

## Syllabus

### SEMESTER-I

#### CHIT-1.1 INORGANIC CHEMISTRY-I

##### UNIT-I

###### Structures and Energetics of Ionic Crystals and Covalent Bonds:

Ionic Bond: Properties of ionic compounds, crystal lattices, closed packed structures, coordination number of an ion, radius ratio rule, structures of crystal lattices- NaCl, CsCl, ZnS and rutile. Lattice energy: Born Lande equation, Born-Haber cycle, uses of Born-Haber type of calculations. Covalent character in ionic bonds, Fajan's rules, hydration energy and solubility of ionic solids.

Covalent Bond: Valence bond theory, resonance, hybridization and energetics of hybridization. VSEPR theory: Deduction of molecular shapes. MOT of homo and heteronuclear molecules and MO treatment for the molecules involving delocalized  $\pi$ -bonding ( $\text{CO}_3^{2-}$ ,  $\text{NO}_3^-$  and  $\text{CO}_2$ ).

Walsh diagrams and Bent's rule.

(12 Hours)

##### UNIT-II

###### Coordination Chemistry:

Coordination numbers 2-10 and their geometries. Crystal field theory of coordination compounds: octahedral, square planar, tetrahedral, trigonal bipyramidal and square pyramidal fields, measurement of  $10 Dq$  and factors affecting it, CFSE, Spectrochemical series and Jahn-Teller effect.

Structural evidences for ligand field splitting: hydration, ligation and lattice energies. Evidences for covalency in M-L bonding. MO theory of coordination compounds: MO energy level diagrams for octahedral and tetrahedral complexes without and with  $\pi$ -bonding.

Electronic Spectra: Spectroscopic ground terms, Orgel diagrams for transition metal complexes ( $T_d$  &  $O_h$ ).

Magnetism: Types, spin moment, spin-orbit coupling.

(12 Hours)

### UNIT-III

#### **Stability of Metal Complexes, Concepts of Acids and Bases and Non-Aqueous Solvents:**

Stability of complexes: Step-wise and overall formation constants, factors affecting stability of metal complexes, determination of stability constants of metal complexes by spectrophotometric and polarographic methods.

Concept of acids and bases: Theories of acids and bases, Bronsted and Lewis acids and bases, Lux-Flood theory, leveling effect of solvents, hardness and softness, HSAB concept and its applications.

Non-aqueous solvents: Classification of solvents, properties of non-aqueous solvents. Reactions in non-aqueous media: Liquid ammonia, anhydrous sulphuric acid, anhydrous HF, liquid sulphur dioxide. Super acids.

**(12 Hours)**

### UNIT-IV

#### **Solid State Chemistry:**

Crystal lattice: Unit Cell, Miller indices and planes, X-ray diffraction method, molecular solids, hydrogen bonding, metallic, covalent and ionic solids; structural classification of binary and tertiary compounds, determination simple structure, spinel and perovskite structures.

Band theory, conductors, semiconductors and insulators, energy bands, intrinsic and extrinsic semiconductors.

Perfect and imperfect crystals, intrinsic and extrinsic defects, point-, line- and plane- defects. Vacancy, Schottky and Frenkel defects.

Schottky and Frenkel defect formation, colour centres, non-stoichiometry.

**(12 Hours)**

**Total 48 Hours**

***Recommended Books:***

1. Inorganic Chemistry–Principles of Structure and Reactivity, 4<sup>th</sup>Edn–J. E. Huheey, E.A. Keiter, R. L. Keiter and O.K. Medhi. Pearson Education (2009).
2. Shriver & Atkins' Inorganic Chemistry, 5<sup>th</sup> Edn–P. Atkins, Tina Overton, J. Rourke, Mark Weller and F. Armstrong.Oxford University Press (2010).
3. Inorganic Chemistry, 2<sup>nd</sup> Edn. Catherine E. Housecroft and A.G. Sharpe, Pearson Prentice Hall (2005).
4. Concise Inorganic Chemistry–J. D. Lee, 5<sup>th</sup> Edn, New Age International (1996).
5. Solid State Chemistry and its Applications–A. R. West, John-Wiley and sons.
6. Solid state Chemistry–N. B. Hannay, Prentice-Hall of India Pvt. Ltd. New Delhi.

**CHI(Pr)–1.5: Lab Course in Inorganic Chemistry**

1. Determination of iron in hematite ore using cerium(IV) solution (0.02M) as the titrant and gravimetric determination of insoluble residue.
2. Determination of calcium and magnesium carbonates in dolomite ore using EDTA titration and gravimetric analysis of insoluble residue.
3. Quantitative analysis of copper-nickel in alloy/mixture:
  - i. Copper volumetrically using  $\text{KIO}_3$
  - ii. Nickel gravimetrically using DMG
4. Determination of lead and tin in a mixture: Analysis of solder using EDTA.
5. Determination of Cr(III) and Fe(III) in a mixture: Kinetic masking.
6. Quantitative determination of iron(III) gravimetrically and calcium(II) volumetrically in a mixture.
7. Determination of iron(II) and nickel (II) in a mixture:
  - i. Iron(II) volumetrically using  $\text{K}_2\text{Cr}_2\text{O}_7$  solution
  - ii. Nickel gravimetrically using DMG solution
8. Quantitative analysis of chloride and iodide in a mixture:

- i. Iodide volumetrically using  $\text{KIO}_3$
- ii. Total halide gravimetrically

9. Preparation of complexes:
- i) Tris (thiourea) copper(I)sulphate monohydrate and
  - ii) Tris (oxalato) aluminate (III)

**Scheme of Examination:**

1. Duration of Examination	: 4 hours
2. Experiment	: 35 marks
3. Viva-voce and Journal	: 05 marks
4. Internal assessment	: 10 marks
Total	: 50 marks

***Recommended Books:***

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc, India.
3. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D
4. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003, Pearson Education Pvt. Ltd., New Delhi.
5. Practical Inorganic Chemistry– G. Pass and H. Sutcliff, Chapman and Hall Ltd (1968)

**CHOT-1.2: ORGANIC CHEMISTRY-I**

**UNIT-I**

**Bonding in Organic Molecules:**

Localized chemical bonding: Hybridization index, bonding in cyclopropane, bond distances, bond angles, bond energies, bond polarity, dipole moment and calculation of heat of reactions.

Delocalised chemical bonding: Conjugation, cross conjugation, steric inhibition of resonance, hyperconjugation, tautomerism, valence tautomerism. Bonding in fullerenes.

Bonding weaker than covalent: Hydrogen bonding, EDA complexes, inclusion compounds, complexes of crown ethers, catenanes and rotaxanes.

Structure and reactivity: Brønsted-Lowry concept of organic acids, conjugate acids and bases, pH, pKa values. Electronic, steric, and solvent effects on their strengths. General and specific acid base catalysis, running scale of acidity. Lewis acids and bases. HSAB concept.

**(12 Hours)**

## UNIT-II

### Organic Reaction Mechanisms:

Classification of organic reactions: Meaning and importance of reaction mechanism. Methods of determination of reaction mechanisms: Kinetic methods, order and molecularity, mechanistic implications from rate laws.

Non-kinetic methods: Product identification, cross over experiments, study of intermediates, isotopic labeling, kinetic isotope effects and stereochemical studies.

Nucleophilic substitutions (aliphatic): Mechanisms of  $S_N2$ ,  $S_N1$  (rearrangements in  $S_N1$  reactions) and  $S_{Ni}$ ,  $S_{RN}1$  pathways. Effects of structure, leaving groups and ambident nucleophiles.

Elimination Reactions:  $E_2$ ,  $E_1$ ,  $E_1CB$  pathways. Stereochemistry, product proportions in dehydration of alcohols, alkyl halides (chiral and achiral), Hoffmann and Saytzeff rules. Substitution v/s elimination and pyrolytic eliminations.

**(12 Hours)**

## UNIT-III

### Stereochemistry and Conformational Analysis:

Elements of symmetry and chirality, optical isomerism, optical activity, specific rotation. molecules with one asymmetric center. Fischer, Wedge and 3D representations, DL and RS systems indicating configuration. Ring compounds, molecules with two chiral centers: Fischer, Saw-Horse, Newmann projections and their transformations.

Enantiomers, diastereomers, epimers, racemization, resolution. Stereochemical correlation. Pseudo-asymmetric compounds.

Geometrical isomerism: E-Z nomenclature, configuration of geometrical isomers and *syn*- & *anti*- isomers.

Conformational analysis: Conformational study of n-Butane, ethylene chlorohydrin, 1,2-dichloroethane, 2-aminoethanol, di- & tri-substituted cyclohexanes and Curtin-Hammett principle.

(12 Hours)

#### UNIT-IV

##### **Aromaticity:**

Aromaticity and Huckel's rule: HMO theory, energy level diagrams, möbius systems, benzenoid and non-benzenoid aromatic compounds. Tropones, tropolones, borazine and azulene.

Heterocyclic Systems: Systems of the type pyrrole, pyridines, pyrilium cation, ferrocene. alternant and non-alternant hydrocarbons. Aromaticity of charged rings (3-8 membered), non aromatic, anti-aromatic and homo aromatic systems.

Physical methods to study aromaticity: X-ray, UV and <sup>1</sup>H-NMR methods.

Ring current as criteria for aromaticity. Annulenes and heteroannulenes [10-18].

(12 Hours)

**Total 48 Hours**

##### ***Books Recommended:***

1. Organic Chemistry-P. Y. Bruice, 7<sup>th</sup> Edition, Pearson Education Pvt. Ltd., New Delhi (2013).
2. Organic Chemistry-S. H. Pine, McGraw-Hill, London (1987).
3. Mechanism and Structure in Organic Chemistry-1965, by E.S. Gould.
4. Organic Chemistry-R. T. Morrison and R.T. Boyd, Prentice Hall, New Delhi (1994).
5. Organic Chemistry-T. W. Graham Solomons, 4<sup>th</sup> Edition, John Wiley and Sons (1988).
6. Organic Chemistry-G. M. Loudon, 4<sup>th</sup> Edition, Oxford University Press, New York (2002).
7. Organic Chemistry Volume-I, II-I. L. Finar, 6<sup>th</sup> Edition, ELBS London (2004).

8. Organic Chemistry–F.A. Carey, 4<sup>th</sup> Edition, McGraw Hill (2000).
9. Advanced Organic Chemistry, Reactions, Mechanism and Structure–J. March, 3<sup>rd</sup> Edition, Wiley Eastern Ltd. (2004).
10. Stereochemistry–Conformation and Mechanism–P. S. Kalsi, Wiley–Eastern Ltd, New Delhi (1992).
11. Guidebook to Mechanism in Organic Chemistry–P. Sykes. Orient Longman, London (2002).
12. Aromaticity–P. J. Garratt, McGraw Hill Book company (1971).

### **CHO(Pr)–1.6 : LAB COURSE IN ORGANIC CHEMISTRY**

#### **Preparation of the following organic compounds:**

1. Benzoic acid and benzyl alcohol from benzaldehyde (Cannizarro reaction).
2. Cyclohexanone from cyclohexanol.
3. Reduction of *p*-nitrobenzaldehyde to *p*-nitrobenzylalcohol.
4. 2,4-Dinitrophenol from chlorobenzene.
5. Benzil from benzaldehyde.
6. *m*-Nitroaniline from nitrobenzene.
7. *m*-Nitro benzoic acid from ethyl benzoate.
8. Benzanilide from benzophenone (Beckmann rearrangement).
9. *p*-Bromoaniline from acetanilide.
10. *p*-Nitroaniline from acetanilide.

#### ***Recommended Books:***

1. Vogel's Textbook of Practical Organic Chemistry Revised–B. S. Furniss, A. J. Hannaford, P.W.G. Smith, A. R. Tatchell, 5<sup>th</sup> Edition, Addison Wesley Longman Limited, UK, 1997.
2. A Hand book of Organic Chemistry–by H. T. Clarke.
3. A Laboratory Manual of Organic Chemistry by B. B. Dey and M. V. Govindachari.
4. Lab Experiments in Organic Chemistry–by Arun Sethi, New Age International Ltd. New Delhi. 2006.

**Scheme of Examination:**

i. Duration of examination	: 04 hours
ii. Experiments	: 35 marks
iii. Viva-Voce & Journal	: 05 marks
iv. Internal assessment	: 10 marks
Total	: 50 marks

**CHPT-13: PHYSICAL CHEMISTRY-I****UNIT-I****Quantum Mechanics:**

Review of classical mechanics: Equation of motion for a particle, Newtonian, Lagrangian and Hamiltonian equations of motion, elementary wave motion. Operators, eigen values and expectation values, commuting operators, linear operator and hermitian operators. Solutions of Schrödinger equations of a free particle, particle in a box problem: in one and three dimensions, degeneracy, reflection and penetration of a particle in a one dimensional box of semi-infinite barrier, a particle in a box of finite walls.

Rigid rotator, derivation of selection rules for transitions in rotating molecule, linear harmonic oscillator, Hermite polynomials. Equation for the hydrogen atom in spherical polar coordinates and an indication of the method of its solution, the quantum numbers and their significance.

Hydrogen-like atoms, properties of the H-atom wave functions. Electronic energy states of H-atom. Many electron systems and the self consistent field method. Electronic configurations in the periodic table. Pauli exclusion principle.

**(12 Hours)**

**UNIT-II****Reaction Kinetics:**

A critical account of collision and transition state theories.

