John Wiley and Sons, Inc. 3rd Edition (1964)
4. Friedlander G., Kennedy J. W. and Miller J. M. "Nuclear and Radiochemistry" John Wiley and Sons, Inc. 2nd Edition (1964)
5. Frost A. A. and Pearson R. G. "Kinetics and Mechanism: A Study of Homogeneous Chemical Reactions" John Wiley and Sons, Inc. Wiley International Edition (1961)
6. Hall L. H. "Group Theory and Symmetry in Chemistry" McGraw-Hill Book Company. (1969)
7. Harvey B. G. "Nuclear Physics and Chemistry" Prentice-Hall, Inc. (1969)
8. JR Flurry R. L. "Symmetry Groups: Theory and Chemical Applications" Prentice-Hall, Inc. (1980)
9. Kaplan A and Szabo L. L. "Clinical Chemistry: Interpretation and Techniques" Lea and Febiger. (1983)
10. Katakis D., Gordon G. "Mechanisms of Inorganic Reactions" John Wiley and Sons. (1987)
11. Naqvi I. I. "Radiochemistry" University Grants Commission. (1990)
12. Schrauzer G. N. "Transition Metals in Homogeneous Catalysis" Marcel Dekker, Inc. (1971)
13. Smart L. and Moore E. "Solid State Chemistry: An Introduction" Chapman and Hall. (1992)

## **4<sup>th</sup> Year: SPECIALIZATION IN ORGANIC CHEMISTRY**

### **Semester-VII**

Any two of the following courses can be taken:

Note: Any additional papers may be added according to availability of experts.

#### **Paper I - Structure Elucidation of Natural Products**

Chemical methods

Spectroscopic methods involving IR, UV, NMR, and Mass Spectroscopy

#### **Paper II - Organic Synthesis**

Organic Synthetic Reactions involving C-C, C-N, C-O Bonds.

Oxidation and Reduction Protective Groups

Note: These courses can be substituted with any of the following:

### **Natural Products**

Terpenoids  
Alkaloids  
Steroids  
Antibiotics

### **Paper III - Reaction Mechanism**

Determination of organic reaction mechanisms by kinetic and non-kinetic methods.

Reactive Intermediates  
Molecular Rearrangements

### **Organic Polymers**

Synthetic Polymers, Bio-Polymers

### **Practicals:**

The experiments may be set making use of the following instruments depending upon their Availability.

### **Instruments:**

UV/Visible spectrophotometers  
Gas chromatography  
HPLC  
Infrared spectrophotometers  
Mass spectrometers  
NMR

### **Experiments:**

Multi-step synthesis of organic compounds (10 Compounds)  
Analysis of commercial drugs (10 Drugs)  
Qualitative and preparative chromatography

## **Semester-VIII**

### **Paper I - Heterocyclic Chemistry**

### **Paper II - Synthetic Applications of Name Reactions**

Note: These courses can be substituted with any of the following:

## **Reactive Intermediates**

Chemistry and synthetic application of: carbenes, nitrenes, ketenes, free radicals, carbonium ions and carbanion

## **Paper III – Chemistry and Biosynthesis of Secondary Metabolites: Terpens, Steroids, Alkaloids, Antibiotia.**

### **Applications of Computational Chemistry**

**Research Project, applied or academic in nature may be allocated.**

### **Practicals / Research**

#### **Books Recommended:**

1. McMurry.J, "Organic Chemistry" Thomson Asia Pte Ltd, Singapore, Fifth Edition (2000).
2. Morrison.R.T, Boyd.R.N, "Organic Chemistry" Prentice-Hall, Inc; Sixth Edition (1992).
3. Solomons.T.W.G, Fryhle.C.B, Johnson.R.G, "Study Guide and Solutions Manual to Accompany Organic Chemistry" John Wiley & Sons, Inc; Seventh Edition (2000).
4. March.J, "Advanced Organic Chemistry Reactions, Mechanisms and Structure" John Wiley & Sons, Inc; Fourth Edition (1992)
5. Hornback.J.M, "Organic Chemistry" Brooks/Cole Publishing Company (1998).
6. Pine.S.H, Hendrickson.J.B, Cram.D.J, Hammond.G.S, "Organic Chemistry" McGraw-Hill, Inc; Fourth Edition (1980).
7. Finar.I.L, "Fundamental Principles of Organic Chemistry" Longman, Third Edition, Vol.I (1959).
8. Finar.I.L, "Stereochemistry and the Chemistry of Natural Products, "English Language book Society and Longman Group Ltd; Fifth Edition, Vol.II (1975).
9. Sykes.P, "A Guide Book to Mechanism in Organic Chemistry" Longman Group Ltd. (1986).
10. Warren.S, "Designing Organic Syntheses A Programmed Introduction to the Synthon Approach" John Wiley & Sons, Inc(1980).
11. Norman.R.O.C, "Principles of Organic Synthesis" Chapman and Hall Ltd, Second Edition (1978).
12. Corey.E.J, Cheng.X.M, "The Logical of Chemical Synthesis" Wiley Interscience(1989).
13. Greene.T.W, Nuts.P.G, "Protecting Groups in Organic Synthesis" John Wiley & Sons, Second Edition (1991).
14. Cleyden.J, Greeves.N, Warren.S and Wothers.P, "Organic Chemistry" Oxford University Press (2001).

15. Nizami.S.S, "Reterosynthetic Approach to Organic Synthesis", Higher Education Commission (2003).
16. Burger. A, "Medicinal Chemistry", John Wiley & Sons, Inc; Third Edition, Part.I (1970).
17. Warren.S, "Organic Synthesis: The Disconnection Approach", John Wiley & Sons Ltd (1982).
18. Cordell.G.A, "Introduction to Alkaloids", John Wiley & Sons,Inc.(1981).
19. Pavia.D.L, Lampman.G.M, Kriz.G.S, "Introduction to Spectroscopy: A Guide for Students of Organic Chemistry" Saunders College Publishing/Holt.Rinehart and Winston (1979).
20. Bender.G.T, "Principles of Chemical Instrumentation", W.B.Saunders Company (1987).
21. Akitt.J.W, "NMR and Chemistry an Introduction to the Fourier transform multinuclear era", J.W.Arrowsmith Ltd, Bristol, Second Edition (1983).
22. Macomber.R.S, "NMR Spectroscopy Basic Principles and Applications", Books for Professionals, Inc (1988).
23. Kemp.W, "NMR in Chemistry A multinuclear Introduction", The Macmillan Press Ltd. (1986).
24. Silverstein.R.M, Bassler.G.C, Morrill.T.C, "Spectrometric Identification of Organic Compounds", John Wiley & Sons; Inc; Fourth Edition (1981).
25. Kemp.W, "Organic Spectroscopy", Macmillan Education Ltd; Third Edition (1991).
26. Budzikiewicz.H, Djerass.C, Williams.D.H, "Mass Spectrometry of Organic Compounds", Holden-Day, Inc (1967).
27. Whittaker.D, "Interpreting Organic Spectra", The Royal Society of Chemistry (2000).
28. Creswell.C.J/Runquist.O.A,Campbell.M.M, "Spectral Analysis of Organic Compounds", Burgess Publishing Company, Second Edition (1972).
29. Stowell.J.C, "Intermediate Organic Chemistry", John Wiley & Sons, Inc; Second Edition (1994).

## **SPECIALIZATION IN PHYSICAL CHEMISTRY**

### **Semester VII**

#### **Quantum Chemistry**

Operators and their properties. Angular momentum. Central field problem. Hydrogen-like atoms. Approximate methods. Perturbation methods and variations principle. Valence bond and molecular orbital theories. pi-electron calculations.

## **Molecular Spectroscopy**

Interaction of electromagnetic radiation with matter. Microwave, Infrared and Raman spectroscopy. Symmetry properties of molecules. Electronic spectra of simple molecules. Nuclear magnetic resonance spectroscopy.

## **Solid State Chemistry**

Intermolecular forces. Symmetry of condensed systems. Properties of solids (electrical, mechanical and optical). Lattice defects, doping for defects. Electron-gas model, heat capacity paradox, electrical conductivity. Band theory of metallic state. Conductors semiconductors and insulators. Controlled valency and hopping phenomena, p & n-type conductivity, p,n-junctions. Solid state reactions. Developments in superconductivity.

## **Practicals :**

The experiments may be set making use of the following instruments depending upon their availability, special experiments may also be designed for which a specimen list of instruments is given below. For the innovative designing of experiments the Journal of Chemical Education may be consulted.

### **Instruments:**

UV/Visible spectrophotometers  
pH-meters  
Conductivity bridge  
Gas chromatography  
HPLC  
Atomic absorption spectrophotometer  
Infrared spectrophotometers  
Dipole meters  
Electrogravimetric apparatus  
Light Scattering Instruments  
Stopped flow spectrophotometers

### **Experiments:**

- Determination of partial molar quantities
- Determination of free energy changes, standard free energies.
- Verification of Kohlrausch law.
- Study of temperature dependence of electrode potentials
- Determination of heat of solution, ionic reactions and other experiments from thermochemistry
- Study of multistep reactions
- Evaluation of energy of activation
- Sugar analysis and inversion studies by polarimetry
- Study of isotherms and experiments of surface chemistry

- Determination of molecular weight of a polymer by viscosity method
- Precipitation value of electrolytes
- Measurement of IR spectra of simple compound and their interpretation
- Measurement of cyclic voltammogram of an organic compound and its interpretation
- Determination of dipole moment of an organic liquid
- Determination of percentage composition of  $\text{KMnO}_4 / \text{K}_2\text{Cr}_2\text{O}_7$  in a given solution by
  - spectrophotometry
- Stoichiometry of a complex in solution by Job's method
- Evaluation of pKa value of an indicator by spectrometric method

## **Semester-VIII**

### **Surface and Catalytic Chemistry**

Solids surfaces. Gas solid interface. Thermodynamics of adsorption. Heterogeneous catalysis. Kinetics and mechanisms of catalyzed reactions. Adsorption at liquid surfaces. Enzymatic catalysis. Organized molecular assemblies. Colloidal solutions. Catalyst preparation methods. Industrial catalysts.

### **Polymer Chemistry**

Definition and classification of polymers. Polymerization and co-polymerization. Polymer solution. Polymer characterization: structure property relationship. Elastomers, plastics, fibers, blends and alloys.

### **Chemical Kinetics**

Advanced theories of unimolecular reactions. Chain and non-chain complex reactions. Fast reactions, experimental techniques for measurement of fast reaction kinetics. Kinetics of catalyzed reaction. Potential energy surfaces. Solar reactions.

### **Statistical Thermodynamics**

Description of various systems. Concepts of states, accessible states and distribution. Probability concepts. Maxwell-Boltzmann's statistics for the systems of independent particles. Partition functions. Statistical thermodynamics. Applications to equilibrium and chemical kinetics. Bose-Einstein's and Fermi-Dirac's statistics.

### **Nuclear Chemistry**

Nuclear systematic. Sources of nuclear instability. Nuclear energetics. Nuclear models: shell model, liquid drop model. Nuclear reactions. Fission and fusion.