Kinetics and mechanism: Steady state approximation and simple examples relating kinetics to mechanism. Theories of Unimolecular reactions: RRKM theory. Isomerisation of methyl isocyanide. Chain Reactions, examples of chain reactions, general aspects of chain reactions. Chain-length, chain transfer reactions, chain inhibition, kinetics of branching chain reactions and explosion limits.

**(12 Hours)**

### UNIT-III

#### **Thermodynamics:**

Thermodynamic criteria for spontaneous chemical changes. Systems at (i) constant volume and temperature and (ii) constant pressure and temperature (derivation of  $dA \leq 0$  &  $dG \leq 0$ ). Dependence of free energy on pressure and temperature. Standard free energies and their determination. Relation between free energy change and equilibrium constant. Gibbs-Helmholtz equation and their different forms. The pressure dependence of free energy of non-ideal gases and fugacity. Standard state for non-ideal gas. Equilibrium constant for system of non-ideal gases. Lewis and Randall rule. Temperature dependence of free energy and equilibrium constants.

Partial miscibility, activity and activity coefficients of components of solutions, partial molar quantities and their determinations. Gibbs-Duhem equation and the calculation of activity of a component in solutions. Duhem-Margules equation. Ternary systems and phase diagram of ternary systems.

**(12 Hours)**

### UNIT-IV

#### **Polymers:**

Review on basic concepts of polymers and their classifications. Homopolymers, copolymers, terpolymers, addition polymers and condensation polymers with examples. Comparison between addition polymers and condensation polymers. Tacticity with examples of polystyrene and PMMA. Elastomers, difference between elastomer and thermoplastic, approaches to increase processability.

Techniques of free-radical polymerization: Bulk, solution, suspension, emulsion and precipitation polymerization.

Reactions of vinyl polymers: Functional group reactions, ring-forming reactions and block & graft copolymer formation. Crosslinking reactions: peroxide crosslinking, sulphur vulcanization, radiation crosslinking, photo crosslinking, electron beam crosslinking and miscellaneous crosslinking reactions. Polymer degradation: Chemical, thermal and radiation degradations.

(12 Hours)

Total: 48 Hours

***Books Recommended:***

1. Introduction to Quantum Chemistry by A. K. Chandra, Ed. 3, Tata McGraw Hill, New Delhi, 1988.
2. Quantum Chemistry by R. K. Prasad, New Age International Publications, New Delhi, 1997.
3. Quantum Chemistry by Eyring, Walter and Kimball, John-Wiley, New York.
4. Physical Chemistry by G. M. Barrow, McGraw Hill, New York, 1996.
5. Fundamentals of Physical Chemistry by Maron and Lando.
6. Physical Chemistry by P. W. Atkins, ELBS, London, 1990 (Ed. 4).
7. Physical Chemistry by K. Vamulapalli, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
8. Physical Chemistry by Daniels and Alberty, Wiley, New York.
9. Physical Chemistry Through Problems by S. K. Dogra and S. Dogra, Wiley Eastern, New Delhi.
10. A Text Book of Physical Chemistry by Samuel Glasstone, McMillan, London.
11. Atomic Structure and Chemical Bonding by Manas Chanda, Tata McGraw Hill Publishing Co., New Delhi.
12. Chemical Kinetics by K. J. Laidler, Tata McGraw Hill Publishing Co., New Delhi.
13. Kinetics and Reaction Mechanisms by Frost and Pearson, Wiley, New York.
14. Polymer Chemistry: An Introduction, Malcolm P. Stevens, Oxford University Press, 1999.
15. Contemporary Polymer Chemistry, Harry R. Allcock and Frederick W. Lampe, Printice-Hall, 1981.
16. Principles of Polymer Chemistry, P. Bahadur and N. V. Shastri, Narosa Publisher, 2002.
17. Polymer Chemistry: Properties and Applications, Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
18. Text Book of Polymer Chemistry, Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
19. Polymer Science, V. R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age International Publisher, 2001.

**CHP (Pr)–1.7: LAB COURSE IN PHYSICAL CHEMISTRY**

1. General Information and Chemical mathematics: Calibration of glasswares, concentration measures of solutions- concept of normality, molarity, molality and mole fraction, preparation of standard solution.  
Treatment of Experimental data – Errors, type of errors, Accuracy and precision. Mean deviation, standard deviation, significant figures, Methods of average and least squares.
2. Spectrophotometry: To obtain the absorption curve of  $\text{KMnO}_4$  solution on a colorimeter and hence verify Beer–Lamberts law.
3. Potentiometry: Determination of the dissociation constant of dibasic acids (minimum two acids and titration with NaOH)
4. Conductance: Simultaneous estimation of  $\text{H}_2\text{C}_2\text{O}_4$  and HCl in the mixture conductometrically by titrating with NaOH.
5. Distribution law: Studying the distribution of benzoic acid between water and benzene and hence determine the degree of association of benzoic acid in benzene.
6. Viscosity: Determination of viscosity average molecular weight of polystyrene in toluene by Ubbelohde Viscometer

7. Thermochemistry: Determine the relative strength of  $\text{CH}_3\text{COOH}$  and  $\text{ClCH}_2\text{COOH}$  by calorimetric method.
8. Reaction Kinetics: Determination of activation parameters of the reaction of acid hydrolysis of methyl acetate at two different temperatures.
9. Cryoscopy: Determination of cryoscopic constant of benzene and nitrobenzene
10. Refractometry: Analysis of a binary mixture (glycerol and water) by refractive indices measurement.

***Recommended Books:***

1. Practical Physical Chemistry by A. M. James and F. E. Prichard, Longmans, London.
2. Experiments in Physical Chemistry by Shoemaker and Garland, McGraw Hill, New York.
3. Experiments in Physical Chemistry by Daniels, Alberty and Willams, McGraw Hill, New York.
4. Experimental Physical Chemistry by W. G. Palmer, Cambridge University Press, London.
5. Advanced Physico-Chemical experiments by J. Rose. 6. Text Book of Physical Chemistry by S. Glasstone, McGraw Hill, London.
6. Text book of Quantitative Analysis by A. I. Vogel, ELBS, Harlow.
7. Advanced Practical Physical Chemistry by J. B. Yadav, Goel Publishing House.
8. Experimental Physical Chemistry by V. D. Athawale and Parul Mathur, New Age International Publishers.
9. Advanced Physical Chemistry Experiments by Gurtu and Gurtu, Pragati Prakashan Educational Publishers, 3<sup>rd</sup> Edition 2007.

**Scheme of Examination:**

- |                             |            |
|-----------------------------|------------|
| i. Duration of examination: | 04 hours   |
| ii. Experiment              | : 35 marks |
| iii. Viva-Voce & Journal    | : 05 marks |
| iv. Internal assessment     | : 10 marks |
| Total                       | : 50 marks |

## CHAT-1.4: ANALYTICAL CHEMISTRY

### UNIT-I

**Language of Analytical Chemistry, Data Treatment and Gravimetric Analysis:**

Language of analytical chemistry: Definition of analysis, determination, measurement, techniques and methods. Classification of analytical techniques. Selection of an analytical method: Accuracy, precision, sensitivity, selectivity, robustness and ruggedness. Figures of merit of analytical methods: Sensitivity, detection limit and linear dynamic range.

Errors and Treatment of analytical Data: Limitations of analytical methods—Errors: determinate and indeterminate errors, minimization of errors. Statistical treatment of finite samples, measures of central tendency and variability, mean, median, range, standard deviation and variance. Student's t-test, confidence interval of mean. Testing for significance and comparison of two means and two standard deviations.

Comparison of an experimental mean and a true mean. Criteria for the rejection of an observation, Q-test. External standard calibration, the least squares methods, regression equation and correlation coefficient.

Gravimetric analysis: Mechanism of precipitation, factors influencing precipitation, coprecipitation, postprecipitation and organic reagents used in gravimetry (oxime and dmg).

(12 Hours)

## UNIT-II

### **Titrimetric Methods:**

Titrimetric Analysis: Principles of titrimetric analysis. Classification of reactions in titrimetry. Titrations based on acid-base reactions: Titration curves for strong acid and strong base, weak acid and strong base and weak base and strong acid titrations. Titration curves, quantitative applications, selecting and standardizing a titrant, inorganic analysis, alkalinity, acidity and ammonium salts.

Complexometric titrations: Indicators for EDTA titrations, theory of common indicators, titration methods employing EDTA, direct, back and displacement titrations, indirect determinations, titration of mixtures using masking and demasking agents.

Redox Titrations: Balancing redox equations, calculation of the equilibrium constant of redox reactions, titration curves, theory of redox indicators, calculation of standard potentials, determination of chemical oxygen demand (COD) in natural and waste waters.

Precipitation titrations: Titration curves, titrants and standards, indicators for precipitation titrations involving silver nitrate, the Volhard, the Mohr and the Fajan's methods.

(12 Hours)

## UNIT-III

### **Separation Methods-I:**

Fundamentals of chromatography: General description, definition, terms and parameters used in chromatography, classification of chromatographic methods, criteria for selection of stationary and mobile phase and nature of adsorbents.

Column chromatography: Theories, plate theory, rate theory, band broadening-eddy diffusion, longitudinal diffusion and resistance to mass transfer, column efficiency, Van Deemter's equation and its modern version, interrelationships, capacity factor, selectivity factor, column resolution, distribution constant and applications of conventional column chromatography, advantages and limitations.

Thin layer chromatography (TLC): Definition, mechanism, efficiency of TLC plates, methodology, selection of stationary and mobile phases, development, spray reagents, identification and detection, reproducibility of  $R_f$  values, qualitative and quantitative analysis.

High performance liquid chromatography (HPLC): Instrumentation, pumps, column packing, characteristics of liquid chromatographic detectors, UV and fluorescence detectors, advantages and applications.

(12 Hours)

## UNIT-IV

## Separation methods–II

Gas chromatography (GC): Principle, instrumentation, columns, study of detectors, thermal conductivity, flame ionization and mass spectrometry, factors affecting separation, retention volume, retention time and applications.

Ion exchange chromatography (IEC): Definition, principle, requirements for ion-exchange resin, types of ion-exchange resins, resin properties-ion-exchange capacity and its determination, resin selectivity and factors affecting the selectivity, applications of IEC in purification and recovery processes.

Solvent extraction: Nernst partition law, efficiency and selectivity of extraction. Extraction systems: Extraction of covalent neutral molecules, extraction of uncharged metal chelates and synergic extraction, extraction of ion-association complexes-non chelated complexes and chelated complexes. Use of salting out agents. Methods of extraction–batch and continuous extractions. Applications (special emphasis on extraction of iron and copper).

(12 Hours)

**Total: 48 Hours**

### ***Recommended Books:***

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8<sup>th</sup> edition, Saunders College Publishing, New York (2005).
2. Analytical Chemistry, G.D. Christian, 6<sup>th</sup> edition, Wiley–India (2007).
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6<sup>th</sup> edition, PHI Learning Pvt Ltd. New Delhi (2009).
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J. D. Barnes and M. J. K. Thomas, 6<sup>th</sup> edition, Third Indian Reprint, Pearson Education Pvt. Ltd. (2007).
5. Analytical Chemistry Principles, John H. Kennedy, 2<sup>nd</sup> edition, Saunders College Publishing, California (1990).

## CHA(Pr)–1.8: Lab Course in Analytical Chemistry

### I. Organic Chemistry Practical

#### Quantitative analysis

1. Titrimetric Estimation of amino acids.
2. Estimation of glucose by Bertrand's method.
3. Estimation of keto group.
4. Iodine value of oil (Chloramine - T method)
5. Estimation of Nitro group by reduction using SnCl<sub>2</sub>.

#### Qualitative Analysis

Separation of binary mixture of organic compounds using ether and identification of separated compounds by systematic qualitative organic analysis.

Please Note: 1) Individual organic compounds are to be given after the candidate reports the nature of the mixture. 2) Ether insoluble acids and ether insoluble Neutral organic compounds may be given. 3) Low boiling liquids and Amino acids need not be given.

The following mixtures may be given.

1. Acid + Base
2. Acid + Neutral
3. Base + Neutral
4. Phenol + Acid
5. Base + Phenol

## II. Physical Chemistry Practicals

1. Determination of molecular radius of glycerol molecule by viscosity method.
2. Estimation of metal ions of ferric-thiocyanate and cupric-ammonia complexes by spectrophotometrically.
3. Determination of relative strength of acids (HCl and H<sub>2</sub>SO<sub>4</sub>) by studying the hydrolysis of methyl acetate.
4. Determination of dissociation constants of weak monobasic acids potentiometrically by titrating against NaOH.
5. Comparison of strengths of chloroacetic acid and acetic acid using conductometric method.
6. Determine the dissociation constant of acetic acid pH-metrically by titrating against NaOH.

### ***Recommended Books:***

1. Practical Physical Chemistry by A. M. James and F. E. Prichard, Longmans, London.
2. Experiments in Physical Chemistry by Shoemaker and Garland, McGraw Hill, New York.
3. Experiments in Physical Chemistry by Daniels, Alberty and Williams, McGraw Hill, New York.
4. Experimental Physical Chemistry by W. G. Palmer, Cambridge University Press, London.
5. Advanced Physico-Chemical experiments by J. Rose.
6. Text Book of Physical Chemistry by S. Glasstone, McGraw Hill, London.
7. Text book of Quantitative Analysis by A. I. Vogel, ELBS, Harlow.
8. Advanced Practical Physical Chemistry by J. B. Yadav, Goel Publishing House.
9. Experimental Physical Chemistry by V. D. Athawale and Parul Mathur, New Age International Publishers.
10. Advanced Physical Chemistry Experiments by Gurtu and Gurtu, Pragati Prakashan Educational Publishers, 3rd Edition 2007.

### **Scheme of Examination:**

- i. Duration of examination : 04 hours
- ii. Experiment : 35 marks

iii. Viva-Voce & Journal	: 05 marks
iv. Internal assessment	: 10 marks
Total	: 50 marks

**SEMESTER-II**  
**CHIT-2.1: INORGANIC CHEMISTRY-II**

**UNIT-I**

**Chemistry of Non-Transition Elements:**

Alkali and alkaline earth metal complexes of crown ethers, cryptands and calixarenes and their biological importance. Synthesis, properties and structures of boron, carbon and silicon compounds: Chemistry of higher boranes, classification, structures and MO description of bonding, framework electron counting, Wade's rules, chemistry of  $B_5H_9$ ,  $B_{10}H_{14}$  and  $B_nH_n^{2-}$ , boron nitride, borazines, carboranes, metalloboranes, metallocarboranes; silicates, silicones, graphite, graphene, carbon nanotubes and zeolites. Hydrogen bonding and its influence on properties.

**(12 Hours)**

**UNIT-II**

**Chemistry of Main Group Elements:**

Nitrogen, phosphorous and sulphur compounds: Hydrides, oxides and oxy acids of nitrogen, phosphorous, sulphur and halogens. Phosphazines, phosphazene polymers, sulphur-nitrogen compounds: Binary sulphur nitrides:  $S_4N_4$ ,  $S_2N_2$  and  $(SN)_x$ . P-O and P-S cage compounds. Chemistry of halogens and xenon: Interhalogens, pseudohalogens, polyhalide ions, oxyhalogen species. Xenon oxides and fluorides.

**(12 Hours)**

**UNIT-III**

**Symmetry and Group Theory:**

Molecular symmetry, representation of symmetry operation as matrices. Definition of groups, set of symmetry operations of molecules satisfying the condition of point groups. Representation, basis of representation, reducible and irreducible representation. The great orthogonality theorem, character tables. The direct product. Applications of group theory: Molecular vibrations; molecular vibration in symmetrical  $AB_2$ . Hybridisation (tetrahedral and trigonal planar geometries)

**(12 Hours)**

## UNIT-IV

### Organometallic Chemistry:

Organometallic compounds: Introduction, classification of organometallic compounds by bond type, nomenclature, classification of ligands  $\sigma$  and  $\pi$  ligands, hapticity of ligands, 18 and 16 electron rules, electron counting schemes. Ferrocene and ruthenocene: Preparation, structure and bonding. Complexes containing alkene and alkyne ligands: Preparation, structure and bonding. Carbene (Fischer and Schrock type) complexes: Synthesis, structure and bonding. The isolobal principles.

Use of organometallic reagents in hydrogenation, hydroformylation, isomerisation and polymerization reactions.

(12 Hours)

Total: 48 Hours

### *Recommended Books:*

1. Inorganic Chemistry–Principles of Structure and Reactivity, 4<sup>th</sup> Edn–J. E. Huheey, E.A. Keiter, R. L. Keiter and O.K. Medhi. Pearson Education (2009).
2. Shriver & Atkins' Inorganic Chemistry, 5<sup>th</sup> Edn–P. Atkins, Tina Overton, J. Rourke, Mark Weller and F. Armstrong. Oxford University Press (2010)
3. Inorganic Chemistry, 2<sup>nd</sup> Edn. Catherine E. Housecroft and A. G. Sharpe, Pearson Prentice Hall (2005)
4. Concise Inorganic Chemistry–J. D. Lee, 5<sup>th</sup> Edn, New Age International (1996).
5. Chemical Applications of Group Theory, 2<sup>nd</sup> Edn–F. A. Cotton, Wiley Eastern Ltd (1971).
6. Symmetry and Spectroscopy of Molecules–K. Veera Reddy, New Age International, (2011).
7. Group Theory in Chemistry–M. S. Gopinathanan and V. Ramakrishnan, Vishal Publishing Co. (2007)
8. Organometallic Chemistry–A unified Approach, R. C. Mehrotra and A. Singh, 2<sup>nd</sup> Edn. New Age International (2011).
9. F. A. Cotton and G. Wilkinson: Advanced Inorganic Chemistry, Wiley, 1991.
10. Basic Organometallic Chemistry – B. D. Gupta and A. J. Elias, Universities Press (2013)

### CHI(Pr)–2.4: Lab Course in Inorganic Chemistry

1. Semimicro qualitative inorganic analysis of a mixture containing three cations (including one less common cation such as W, Mo, Ti, Zr, Ce, V and Li) and two anions (one of them may or may not be interfering anion such as  $\text{PO}_4^{3-}$ ,  $\text{BO}_3^{3-}$ ,  $\text{C}_2\text{O}_4^{2-}$ ,  $\text{F}^-$  and  $\text{CH}_3\text{COO}^-$ ).

2. Separation and determination of Zn and Mg on an anion exchanger.
3. Demonstration experiment: Determination of iron as the 8-hydroxy quinolate by solvent extraction.

**Scheme of Examination:**

- |                            |            |
|----------------------------|------------|
| 1. Duration of Examination | : 4 hours  |
| 2. Experiment              | : 35 marks |
| 3. Viva-voce and Journal   | : 05 marks |
| 4. Internal assessment     | : 10 marks |
| Total                      | : 50 marks |

**Recommended Books:**

1. Vogel's Text Book of Quantitative Chemical Analysis (5<sup>th</sup> Ed), G. H. Jeffrey, J. Bassette, J. Mendham and R. C. Denny, Longman, 1999.
2. Vogel's Qualitative Inorganic Analysis (7<sup>th</sup> Ed), G. Svehla, Longman (2001)

## CHOT-2.2: ORGANIC CHEMISTRY-II

### UNIT-I

**Reaction Mechanism:**

Aliphatic electrophilic substitutions: Bimolecular pathways.  $S_E2$ ,  $S_E1$  and  $S_Ei$  mechanisms. Reactions involving double bond shifts,  $\alpha$ -halogenation of aldehydes, Ketones, aliphatic diazonium coupling, nitrosation at carbon bearing active hydrogen, mercury exchange reactions.

Aromatic electrophilic substitutions: Mechanisms of aromatic, nitration, sulphonation, halogenation, isotope effects, energy profile diagrams. Kinetic and thermodynamic control, amination and sulphonation, Hammond's Postulate, o/p ratio, ipso-substitution, Vilsmeier Haack, Pechmann and Fries rearrangement.

Aromatic nucleophilic substitutions:  $S_NAr$ ,  $S_N1$  and aryne pathways. Meisenheimer complexes, mechanism and synthetic applications of vicarious nucleophilic substitution (VNS), Von-Richter, Goldberg, Bucherer, Shiemann reactions and Smiles rearrangement.

**(12 Hours)**

## UNIT-II

### Advanced Stereochemistry:

Prochirality: Homotopic, enantiotopic and diastereotopic atoms, groups and faces.

Stereochemical descriptors: Application to reduction of carbonyl compounds, cyanohydrin formation, addition of water to alkenes.

Optical activity due to molecular dissymmetry: Allenes, spiranes, biphenyls, atropisomerism, molecular crowding.

Conformational analysis of cyclohexane, mono substituted and disubstituted (1,2, 1,3, 1,4) cyclohexanes. *cis*- and *trans*-decalins. Chirality of cyclohexanes.

(12 Hours)

## UNIT-III

### Carbohydrates:

Monosaccharides: Conformational representation of monosaccharides and their transformations. Determination of configuration of the monosaccharides, mechanism of mutarotation-base catalyzed isomerisation of aldoses and ketoses. Epimerisation, anomeric effect, glycosides, ether and ester derivatives of carbohydrates. Acetone, amino ( $\beta$ -D-glucosamine, galactosamine, N-acetylmuramic acid (NAMA), N-acetyl neuraminic acid (NANA) and deoxysugars. Oxidation and reduction reactions of carbohydrates.

Disaccharides: Structure elucidation of maltose, lactose, sucrose, gentiobiose and meliobiose.

Trisaccharides: Raffinose and melezitose.

Polysaccharides: Structure and degradation of starch, cellulose and glycogen.

(12 Hours)

## UNIT-IV

Chemistry of heterocycles: Nomenclature of heterocyclic compounds: (i) Hantzsch-Widmann (ii) Replacement Nomenclature

Structure, synthesis, reactivity and chemical reactions of indole, quinoline, isoquinoline, thiazole, imidazole, benzimidazole, coumarin, chromones, flavones and isoflavones.

(12 Hours)

Total 48 hrs

### Recommended Books:

1. Advanced Organic Chemistry part A and B-F. A. Carey and R. J. Sundberg, 4<sup>th</sup> Edition, Plenum Publishers (2000).
2. Advanced Organic Chemistry, Reactions, Mechanism and Structure-J March, 3<sup>rd</sup> Edition, Wiley Eastern Ltd. (2004).
3. Guide Book to Mechanism in Organic chemistry-Peter Sykes Orient- Longman (1985).

4. Stereochemistry of Carbon Compounds–Eliel, Tata McGraw Hill, New Delhi (1976).
5. Stereochemistry of Organic Compounds, Principles and Applications – D. Nasipuri, Wiley Eastern Ltd (1992).
6. Organic Chemistry Vol–I, II, III–S. M. Mukherji, S. P. Singh and R. P. Kapoor, New Age International Ltd, New Delhi (2000).
7. Organic Chemistry Volume–I, II– I. L. Finar, 6<sup>th</sup> Edition, ELBS London (2004).
8. Chemistry of Carbohydrates–G. C. Percival.
9. Carbohydrates –Chemistry and Biochemistry –Pigman and Harton.
10. Heterocyclic Chemistry–T. L. Gilchrist, 3<sup>rd</sup> Edition, Pearson Education Delhi, (2005).
11. Heterocyclic Chemistry –J.A. Joule and G.F. Smith, 2<sup>nd</sup> Edition, Van Nostrand London (1978).
12. Heterocyclic Chemistry–R. K. Bansal, 3<sup>rd</sup> Edition, New–Age Interantional, New Delhi, 2004.
13. [https://profiles.uonbi.ac.ke/sdereese/files/upc\\_213nomenclature\\_of\\_heterocyclic\\_compounds\\_0.pdf](https://profiles.uonbi.ac.ke/sdereese/files/upc_213nomenclature_of_heterocyclic_compounds_0.pdf)

#### **CHO(Pr)–2.5 : Lab Course In Organic Chemistry**

1. Quantitative Estimation of the following Organic compounds: (i) Acid (ii) Acid + Amide (iii) Acid + Ester (iv) Molecular weight determination by base hydrochloride method (v) Phenol (Bromometric method).
2. Preparations of derivatives of heterocycles like coumarins, quinolines, benzimidazoles, benzoxazines, pyrazoles by convention, microwave and by sonication.
3. Preparations based on functional group reactions of organic compounds like aldehydes, ketones, esters, phenols etc.

Note: Any two of the above experiments will be prescribed for the examination.

#### **Scheme of Examination**

i. Duration of examination	: 04 hours
ii. Experiments	: 35 marks
iii. Viva-Voce & Journal	: 05 marks
iv. Internal assessment	: 10 marks
Total	: 50 marks

#### ***Recommended Books:***

1. Vogel's Textbook of Practical Organic Chemistry Revised–B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell, 5<sup>th</sup> Edition, Addison Wesley Longman Limited, UK, 1997.
2. A Hand book of Organic Chemistry–H.T. Clarke.
3. A Laboratory Manual of Organic Chemistry–B. B. Dey and M.V. Govindachari.
4. Lab Experiments in Organic Chemistry–Arun. Sethi, New Age International Ltd. New Delhi. 2006.
5. Experimental Organic Chemistry–L. M. Harwood, and C. J. Moody, Blackwell Scientfic, London, 1989.
6. Practical Organic Chemistry–W. Kemp, McGraw Hill, London, 1967.

## CHT-2.3: PHYSICAL CHEMISTRY-II

### UNIT-I

#### **Microwave Spectroscopy and X-ray Diffraction:**

Microwave spectroscopy: Gaseous microwave spectra and rotational transitions: Study of inversion of ammonia and hindered rotations in molecules. Instrumentation. Stark effect in molecular spectra, first and second order Stark effects.

X-ray diffraction: Origin and production of X-rays, interaction of X-rays with matter: Absorption, scattering and diffraction. Reciprocal lattice: Bragg's law in reciprocal space. Instrumentation: Sources, filters, monochromatic detectors. Crystal structure: Unit cell, lattices, planes and miller indices. Debye-Scherrer powder methods and Weissenberg camera. Numerical problems.

**(12 Hours)**

### UNIT-II

#### **Reaction Kinetics:**

Kinetics in Solution: Effect of solvent, pressure and ionic strength for ion-ion, ion-neutral molecule type reactions and cage effects.

Potential energy surfaces, methods employed in the construct of potential surfaces, calculating reactions.

Fast Reactions: Techniques for fast reactions, flow methods, stopped flow technique, relaxation methods and flash photolysis. Numerical problems.

**(12 Hours)**

### UNIT-III

#### **Electrochemistry:**

Introduction to electrochemistry, Debye-Huckel and Bjerrum models and the corresponding theoretical expression for activity coefficient and Debye-Huckel-Onsager theory of conductance of strong electrolytes.