## **Photochemical reactions**

Photochemical reactions in gas phase and in solutions. Quantum yield, flash photolysis. Advanced approach to kinetics of photochemical reactions.

## **Theories of Electrolytes:**

Interfacial phenomena. Electrode kinetics. Mechanisms of electrode reactions. Cyclic voltammetry and its applications. Electrochemical impedance spectroscopy.

## **Recommended Books:**

1. Albery J., Electrode Kinetics, Clarendon, Oxford, 1975.
2. Asperger S., "Chemical Kinetics and Inorganic Reaction Mechanisms" 2nd Ed., Springer Verlag (2003).
3. Aston J.G. and Fritz J.J, "Thermodynamics and Statistical Thermodynamics" New York, John-Wiley (1959).
4. Aziz F. and Rodgers M. A.J., "Radiation Chemistry Principles and Application" Ed., VCH Publishers, Inc, (1987).
5. Banwell C.N., "Fundamentals of Molecular Spectroscopy" 3<sup>rd</sup> Ed., , New Delhi,
6. Bard A. and Faulkner L. R, "Electrochemical Methods, Fundamentals and Application" John Wiley, New York. (latest available edition).
7. Barrow G.M., "Introduction to Molecular Spectroscopy," New York, McGraw-Hill (1962).
8. Becker E.D., "High Resolution NMR; Theory & Chemical Application", New York, Academic Press (1980).
9. Bible R. H., Jr., "Interpretation of NMR Spectra: An Empirical Approach," Plenum Press, New York, (1965).
10. Bond G.C "Heterogeneous Catalysis" 2nd Ed., , Clarendon Press. Oxford (1987).
11. Cassidy H.G., "Fundamentals of Chromatography". Interscience Publishers New York, 1957.
12. Engel, Thomas and Philip Reid, "Thermodynamics, Statistical Thermodynamics", and Kinetics 1st Ed., Benjamin Cummings, (2006).
13. Espenson, J. H. Chemical Kinetics and Reaction Mechanism "2nd Ed., McGraw Hill London (2002)
14. Flory, "Principle of Polymer Chemistry" Cornell (1953).
15. Fried J.R. "Polymer Science and Technology". Prentice Hall 1995.
16. Friedlander G. and Kennedy J.W "Nuclear and Radiochemistry", 3<sup>rd</sup> Ed. John Wiley & Sons, New York (1981).
17. Graybal J.D., "Molecular Spectroscopy," New York, McGraw-Hill(1988)
18. Gregory R. Choppin and Jan Rayberg "Nuclear Chemistry Theory and Applications", 1<sup>st</sup> Ed., Pergaman Press, Oxford. New York (1998).
19. Griffiths, David J., " Introduction to Quantum Mechanics" 2nd Ed., Prentice Hall (2004)



20. Hayward, David O., "Quantum Mechanics for Chemists" 1st Ed., John Wiley (2003).
21. Hiemenz P.C., and Rajagopalan, "Principles of Colloid & Surface Chemistry," 3<sup>rd</sup> Ed., Marcel Dekker, New York, (1997).
22. Hill T.L., "Statistical Mechanics, , New York, McGraw-Hill (1956).
23. House, James E., "Fundamentals of Quantum Mechanics" 2nd Ed., Elsevier-Academic Press (2003)
24. I.I Naqvi "Electrochemistry" Higher Education Commission (In Press)
25. J.H Espenson "Chemical Kinetics and Reaction Mechanisms", 2<sup>nd</sup> Ed. McGraw Hill, New York (1995)
26. Kemp, W., "NMR Chemistry: A Multinuclear Introduction', London, Macmillan Education (1986).
27. Lajunen L.H.J., "Spectrochemical Analysis by Atomic Absorption and Emission"  
Royal Society of Chemistry, Cambridge, 1992.
28. Malcolm, P. S., "Polymer Chemistry" Oxford University Press (2005).
29. Mandelkern "An Introduction to Macromolecules", 2<sup>nd</sup>, Springer (1983).
30. Mathews F.L. and Rawlings R.D, "Composite Materials: Engineering and Science" Chapman and Hall, 1994.
31. Micheal, J. P., "Reaction Kinetics" Oxford University Press (2005).
32. Mohammad and Amjad. 'Principles of Electrode Kinetics" Roohi Printers, Lahore.
33. N. Davidson "Statistical Mechanics, New York, McGraw-Hill (1962).
34. Pople C.P., "Electron Spin Resonance", John Wiley New York (1967).
35. Ravue, "Principles of Polymer Chemistry". 2<sup>nd</sup> Ed. Plenum Publishers. (2000)
36. Skoog D.A., West D.D., and Holler F.J., "Fundamentals of Analytical Chemistry" 6<sup>th</sup> Ed., Saunders College Publishing, 1992.
37. Spinks J.W.T., and Woods R.J., "An Introduction to Radio Chemistry" by 2<sup>nd</sup> Ed., John Wiley, New York (1976).
38. Stock and Rice, "Chromatographic Methods", Chapman and Hall, (1967).
39. F.W Billmeyer, Jr "Textbook of Polymer Science ", John Wiley & Sons 1994.
40. Wallace S. and Brey JR., "Physical Method For Determining Molecular Geometry"
41. Wayne R. P. "Principles and Applications of Photochemistry", University Press Oxford London (1988).
42. West A.R., "Solid State Chemistry", J. Wiley, New York (1989).

# 4<sup>th</sup> Year: SPECIALIZATION IN ENVIRONMENTAL CHEMISTRY

## Semester-VIII

### Introduction

Concept and scope of environmental chemistry, Environmental aspects, Impact and significant aspect, Nomenclature and environmental components, Environmental impact assessment

### Sources of Energy

Sources of generation and environmental impact, Fossil fuel, Nuclear energy and synthetic chemical fuels, Emission from thermal units, waste from fuel and safe disposal.

### The Atmosphere

Composition, structure and evolution of atmosphere, Earth radiation balances, pentacles, radicals in atmosphere, Chemical and photochemical reactions in atmosphere, Greenhouse effect.

### Atmosphere Pollution

Importance of air, nature and composition of atmosphere, Temperature and pressure profiles of different layers of the atmosphere, common air pollutants and their sources, oxides of C, N and S hydrologic cycle and global warming, Stratospheric ozone depletion, Vehicular emissions, particulate matter and aerosols, airborne lead, acid rain and its impacts, photochemical smog, photochemistry of the atmosphere, role of hydroxyl radicals, indoor air quality, Smoke, Fog, Smog, Acid rain, Monitoring and mentoring as per National Environmental Quality Standard (NEQS), Pakistan Environmental Pollution Act (PEPA) 1997.

### The Hydrosphere

Importance of water, physical and chemical properties of water, criteria for water quality, BOD and COD, sources of water pollution (industrial, agricultural, municipal and natural), Fertilizers, pesticides, detergents, heavy metals, bio-accumulation and bioamplification, primary, secondary and advanced treatment of water. Drinking water quality

### The Lithosphere

Importance of soil, nature and composition of soil, macro and micro-nutrients in soil, soil erosion, pH of soil and nutrients availability, ion-exchange in soil, sources of soil pollution (industry, agro-chemicals, mining, municipal waste, hospital wastes (littering), reclamation of soil.

## **Toxicology**

Toxic elements in environment, persistent organic pollutants, aflatoxins, Pesticides and detergents, house hold chemicals and solvents. Impact of chemicals on human health, crops and vegetation, buildings and monuments, aquatic life, biodiversity and visibility

## **Recommended Books**

1. A. Kumar, Environmental Chemistry, Wiley Eastern, New Delhi.
2. J. W. Moore & E.M. Moore, Environmental Chemistry, Academic Press, New York.
3. S. K. Banerji, Environmental Chemistry, Prentice Hall, Delhi.
4. S. K. Banerji, Environmental Chemistry, Tata Publisher, Delhi.
5. Staneley E. Manahan, Environmental Chemistry, Brooks, California
6. Neil, P.O. Environmental Chemistry, Chapman, London.
7. Baird, C. Environmental Chemistry, Freeman, New York.
8. Pakistan Environmental Pollution Act 1997.

## **INDUSTRIAL PROCESSES AND QUALITY CONTROL**

### **1. Sampling and Data Handling**

Basic tools and operations of Analytical Chemistry, valid measurements, accuracy and precision, errors, standard deviation, relative standard deviation, applications of statistics in data handling, data quality, quality control and assurance, use of computers in data handling.

### **2.( a). Separation Techniques**

- i. Solvent extraction: Principle, factors affecting the extraction systems; Practical applications in chemical analysis.
- ii. Chromatographic methods: General theory of chromatography, classification of chromatographic methods, column, paper, thin-layer, and ion-exchange chromatography. Gas chromatography; HPLC and Electrophoresis.

### **(b). Atomic Spectroscopy**

Basic Principles of atomic emission and absorption spectroscopy; Instrumentation; Applications and limitations of flame emission and atomic absorption spectroscopy.

### **3. Polymers**

Naturally occurring and synthetic polymers; polymerization techniques; Kinetics and mechanism of chain reaction; Structure and properties of polymers in the solid and liquid states, determination of polymer molecular weights. A brief

outline of the reactions and the processes involved in the manufacture of polyethylene, polystyrene, polyamides, polyurethane and polyesters. Characterization of polymers.

#### **4. Industrial Pollution and Waste Treatment**

Origin and effects of the particulate, gaseous, and liquid pollutants, threshold limits of pollutants and their adverse effects on health, utilization and recycling of the effluents from the textile, leather, paper, steel, soap, agrochemical and armament industries; pollution abatement and international regulatory standards.

#### **5. Biomolecules and Biochemical Processes.**

Biological significance of carbohydrates, lipids, proteins, enzymes and nucleic acids. Structure, classification and characterization of the biomolecules, fermentation, purification techniques of biomolecules and quality control procedures.

#### **Practicals:**

- General safety precautions and calibration of glassware.
- Determination of aluminium in pharmaceutical samples by complexometric titration.
- Separation and detection of amino acids by paper and thin-layer chromatography.
- Separation and detection of constituents in a mixture of commercial dyes by paper and thin-layer chromatography.
- Determination of sodium and potassium in biological samples by flame photometry.
- Determination of iron in foods and pharmaceutical products spectrophotometrically.
- Determination of phosphate content in commercial fertilizers by spectrophotometry.
- Determination of nickel in vegetable Ghee by spectrophotometry involving solvent extraction.
- Estimation of total hardness, alkalinity and pH of water samples.
- Identification and spectrophotometric determination of aspirin, phenacetine and caffeine in pharmaceutical samples.
- Estimation of bicarbonate content of blood by titrimetry.
- Preparation and characterization of phenol formaldehyde and urea formaldehyde resins.
- Preparation and characterization of alkyd resin.
- Utilization of dairy and cellulose wastes for the preparation of sugars and alcohol.
- Estimation of vitamin C and total acidity in fruit juices.

- Spectrophotometric determination of carbohydrates in food samples.
- Proximate Analysis of food samples (moisture, crude protein, crude fibre, ether extract and ash .
- Analysis of blood and urine using atomic absorption and emission spectroscopy.

### **Recommended Books:**

(Latest available Editions of the following books are recommended)

1. H.G.Cassidy, Fundamentals of Chromatography, Inter Science Publishers, London.
2. D.Skoog and D.M.West, Fundamentals of Analytical Chemistry, Holt Reinhart Inc, London.
3. H.H.Willard and L.Meritt, Instrumental Methods of Analysis, D.Van. Nostrand, company Inc. London.
4. G.D.Christian, Analytical Chemistry, John Wiley & Sons.
5. E.Lederer 7 m.Lederer, Chromatography, Elsevier Co, Amsterdam.
6. Stock and Rice, chromatography Methods of Analysis, Elsevier Amsterdam.
7. H.H.Baner, G.D., Christian and J.E.O. Reilly, Instrumental Analysis, Allyn and Bacon, London.
8. C.Reilley, Laboratory and Manual of Analytical Chemistry, Allyn and Bacon, London.
9. W.J.Blaedal & V.W. Medloche, Elementary Quantitative Analysis (Second Edition), Harper & Row, N.T.
10. P.O.Neil, Environmental Chemistry, Chapman and Hall, London.
11. N.I.Nemerow, Industrial Water Pollution, Addison Wesley Publishing Company, Amstardam.
12. L.T.Pyrde, Environmental Chemistry An introduction, Cummings Publishing Company, California.

# CURRICULUM FOR 2 YEARS M.S SCHEME OF STUDIES

## 1<sup>st</sup> Year

### Semester - I

Paper I : \_\_\_\_\_  
Paper II : \_\_\_\_\_  
Paper III : \_\_\_\_\_  
Paper IV : \_\_\_\_\_

### Semester – II

Paper I : \_\_\_\_\_  
Paper II : \_\_\_\_\_  
Paper III : \_\_\_\_\_  
Paper IV : \_\_\_\_\_

## 2<sup>nd</sup> Year

Seminar I 1 Cr.  
Seminar II and Research Report 1 Cr.  
Thesis / Dissertation  
Research

# Inorganic Chemistry

## SCHEME OF STUDIES

In the first year there shall be four courses in each semester. Second year shall be devoted to research specialized study and research seminars only.

### 1<sup>st</sup> Year

#### Semester-I

- Paper-I	Solid State Chemistry	3 Cr. Hr.
- Paper -II	Group Theory	3 Cr. Hr
- Paper -III	Chemistry of Organometallic Compounds	3 Cr. Hr
- Paper -IV	Lab / Theory	3 Cr. Hr
		<b>Total 12 Cr. Hr.</b>

#### **Semester-II**

- Paper –V	Photochemical Reactions of Transition Metals	3 Cr. Hr
- Paper –VI	Applied Transition Metal Catalytic Chemistry	3 Cr. Hr
- Paper –VII	Main Group Organometallic Reagents	3 Cr. Hr
- Paper –VIII	Lab / Theory of opted Field of Specialization	3 Cr. Hr
		<b>Total 12 Cr. Hr.</b>

### 2<sup>nd</sup> Year

#### **Semester-III-IV**

<b>Seminar-I</b>	(1 Cr. Hr)
<b>Seminar-II</b>	(1 Cr. Hr)

<b>Dissertation/Research</b>	(6 Cr. Hr.)
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The students shall submit a Dissertation/Thesis on the subject of his/her research work.

In lieu of labs in semester I and II, any two courses from the following list may be offered as Paper IV and Paper VIII.

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\* As per HEC policy and international standards credit hours for MS would be 30 credit, 24 credit hours for courses and 6 credit hours for research.

## **List of Courses**

1. Inorganic Electronics Spectroscopy
2. Kinetics and Mechanisms of Inorganic Reactions.
3. Inorganic Chemistry of Biological Processes
4. Nuclear and Radio-Chemistry
5. Medicinal uses of Transition Metals / Inorganic Compounds
6. Special Topics in Inorganic Chemistry.
7. Advances in Periodic Table
8. Chemistry of Advanced Materials
8. Inorganic Polymers and Cluster Compounds
9. Inorganic Environmental Pollutants
10. Nanotechnology in Inorganic Chemistry
11. Combinatorial Chemistry
12. Manipulation of Air Sensitive Compounds
13. Synthetic Techniques in Inorganic Chemistry

## **Details of Courses**

### **SOILD STATE CHEMISTRY**

Classification of bonds and crystals, The effect of radius ratio and charge on crystals, Application of the isoelectronic principle, Ordered solids including interstitial compounds, Alloys, Superclustures and Storage batteries, Amorphous solids (Glass and Polymers)

### **PHOTOCHEMICAL REACTIONS OF TRANSITION METALS**

Introduction, Basic Photochemical processes, Photosubstitution reactions, Photoredox reactions, Reactivity of CTM and CTTL excited states, Ligand photoreactions, Scavenging of reaction intermediates, Photoreaction and solar energy conversion, Photochemistry techniques.

### **APPLIED TRANSITION METAL CATALYTIC CHEMISTRY**

Ziegler-Natta and Wacker catalyst, polymerization and Oligomerization of ethylene, propylene, olefins, cyclic olefins and alkynes, Fischer-Tropsch process, Oxidation reaction, synthesis of acrylates and related derivative,

### **GROUP THEORY**

Introduction, symmetry elements and symmetry operations, Introduction to groups. Symmetry points groups. Class structure, Representations and character tables, chemical applications of group theory.



## **CHEMISTRY OF ORGANOMETALLIC COMPOUNDS**

Nature of metal-carbon bond and electronic configuration of transition metal complexes, Fundamental process in reactions of organotransition metal complexes like insertion and extrusion of CO, SO<sub>2</sub>, NO, olefins and diffraction, Experimental techniques in organometallics (techniques using Schlenk glass ware, chemical analysis, IR Raman, photoelectronic, Mossbauer and NMR spectroscopy, X-ray and neutron diffraction)

## **MAIN GROUP ORGANOMETALLIC REAGENTS**

Introduction, preparation, classes of nucleophilic organometallic reagents, Organo-Li, S, Se, Si, B, Sn, Sb and Zn in organic synthesis, Control side reactions (Enolization vs. nucleophilic addition, substitution vs. elimination, selectively among functional groups via organometallic reagents.)

## **INOGRANIC ELECTRONIC SPECTROSCOPY**

Introduction, Term symbols, Russel Sander's coupling scheme, Development of correlation and Tanabe-sugano diagram, Ligand field spectra of octahedral complexes, Absorption spectra of coordination compounds, Band assignments and interpretation of absorption spectra of complexes, Charge transfer spectra, Spectra of low symmetry complexes, Magneto chemistry.

## **KINETICS AND MECHANISMS OF INORGANIC REACTIONS**

Principles of kinetics. Steady state approximation. Determination of rate law. Inert and labile complexes. Substitution reactions of octahedral, square planer and tetrahedral complexes. Oxidation-reduction reactions of metal ions. Organo-transition metal compounds. Free radical reactions.

## **INORGANIC CHEMISTRY OF BIOLOGICAL PROCESSES**

Development and importance of bio-inorganic chemistry. Introduction to metals of biological importance. Function of metals in enzyme catalysis. Oxygen carriers; nitrogen fixation; vitamin B<sub>6</sub> and B<sub>12</sub>. Importance of metals and non-metals in biological systems. Metal ions and chelating agents for medicinal purposes.

## **NUCLEAR AND RADIOCHEMISTRY**

Fundamentals and applied aspects of Radio activity and nuclear chemistry. Trans-Uranium elements; Natural and artificial radioactivity, nuclear reactions; The structure of the nucleus; nuclear stability and radioactive decay; Types,

characteristics and detection of radio active Particles; laws of radioactive decay; the interaction of radiation with matter including radiological health hazards; Processing of the nuclear materials. Applications of radioisotopes. Nuclear engineering of reactors, reactor accident, fuel cycle and waste disposal.

### **MEDICINAL USES OF TRANSITION METALS / INORGANIC COMPOUNDS**

Role of Micro-nutrient elements in human body; metal bearing enzymes and their functions; adverse effects of excess / deficiency of essential Micro-nutrients. Sulphur phosphorus and Nitrogen containing compounds in biological systems; Use of transition metals and other inorganic compounds in diagnosis and treatment of various diseases.

### **SPECIAL TOPICS IN INORGANIC CHEMISTRY**

Topics under recent investigation and of current interest (the choice will depend upon the interests of the teacher giving this course)

### **BOOKS RECOMMENDED FOR INORGANIC CHEMISTRY**

1. Atkins, P., Jones, L. "Chemical Principles" Freeman and Company (2002)
2. Badar-ud-Din and Ali S. M. "Inorganic Chemistry". Ferozsons Pvt. Ltd.
3. Baig M. M. "Inorganic Chemical Analysis" Kifayat Academy (1974)
4. Basolo F., and Johnson R. C. "Coordination Chemistry: The Chemistry of Metal Complexes" W. A. Benjamin, Inc. (1964)
5. Bassette J., Denney C., Jeffery G. H. and Mendham J. "Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis" English Language Book Society. 4th Edition (1978)
6. Brady, J.E., Holum, J.R. "Chemistry-The Study of Matter and Its Changes" John Wiley and Sons, Inc. (1996)
7. Butler, I.S., Harrod, J.F., "Inorganic Chemistry" The Benjamin/Cummings Publishing Company, Inc., (1989)
8. Cartmell E. and Fowles G. W. A. "Valency and Molecular Structure". 3rd Ed. Adlard and Sons Limited. (1966).
9. Cotton, F. A. and Wilkinson, G. "Advance Inorganic Chemistry", John Wiley & Sons, Inc. 5th Edition, (1988)
10. Cotton, F. A., Wilkinson G., Murillo C.A. and Bockhmann, M. "Advanced Inorganic Chemistry" John Wiley & Sons, Inc. (1999)
11. Cotton, F. A., Wilkinson G., Murillo C.A. and Bockhmann, M. "Basic Inorganic Chemistry" John Wiley & Sons, Inc. 2nd Edition (1987)
12. Cox P. A. "The Elements on Earth: Inorganic Chemistry in the Environment" Oxford University Press. (1995)