Electrochemistry of Solution: Activity of ions in solution, solvation number and their determination, ion-solvent interactions, ion-ion interactions and free energy of ions in solution and triple ion formation, conductance minima and free energy of ions in solution. Born model for calculating the free energy of ion-solvent interaction and its modifications. The enthalpy and entropy of ion-solvent interaction.

Electrical double layer: Electrocapilarity, Lippman equation (surface excess), theories of electrical double layer: Helmholtz-Perrin, Gouy-Chapman and Stern theories. Effect of ions on zeta potential. Over potentials, exchange current density, derivation of Butler-volmer equation and Tafel plot.

**(12 Hours)**

## UNIT-IV

### Polymer chemistry:

Transitions in polymers: Definition of glass transition temperature ( $T_g$ ) and flow temperature ( $T_f$ ) and melting temperature ( $T_m$ ), thermal behaviour of amorphous and crystalline polymers, factors affecting the  $T_g$ . Plasticizers, properties and their effect on  $T_g$  of PVC and diethylhexylsuccinate, efficiency of plasticizers, comparison of  $T_g$  and  $T_m$ .  $T_g$  of copolymers and polymer blends, relation between  $T_g$  and  $T_m$ .

Polymer molecular weight: Number average and weight average molecular weights, polydispersity and molecular weight distribution in polymers. Numerical problems on determination of molecular weights.

Kinetics of polymerization: Kinetics of free-radical addition polymerization, cationic polymerization, anionic polymerization, copolymerization and determination of reactivity ratios.

Polymer synthesis: Ziegler-Natta polymerization (isotactic and syndiotactic) and its limitations. Metallocene catalysis polymerization (isotactic). Metathesis polymerization: Acyclic diene metathesis polymerization (ADMET) and ring opening metathesis polymerization (ROMP). Group transfer polymerization (GTP) and advantages of GTP.

(12 Hours)

Total 48 Hours

### *Recommended Books:*

1. Fundamentals of Molecular Spectroscopy by C. N. Banwell, Tata McGraw Hill Publishing Co., New Delhi.
1. An introduction to Molecular Spectroscopy by G. M. Barrow, McGraw Hill, New York.
3. Molecular Spectra and Molecular Structure: I Spectra of Diatomic Molecules by G. Herzberg, Van Nostrand, Princeton.
4. Physical Chemistry by P. W. Atkins, ELBS, London.
5. Physical Chemistry by G. M. Barrow, McGraw Hill, New York.
6. Atomic and Molecular Spectroscopy by M. C. Gupta, New Age International Publishers, New Delhi.
7. Chemical Kinetics by K. J. Laidler, Tata McGraw Hill Publishing Co., New Delhi.
8. Kinetics and Reaction Mechanisms by Frost and Pearson, Wiley, New York.
9. Chemical Kinetics by K. J. Laidler, McGraw Hill, 1950.
10. Kinetics and mechanism of chemical transformations by J. Rajaraman and J. Kuriacose, McMillan.
11. Theory of rate processes by S. Glasstone, K. J. Laidler and H. Eyring, McGraw-Hill, 1941.
12. Theories of Chemical reaction Rates by K. J. Laidler, McGraw-Hill, 1969.

13. Techniques of Organic by Weissberger(ed.), Interscience, Vol.VIII, 1963,
14. Kinetics of Chemical Changes in Solution by E. S. Amis, MacMillan, 1948
15. The Foundations of Chemical Kinetics by S. W. Benson, MacGraw-Hill, 1960.
16. An Introduction to Electrochemistry by S. Glasstone, Van Nostrand, London
17. A Text book of Electrochemistry by G.F.A. Kortum and J.O.M. Bockris, Elsevier, New York.
18. Modern Electrochemistry by J.O.M. Bockris and A.K.N. Reddy Vol. I and Vol. II, Butterworths, London.
19. Polymer Chemistry: An Introduction, Malcolm P. Stevens, Oxford University Press, 1999.
20. Contemporary Polymer Chemistry, Harry R. Allcock and Frederick W. Lampe, Printice-Hall, 1981.
21. Principles of Polymer Chemistry, P. Bahadur and N. V. Shastri, Narosa Publisher, 2002
22. Polymer Chemistry: Properties and Applications, Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
23. Text Book of Polymer Chemistry, Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
24. Polymer Science, V. R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age International Publisher, 2001.

#### **CHP(Pr)–2.6: Lab Course In Physical Chemistry**

1. Solubility: Determine the heat of solution of a solute (e.g oxalic acid or benzoic acid) by solubility method.
2. Coulometric titration: Titration of  $I_2$  against  $Na_2S_2O_3$ .
3. Cryoscopy: Determination of the degree of dissociation of a given strong electrolyte and the determination of the number of ions present in the solute using cryoscopy method.
4. Spectrophotometry: To obtain the absorption spectra of coloured complexes (Ferric-thiocyanate and Cupric–ammonia complexes) and hence verify the Beer–Lambert’s law and estimation of metal ions in solution by spectrophotometry.
5. Conductance: (i) Determination of equivalent conductance of a weak electrolyte at different concentrations and the applicability of Ostwald’s law. (ii) Determination of equivalent conductance of a weak electrolyte from Kohlrausch’s law.
6. Potentiometry: Potentiometric determination of formal redox potential of  $Fe^{2+}/Fe^{3+}$  and  $Ce^{4+}/Ce^{3+}$  or  $Cr^{6+}/Cr^{3+}$  couples by titrating  $Fe^{2+}$  solution with  $Ce^{4+}$  or  $Cr^{6+}$ .
7. Reaction Kinetics: Investigation of autocatalytic reaction between potassium permanganate and oxalic acid in the presence of  $H_2SO_4$ .
8. Viscosity: Determination of limiting viscosity number (Staudinger index) of polystyrene.
9. pH metry: Titration of acetic acid against NaOH and hence determine the acid dissociation constant ( $K_a$ ).

#### ***Recommended Books:***

1. Findlay’s Practical Physical Chemistry, 9th edition, revised by B. P. Levitt, Longman, London.
2. Practical Physical Chemistry by A. M. James and F. E. Prichard, Longman, London.
3. Experiments in Physical Chemistry by Shoemaker and Garland, McGraw Hill, New York.
4. Experiments in Physical Chemistry by Daniels, Alberty and Willams McGraw Hill, New York.
5. Laboratory Physical Chemistry by Oelke/M.A.C.T.L.A.C.
6. Experimental Physical Chemistry by W. G. Palmer, C.U.P., London.
7. Advanced Physico-Chemical Experiments by J. Rose.
8. Text Book of Physical Chemistry by S. Glasstone, Macmillon and Co., London.

9. Text Book of Quantitative Analysis by A. I. Vogel, ELBS, Harlow.
10. Advanced Practical Physical Chemistry by J. B. Yadav. Goel Publishing House.
11. Experimental Physical Chemistry by V. D. Athawale and Parul Mathur, New Age International Publishers.
12. Advanced Physical Chemistry Experiments by Gurtu and Gurtu, Pragati Prakashan Educational Publishers, 3rd Edition, 2007.

**Scheme of Examination:**

- |                            |            |
|----------------------------|------------|
| i. Duration of examination | : 04 hours |
| ii. Experiment             | : 35 marks |
| iii. Viva-Voce & Journal   | : 05 marks |
| iv. Internal assessment    | : 10 marks |
| Total                      | : 50 marks |

**CHEIT 2.1: APPLIED INORGANIC CHEMISTRY (ELECTIVE)**

**UNIT-I**

**Data Analysis:**

Types of errors, accuracy and precision, methods of minimization of systematic errors, mean and standard deviation, distribution of random errors, reliability of results, comparison of results-Student t-test, F-test and chi-square test, significant figures, confidence intervals, method of least squares, calibration curve and standard addition method.

**(12 Hours)**

**UNIT-II**

**Thermal Methods of Analysis and Inorganic Polymers:**

Thermal methods of analysis: Thermobalance, factors influencing thermogravimetric results, differential thermal analysis: Instrumentation for differential thermal analysis (DTA) and differential scanning calorimetry (DSC). Applications of TG, DTA and DSC.

Inorganic Polymers: Silicones, polyphosphazenes, synthesis, structure and applications.

**(12 Hours)**

**UNIT-III**

**Bioinorganic Chemistry:**

Metal ions in biological systems, deficiency of trace metal ions (Fe, Zn, Cu and Mn), metal ions and chelating agents in medicine: Treatment of toxicity due to inorganics (chelation therapy) and metal complexes as therapeutic agents. Proteins and their functions: Heme proteins, oxygen uptake proteins-hemoglobin and myoglobin,

**(12 Hours)**

#### UNIT-IV

##### **Chromatography:**

Gas chromatography: Principles, instrumentation, stationary phases and types of carrier gases used in GC. Methods of sample injection, types of detectors, programmed temperature GC, plate and plate height theory in GC. Applications of GC and use of GC-MS in detection of samples.

**(12 Hours)**

**Total 48 hours**

##### ***Recommended Books:***

1. Vogel's Textbook of Quantitative Analysis. 6<sup>th</sup> Edition–J. Mendham, R. C. Denney, J. D. Branes and MJK Thomas. Publisher: Pearson Education.
2. Contemporary polymer Chemistry, Third edition–H. R. Allcock, F. W. Campe and J. E. Mark, Publisher: Pearson Education.
3. Inorganic Chemistry, 4<sup>th</sup> edn–J. E Huheey, R. L. Keiter and A. L. Keiter, Addison Wesley, 2000.
4. Inorganic Chemistry of Biological Processes, 2<sup>nd</sup> edn. –M. N. Hughes, Wiley, 1988.
5. Bioinorganic Chemistry–I. Bertini. H. B. Gray, S. J. Lippard and J. S. Valentine, Viva Books, 1998.
6. Bioinorganic Chemistry–A.K. Das, Books and Allied (P) Ltd, 2007.
7. Principles of Instrumental Analysis-Skoog, Holler and Nieman, Harcourt Afca, 2001.
8. Vogel's Text Book of Quantitative Inorganic Analysis., 4<sup>th</sup> Edn. –J. Bessett, R. C. Denney, G. H. Jeffery and J. Mendham, Longman Green and Company Ltd.
9. Quantitative Chemical Analysis, 6<sup>th</sup> Edn-D. C. Harris, W. H. Freeman and Company, New York, 2003.

#### III SEMESTER

#### CHIT-3.1: ADVANCED INORGANIC AND BIOINORGANIC CHEMISTRY

## UNIT-I

### Electronic spectra and magnetic properties:

Spectral properties of complexes: Term symbols for  $d^n$  ions, spectroscopic ground states, selection rules, nature of spectral bands- band shapes, band intensities, band widths, spin-orbit coupling, Orgel diagrams, Tanabe-Sugano diagrams, Racah parameters, interpretation of spectra of octahedral, distorted octahedral, tetrahedral and square planar complexes, determination of  $10Dq$ ,  $B'$  and nephelauxetic parameter from absorption spectra of octahedral and tetrahedral complexes, charge transfer bands: Origin, types, and characteristics, intervalence charge-transfer bands.

Magnetism: Determination of magnetic susceptibility (Gouy and Faraday methods), diamagnetic corrections, orbital contribution, ferro-ferri- and anti-ferro magnetism, Curie law, Curie-Weiss law, effect of temperature on dia-, para-, ferro- and anti-ferromagnetic compounds, temperature independent paramagnetism, effect of spin orbit coupling on spectral and magnetic properties and spin cross-over systems.

(12 Hours)

## UNIT -II

### Inorganic reaction mechanisms

Basic principles, lability, inertness, substitution reactions of octahedral complexes. Nature of substitution reactions: Theoretical approach to substitution mechanisms, mechanism of substitution reaction of complexes of cobalt: Acid hydrolysis and base hydrolysis of  $Co(III)$  complexes, substitution reactions of square planar complexes, reaction of  $Pt(II)$  complexes, trans-effect, theories of trans-effect, mechanism and kinetics of substitution of  $Pt(II)$  complexes. Electron tunneling hypothesis: Marcus-Hush theory, atom transfer reaction, one- and two-electron transfer. Inner sphere and outer sphere mechanisms.

(12 Hours)

## UNIT-III

### Bioinorganic chemistry-I

Metal ions in biological systems, essential and trace metals, disease due to metal deficiency and treatment: Iron, zinc, copper, manganese, sodium, potassium, magnesium and calcium. Metal complexes as therapeutic agents: Metal complexes in cancer therapy, metal complexes for the treatment of rheumatoid arthritis, vanadium in diabetes, metal complexes as radio diagnostic agents. Treatment of toxicity due to inorganics: Chelation therapy and requirements of a chelate/antidote. Mechanism of antidotes with poison rendering it inert: Arsenic, lead, mercury, iron, copper, plutonium, cyanide and carbon monoxide poisoning.

Ion transport across membranes and active transport of ions across biological membranes, ionophores.

Metal complexes in transmission of energy: Chlorophyll, photosystems-I and II in cleavage of water and model systems.

(12 Hours)

#### UNIT-IV

##### Bioinorganic chemistry-II

Transport and storage of dioxygen, heme proteins, oxygen uptake, functions of haemoglobin, myoglobin, hemerythrin and hemocyanins, synthetic oxygen carriers. Metal storage and transport: Ferritin, transferrin and ceruloplasmin. Electron transfer proteins: Cytochromes, iron-sulphur proteins. Metalloproteins as enzymes: Carboxy peptidase, carbonic anhydrase, catalases, peroxidases, cytochrome P-450, cytochrome c-oxidase, superoxide dismutase, copper oxidases and vitamin B<sub>12</sub> coenzyme.