13. Das A. K. "A Text Book on Medicinal Aspects of Bio-Inorganic Chemistry" CBS Publishers and Distributors. (1990)
14. Dillard, C.R., Goldberg, D.E., "Chemistry, Reactions, Structure and Properties" Colliers-Macmillan Limited, London (1971)
15. Douglas B. E., McDaniel D. H. and Alexander J. J. "Concepts and Models of Inorganic Chemistry" John Wiley & Sons, Inc. 2nd Edition (1983)
16. Douglas B., McDaniel D. and Alexander J. "Concepts and Models of Inorganic Chemistry" John Wiley & Sons, Inc. 3rd Edition (1994)
17. Ebbing, D.D., "General Chemistry" Houghton Mifflin Company (1996)
18. Fritz J. S., Schenk G. H. "Quantitative Analytical Chemistry" Allyn and Bacon, Inc. 4th Edition (1979)
19. Fritz J. S., Schenk G. H. "Quantitative Analytical Chemistry" Allyn and Bacon, Inc. 4<sup>th</sup> Edition (1979)
20. Gould E. S. "Inorganic Reactions and Structures" Holt, Rinehart and Winston, Inc. Revised Edition (1962)
21. Harrington T. J. and Earnshaw A. "The Chemistry of the Transition Elements". Oxford University Press. (1973).
22. Harris W. E., Kratochvil B. "An Introduction to Chemical Analysis" Saunders College Publishing. Holt-Saunders International Edition (1981)
23. Harvey K. B. and Porter G. B. "Introduction to Inorganic Physical Chemistry" Addison-Wesley Publishing Company, Inc. (1963)
24. Hatch R. C. "Experimental Chemistry" Van Nostrand Reinhold Company (1972)
25. Hay R. W. "Bio-inorganic Chemistry" Ellis Horwood Limited. (1987)
26. Hill J. W. and Petrucci R. H. "General Chemistry" Prentice-Hall, Inc. (1996)
27. Holliday, A.K and Massey, A. G. "Inorganic Chemistry in Non-Aqueous Solvents", Pergamon Press. (1985)
28. Huheey J. E. "Inorganic Chemistry Principles of Structure and Reactivity" Harper and Row Publishers 2nd Edition (1978)
29. Huheey J. E. "Inorganic Chemistry Principles of Structure and Reactivity" Harper and Row Publishers. SI Unit Edition (1975)
30. Jefferey, G.H., J. Bassett, J. Mendham and R. C. Denney, 'Vogel's Textbook of Quantitative Analysis'
31. Kettle S. F. A. "Coordination Compounds" Thomas Nelson & Sons Ltd. (1969)
32. Larsen E. M. "Transitional Elements". W. A. Benjamin, Inc. (1995)
33. Lee J. D. "Concise Inorganic Chemistry" 5<sup>th</sup> Ed. Chapman and Hall. (1996)
34. Lee J. D. "Concise Inorganic Chemistry" Chapman and Hall. 5th Edition (1996)
35. Lippard S. J. and Berg J. M. "Principles of Bioinorganic Chemistry" University Science Books. (1994)
36. Mackay K. M., Mackay R. A. and Henderson W. "Introduction to Modern Inorganic Chemistry". 5<sup>th</sup> Ed. Stanley Thornes (Publishers) Ltd. (1996)

37. Mackay K. M., Mackay R. A. and Henderson W. "Introduction to Modern Inorganic Chemistry" Stanley Thornes (Publishers) Ltd. 5th Edition. (1996)
38. Marr G. and Rockett B. W. "Practical Inorganic Chemistry" Van Nostrand Reinhold Company. (1972)
39. Miessler G. L. and Tarr Donald A. "Inorganic Chemistry". Prentice-Hall International Ed. Prentice-Hall International, Inc. (1991)
40. Moody B. "Comparative Inorganic Chemistry" Routledge, Chapman and Hall, Inc. 3rd Edition (1991)
41. Mortimer C. E. "Chemistry: A Conceptual Approach" D. Van Nostrand Company. 3<sup>rd</sup> Edition (1975)
42. Mortimer C. E. "Chemistry: A Conceptual Approach" D. Van Nostrand Company. 3<sup>rd</sup> Edition (1975)
43. Olmsted, J., Williams, G.M., "Chemistry-The Molecular Science" Mosby-Year Book, Inc. (1994)
44. Pass G. and Sutcliffe H. "Practical Inorganic Chemistry: Preparations, Reactions and Instrumental Methods" Chapman and Hall. 3rd Edition (1985)
45. Pass G. and Sutcliffe H. "Practical Inorganic Chemistry: Preparations, Reactions and Instrumental Methods" Chapman and Hall. 2nd Edition (1974)
46. Purcell, K.F. and Kortz, J.C. "Inorganic Chemistry" W. B. Saunders Company. Holt-Saunders International Editions (1977)
47. Purcell, K.F., Kortz, J.C., "An Introduction to Inorganic Chemistry" Saunders College Publishing (1980)
48. Sharpe, A.G. "Inorganic Chemistry" Longman Group Limited (1992)
49. Shriver, D.F., Atkins P.W. and Langford C. H. "Inorganic Chemistry" Oxford University Press 2nd Edition (1994)
50. Sultana N. and Arayne M. S. "A Text Book of Coordination Chemistry:" B. C. C. & T Press, University of Karachi. (1992)

# Analytical Chemistry

## SCHEME OF STUDIES

In the first year there shall be four courses in each semester. Second year shall be devoted to research specialized study and research seminars only.

### 1<sup>st</sup> Year

#### (Semester-I &II )

(Credits Hours-3 Each)

- Course-I : Laser and Emission Spectroscopy 3 Cr. Hr
- Course –II : Radioanalytical Methods & Quality assurance 3 Cr. Hr
- Course –III: Automation and Thermal Analysis 3 Cr. Hr
- Course –IV: Lab / Theory 3 Cr. Hr

**Total Credit Hours 12**

#### **Semester-II**

(Credits-3 Each)

- Course-V : Environmental Analysis 3 Cr. Hr.
- Course –VI: Electroanalytical Techniques 3 Cr. Hr
- Course –VII : Chromatographic Techniques 3 Cr. Hr
- Course –VII: Lab / Theory 3 Cr. Hr

**Total Credit Hours 12**

### 2<sup>nd</sup> Year

#### **Semester-III-IV**

### 2<sup>nd</sup> Year

#### **Semester-III-IV**

**Seminar-I** (1 Cr. Hr)

**Seminar-II** (1 Cr. Hr)

**Dissertation/Research** (6 Cr. Hr.)

The students shall submit a dissertation/Thesis on the subject of his/her research work.

**(Credits -2)**

- Two seminars are mandatory
- Research Seminar / Report

**(Credits-24)**

- Research

## **DETAIL OF COURSES:**

### **LASER SPECTROSCOPY**

Introduction, principle, laser operation, spontaneous emission, stimulated emission, population inversion, population inversion in two level system, three level system in four level system. Properties of laser light. Types of lasers; nitrogen laser CO<sub>2</sub> laser, ruby laser, dye laser. Uses of lasers. Radiation in absorption fluorescence spectroscopic methods. Applications. Laser induced chemical reactions laser in industrial chemical processes.

### **ADVANCED EMISSION SPECTROSCOPY**

Introduction, principles of plasma emission spectroscopy. The direct current plasma spectroscopy. Inductively coupled plasma. ICP instrumentation. ICP-AES instrumentation, Applications.

### **RADIOANALYTICAL METHODS OF ANALYSIS**

Introduction, determination of the naturally occurring radio elements, determination of artificial radio elements. Trace analysis Isotope dilution analysis, Radiometric and radio release methods, Radio activation analysis. The measurement of radio activity, The laboratory: its origination and working methods.

### **QUALITY ASSURANCE AND QUALITY CONTROL**

Introduction, A Generic approach to quality General Aspects in Analytical Chemistry, Quality Systems in the Analytical Measurements Analytical Quality Control, Assessment of Analytical Quality, Quality assurance and accreditation, Analytical procedures Analyst validation. Good laboratory practices, Supports of Quality Assurance, Costs and Benefits of Analytical Systems.

### **AUTOMATED ANALYTICAL METHODS FOR INDUSTRY**

Introduction. Principles of Automation. Automated instruments, process Control, Automatic instruments. Flow injection Analysis, Microprocessors and Computers.

### **ENVIRONMENTAL ANALYSIS**

Introduction, General principle and Techniques. Soil, sludge, sediment and dust analysis. Analysis of plant Material, Analysis of Atmospheric samples, Analysis of Water determination of toxic organic Chemistry. Analysis of toxic heavy metals. Biological indicators, Echo toxicology.

## **ELECTROANALYTICAL TECHNIQUES**

### a) Polarography and Amperometric Techniques.

Basic principle, Instrumentation including various electrodes, Modes of operations uses in polarography, Applications of polarography in Analytical Chemistry, Basic principle of Amperometric and Instrumentation.

### b) Voltammetric techniques.

Instrumentation, Linear Potential Sweep (DC) Voltammeter, Potential Methods, Phase-Sensitive Alternating current Voltammeter, Stripping Voltammeter, Qualitative and Quantitative aspects of Voltammeter Quantitative

## **ADVANCED CHROMATOGRAPHIC TECHNIQUES -I**

Introduction theory, instrumentation and Applications of High performance Liquid Chromatography. Gas Chromatography-Mass spectrometry and Supercritical. Fluid Chromatography.

## **ADVANCED CHROMATOGRAPHIC TECHNIQUES -II**

Introduction, Theory, instrumentation and applications Ion Chromatography, HPTLC, Flow Injection Analysis and Field flow fractionation.

Note: These papers may be substituted with any of the following courses. Additional courses may also be added, depending on the expert availability:

## **LUMINESCENCE SPECTROSCOPY (FLUORESCENCE AND PHOSPHORESCENCE)**

Atomic and molecular fluorescence spectroscopy basic principle and instrumentation, structural factors, instrumentation for fluorescence and Phosphorescence Measurement, Room temperature Phosphorescence, Comparison of Luminescence and UV-Visible Absorption Methods.

## **THERMAL METHODS OF ANALYSIS**

Introduction Thermogravimetry. Types of thermobalances factors effecting TG curves source of errors, applications DTA and DSC theory instrumentation factor affecting DTA curves, Quantative analysis, applications.

**Note:** These papers may be substituted with any of the following courses subject to the availability of faculty:

1. Advanced GC-MS and LC-MS
2. FTIR and Raman Spectroscopy
3. Forensic Analysis
4. Food Analysis
5. Computational Chemistry
6. X-ray Fluorescence Spectrometry
7. Basic Electronics in Instrumental Analysis
8. Drug Analysis
9. Bio-Analytical Methods
10. Special Topics in Analytical Chemistry

**BOOKS RECOMMENDED FOR ANALYTICAL CHEMISTRY:**

1. A. Pople, W. G. Schneider and H. J. Bernstein, "High Resolution Nuclear Magnetic Resonance," McGraw-Hill Book Co., New York, 1959. (AD/591/P6)
2. A.J. Bard and L.R. Faulkner, "Electrochemical Methods, Fundamentals and Applications", 2nd. Ed., Wiley, N.Y., 2001.
3. Alkemade, C.Th.J., Herrmann, R., Fundamentals of Analytical Flame Spectroscopy, Hilger, Bristol, UK.
4. Ault and G. Dudek, "An Introduction to Proton NMR Spectroscopy," Holden Day, San Francisco, 1976.
5. B.B. Kebbekus, S. Mitra "Environmental Chemical Analysis", Blackie Academic & Professional, New York, NY, 1998.
6. Banwell, C. N. "Fundamentals of Molecular Spectroscopy" 2nd ed.; McGraw-Hill Book Company (U.K.): Maidenhead, U.K., 1972
7. Bernhard Welz "Atomic Absorption Spectroscopy" 2<sup>nd</sup> Ed (1985).
8. Bertin, EP. "Principles and Practice of X-ray Spectrometric Analysis", Plenum Press (1975).
9. BH Vassos and GW Ewing, "Electroanalytical Chemistry", Wiley, New York 1983
10. D. H. Williams and I. Fleming, "Spectroscopic Methods in Organic Chemistry," 4th ed., 1988.
11. D. L. Pavia, G. M. Lampman, G. S. Kriz, Jr., "Introduction to Spectroscopy," W. B. Saunders, 1979.
12. D. W. Mathieson, "Nuclear Magnetic Resonance for Organic Chemistry," Academic Press, London, 1967.
13. L. M. Jackman and S. Sternhell, "Applications of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry," Pergamon Press, Oxford, 1969.



14. D.T. Sawyer, J. L. Roberts, Jr., "Experimental Electrochemistry for Chemists" J. Wiley, New York, 1974.
15. Dahmen EAMF "Electroanalysis" Elsevier, Amsterdam 1986
16. Douglas A. Skoog, F. James Holler, Timothy A. Nieman "Principles of Instrumental Analysis", 5th Edition, , Saunders College Publishing, New York, 1997.
17. E. A. V. Ebsworth, D. W. H. Rankin, S. Craddock, "Structural Methods in Inorganic Chemistry," Blackwell, 1987.
18. Ebdon, E.H. Evans (ed.), A. Fisher and S.J. Hill "An Introduction to Analytical Atomic Spectrometry" Wiley, Chichester, 1998.
19. Edmond De Hoffmann, Vincent Stroobant (Editors) "Mass Spectrometry: Principles and Applications" John Wiley & Sons; 2nd edition 2001.
20. G.D. Christian and J.E. O'Reilley, Allyn and Bacon, "Instrumental Analysis," 2nd edition, Boston 1986.
21. G.W. Ewing "Instrumental Methods of Chemical Analysis, 5th edition, McGraw-Hill, New York 1985.
22. G.W.C. Milner, G. Phillip, "Coulometry in Analytical Chemistry" Pergamon Press, 1967.
23. R.P.W. Scott, Techniques and Practices of Chromatography, Marcel Dekker, 1995.
24. H. A. Liebhafsky, H. G. Pfeiffer, E. H. Winslow, and P. D. Zeman, "X-Rays, Electrons, and Analytical Chemistry -- Spectrochemical Analysis with X-Rays", Wiley-Interscience, N. Y., (1972)
25. H. Budzikewitz, C. Djerassi, and D. H. Williams, "Mass Spectrometry of Organic Compounds," Holden-Day.  
J. R. Chapman, "Practical Organic Mass Spectrometry," Wiley, 1985
26. H. Gunther, "NMR Spectroscopy - An Introduction," John Wiley, 1980.
27. H. H. Jaffé and M. Orchin, "Theory and Applications of Ultraviolet Spectroscopy," Wiley, 1962
28. H. Strobel and W. Heineman, "Chemical Instrumentation: A Systematic Approach", 3rd edition, Wiley, New York 1989.
29. H. Willard, L. Merritt, J. Dean, and F. Settle, "Instrumental Methods of Analysis", 7th edition van Nostrand Co., New York 1992.
30. Harold Gomes Cassidy "Fundamentals of Chromatography" New York, Interscience Publishers, 1957.
31. J. Akitt, "NMR and Chemistry; An Introduction to Nuclear Magnetic Resonance Spectroscopy," Chapman and Hall, London, 1973.
32. J. Heyrovsky and J. Kuta, "Principles of Polarography", Academic Press, 1966.
33. J. R. Dyer, "Applications of Absorption Spectroscopy to Organic Compounds," Prentice-Hall, 1965.
34. J.D. Ingle and S.R. Crouch "Spectrochemical Methods of Analysis" Prentice-Hall, New Jersey 1988

35. J.P.Glusker and K.N.Trueblood , "Crystal Structure Analysis: a primer" , 2nd Ed, Oxford University Press, New York, 1985.
36. L. Ebdon, E.H. Evans (ed.), A. Fisher and S.J. Hill "An Introduction to Analytical Atomic Spectrometry" Wiley, Chichester, 1998.
37. L.H.J. Lajunen "Spectrochemical Analysis by Atomic Absorption and Emission" Royal Society of Chemistry, Cambridge, 1992.
38. Lingane,J.J "Electroanalytical Chemistry", 2 Ed., Interscience, 1970.
39. McLafferty, F. W. "Interpretation of Mass Spectra," 1980.
40. Melvin and Kelvin "Electrophoresis" Analytical Chemistry by Open Learning, Published by John Wiley and Sons.
41. N. Levine, "Molecular Spectroscopy", Wiley (1975).
42. R.M. Silverstein, G.C. Bassler and T.C. Morrill "Spectrometric Identification of Organic Compounds," John Wiley & Sons, New York, 5th Ed. 1991.
43. Reiger, P.H. "Electrochemistry", Prentice Hall N.J, 1987
44. Schomburg, Gerhard "Gas Chromatography-A Practical Course" VCH(1990).
45. Snyder and J. J. Kirkland," Introduction to Modern Liquid Chromatography", Wiley, New York, 2nd ed., 1979.
46. Stock and Rice, Chromatographic methods, Chapman and Hall, 1967
47. Thomspson K.C. Reynold R.J. "Atomic Absorption, Fluorescence and Flame Emission Spectroscopy" 2<sup>nd</sup> Ed. John Wiley and Sons (1978).
48. Wendlandt, Wesley Wm, "Thermal Analysis" Third Edition, Wiley (1986).
49. G. Herzberg, "Molecular Spectra and Molecular Structure. II. Infrared and Raman Spectra of Polyatomic Molecules", Van Nostrand (1945).
50. G. Herzberg, "Molecular Spectra and Molecular Structure. II. Infrared and Raman Spectra of Polyatomic Molecules" Van Nostrand (1945) .
51. G. Herzberg, "Molecular Spectra and Molecular Structure. III. Electronic Spectra of Polyatomic Molecules", Van Nostrand (1967)
52. G. Herzberg, "Molecular Spectra and Molecular Structure. III. Electronic Spectra of Polyatomic Molecules", Van Nostrand (1967)

# Applied Chemistry

## SCHEME OF STUDIES

In the first year there shall be four courses in each semester. Second year shall be devoted to research specialized study and research seminars only.

### 1<sup>st</sup> Year

#### Semester-I

- Paper-I	Steel and Metallurgical Products & Electroplating	3 Cr. Hr.
- Paper -II	Petroleum, Petrochemical and Fuel gases	3 Cr. Hr.
- Paper -III	Rubber, Polymers, Leather and Gelatin	3 Cr. Hr.
- Paper -IV	Lab / Theory	<u>3</u> Cr. Hr.

**Total Credit Hours = 12**

#### **Semester-II**

- Paper –V	Agrochemicals	3 Cr. Hr
- Paper –VI	Paint, Varnish and Allied Industries	3 Cr. Hr
- Paper –VII	Oils, Waxes, Fats and Ghee Industries	3 Cr. Hr
- Paper –VIII	Lab / Theory	3 Cr. Hr

**Total Credit Hours = 12**

In lieu of labs in semester I and II, any two courses from the following list may be offered as Paper IV and Paper VIII.

### 2<sup>nd</sup> Year

#### **Semester-III-IV**

**Seminar-I** (1 Cr. Hr)

**Seminar-II** (1 Cr. Hr)

**Dissertation/Research** (6 Cr. Hr)

The students shall submit a Dissertation/Thesis on the subject of his/her research work.

## **DETAIL OF COURSES:**

### **AGROCHEMICALS**

Introduction to pesticides, herbicides, weedicides, insecticides and fungicides. Specific pesticides for specific vector of diseases for various categories of crops (mainly Pakistani crops, fruits etc ). Manufacture, properties, uses and care in handling. Synthetic pesticides, 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> gen. Micronutrients and plant regulators. Chlorinated, organophosphate, carbamate, parathyroid. Hazards associated with use of Agro-Chemicals and environmental aspects.

### **CORROSION CHEMISTRY**

Introduction to corrosion, corrosion causing substances. Corrosive media, corrosion control, Galvanic protection, Corrosion and Corrosion in industry (Acid basic pickling and other industries) Materials of construction to combat corrosion, special paints and coating, plastics rubber lined equipment fiber glass materials.

### **LUBRICANTS AND WAXES**

Introduction to different types of lubricants and waxes and their origin types of lubricants their physical and chemical properties. Types of waxes their physical and chemical properties. Specific use of lubricants and waxes their role in industrial applications, protections of machinery. Environmental aspect of their use.

### **PAINT VARNISH AND ALLIED INDUSTRIES**

Introduction to surface coating materials; Manufacturing of paints, pigments, varnishes, lacquers, industrial coatings and printing inks and industrial polishes. Process for manufacture of various paints like water based paints, emulsion, mineral oil based paints (enamels). Process for manufacture of varnish, turpentine oil methylated spirit. Paints for industrial applications for handling corrosion and aggressive chemicals. Epoxy paints and coating.

### **RUBBER AND SYNTHETIC POLYMERS**

Historical background, general classification of rubber; Properties and manufacturing of natural rubber, synthetic rubber. Rubber fabrication and rubber compounding. Latex compounds and rubber derivatives.

### **PETROLEUM AND PETRO-CHEMICALS**

**Petroleum:** Historical Background; recovery and constituents of crude oils; Various unit processes involved like fractional distillation; refining, cracking; reforming, isomerization; Polymerization, and alkylation.

**Petrochemicals:** Chemistry and importance of the following petrochemicals: Acetylene; ethylene; propylene, benzene, toluene, xylene and naphthalene. Oxidation halogenation and nitration of petrochemicals of industrial significance.

## **LEATHER AND GELATIN INDUSTRIES**

### **Leather Tanning Industries:**

Introduction, important steps in leather manufacturing, theory of leather tanning, waste disposal and pollution aspects involved in tanning industries. Chemical involved in raw lather and chrome lather manufacture environmental aspects in lather manufatur effluents and their treatment for safe disposal.

## **OILS, FATS AND GHEE INDUSTRIES**

Classification of oils and fats, vegetable oils, essential oils, various methods of extraction of oils, refining and hydrogenation of oils, esterification, Industrial applications of oils in resins, surfactants, lubricants and paints.

## **FERTILIZER INDUSTRIES (AMMONIA, UREA OTHER FERTILIZERS)**

### **Ammonia**

Raw materials, various sources of hydrogen and nitrogen, manufacture of ammonia (Haber's process), its use as fertilizer and other applications.

### **Urea**

Raw materials, manufacture of urea, assimilation in soil.

### **Calcium Fertilizers**

Calcium ammonium nitrate, calcium cyanamide, calcium super phosphate and triple super phosphate.

### **Potash Fertilizers**

Manufacture and use of potash fertilizers.

## **STEEL AND METALLURGICAL PRODUCTS**

### **1. Steel, Metallurgical Products and Electroplating**

#### **a) Steel and Metallurgical Products**

Manufacture of cast iron and steel, wrought iron, formation of alloys, heat treatment of steel, classification of steel, passivity, different theories of rusting of iron and its prevention.

## b) **Electroplating**

Principle of electroplating, purpose of electroplating, different processes involved in electroplating, chrome plating, nickel plating and electroplating of plastics.

c) Ferrous and non ferrous metals and their metallurgy types of furnaces like blast furnaces and electric arc furnaces austenitic and ferritic steel: uses and properties of steels and steel alloys metallurgical processes for alloys manufacture .