Biological nitrogen fixation, in *vivo*- and in *vitro*- nitrogen fixation.

(12 Hours)

Total: 48 Hours

##### ***Recommended Books:***

1. Inorganic Chemistry-Principles of Structure and Reactivity, 4<sup>th</sup>Edn-J. E. Huheey, E.A. Keiter, R. L. Keiter and O.K. Medhi. Pearson Education (2009).
2. Shriver & Atkins' Inorganic Chemistry, 5<sup>th</sup> Edn-P. Atkins, Tina Overton, J. Rourke, Mark Weller and F.Armstrong.Oxford University Press (2010)
3. Electronic absorption Spectroscopy and Related Techniques-D. N. Satyanarayana, OUP, 2001.
4. Concepts and models of Inorganic Chemistry-B.Douglas, D. McDaniel & J.Alexander, 3<sup>rd</sup> Edn. Wiley Student Edn. (2013).
5. Elements of Magnetochemistry-R. L. Dutta and A Syamal : Affiliated East-West, 1993.
6. Inorganic Chemistry of Biological Processes, (2<sup>nd</sup> edn.)-M. N. Hughes, Wiley, 1988.
7. Bioinorganic Chemistry-Asim K. Das, Books and Allied (P) Ltd, (2007).
8. Principles of Bioinorganic Chemistry-S. J. Lippard and J. M. Berga. Panima Publishing Corporation.

#### CHI(Pr)-3.4: LAB COURSE IN INORGANIC CHEMISTRY

##### I. Preparation of selected coordination compounds

1. Bis(glycinato)copper(II) complex: cis-and trans-forms.
2. Co(DMG)<sub>2</sub> model for Vit B<sub>12</sub> and reactions.
3. Hexaamminecobalt(III) chloride
4. Mercuric phenyl acetate
5. Pentaamminechloridocobalt(III) chloride.

6. Preparation of nitro- and nitrito-complexes. (examples for linkage isomers)
7. Separation of optical isomers of cis-[Co(en)<sub>2</sub>Cl<sub>2</sub>]Cl.
8. Tris(thiourea)copper(I) sulphate monohydrate.
9. Hexaamminenickel(II) chloride.
10. Mercury tetrathiocyanatocobaltate(II).
11. Tris(acetylacetonato)manganese(III).
12. Trans and cis-potassium dioxalatodiaquochromate(III).
13. N, N-bis(salicylaldehyde)ethylenediaminecopper(II).

## II. Characterization

1. Elemental analysis.
2. N<sub>2</sub> analysis by Kjeldahl's method.
3. Metal ion determination in above complexes.
4. Anion determination in above complexes.
5. IR, Electronic, NMR, Magnetic and CV studies wherever possible.
6. Interpretation of UV-VIS, IR and NMR spectra.

### Scheme of Examination

- |                                    |            |
|------------------------------------|------------|
| 1. Duration of Examination         | : 4 hours  |
| 2. Interpretation of given spectra | : 10 marks |
| 3. Experiment                      | : 25 marks |
| 4. Viva-voce and Journal           | : 05 marks |
| 5. Internal assessment             | : 10 marks |
| Total                              | : 50 marks |

### *Recommended Books:*

1. Vogel's Text Book of Quantitative Inorganic Analysis-J. Basett, R. C. Denney, H. Jeffery and J. Mendham, Longmans, Green and company Ltd.
2. Practical Inorganic Chemistry-G. Pass and H. Sutcliffe, Chapman and Hall Ltd. (1968).
3. General Chemistry Experiments-A. J. Elias, University Press.

## CHIT-3.2: MOLECULAR SPECTROSCOPY

### UNIT-I

#### Introduction and Vibrational Spectroscopy:

Basic concepts and Introduction: Properties of electromagnetic radiation, Wave property: Interference and diffraction. Particle property: Photoelectric effect. Regions of the electromagnetic spectrum, energies corresponding to various kinds of radiation. Interaction of electromagnetic radiation with matter (absorption, emission, transmission, reflection, dispersion, polarisation and scattering). General application.

2

### Hours

Vibrational spectroscopy: Infrared spectroscopy: Vibrational energy levels, infrared spectra of diatomic and polyatomic molecules, normal modes of vibration, force constant, selection rules, anharmonicity, the vibration-rotation spectroscopy. Infrared spectra of simple molecules and coordination compounds, changes in infrared spectra of donor molecules upon coordination (N,N-dimethylacetamide, urea, DMSO, pyridine N-oxide, ammine, cyano, cyanato and thiocyanato complexes), mono and multinuclear carbonyl complexes, nitrosyls, phosphine and arsine complexes. Change in spectra accompanying change in symmetry upon coordination ( $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_2^-$ , and  $\text{ClO}_4^-$ ), hydrogen bonding. Instrumentation including FTIR.

Raman spectroscopy: Theory, relation with IR spectroscopy, resonance Raman stimulated hyper and inverse Raman effects. Experimental techniques, structure determination from IR and Raman spectra.

(12 Hours)

## UNIT-II

### Magnetic Resonance spectroscopy-I:

Nuclear magnetic resonance spectroscopy: Magnetic properties of nuclei, population of energy levels, the Larmor precession, relaxation processes, chemical shift, shielding mechanism, spin-spin interactions, rules governing the interpretation of first order spectra, effect of chemical exchange on spectra. Analysis of complex NMR spectra,  $^1\text{H}$ -NMR spectra of organic molecules and complex metal ligands. Spin-systems: First order and second order patterns. Long range coupling: Spin decoupling, CIDNP and NOE. NMR shift reagents. NMR studies of nuclei other than proton,  $^{13}\text{C}$ -NMR (including heteronuclear coupling with other nuclei viz.,  $^{19}\text{F}$  and  $^{31}\text{P}$ ): Broad band and off resonance, decoupling methods, use of  $^{13}\text{C}$ -NMR in structural determination of organic and inorganic molecules.  $^{19}\text{F}$ ,  $^{31}\text{P}$ ,  $^{11}\text{B}$ ,  $^{15}\text{N}$ . Spectra of paramagnetic complexes, contact shift, double resonance technique. Instrumentation including FT-NMR. Correlation NMR spectroscopy:  $^1\text{H}$ - $^1\text{H}$  (COSY) and  $^{13}\text{C}$ - $^1\text{H}$  (HETEROCOSY) methods.

(12 Hours)

## UNIT-III

### Magnetic Resonance spectroscopy-II and Mössbauer Spectroscopy:

Electron Paramagnetic Resonance (EPR) Spectroscopy: Basic principles, selection rules, intensity, width, position of spectral line, multiplet structure of EPR spectra, hyperfine interaction, spin-orbit coupling, zero-field splitting and Kramer's degeneracy, rules for interpreting spectra, factors affecting the magnitude of values. Instrumentation. Applications to the study of free radicals, coordination compounds, biological studies and rate of electron exchange reactions.

Nuclear Quadrupole Resonance (NQR) Spectroscopy: Quadrupole nuclei, quadrupole moment, electric field gradient, the NQR experiment, structural information from NQR spectra.

Mössbauer Spectroscopy: Introduction, principles, conditions for Mössbauer spectroscopy, parameters from Mössbauer spectra, isomer shifts, electric quadrupole interaction, magnetic interactions, Mössbauer spectrometer. Applications in structure determination of  $\text{Fe}_3(\text{CO})_{12}$ , Prussian blue, oxyhemerythrin, hexacyanoferrates, nitroprusside, tin halides.

**(12 Hours)**

### UNIT-III

#### **Electronic Spectroscopy and Mass Spectrometry:**

Electronic spectroscopy: Molecular electronic absorption spectroscopy (UV-Visible), electronic spectra of diatomic molecules, electronic transitions, selection rules, assignment of transition, band intensities, substituent and solvent effect and charge transfer transitions. Application to organic and inorganic molecules.

Photoelectron spectroscopy: Basic principles: Photo-electric effect, ionisation process, Koopman's theorem. Photoelectron spectra of simple molecules, ESCA and chemical information from ESCA. Instrumentation. Auger electron spectroscopy, basic ideas.

Mass Spectrometry: Ionization and mass analysis. Instrumentation. Methods of ionization: EI, CI, DI, SI methods.

Fragmentation: Principles, odd electron ( $\text{OE}^+$ ) and even electron ( $\text{EE}^+$ ) ions, molecular ion and base peak, nitrogen rule, metastable ions. Isotope effects in chloro and bromo compounds. Fragmentation of inorganic and organic compounds: (i) normal and branched alkanes. (ii) alkenes. (iii) benzene and its derivatives. (iv) alcohols. (v) aldehydes. (vi) ketones. (vii) acids. (viii) esters. (ix) ethers. (x) amines. (xi) nitro compounds. (xii) halo compounds.

**(12 Hours)**

**Total 48 Hours**

#### ***Books Recommended:***

1. Fundamentals of Molecular Spectroscopy - C. N. Banwell.
2. Physical Methods in Chemistry - R. S. Drago, Saunders college.

3. Structural Methods in Inorganic Chemistry - E. A. Ebsworth, D. W. H. Rankin and S. Craddock, ELBS.
4. Infrared Spectra of Inorganic and Coordination Compounds - K. Nakamoto.
5. Infrared Spectroscopy - C.N.R. Rao.
6. Electron Absorption Spectroscopy and Selected Techniques - D. N. Satyanarayana, University Press India Ltd. Hyderabad.
7. Introduction to Spectroscopy – D. L. Pavia, G. M. Lampman and G. S. Kriz, Thomson Learning, Singapore (2001)
8. Spectroscopic Identification of organic compounds – R. M. Silverstein and F. X. Webster, 6<sup>th</sup> Edition, Wiley and Sons, India Ltd. (2006).
9. Interpretation of Mass Spectroscopy–McLafferty.

### CHI(Pr)–3.5: Lab course in Inorganic chemistry

#### Instrumental methods of analysis

1. Colorimetry: (i) Determination of Fe using o-Phenanthroline, (ii) Determination of Zr using Alizarin red S, (iii) Determination of Ti by H<sub>2</sub>O<sub>2</sub> method, (iv) Determination of Mn / Cr / V in steel samples, (v) Job's method for Fe-1,10-phen complex, (vi) Mole ratio method–Zr + Alizarin red-S, (vii) Slope ratio method–Cu + en complex, (viii) Determination of stability constant of (7), (ix) Determination of pK<sub>a</sub> of an indicator (methyl red) in aqueous solution.
2. Conductometry: (Cl<sup>-</sup>, Br<sup>-</sup>, I<sup>-</sup> and SO<sub>4</sub><sup>2-</sup>)
3. Potentiometry: (Halide mixture and Co<sup>2+</sup> vs. ferricyanide)
4. Electrogravimetric analysis (Cu and Ni mixture)
5. Magnetic susceptibility determination

#### Scheme of Examination

	1. Duration of Examination	: 04 hours
	2. Experiment	: 35 marks
	3. Viva-voce and Journal	: 05 marks
	4. Internal assessment	: 10 marks
Total		: 50 marks

#### *Recommended book:*

1. Vogel's Text Book of Quantitative Inorganic Analysis-J. Basett, R. C. Denney, H. Jeffery and J. Mendham, Longmans, Green and company Ltd.

### CHIT–3.3: SELECTED TOPICS IN INORGANIC CHEMISTRY

## UNIT-I

### **Metal Clusters:**

Metal  $\pi$ -acceptor complexes: Metal carbonyls, preparative methods, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, magnetic and X-ray evidences of structures, MO representation of bi- and tri-nuclear carbonyls, reactions of metal carbonyls. Metal carbonylates and carbonyl halides: Preparation and important reactions. Chemistry of metal nitrosyls: Preparation, structure and bonding, dinitrogen and dioxygen complexes. Metal-metal bonding in carbonyls and halides, evidences for M-M bonding, factors favouring M-M bond formation. Metal clusters: Bi-, tri-, tetra-, penta- and hexanuclear metal clusters and bonding in metal clusters.

**(12 Hours)**

## UNIT-II

### **Lanthanides and actinides:**

Correlation of general properties of d-block elements with those of 4f and 5f elements.

Lanthanide series: Introduction, electronic structure, oxidation states, lanthanide contraction, abundance and extraction (solvent extraction and ion-exchange methods), lanthanides as shift reagents, chemical properties of compounds of lanthanides in II, III, and IV oxidation states. Magnetic properties, colour and spectra.

Actinides: Electronic structure and position in the periodic table, oxidation states, occurrence and synthesis of elements. Spectral and magnetic properties of compounds of actinides in comparison with those of lanthanides and d-block elements. Chemistry of separation of Np, Pu & Am from U & fission products. Uranium: Isotope separation/enrichment and chemistry of uranium salts.

**(12 Hours)**

## Unit-III

### **Fuel analysis and agricultural chemistry:**

Fuels: Solid, liquid and gaseous fuels, ultimate and proximate analysis, calorific values, grading of coal. Liquid fuels: Flash point, aniline point, octane number and carbon residues. Gaseous fuels: Producer gas and water gas.

Analysis of soil: Inorganic and organic components of soil, collection and preparation of soil samples for analysis. Measurement of soil moisture, pH, total nitrogen, phosphorous, silica, lime, magnesia, manganese, sulphur and alkali salts.

Fertilizers: Fertilizer industries in India, manufacture of ammonia, ammonium salts, urea, nitrates, phosphates and superphosphates and mixed fertilizers.

(12 Hours)

#### UNIT-IV

##### Photoinorganic chemistry:

Photochemical Reactions: Prompt and delayed reactions, quantum yield, laws of photochemistry, recapitulation of fluorescence and phosphorescence, d-d and charge transfer reactions. Excited states of metal complexes, energy transfer under conditions of weak interaction and strong interaction, exciplex formation. Conditions of the excited states to be useful as redox reactants: Photosubstitution, photooxidation, photoreduction and photochemical reactions of transition metal complexes including  $[\text{Ru}(\text{bipy})_3]^{2+}$  and  $[\text{Fe}(\text{bipy})_3]^{2+}$ . Application to photovoltaics: Water photolysis and carbon dioxide reduction. Solar energy conversion and storage.

(12 Hours)

##### *Recommended Books:*

1. Inorganic Chemistry–Principles of Structure and Reactivity, 4<sup>th</sup> Edn-J. E. Huheey, E.A. Keiter, R. L. Keiter and O.K. Medhi. Pearson Education (2009).
2. Shriver & Atkins' Inorganic Chemistry, 5<sup>th</sup> Edn-P. Atkins, Tina Overton, J. Rourke, Mark Weller and F. Armstrong. Oxford University Press (2010)
3. Concepts and models of Inorganic Chemistry-B. Douglas, D. McDaniel & J. Alexander, 3<sup>rd</sup> Edn. Wiley Student Edn. (2013).
4. Fundamentals of photochemistry–K. K. Rohatgi-Mukherjee, Revised Edn. New Age International.
5. Ferraudi G. L, Elements of Inorganic photochemistry, Wiley Eastern, 1988
6. Photochemistry and Photophysics of Ru (II) polypyridine complexes in the Bologna group. From early studies to recent developments, Coordination chemistry reviews, Vincenzo Balzani, Alberto Juris, 211, 97-115 ((2001).
7. F. A. Cotton and G. Wilkinson: Advanced Inorganic Chemistry, Wiley, 1991.
8. Environmental Chemistry–A. K. De (Wiley Eastern).
9. Environmental Chemistry–S. K. Banerji, ( Prentice Hall India), 1993.

##### CHI(Pr)–3.6: Lab course in Inorganic chemistry

1. Determination of vitamin C in juice/tablet by titrimetric method.
2. Fluorimetric determination of riboflavin (Vit B<sub>2</sub>) in tablets.
3. Determination of iron in pharmaceuticals by visual and potentiometric titration using cerium(IV) sulphate.

4. Determination of sulphha drugs by potentiometry using  $\text{NaNO}_2$  and iodometric assay of penicillin.
5. Assay of aspirin/caffeiene/phenacetin by spectrophoptmetry/titrimetry
6. Determination of vitamin A in vanaspathi by UV spectrophotometry
7. Analysis of a soil sample for (i) Available phosphorus by spectrophotometry, (ii) Nitrate-nitrogen/nitrite nitrogen/ammonia nitrogen by spectrophotometry, (iii) sodium and potassium by flame photometry.
8. Analysis of fertilizers: Urea and super phosphates

**Scheme of Examination**

1. Duration of Examination	: 04 hours
2. Experiment	: 35 marks
3. Viva-voce and Journal	: 05 marks
4. Internal assessment	: 10 marks
Total	: 50 marks

***Recommended Books:***

1. Vogel's Text Book of Quantitative Inorganic Analysis-J. Bassett, R. C. Denney, G. H. Jaffery and J. Mandham, Longmans, Green and Company Ltd.
2. Chemical analysis of foods and food products-Morris B. Jacobs (3rd Edn.), D. Van Nostrand Company. Inc.
3. Standard methods of chemical analysis-F. J. Welcher (6th Edn., Vol. 3 Part-B), D. Van Nostrand Company, Inc. Indian, United States and European Pharmacopea.
4. General Chemistry Experiments-A. J. Elias, University Press.

**CHOT-3.1: ORGANIC SPECTROSCOPY**

**UNIT-I**

**Electronic and Vibrational Spectroscopy:**

Introduction, energy considerations, experimental methods, Beer-Lambert's law, theory and classification of electronic transitions, terminology, substituent and solvent effects.

UV spectral study of alkenes, dienes, polyenes, carbonyl and aromatic compounds. Steric effects, isobestic points, model compounds and charge transfer bands.

Vibrational Spectroscopy: Introduction, experimental methods, units, notation and regions. FT-IR, sampling techniques, complementarity of IR and Raman. Fundamental vibrations, overtones, Fermi resonance, group frequencies, factors affecting group frequencies: Conjugation, inductive, resonance, steric effects. Mechanical coupling, applications of IR in the study of H-bonding, stereoisomerism and tautomerism.

Identification of the following organic compounds by IR: Alkanes, alkenes, alkynes, aromatic compounds, aldehydes, ketones, alcohols, thiols, acids, acid chlorides, amides, amines, esters, halides, nitro compounds, etc.

(12 Hours)

## UNIT-II

### Proton Magnetic Resonance Spectroscopy:

Introduction, magnetic properties of nuclei, resonance condition. Field frequency diagram, precession of nuclei, relaxation. Instrumentation: CW and FT-NMR techniques. Sample handling.

Chemical shift, mechanism of shielding and deshielding in alkanes, alkyl halides, alkenes, aromatic compounds, carbonyl compounds and annulenes. Chemical shifts of different types of organic compounds. Empirical rules.

Equivalence of protons: Chemical and magnetic equivalence. Spin-spin coupling, geminal-vicinal coupling, relative intensities. Karplus equation-Curve. Spin-systems, first order and second order patterns. Long range coupling: Spin decoupling, CIDNP and NOE.

Lanthanide Shift reagents.

Proton attached to elements other than carbon (OH, NH and SH). Exchange phenomena and temperature effects.

(12 Hours)

## UNIT-III

### Multi-Nuclear NMR and Correlation Spectroscopy:

$^{13}\text{C}$ -NMR, broad band and off resonance decoupling methods of detection.

$^{13}\text{C}$ -chemical shifts of different classes of organic compounds: Alkanes, alkyl halides, alkenes, alcohols, ethers, carbonyl compounds and aromatic compounds.

$^{13}\text{C}$ - $^1\text{H}$  coupling DEPT. Introductory aspects of  $^{15}\text{N}$ -,  $^{19}\text{F}$ -,  $^{31}\text{P}$ -,  $^{10}\text{B}$ -,  $^{11}\text{B}$ -NMR.

Correlation NMR Spectroscopy: Theory, pulse sequences. FT-methods.  $^1\text{H}$ - $^1\text{H}$  (COSY) and  $^{13}\text{C}$ - $^1\text{H}$  (HETEROCOSY) methods.

(12 Hours)

## UNIT-IV

### Mass Spectrometry and Composite Problems:

Ionisation and mass analysis. Instrumentation, methods of ionization, EI, CI, DI, SI methods.

Fragmentation: Principles, odd electron ( $\text{OE}^+$ ) and even electron ( $\text{EE}^+$ ) ions, molecular ion and base peak, nitrogen rule, metastable ions.

Isotope effects in chloro and bromo compounds. Stevenson rule. Fragmentation of: (i) normal and branched alkanes. (ii) alkenes (iii) benzene and its derivatives (iv) alcohols (v) aldehydes (vi) ketones (vii) acids (viii) esters (ix) ethers (x) amines (xi) nitro compounds (xii) halo compounds (xiii) peptides. McLafferty and McLafferty + 1 rearrangement. Calculation of molecular formula. Calculation of H-deficiency index.

Composite problems: Applications of UV, IR, NMR and MS methods and chemical reactions in structure elucidation of organic compounds.

(12 Hours)

**Total 48 hours**

***Recommended Books:***

1. Introduction to Spectroscopy – by D. L. Pavia, G. M. Lampman and G. S. Kriz, Saunders Golden Sunburst Series London (2015).
2. Spectroscopic Identification of organic compounds – by R. M. Silverstein and F. X. Webster, 7<sup>th</sup> Edition, Wiley and Sons, India Ltd (2006).
3. Organic Spectroscopy – by William Kemp, 3<sup>rd</sup> Edition, Palgrave publishers, (2008).
4. Organic Structural Spectroscopy – by J. B. Lambert, H. F. Shurvell, D. A. Lightner, R. G. Cooks, Prentice Hall Publishers, Jersey (1998).
5. Organic Spectroscopy – by D. W. Brown, A. J. Floyd and M. Sainsbury, John Wiley and Sons.
6. Applications of Absorption Spectroscopy of Organic Compounds – by J.R Dyer, Prentice Hall Publishers, New Delhi (1969).
7. Interpretation of Mass Spectroscopy – by F. W. McLafferty and F. Turecek, 4<sup>th</sup> Edition, University Science Books, 1993.
8. Spectroscopy of Organic Compounds – by P. S. Kalsi, 4<sup>th</sup> Edition, New Delhi (2007).
9. Organic Spectroscopy – by Jag Mohan (Narosa Publishing House) 2001.

**CHO(Pr)–3.4: LAB COURSE IN ORGANIC CHEMISTRY**

Identification of the nature, bulk separation, purification and qualitative analysis (using ether) of the binary mixture of the following classes: Acids, bases, phenols and neutral compounds (without derivatives).

***Recommended Books:***

1. Vogel's Textbook of Practical Organic Chemistry Revised by B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell, 5<sup>th</sup> Edition, Addison Wesley Longman Limited, UK, 1997.
2. A Hand book of Organic Chemistry by H. T. Clarke.
3. A Laboratory Manual of Organic Chemistry by B. B. Dey and M. V. Govindachari.
4. Lab Experiments in Organic Chemistry by Arun Sethi, New Age International Ltd. New Delhi. 2006.

**Scheme of Examination**

Duration of examination : 04 hours  
Experiments : 35 marks

Journal and Viva	: 05 marks
Internal Assessment	: 10 marks
Total	: 50 marks

## CHOT-3.2: STEREOCHEMISTRY AND REACTION MECHANISM

### UNIT-I

#### Dynamic Stereochemistry:

Stereoselectivity in organic synthesis, stereospecific and stereoselective reaction, principle of stereoselectivity, stereoselectivity in addition, elimination and substitution reaction.

Asymmetric Synthesis: Chiral pool synthesis, enantioselectivity and diastereoselectivity in acyclic system, addition of nucleophiles to carbonyl group, Cram's rule and Prelog's rule for diastereoselection.

1,2-Addition predictions: Various outcomes using predictive models such as Cram chelate and Felkin-Anh.

Chiral Auxiliaries: Chiral auxiliaries in aldol condensations and Diels-Alder reaction. Oxazolidinones and chiral sulphoxides.

Chiral Reagents: Isopinocampheylboranes, BINOL and DIBAL.

Chiral Catalysts: Calculation of enantiomeric excess, asymmetric epoxidation-Sharpless and Jacobsen Katsuki asymmetric epoxidation, epoxidation using dioxiranes.

Stereochemistry of catalytic hydrogenation: Metal (Pd, Pt, Ni) catalyzed hydrogenation, diimide reduction, rhodium and Ruthenium catalysts with chiral phosphine ligands like (R)-PROPHOS, (R)-BINAP and (R, R)-DIOP. Asymmetric transformations, stereochemistry of carbene and nitrene addition.

**(12 Hours)**

### UNIT-II

#### Stereochemistry of Compounds other than Carbon:

Stereochemistry of nitrogen compounds: Quaternary ammonium salts, amines, tertiary amine oxides, oximes, determination of configuration of aldoximes and ketoximes, stereochemistry of compounds (cyclic and acyclic) containing nitrogen.

Stereochemistry of Phosphorus compounds, arsenic, sulphur compounds and silicon compounds.

**(12 Hours)**

### UNIT-III

#### Reaction Mechanism-I:

Nucleophilic substitution at allylic and trigonal carbon atom, Tsuji-Trost reaction. Neighbouring group participation: Definition, participation of  $\sigma$ ,  $\pi$  cyclopropane aromatic rings in nucleophilic substitution reaction. Nucleophilic substitution at silicon.

Addition Reactions: Electrophilic addition across alkenes, *cis-* and *trans*-alkenes and dienes. Addition of nitrogen, oxygen and sulphur nucleophiles across carbonyl compounds.

(12 Hours)

### UNIT-IV

#### Reactive Intermediates and Activating agents

Reactive Intermediates: Formation, structure, stability and reactions of the following reactive intermediates: Carbocations (classical and non-classical), carbanions, carbenes (identification by  $^1\text{H}$  NMR and  $^{13}\text{C}$  NMR), carbenoids, free radicals (ESR of organic free radicals), nitrenes, ylides, Wittig and Tebbe olefination, enamines and Stork enamine reactions.

Applications of the following in organic synthesis: Acetyl chloride, antimony pentachloride, borontrifluoride etherate, copper (I) trifluoromethane sulphonate, ethylaluminium dichloride, lithium halides and lithium perchlorides.