## **SUGAR STARCH AND FERMENTATION INDUSTRIES**

Extraction of juice from sugar cane, beetroots purification of juice, clarification, concentration, refining and crystallization. Beet sugar. Glucose and hydrogenated glucose syrups.

Fermentation and products of fermentation molasses production and its industrial application as raw material. Environmental aspects / treatments

## **FOSSIL FUELS AND INDUSTRIAL GASES**

The destructive distillation of coal, coking of coal distillation of coal tar; Liquid Fuels: Hydrogenolysis Natural gas; Coal Gas: Water Gas; Liquefied Petroleum Gases; Gaseous and liquid Nitrogen; Gaseous and solid Carbondioxide; liquid oxygen; argon; acetylene gas.

## **EXPLOSIVES AND PROPELLENTS**

General classification of explosives, characteristics of explosives; Miscellaneous industrial explosives and their uses like pyrotechnics, matches, military explosives. Propellants for rockets.

## **INDUSTRIAL WATER CONDITIONING**

Introduction to water softening and conditioning: use of resins for water softening Deionized / Demineralized water. Chain type DI water equipment. RO water for industrial use. Uses of Demneralized water for boiler operation etc types and classification of resins used.

Water hardness, its measurement and removal, methods used for water softening including ion-exchange, distillation and precipitation. Types of boiler scales. Chemical and mechanical methods to eliminate the scaling.

## **COSMETIC INDUSTRIES**

Introduction to cosmetics, types, classification and uses. Use of waxes synthetic silica, soapstone, leavening agents, colors, solvents emulsifiers stabilizers surface active agents, amyl alcohol, acetone, aerosol etc in manufacture of various cosmetics. Environmental aspects of cosmetics industry. Perfume manufacture, the ingredients involved like deodorized ethanol, concentrates etc.

## **MAN-MADE FIBERS**

Introduction to chemistry of man-made fibers classification chemistry manufacture and properties. Classification of synthetic fibers, chemistry and manufacturing of viscose rayon, true synthetic fibers including nylons and polyester fibers. Finishing processes for 100% cotton fabrics such as singeing, desizing, scouring, mercerizing and bleaching. Nylon its manufacture physical / chemical properties and uses. Acetate fiber, rayon manufacturing producer by product of industry and their utilization a/w safe disposal of effluents. Viscose fiber manufacture properties and uses, by products and their utilization, safe disposal of a effluents. Advantages of viscose fiber over acetate fiber man-made fiber industry in Pakistan and their related problems.

## **SYNTHETIC TEXTILE FIBERS**

Basics of fibers polymers constitution and physical and chemical characterization of fibres. Classification of synthetic fibers, chemistry and manufacturing of viscose rayon, true synthetic fibers including polyamides, polypropylene, polyester, polyurethane and polyacrylonitrile fibers. Identifying fibers by using quick tests like burning and dyeing methods.

## **INDUSTRIAL EFFLUENT ANALYSIS**

Classification of industrial effluents.

Pollution creating substance / media.

Solid liquid and gaseous effluents.

Air / atmospheres pollution.

Noise pollution, levels of pollution and its harmful effects

Analysis of effluents to NEQS parameters

32 parameters for liquid effluents

Gaseous for most common industrial pollutants like SOX, NOX, COX dust particulate matter use of gas analysis, tester tubes for monitoring.

## **BOOKS RECOMMENDED FOR APPLIED CHEMISTRY**

(Latest available editions of the following books are recommended)

1. Chemical Process Industries, Streven & Brink, McGraw Hill
2. Industrial Inorganic Chemistry, Buchel, Moretto & Wodith, Jhon Wiley & Sons.

3. Industrial Organic Chemistry, Weissner & Ape. Verlage Chemie.
4. Text Book of Chemical Technology, Vol. 1 & II. Pndey Vikas Publishing Co. New Dehli
5. Unit Operation in Organic Synthesis, Crooks, McGraw Hill.
6. Industrial Chemistry, Vol. I & II, Arovan Singh, Anmd. Publishers. New Dehli
7. Shreve's Chemical process Industries by G.T. Austin (1975).
8. Unit Operation in Chemical engineering by P.Chattopadhyay
9. Industrial Organic Chemicals by H.A. Witwaff and B.J. Reuben,
10. John Wiley and sons Inc. New York.
11. J. H. Perry, Chemical Engineer's hand book
12. Clerk, Hand Book on Corrosion, 6<sup>th</sup> Edition.
13. Chemical Process Industries, Streven & Brink, McGraw Hill
14. Industrial Inorganic Chemistry, Buchel, Moretto & Wodith, Jhon Wiley & Sons.
15. Industrial Organic Chemistry, Weissner & Ape. Verlage Chemie.
16. Text Book of Chemical Technology, Vol. 1 & II. Pndey Vikas Publishing Co. New Dehli
17. Unit Operation in Organic Synthesis, Crooks, McGraw Hill.
18. Industrial Chemistry, Vol. I & II, Arovan Singh, Anmd. Publishers. New Dehli



# Organic Chemistry

## SCHEME OF STUDIES

In the first year there shall be four courses in each semester. Second year shall be devoted to research specialized study and research seminars only.

### 1<sup>st</sup> Year

#### **Semester-I**

-	Paper-I	Asymmetric Organic Synthesis	3 Cr. Hr.
-	Paper-II	Advanced Stereochemistry	3 Cr. Hr.
-	Paper-III	Advanced Natural Products	3 Cr. Hr.
-	Paper-IV	Lab / Theory	3 Cr. Hr.

**Total Credit Hours = 12**

#### **Semester-II**

-	Paper-IV	Advanced Spectroscopy	3 Cr. Hr.
-	Paper-V	Synthetic Application of named reactions	3 Cr. Hr.
-	Paper-VI	Physico-organic Chemistry and Reaction Mechanism	3 Cr. Hr.
-	Paper-VII	Lab / Theory	3 Cr. Hr.

### 2<sup>nd</sup> Year

#### **Semester-III-IV**

**Seminar-I** (1 Cr. Hr)

**Seminar-II** (1 Cr. Hr)

**Dissertation/Research** (6 Cr. Hr.)

The students shall submit a dissertation/Thesis on the subject of his/her research work.

- |   |                            |           |
|---|----------------------------|-----------|
| - | Two seminars are mandatory |           |
| - | Research Seminar / Report  | 2 Cr. Hr. |
| - | Research                   | 6 Cr. Hr. |

For each specialization, topics may be selected from the disciplines detailed below:

**Note:** These papers may be substituted with any of the following courses. Additional courses may also be added, depending on the expert availability:

1. Organometalics
2. Heterocyclic Chemistry
3. Macro molecules (Bio and synthetic Polymers)
4. Organic Geo Chemistry
5. Theoretical Organic Chemistry
6. Preparative Organic Photochemistry
7. Colour and Dyes-Synthetic and natural
8. Pericyclic Reactions

## **DETAIL OF COURSES:**

### **Modern Trends in Organic Synthesis**

Introduction to retrosynthesis and disconnection approach, synthesis of aromatic compounds. One and two group C-X disconnections. Donor and acceptor synthesis and concepts of "Umpulung". C-C disconnections and disfunctionalized compounds. Devising synthetic schemes for unknown molecules and some natural products.

### **Advanced Stereochemistry**

Configuration and conformation of cyclic molecules: Stereochemistry and conformational analysis of cyclohexane system, six-membered  $sp^2$ -hybridized cyclic systems and six-membered  $sp^2$ -hybridized cyclic systems and six-membered saturated heterocycles. Stereochemistry and conformational effects in small, common and medium rings. Bicyclic and polycyclic fused rings systems. Bridged rings and stereochemical restrictions. Chiroptical properties: Optical Rotatory Dispersion and Circular Dichroism.

### **Physico-organic Chemistry and Reaction Mechanism**

Chemical reactions and energy changes; qualitative aspects of collision. Transition state theories, rates and equilibria; tracer techniques, trapping of intermediates. Interpretation of kinetic data. Correlation of structure with reactivity; Linear free energy relationship, stereochemical and spectroscopic evidences. Study of reaction mechanism of some recent reactions.

## **Chemistry of Isoprenoids**

Introduction to terpene and steroids. Isolation, structure elucidation reactions and biological activity of terpene, bile acids, cholesterol, vitamin D, estrogens, androgens, adrenocortical hormones, cardiac steroids and bufadienolides. Total synthesis of equilenin, cholesterol, oestrone and epiandrosterone.

## **Chemistry of Glycosides**

Glycosides of flavonoids, coumarins and saponins: Isolation, detection and chromatographic separation; acid, alkaline and enzymatic hydrolysis to aglycones; identification of sugar residue. Spectroscopic determination of aglycone and glycoside structures. Derivatization, structural elucidation and biological importance of glycosides.

## **Biosynthesis of Natural Products**

Introduction to biosynthesis. Biosynthesis of fatty acids, polyketides, isoprenoids, amino acids and alkaloids, Metabolites from shikimic acid (ARC1 ARC2 and ARC3 metabolites) and of mixed biosynthetic origin (metabolites derived from acetate and mevalonate,)

## **Chemistry of Organometallic Compounds**

Introduction, nature of bonding,  $\pi$  and  $\sigma$  complexes. Preparation of organometallic compounds. Application of organometallic compounds in organic chemistry for hydrogenation, isomerization, hydrosilylation, polymerization, hydroformylation. Cyclization, carbonylation, olefin metathesis and hydrocyanation.

## **Reactive Intermediates in Organic Chemistry**

Reactive intermediates and transition states; classical and non-classical carbocations, reactions with stereochemical aspects of non-classical carbocations, pericyclic reactions involving carbocations. Carbanions, kinetics and thermodynamic control during generation of carbanions, enolates, stability and reactions, carbanions stabilized by heteroatoms, rearrangements. Carbenes, nitrenes and arynes, generation and reactions; relative stability and stereochemical aspects of reactions.

## **Advanced Heterocyclic Chemistry**

Chemistry of heterocyclic compounds containing oxygen, nitrogen and sulphur with emphasis on their synthesis, reaction, stereochemistry and spectroscopy; fused ring systems involving furan, pyrrole and thiophene, heterocyclic analogues of quinoline, heterocyclic compounds with more than one heteroatom, heterocyclic compounds with a seven membered ring.

## **Advanced Mass Spectrometry**

The mass spectrometer, ionization and ion source, mass analyzers, metastable ion, ion detection and recording. Electron impact and chemical ionization, field ionization, field desorption, fast atom bombardment, plasma desorption, thermospray, electrospray mass spectra. Fragmentation pattern of common functional groups. Structure elucidation using mass spectrometry in conjunction with other spectroscopic techniques.

## **Nuclear Magnetic Resonance in Organic Chemistry**

Theoretical principles. Chemical shift and spin coupling in  $^1\text{H}$  and  $^{13}\text{C}$  nuclei, factors affecting chemical shift and spin coupling in different spin systems. 2D NMR spectroscopy; 2D J-resolved spectroscopy. 2D shift-correlated spectroscopy, NOESY, 2D-NOESY, heteronuclear NOE (HOESY) spectroscopy. Application of NMR to structure determination, stereochemistry and dynamic studies.