(12 Hours)

Total: 48 Hours

#### *Recommended Books:*

1. Stereochemistry of Organic compounds – Eliel, Tata McGraw Hill (2009).
2. Stereochemistry, Conformation and Mechanism – P. S. Kalsi, 6<sup>th</sup> Edition, New Age International Ltd. (2006).
3. Stereochemistry of Organic Compounds, Principles and Applications– D. Nasipuri, Wiley Eastern Ltd. (2018).
4. Advanced Organic Chemistry part A and B –F.A. Carey and R. J. Sundberg, 4<sup>th</sup> Edition, Plenum Publishers, (2000).
5. Advanced Organic Chemistry, Reactions, Mechanism and Structure – J March, 7<sup>th</sup> Edition, Wiley Eastern Ltd. (2015).
6. Mechanism and Theory in Organic Chemistry –T. A. Lowry and K. S. Richardson, 3<sup>rd</sup> Edition, Addison-Wesley, UK (1998).
7. Organic Chemistry Volume-I, II and III –S. M. Mukherji, S. P. Singh and R. P. Kapoor New Age International Ltd (2000).
8. Organic Reaction Mechanism – by R. K. Bansal, 3<sup>rd</sup> Edition, Tata McGraw Hill (2006).
9. Advanced Organic Chemistry – R. Buckner, HAP Publishers, Sandiego, USA (2002)
10. Reactive Intermediates in Organic Chemistry – N. S. Isaacs, John Wiley and Sons, (1974).

11. Handbook of Reagents in organic syhtesis: Activating agents and protecting groups-A J Pearson and W.R. Roush, John-Wily and sons, New York,

### **CHO(Pr)-3.5: LAB COURSE IN ORGANIC CHEMISTRY**

1. Applications of computers in structure, stereochemistry, mechanism and conformational studies of organic compounds.
2. Chromatographic techniques: TLC and column chromatography.  
Preparation of derivatives.

#### ***Recommended Books:***

1. Applications of Computers in Chemistry.-Raman
2. Computers and Their Applications to Chemistry-Ramesh Kumari, Narosa Publishing House (2002)
3. Vogel's Textbook of Practical Organic Chemistry Revised - B.S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, 5<sup>th</sup> Edition, Addison Wesley Longman Limited, UK, 1997.
4. A Hand book of Organic Chemistry-H. T. Clarke.
5. A Laboratory Manual of Organic Chemistry - B. B. Dey and M.V. Govindachari.
6. Lab Experiments in Organic Chemistry – by Arun Sethi, New Age International Ltd. New Delhi. 2006.

#### **Scheme of Examination**

Duration of examination	: 04 hours
Experiments	: 35 marks
Journal and Viva	: 05 marks
Internal Assessment	: 10 marks
Total	: 50 marks

### **CHOT-3.3: CHEMISTRY OF NATURAL PRODUCTS**

#### **UNIT-I**

##### **Steroids and Steroidal Hormones:**

Structure, synthesis, stereochemistry and spectral features of cholesterol and ergosterol.

Steroidal Hormones: Estrogenic hormones-estrone, androgenic hormones-androsterone, corpus luteum hormones-progesterone.Transformations in steroids and hormones.

**(12 Hours)**

## UNIT-II

### Plant Products:

Structure, synthesis, stereochemistry and spectral properties (wherever applicable) of the following:

Alkaloids: Papaverine, reserpine, morphine, lysergic acid, physostigmine, yohimbine. Photochemical synthesis of nuciferene, corydaline and tylophorine.

Terpenoids:  $\alpha$ -Cadeine, zingiberene,  $\alpha$ -Pinene, gibberillic acid, camphor, caryophyllene, abietic acid and farnesol.

(12 Hours)

## UNIT-III

### Prostaglandins and Lipids:

Prostaglandins: Introduction, nomenclature, classification and biological role of prostaglandins. Structure elucidation and stereochemistry of PGE<sub>1</sub>. Synthesis of prostaglandins by Corey and Stork routes.

Lipids: Sphingolipids, phospholipids, cyanolipids and glycolipids, naturally occurring fatty acids and their triglycerides, essential fatty acids, unusual fatty acids, methods of isolation: Gunstone's partition method. Reactions of fatty acids: Fischer- and trans-esterification, oxidation, hydrogenation, margarine and acyl group transfer reactions. Analytical values: Cetane number. Applications of GC, IR, <sup>1</sup>H-NMR, <sup>13</sup>C-NMR and MS techniques in the study of their structures.

Emulsions and biodiesel.

Oleochemicals and their applications in the synthesis of heterocycles.

(12 Hours)

## UNIT-IV

### Biomolecules:

Structure and synthesis of nucleosides and nucleotides. Methods of formation of internucleotide bonds. Polynucleotides, structure, formation and hydrolysis products of DNA and RNA. Role of nucleic acids in protein synthesis. Genetic code.

Peptide bond formation, structure and stereochemistry.

Peptide linkage, primary structure of peptides. C-terminal amino acid determination (hydrazinolysis), N-terminal amino acid determination. Edman's and Sanger's method. Application of dansyl chloride, partial hydrolysis of peptides. Mass spectra of peptides.

Synthesis of Peptides: Oxytocin, glutathione, Merrifield Solid phase peptide synthesis. Structure of proteins.

Reaction and mechanism of biochemical reactions associated with thiamine pyrophosphate, pyridoxal phosphate, Vit B<sub>12</sub>, flavin and NADH.

(12 Hours)

***Recommended Books:***

1. Steroids – Fieser and Fieser's Reagents for Organic Synthesis, Volumes 1-28.
2. Organic Chemistry Volume-I, II – I. L. Finar, 6<sup>th</sup> Edition, ELBS London (2004).
3. Advanced Organic Chemistry Part A and B –F.A. Carey and R. J. Sundberg, 4<sup>th</sup> Edition, Plenum Publishers (2000).
4. The Alkaloids Volume II, IV– K. W. Bentley.
5. The Chemistry of Alkaloids –S. W. Pelletier.
6. Terpenoids Volume I and II – P. De Mayo.
7. Prostaglandins –A. Mitra.
8. Industrial Oil and Products Volume I–A. Baileys
9. Introduction to the Chemistry and Biochemistry of fatty acids and their Glycerides–F.D. Gunstone, Chapman and Hall, London (1980).
10. Introduction to Nucleic acids–Harber, Domagle and Muller.

**CHO(Pr )–3.6: LAB COURSE IN ORGANIC CHEMISTRY**

**Isolation, Characterization of Natural products:**

1. Cysteine from human hair.
2. Hesperidine from orange peel.
3. Caffeine from tea leaves.
4. Myristine from nutmeg.
5. Piperine form black pepper.
6. Azaleic acid from castor oil.
7. Lycopene from tomato.

***Recommended Books:***

1. Unitized Experiments in Organic Chemistry- Brewester and McEveen
2. Vogel's Textbook of Practical Organic Chemistry Revised -B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell, 5<sup>th</sup> Edition, Addison Wesley Longman Limited, UK, 1997.
3. A Hand book of Organic Chemistry –H. T. Clarke.
4. A Laboratory Manual of Organic Chemistry - B. B. Dey and M.V. Govindachari.
5. Lab Experiments in Organic Chemistry –Arun. Sethi, New Age International Ltd. New Delhi. 2006.
6. Natural products, A Laboratory Guide – R. Ikan Academic Press, London 1969.
7. Chemistry of Natural Products, S. V. Bhat, B. A. Nagasampagi, M. Sivakumar, Narosa Publishers, 2010.

**Scheme of Examination**

Duration of examination	: 04 hours
Experiments	: 35 marks
Journal and Viva	: 05 marks
Internal Assessment	: 10 marks
Total	: 50 marks

**CHPT-3.1: QUANTUM MECHANICS, DIFFRACTION & GROUP THEORY****UNIT-I****Quantum Mechanics:**

Equation for hydrogen atom and its solutions, separation of variables, the  $\phi$ ,  $\theta$  and radial equations, the problems of spherical symmetry.

Approximate methods in quantum mechanics: variation method and variation theorem, linear variation functions, secular equations and secular determinants. Application of variation method to hydrogen molecule ion, hydrogen molecule and normal helium atom.

Perturbation theory (first order and non-degenerate), application of perturbation theory to the helium atom.

**(12 Hours)**

**UNIT-II****Atomic Structure and Atomic Spectra:**

A summary of the hydrogen spectrum. Alkali spectra and alkali like spectra, spark spectra and arc spectra. Moseley lines.

Helium and alkaline earth spectra. Multiplet structure of line spectra. Doublet structure of alkali spectra and compound doublets, triplets and singlets of alkaline earths and helium, prohibition of intercombinations. Multiplicities and term symbols.

Space Quantization: Zeeman effect, normal and anomalous Zeeman effects, Paschen-Back effect and Stark effect.

**(12 Hours)**

**UNIT-III****Symmetry Properties of Molecules and Group Theory:**

Introduction to symmetry, molecular symmetry, symmetry elements, symmetry operations and matrix method in symmetry. Molecular point groups: point groups identification of point groups, construction of group multiplication tables, symmetry species and point group character tables.

Reducible and irreducible representations, properties of irreducible representation, Mulliken symbolism rules for irreducible representation, structure of character tables, the standard reduction formula and the great orthogonality theorem. Normal mode analysis: number of normal modes of vibrational symmetry types, infrared and Raman activity, Rule of mutual exclusion.

**(12 Hours)**

#### UNIT-IV

##### **Diffraction Studies:**

X-ray diffraction: Reciprocal lattice, indexing of single crystal rotation photographs, determination of molecular parameters, the structure factor calculations, Fourier series and phase problems. Refinements of Fourier procedures and general concept of solution of structures.

Neutron diffraction: Neutron diffraction and differences from X-ray diffraction.

Electron diffraction: Theoretical principles, structure analysis: visual comparison of intensities, radial distribution function and its refinements. The rotating sector method.

**(12 Hours)**

**Total 48 Hours**

##### ***Recommended Books:***

1. Quantum Mechanics–L.T.Schiff, Prentice–Hall.
2. Quantum Chemistry–H. Eyring, J. Walter and G. E. Kimball, John Wiley.
3. Quantum Mechanics–An Introduction–H. L. Strauss, Prentice Hall of India.
4. Quantum Mechanics–L. Pauling and E.B.Wilson, McGraw Hill.
5. Contemporary Quantum Chemistry–J. Goodisman, Plenum/Rosetta.
6. Quantum Chemistry–K. S. Pitzer, Prentice-Hall
7. Introductory Quantum Mechanics–Valdimir Rojanstry.
8. Quantum Chemistry–John P.Lowe.
9. Quantum Chemistry –Ira N. Levine, Prentice Hall of India Pvt. Ltd.
10. Quantum Chemistry–Donald A. McQuarrie, Viva Book Pvt. Ltd.
11. Physical Chemistry–P.W. Atkins, Clarendon Press, Oxford, 1970.
12. Molecular Quantum Mechanics–P.W.Atkins, Clarendon Press, Oxford, 1970.
13. Introduction to Quantum Chemistry–J. M. Anderson.
14. Introduction to Quantum Mechanics–R. H. Dicke, J. P. Wittke.
15. Introductory Quantum Chemistry–A. K. Chandra, Tata McGraw Hill, New Delhi 1994.
16. Quantum Mechanics in Chemistry–M.W. Hanna.
17. Quantum Chemistry–R. K. Prasad, New Age International Publishers, New Delhi.
18. Atomic Spectra and Atomic structure–G. Herzberg, Van Nostrand
19. Chemical Applications of Group Theory–F.A.Cotton, Wiley Eastern, New Delhi

20. Molecular Symmetry–D.S.Schonlnd, Van Nostrand Comp.London,1965
21. Symmetry in Chemistry–Jeffe and Orchin, Wiley Inter Science, NewYork.
22. Symmetry, Orbitals and Spectra–Jeffe and Orchin, -Jeffe and Orchin, Wiley Inter Science, New York, 1971.
23. Electron Diffraction–T.B. Rymer, Methuen, London,1970
24. Neutron Diffraction–G.E.Becon
25. Symmetry in Molecules–J.M.Hollar
26. X-Ray Crystallography–Buerger
27. Diffraction Methods–Wernard
28. Chemical Crystallography–L.W.Bunn. N.Y.and Oxford,1945
29. Crystals and X–Rays K.landsdale, N.Y.1945
30. Crystal Structure Analysis–M.J.Berger, John Wiley and Sons, N.Y.1960
31. The Determination of Molecular Structure–P.J.Wheatley, Clarendon, Oxford,1960
32. Physical Chemistry–G.M.Barrow, McGraw Hill, New York, 1991
33. X-ray Diffraction–D.B.Cullity, Mass Addison, Wesley, 1978.

#### **CHP(Pr)–3.4: LAB COURSE IN PHYSICAL CHEMISTRY**

1. Viscosity: Determination of number average molecular weight by hydroxyl end group analysis.
2. Conductance: Verification of the Debye-Huckel-Onsagr equation for strong electrolytes.
3. Reaction Kinetics: Studying the acid catalysed kinetics of oxidation of glycene by Chloramine-T (CAT) and hence determination of order of reaction w.r.t. CAT and glycene and hence overall order of the reaction.
4. Potentiometry: Potentiometric estimation of a mixture of a halide, (KCl, KBr and KI) by titrating against  $\text{AgNO}_3$
5. Cryoscopy: Determination of the molecular weight of the given solute by the vacuum flask method.
6. pH metry: Determine the acid and base dissociation constant of an amino acid and hence find its isoelectric point
7. Refractometry: Analysis of a binary mixture (glycerol and water) by refractive indices measurement.
8. Spectrophotometry: Individual and simultaneous estimation of Fe(III) and Cu(II) spectrophotometrically by titrating against EDTA.
9. X-Ray diffraction: To determine the lattice constant and Bravais lattice using X-ray diffraction pattern.
10. Zeeman effect: Study the Zeeman effect and determine  $e/m$  ratio of electron.