## **Organic Photochemistry**

Introduction of photochemistry. Electronic structure of molecules, electronic transitions, radiative and non-radiative processes, energy transfer and sensitization. Hydrogen abstraction, reaction, of carbonyl compounds and olefins, photo-elimination, photo-substitution, photo-oxidation and photo-reduction, non-concerted cycloadditions, dimerization and rearrangements. Applications of photochemistry in organic industrial process.

## **Organic Polymer Chemistry**

Introduction to polymer chemistry. Step-growth polymerization, free radical addition polymerization, ionic polymerization; stereochemistry polymers; polymerization using Ziegler-Natta catalyst. Stereo-regulation and conformation of polymers. Molecular weight determination. Structure-property relation. Reactions of synthetic polymers; polymers degradation and stability with special emphasis on thermal and photo-degradation.

## Pericyclic Reactions

Huckel molecular orbital-and perturbation orbital theories; Frontier orbitals (HOMO-LUMO) concept; orbital symmetry; alternate and non-alternate hydrocarbons, Huckel and Mobious systems, Classes of peicyclic reations: electrocyclic, cycloaddition, sigmatropic and chelotropic reactions and their interpretation through (a) orbital symmetry conservation (b) frontier orbital treatment and (c) Huckel-Mobious approach Applications to organic synthesis.

## Special Topics in Organic Chemistry

Topics under recent investigation and of current interest (the choice will depend upon the interests of the teacher giving this course.)

## New Trends in Synthetic Chemistry :

### Books Recommended

1. Fred W. Bill Meyer "Text Book of Polymer Science", 3<sup>rd</sup> Ed., Johan Wiley & Sons
2. L.H Sperling "Introduction to Physical Polymer Sciences", 2<sup>nd</sup> Ed., John Wiley & Sons
3. Joel R. Fried "Polymer Science & Technology", Prentice Hall, Inc. (1995).
4. G. Odioin "Principles of Polymerization", 2<sup>nd</sup> Ed. John Wiley & Sons
5. Rephael Ikan , "Naturally Occurring Glycosides", John Wiley & Sons
6. Bruce A.A Borm "Introduction to Flavonoids", Harwood Academic publishers Canada (1998).
7. J.B Harborn , "The Flavonodids-Advance in Research" since 1986., Chapman & Hall. London (1994)
8. H.E Duckworth, R.C Barber and V.S Barber and V.S Venkatasubramanian "Mass Spectroscopy", Cambridge University Press, London (1996)
9. E.D.Hoffmann, J. Charette, V. Stroobant "Mass Spectrometry, Principes & Applications", John Wiley & Sons (1996)
10. A. Frigerio "Essential Aspects of Mass Spectrometry", Spectrum Publication, Ine New York (1974)
11. Koji Nakanishi et "Natural Products Chemistry", Vol. I. (1974)
12. I.I Finar "Organic Chemistry", Vol. II, I.I, 5<sup>th</sup> Ed. Longman, London
13. R.O.C Norman "Principles of Organic Synthesis", Blackie Academic & Professional, 3<sup>rd</sup> Ed. (1993)
14. Mann, "Secondary Metabolism", Oxford Science Publication, 2<sup>nd</sup> Ed. (1987)
15. John D. Bu Lock "The Biosynthesis of Natural Products", McGraw-Hill, London (1965).
16. D. Ranganathan and S. Ranganathan "Art in Biosynthesis", Academic Press, New York (1976).

17. F.L Ansari, R. Qureshi and M.L Qureshi "Electrocyclic Reactions – from Fundamentals to Research", Wiley – VCH (1999).
18. T.H Lowry, K.S Richardson "Mechanism and Theory in Organic Chemistry", 3<sup>rd</sup> Edition, Harper and Row Publisher (1987)
19. G.M Lonon "Organic Chemistry", 3<sup>rd</sup> Ed. Addison Weseley London Company (1995)
20. Isaacs "Physical Organic Chemistry", Longman Scientific & Technical (1995)
21. E.A Halevi "Orbital Symmetry and Reaction Mechanism", Springer Verlage (1992)
22. N.S Isaacs "Reactive Intermediates in Organic Chemistry", John Wiley & Sons (1974)
23. M. Jones & R.A Moss "Reactive Intermediates", John Wiley & Sons, New York.
24. A.W parking& R.C Poller "An Introduction to Organometallic Chemistry", McMillan Education Ltd. New York (1987).
25. P. Powell "Principles of Organometallic Chemistry", Chapman, & Hall, New York (1988).
26. H. Friebolin "Basic one and two dimensional NMR Spectroscopy", 2<sup>nd</sup> Enlarged Edition, VCH (1988).
27. G.E Martin and A.S Zektzer "Two Dimensional NMR Methods for Establishing Molecular Connectivity", VCH (1988).
28. W. Voelter "Carbon-13 NMR Spectroscopy", 3<sup>rd</sup> Ed., VCH (1990).
29. Atta-ur-Rahman "Nuclear Manetic Resonsance Spectroscopy",UGC, Islamabad (1989)
30. J.M.G Cowie "Polymer Chemistry & Modern Materials", Billing & Sons Ltd., London.
31. W.Robert,"Organic Chemistry of Synthetic High Polymers", Ler.z. Inrterscience Publishers, New York.
32. J.A Barltrope and J.E Coyle "Principles of Photochemistry", John Wiley & Sons. New York.
33. H. Okabe "Photochemistry of small Molecules", John Wiley & Sons, New York (1978).
34. E. Block "Heteroatom Chemistry",Verlag Gesellchaft, Germany (1989).
35. David T. Davies "Atomic Heterocyclic Chemistry",Oxford Science Publications, England (1991).
36. K. Mislow "Stereochemistry", Publicaiton Benjamin Inc. (1965).
37. E.L Eleil, S.H Wilen and L.N Mander," Stereochemistry of Organic Compounds",John Wiew & Sons (1994).
38. E.L Eliel, S.h Wilen and M.P. Doyle "Basic Organic Stereochemistry", John Wiley & Sons.
39. S.H. Pine, "Organic Chemistry", McGraw Hill,New York (1987).
40. G.M. London, " Organic Chemistry", Addison Wesley, London (1998).

41. R.C. Lanock, "Comperhensive Organic Transformations", 2<sup>nd</sup> Ed. Wiley VCH, New York (1999).
42. J. Clayden, N. Greeve, S. Warren and P. Wothers, "Orgaic Chemistry", Oxford University Press, Oxford(2001).
43. P. Sykes, "A Guide Book in Modern Organic Chemistry", Longman, London( 1982).
44. H. Gunther, " NMR Spectroscopy", Wiley New York( 1972).
45. H.O. House "Modern Synthetic Reactions", Benjamin, California(1972).
46. K.I. Rinehart, "General Oxidation Reaction of Orgainc Compounds",Prentice Hall, New Jersey( 1973).
47. R.M. Silverstein, and G.G. Bassler, "Spectrometric Identification of Organic Compounds",John Wiley & Sons, New York(1998).
48. W.A. Water, "Mechanism of Oxidation Reactions".
49. G.G. Mann and B.C Saunders, " Practical Organic Chemistry", Longman, London (1974).
50. R.I. Shariner, D.Y. Curin, R.C. Fuson and T.C. Moril, " The Systematic Identification of Organic Compounds", 5<sup>th</sup> Ed. Wiley, New York ( 1980).
51. A.I. Vogel, "Elementary Practical Organic Chemistry, Part I,IIand III, Quantitative Organic Analysis", ELBS.
52. A. Braithwaite and F. Y Smith, "Chromatographic Methods", Chapman & London, (1985).
53. B.S. Fumiss, A.J Ilannaford P.W.G Smith and A.R Tatchell "Vogel's Practical Organic Chemistry", Addition Wesley Longman, Harlow, England( 1989).
54. J.Leonard B. Lygo and G. Proctro, " Advanced Practical Organic Chemistry"Chapman, & Hall, London( 1995).
55. H.LClarke and D. Hynes, "A Hand Book of Organic Analysis", Edward Arnold, London( 1995).
56. F.A Carey and R.J Sunderg. "Advanced Organic Chemistry". Part A & B, Pleman Press, New York(1990).
57. F.W. Greene, "Protective Groups in Organic Synthesis". Wiley New York(1981).
58. W. Kemp, "Organic Spectroscopy", Macmillan, London (1991).
59. C.W Hand and H.I. Blewitt, "Acid-Base Chemistry", Macmillan, London (1986).
60. T.W.G Solomons, "Organic Chemistry", Wiley, New York ( 1996).
61. C.W Rees and T.I Gilehrst, Carbenes, Nitrenes Arynes," Nelson, London 1973.
62. N.S Issacs, " Reactive Intermediates in Organic Chemistry", Wiley New York(1975).
63. F.A Carey and R.J Sunberg, "Advanced Organic Chemistry", Part A & B, Plenum Press, New York( 1990).
64. R.I. Morrision and R.N. "Organic Chemistry", Printice Hall, Englewood Glin. New Jersey.

# Physical Chemistry

## SCHEME OF STUDIES

### 1<sup>st</sup> Year

#### Semester – I – II

### 2<sup>nd</sup> Year

#### Semester-III-IV

**Seminar-I** (1 Cr. Hr)

**Seminar-II** (1 Cr. Hr)

**Dissertation/Research** (6 Cr. Hr.)

The students shall submit a dissertation/Thesis on the subject of his/her research work.

#### **Physical Chemistry of High Polymers**

Molecular forces and chemical bonding in polymers, configuration and conformation of polymer chains, theories of polymer solutions; phase separation and fractionation, plasticization, molecular size measurement, spectroscopic analysis, thermal analysis, morphology and order in crystalline polymers, polymer rheology, electrical and magnetic properties of polymers.

#### **Quantum Chemistry**

Angular momentum. Central field problem. Variation and perturbation methods. Many electron atoms, molecules, self-consistent field method. Approximate methods in molecular quantum chemistry. Applications to quantum mechanical systems.

#### **Electrode Processes**

Theories of electron transfer reactions, electron transfer process, electro-analytical techniques, methods for studying homogeneous and heterogeneous electron transfer reactions. semiconductor electrochemistry. Industrial electro-chemistry. Electro-chemical energy conversion systems.

#### **Magnetic Resonance Spectroscopy**

Principles of magnetic resonance. Nuclear magnetic resonance (NMR) spectroscopy. Coupling phenomenon in simple (AX<sub>n</sub>) and complex systems.



Relaxation mechanisms and their applications. Dynamic NMR. Applications in structure elucidation. Electron spin resonance spectroscopy (ESR). Principles and applications to solids and solutions.

### **Advanced Chemical Kinetics**

Potential energy surfaces, statistical and quantum mechanical approaches for the study of unimolecular decomposition rate. Transition state theory and microscopic reversibility temperature effect, heat capacity of activation. Pressure effects and the volume of activation. Applications of transition state theory. Solvent effects, salt effects, kinetic isotope effects. Composite rate constants, isokinetic relationship. Extrakinetic probes of mechanism.

### **Molecular Spectroscopy**

Microwave, infrared and Raman Spectroscopy. Normal coordinate analysis. Electronic spectra of diatomic and simple polyatomic molecules. Molecular symmetry, group theory and applications in chemistry. Applications of spectroscopy in structural chemistry

### **Photochemistry**

Principle of photochemistry. Sources of radiation, actinometry (both physical and chemical), primary and secondary photochemical processes, quantum yields, experimental techniques, photolytic studies of aqueous and non-aqueous systems, effects of radiation on solids. Kinetics, mechanism, energetics of photochemical reactions

### **Surface Chemistry**

Solid-liquid interface. Adsorption from solutions. Gibbs adsorption isotherm. Solid-gas interface, adsorption isotherms. Diffusion limitations and compensation effect. Catalysis, homogeneous and heterogeneous catalysis. Catalytic activity geometric factor in catalysis, supported metal catalysts, catalytic reactors, catalytic preparation techniques. Applied catalysis in steam reforming reaction, methanation reaction, Fisher-Tropsch synthesis, ammonia synthesis processes.

### **Solution Chemistry**

Physicochemical characteristics of solvents. Solute-solvent interaction, solvation of ions, preferential solvation. Thermodynamic properties of solute in pure solvents and mixed solvents. Transport properties of solutions, concept of association constant of ions in solution. Study of solute-solvent-solute interactions by spectroscopic techniques.

### **Advanced Composite Materials**

Definitions and classification, natural composites. Property enhancement by reinforcement and orientation, matrix interface, synthetic fibers, properties and

processing of composites with metallic, ceramic and polymeric matrices, interface reactions, mechanical and thermal properties of composite materials, stress relaxation and creep studies, dynamical mechanical properties, toughening mechanism and mechanical failure in polymeric composites.

### **Statistical Mechanics**

Ensembles, microcanonical, canonical and grand canonical. Average values, fluctuations. Partition functions of diatomic and polyatomic gases. Statistical mechanical treatment of chemical processes and equilibria. Imperfect gases, liquid state, dilute solutions and perfect crystals. Applications of Fermi-Dirac and Bose-Einstein statistics.

### **Solid State and Semiconductors**

Solid state. Metal conductors. Band theory. Semiconductors. Insulators. Work function. Electrochemical Potential and Fermi levels. Superconductivity: Recent theories, preparation and characterization of superconducting ceramics and their electrical and magnetic properties.

### **Colloids and Surfactants**

Liquid interfaces, surface tension and adsorption from solution, insoluble surface monolayer (Langmuir-Blodgett films). Surfactant, detergency, organized molecular assemblies (micelles, vesicles and membranes). Micro and macroemulsions. Colloidal dispersions, coagulation and flocculation. Optical properties of colloids.

### **Nuclear and radiation Chemistry**

Nuclear Chemistry, Principles, sources of nuclear radiation. Nuclear track detectors. Etchants. Kinetics and mechanism of track etching. Nuclear materials. Nuclear techniques. Tracers. Radiation Chemistry, theoretical aspects. Various models. Kinetic studies of radiolytic processes. Dosimetry (physical and chemical). Radiation chemical yields. Dose and dose rate effects on primary and secondary products. Steady state and pulse radiolysis techniques. Radiolytic studies of gaseous, water, aqueous and organic systems. Radiology.

### **Biophysical Chemistry**

Principles of biophysical chemistry; thermodynamic aspect of simple molecules, macro molecules, colloidal particles in solution; biogenetics; association of biopolymers; lipids and biological membranes; nucleic acids and proteins; enzyme kinetics and catalysis; experimental techniques.

### **Physical Aspects of Environment**

Human environment and its resources; resource depletion and environmental pollution. Interaction of pollutants with materials; noxious emissions from

industrial processes, aerosol production. Chemistry of pollutants. Nuclear waste and its management. Kinetic and thermodynamic aspects of atmospheric phenomena. Clean energy for future experimental techniques for environmental monitoring.

### **Theoretical and Computational Chemistry**

Molecular orbital calculations. Essential concepts, semiempirical and Ab-initio methods. Reactivity. Configuration interaction method. Potential energy surfaces. Quantitative structure-activity relationship (QSAR). Molecular mechanics. Energy minimization force field parameterization and conformational analysis. Computer programming and three dimensional graphics using standard packages.

### **Group Theory and its applications in Chemistry**

Symmetry elements and symmetry properties. Group Algebra. Point groups. Classes Symmetry Reducible and irreducible representations character table. Applications of group theory in spectroscopy and molecular orbital theory.

<b>Special Topics in Advanced Physical Chemistry</b>	<b>(3 Cr. Hr.)</b>
<b>Seminar-I</b>	<b>(1 Cr. Hr.)</b>
<b>Seminar-II</b>	<b>(1 Cr. Hr.)</b>
<b>Dissertation/Research</b>	<b>(6 Cr. Hr.)</b>

The student shall submit a dissertation on the subject of his/her research work.

### **Books Recommended:**

1. Anthony, R. W., "Solid State Chemistry and Its Application" Wiley Student Ed., John Wiley and Sons (2004).
2. Arora, A. K. and Tata, B. V. R., "Ordering and Phase Transition in Charged Colloids" V.C .H. (1996).
3. Aziz, F. and Micheal, A. J.R., "Radiation Chemistry Principle and Application", 2<sup>nd</sup> Ed., Jhon Willey and Sons, New York (1987).
4. Bard A., Faulkner, L.R., "Electrochemical Methods: Fundamentals and Applications", John Wiley New York.
5. Becker E.D, "High Resolution NMR: Theory and Chemical Applications", Academic Press (1980).
6. Bill Meyer Jr., "Text Book of Polymer Science" John Wiley And Sons. (1994)
7. Bond, G.C., "Heterogeneous Catalysis" 2<sup>nd</sup> Ed., Clarendon Press Oxford (1987).
8. Burgess John, "Metal Ions in Solution" Chichester Ellis Howard (1978).
9. C.N. Banwell "Fundamentals of Molecular Spectroscopy" Tata McGraw Hill New Delhi (1983)
10. C.P Pople "Electron Spin Resonance" New York John Wiley (1967)
11. Choppins, G.R. and Rayberg J., "Nuclear Chemistry and Application " 1<sup>st</sup> Ed., Pergaman Press, Oxford New York (1989).

12. Cox A. and Camp, T.J., "Introduction of Photochemistry" Mc Graw Hill New York (1971).
13. Davidson, N., "Statistical Mechanics" McGraw Hill New York (1956)
14. Espenson, J. H., "Chemical Kinetics and Reaction Mechanism" 2<sup>nd</sup> Ed., Mc Graw Hill New York (1995).
15. F. Reif , "Statistical Physics-Berkeley Physics Course), New York, McGraw Hill (1965)
16. Fennel, D. Evans, "The Colloidal Domain" Verlag Chemie H., (1994).
17. Fried, J. R. " Polymer Science And Technology" Prentice Hall (1995).
18. Friendler G. and Kennedy, J. W., "Nuclear and Radiochemistry" 3<sup>rd</sup> Ed., John Wiley and Sons, New York (1981).
19. G.M. Barrow " Introduction to Molecular Spectroscopy", McGraw Hill New York (1962)
20. Grant, G. H. and Richard, W.G., 'Computational Chemistry" Oxford Science Publications.
21. Graybal, J.D. "Molecular Spectroscopy". New York McGraw Hill (1988).
22. Heimenzt and Rajagopalan, R., "Principle Of Collides and Surface Chemistry" Marcell Dekker Inc, New York (1997).
23. J.G. Aston and Fritz J.J. "Thermodynamics and Statistical Thermodynamics", New York, John-Wiley (1959)
24. Johns, M.N., "Biochemical Thermodynamics" Elsevier Scientific Publishing Company, Amsterdam- Oxford- New York (1979).
25. Kemp William, "NMR in Chemistry: A Multinuclear Approach". London Mc millan Education (1986).
26. Mahboob Mohammad and Ajmad Mohd., "Principles of Electrode Kinetics" Roohe Printers, Lahore.
27. Martin, R. B., 'Introduction to Biophysical Chemistry" Mc Graw Hill Book Company, New York.
28. Methews, F.L. and Rawlings, R.D., "Composite Materials: Engineering and Science" Chapman and Hall (1994).
29. P.B. Ayscough "Electron Spin Resonance in Chemistry", Methuan & Co. London (1967)
30. Poland, D., "Cooperative equilibrium in Physical Biochemistry". Calderon Press Oxford (1978).
31. Pople J.A "High Resolution Nuclear Magnetic Resonance", McGraw Hill (1959).
32. Rauve "Principles of Polymer Chemistry", 2<sup>nd</sup> Ed. Plenum Publishers N.Y.
33. Richard, P. W., "Principles and Applications of Photochemistry" Oxford University Press (1988).
34. Richard.,G. " Computer Simulations with Mathematics". Springer Verlag Germany (2000).
35. Rosen, M. J., "Surfactant and Interfacial Phenomena" Marcel Dekker Inc., new York (1989).

36. Scifullon, R.S., "Physical Chemistry of Inorganic Polymeric Composite Materials" Ellis Harwood (1992).
37. Shalin R.E., "Polymer Matrix Composites" Chapman and Hall (1995).
38. Spinks , J. W. T., and Woods R. J., " An Introduction to radiation Chemistry" 2<sup>nd</sup> Ed., Jhon Wiley and Sons, New York (1976).
39. Valvert, J.G. and Pitts J.N., "Photochemistry" John Wiley and Sons New York (1966).
40. Wesly W. E. Jr., "Industrial Water Pollution Control" Mc Graw Hill New York (2000).

## RECOMMENDATION

1. In the first two years (4 semesters) of the BS program all Science subjects shall be given equal weightage.
2. Highly qualified preferably Ph.D. degree holders and experienced teachers should be hired on contract in the initial stages for implementation of 4 years BS program.
3. Paper Infrastructure and additional staff should be provided.
4. Development of laboratories for 4 years BS Program: Necessary equipment/glassware/chemicals required for successfully running the BS Program should be provided to the institutions. The necessary instruments are: UV, IR, NMR, MS, Flame Photometer, Atomic Absorption Spectrophotometer, HPLC, Polarimeter, pH- Meter, CHN Analyzer, Conductivity Meter, Dipole Meter, Impedance Analyzer, Polarograph, Potentiostats, working-counter and reference electrodes and Gas Chromatograph be provided to all chemistry departments in colleges/universities. Electronic engineers and technicians be also provided for operation and maintenance.
5. Admission to existing two year B.Sc/M.Sc. program should be phased out.
6. Graduates having 4 years BS degree should be eligible for appointment to Grade-17 jobs. Higher Education Commission should approach Federal and Provincial Governments, Federal Public Service Commission and Provincial Service Commission to treat 4 years BS degree equivalent to existing M. Sc. degree.
7. Internship for students of final year BS program in Industry (Chemical, Pharmaceutical, Textile and Ceramic), Hospitals, and R & D Organizations be encouraged.
8. Training of in-service and pre-service teachers be made compulsory.
9. On hand training on instruments be made compulsory for faculty members.
10. A paper of 100 marks may include the following:

Internal Evaluation	
(Assignment, Quizzes, Tests)	50 Marks
Final Examination	<u>50 Marks</u>
	Total 100 Marks
11. Students taking courses that have a laboratory component should be required to complete a laboratory safety course, prior to engaging themselves in any laboratory course.