#### ***Books Recommended:***

1. Findlay's Practical Physical Chemistry, 9th edition, revised by B. P. Levitt.
2. Practical Physical Chemistry by A. M. James and F. E. Prichard
3. Experiments in Physical Chemistry by Shoemaker and Garland
4. Experiments in Physical Chemistry by Daniels, Alberty and Williams et.al.

4. Laboratory Physical Chemistry by Oelke/ M.A.C.T.L.A.C.
5. Experimental Physical Chemistry by W.G. Palamer
6. Advanced Physico-chemical experiments by J. Rose
7. Experimental Physical Chemistry by V. D. Athwale and Paul Mathur, New Age International Publishers.
8. Text book of Physical Chemistry by S. Glasstone
9. Text book of quantitative analysis by A. I. Vogel
10. Advanced Practical Physical Chemistry by J. B. Yadhav, Goel Publishing house, Meerut.

**Scheme of Examination:**

- |                            |            |
|----------------------------|------------|
| i. Duration of examination | : 04 hours |
| ii. Experiment             | : 35 marks |
| iii. Viva-Voce & Journal   | : 05 marks |
| iv. Internal assessment    | : 10 marks |
| Total                      | : 50 marks |

## CHPT-3.2: SPECTROSCOPY & VOLTAMMETRY

### UNIT-I

**Rotational and Vibrational Spectroscopy:**

Rotation of polyatomic molecules: classification of molecules, momental ellipsoid, energy levels of linear, symmetric, spherical and asymmetric top molecules and their symmetry properties. Selection rules. Thermal distribution of rotational energy levels. Infrared rotational spectra and non rigid rotor treatment.

Vibration of molecules: Molecule as harmonic oscillator, vibrational eigen functions and eigen values. Hermite polynomials, calculation of transition of probabilities and selection rules. The anharmonic oscillator, energy levels, selection rules and IR spectra. Anharmonicity and Morse equations.

Rotation-vibration spectra of polyatomic molecules: Rotation - vibration spectra, shapes of absorption bands in case of (i) linear, (ii) symmetric top, (iii) spherical top and (iv) asymmetric top, molecules. Isotopic effects. Applications of IR spectroscopy. Numerical problems on IR spectroscopy.

**(12 Hours)**

## UNIT-II

### **Nuclear Magnetic Resonance-I:**

Magnetic properties of nuclei: concept of nuclear spin, interaction between spin and external magnetic field, energies and energy levels of nuclear spin states, population of energy levels. Larmor precession, relaxation processes and relaxation times, theoretical principles underlying NMR, experimental set up and instrumentation: continuous wave and pulsed Fourier transform technique in NMR.

Concept of chemical shift, shielding and deshielding mechanisms, diamagnetic-anisotropy, ring currents.

Spin-spin coupling, coupling constants and rules governing the interpretation of first order  $^1\text{H}$ -NMR spectra and elucidation of structure. Kinetic applications.

**(12 Hours)**

## UNIT-III

### **Magnetic Resonance Spectroscopy-II and Optical Spectroscopy**

Nuclear quadrupole resonance spectroscopy: Theory and instrumentation, effect of magnetic field on the spectra, relationship between electric field gradients and molecular structure. Applications. The interpretation of eQq data, effect of crystal lattices on the magnitude of eQq. Structural information from NQR spectra.

Electron spin resonance spectroscopy: Introduction and theoretical principles. Intensity, frequency, position and representation of ESR absorptions. Hyperfine structure of ESR absorptions. Zero field splitting and Kramer's degeneracy. Instrumentation. Applications to the study of free radicals and compounds with unpaired electrons: ESR spectra of hydrogen and nitrogen atoms, semi-quinone ion, naphthalene negative ion, methyl radical and methyl substituted radicals. Measurements of distribution of unpaired electron density in radicals. Study of coordination compounds by ESR technique.

Optical rotatory dispersion and circular dichroism: Simple theoretical account and instrumentation. Treatment of data, applications to gross structure determination, octant rule, determination of stereochemistry and absolute configuration.

**(12 Hours)**

## UNIT-IV

### **Voltammetry:**

Voltammetry: Principles, and instrumentation, voltammetric techniques: Linear sweep voltammetry, staircase and square wave voltammetry, anodic stripping voltammetry, cathodic stripping voltammetry, cyclic voltammetry, normal and differential pulse voltammetry and their theoretical aspects, electrodes, cells and their set-up. Electron transfer (ET) or charge transfer process: reversible ET, irreversible ET, quasi reversible ET and their diagnostic tests. Applications of voltammetric techniques.

Polarography: Principles, dropping mercury electrode (DME), instrumentation, linear scan polarography, polarography currents, polarograms. Diffusion current at dropping electrodes, residual currents, advantages and disadvantages of dropping mercury electrode, current-sampled polarography, half wave potentials. Pulse polarography. Applications.

**(12 Hours)**

***Recommended Books:***

1. Introduction to Molecular Spectroscopy–G.M.Barrow, McGraw Hill
2. Physical Methods in Inorganic Chemistry-R. S. Drago East-West Press, New Delhi.
3. Molecular Spectroscopy–J D. Graybeal. McGraw Hill
4. Spectroscopy, Volume I,II,III Ed–B.P. Straughan and S. Walker Chapman Gall, 1976.
5. Molecular Magnetic Resonance Spectroscopy–R.M.L.Bell and R.K. Harris
6. Spectra of Diatomic Molecules, G. Hertzberg-D. Van Norstrand Co. Inc. Prenceton N.J. 1950
7. Infrared and Raman Spectra of Polyatomic molecules–G.Hertzberg, D. Van Norstrand Co.Inc. Prenceton N.J. 1950
8. Absorption Spectroscopy–R.P.Bauman.
9. Molecular' Structure : A Physical Approach–J.C.D. Brand and J.C. Speakaman, Edward Arnold Ltd., London.
10. Microwave Spectroscopy–J.M. Sugden and C.N. Kenny.
11. Fundamentals of Molecular Spectroscopy–C. N.Banwell, Tata- Mcgraw Hill, New Delhi, 1975.
12. Microwave Spectroscopy–D. Gordy, W.V.Smith and R.F.Trambarulo, John Wiley and Sons, N.Y. 1969.
13. Molecular Vibrations–E.B.Wilson, J.C. Decius and P.G.Cross.
14. Nuclear Magnetic Resonance–E.R.Andrew, Chambridge University Press, Cambridge, 1955.
15. Nulcear Magentic Resonance–J.D. Roberts, McGraw Hill Book Co. N.Y. 1959.
16. Microwave Spectroscopy–C.H. Townes and A.L. Schawlow, McGraw Hill Book Co. N.Y. 1955.
17. Treatise on Physical Chemistry–H.S.Taylor and S. Glasstone, Vol. I and II, D.Van Nostrand, N.Y. 1957.
18. Basic Principles of Spectroscopy–Raymand Chang. McGraw Hill, Kogakusha Tokyo, 1971.
19. Theoretical Chemistry–S. Glasstone.
20. Instrumental Methods of Analysis–Willard, Merit and Dean, Tata McGraw Hill, New Delhi, 1993.
21. Introduction to Magnetic resonance–A Carrington and A.D. Mclachlan, Harper Rao.
22. Electrochemical Methods: Fundamentals and Applications–A. J. Bard and L. R. Faulkner
23. An Introduction to Electrochemistry by S. Glasstone, Van Nostrand, London
24. A Text book of Electrochemistry by G.F.A. Kortum and J.O.M. Bockris, Elsevier, New York.
25. Modern Electrochemistry by J.O.M. Bockris and A.K.N. Reddy Vol. I and Vol. II, Butterworths, London.

**CHP(Pr)–3.5: Lab. Course In Physical Chemistry**

1. Surface Tension: Variation of surface tension of aqueous solutions of a liquid (n-propyl alcohol) with concentration and determination of limiting cross sectional area of the alcohol molecule.

2. Adsorption: Investigation of adsorption of oxalic acid from aqueous solution by activated charcoal and examine the validity of Freundlich and Langmuir's adsorption isotherm.
3. Conductance: Moderately weak acid like salicylic acid vs NaOH (Salt line method and alkali method).
4. Reaction Kinetics: Determination of degree of hydrolysis of urea hydrochloride by studying kinetics of hydrolysis of methyl acetate using HCl and equinormal urea hydrochloride solutions.
5. Potentiometry: (i) Acid and base dissociation constants of an amino acid and its isoelectric point and (ii) Mean ionic activity coefficient of hydrochloric acid at different concentrations using a concentration cell without transference: influence of ionic strength on the mean ionic activity coefficient.
6. Refractometry: Variation of refractive index with composition of mixture (e.g.,  $\text{CCl}_4$  and  $\text{CH}_3\text{COOC}_2\text{H}_5$ ).
7. Transport Number: Transference number of  $\text{Ag}^+$  and  $\text{Cl}^-$  ions by making boundary method.
8. Viscosity: Determination of molecular weight of polyhexamethylene sebacamide (nylon 6, 10) by amine end group analysis.
9. Optics: To determine the wavelength of He-Ne laser by measuring the fringe width from interference pattern.

***Recommended Books:***

1. Findlay's Practical Physical Chemistry, 9th edition, revised by B. P. Levitt.
2. Practical Physical Chemistry by A. M. James and F. E. Prichard.
3. Experiments in Physical Chemistry by Shoemaker and Garland.
4. Experiments in Physical Chemistry by Daniels, Alberty and Williams et.al.
5. Laboratory Physical Chemistry by Oelke/ M.A.C.T.L.A.C.
6. Experimental Physical Chemistry by W.G. Palamer
7. Advanced Physico-Chemical Experiments by J. Rose
8. Experimental Physical Chemistry by V. D. Athwale and Paul Mathur, New Age International Publishers.
9. Text Book of Physical Chemistry by S. Glasstone
10. Text Book of Quantitative Analysis by A. I. Vogel
11. Advanced Practical Physical Chemistry by J. B. Yadhav, Goel Publishing House, Meerut.

**Scheme of Examination:**

i. Duration of examination	: 04 hours
ii. Experiment	: 35 marks
iii. Viva-Voce & Journal	: 05 marks
iv. Internal assessment	: 10 marks
Total	: 50 marks

## UNIT-I

### **Statistical Mechanics and Statistical Thermodynamics-I:**

Microscopic and macroscopic systems. Microstates and macrostates. Assemblies of independent localised and non-localised systems. Phase space or  $\gamma$ -space and  $\mu$ -space. Ensembles.

Classical statistics: Maxwell-Boltzmann distribution for ideal gases and mixture of gases. Determination of Lagrangian multipliers, alpha and beta.

Heat capacities of solids: Einstein's theory of heat capacity of solids, Debye's theory, characteristic temperature and use of Debye equation for the determination of heat capacity at low temperature.

Entropies and heat capacities of ortho-, para-hydrogen systems, comparison of third law entropies with statistical entropies.

(12 Hours)

## UNIT-II

### **Statistical Mechanics and Statistical Thermodynamics-II:**

Quantum statistics: Bose-Einstein, Fermi-Dirac and comparison with Maxwell-Boltzmann statistics. Numerical problems.

Partition functions: Definition of partition function and separation of partition functions. Translational, Sackur-Tetrode equation, rotational, vibrational and electronic partition functions for monoatomic, diatomic and polyatomic gaseous molecules. Equipartition of energies.

(12 Hours)

## UNIT-III

### **Polymer Chemistry and Fuel cells:**

Dendrimers and hyper-branched polymers: introduction to dendrimers, methods of preparation, common properties and applications. Synthesis of polyamidoamines using divergent route and dendratic polyether macromolecules using convergent route. Hyper-branched polymers, preparation of aromatic polyesters by the self-condensation of 3, 5-bis (acetoxy)benzoic acid.

Polymeric nonlinear optical: Materials, definition, classification of NLO materials, basic molecular characteristics of second-order NLO materials, types of second-order NLO materials with examples, schematic representation of experimental setup for the measurement of second harmonic generation (SHG). Preparation of polyimide from diamino NLO chromophores.

Semiconducting polymers: basic criteria for semiconducting properties, electrochemical polymerization, precursor route to poly (p-phenylenevinylene) (PPV) and synthesis of poly (3-allythiophene).

Fuel cells: Introduction, difference between conventional cell and a fuel cell, limitations, advantages, types of fuel cells. Construction and working of hydrogen-oxygen and methanol-oxygen fuel cells. Applications of fuel cells.

(12 Hours)

## UNIT-IV

### **Polymer Membrane Chemistry:**

Polymer membranes in separation science: mechanism of transport in polymeric membranes and rejection performance, and industrial applications of micro filtration (MF) and ultrafiltration (UF) membranes. Reverse osmosis (RO): principles of RO process and determination of its efficiency in terms of flow of water and salt. Preparation of polyamide and cellulose based RO membranes.

Electrodialysis: principle of ED, working model of ED. Preparation of ion-exchange membranes grafted on polyethylene film using styrene and chloromethylstyrene. Preparation of styrene-divinyl benzene based ion exchange membranes. Preparation of anion exchange membranes using chloromethylated polysulfone and 4, 4'-bipyridine. Preparation of sulfonated poly(phosphazene) membrane. Preparation of ion exchange membrane using 4-vinyl pyridine and epichlorohydrin. Applications of Electrodialysis. Vinyl polymers (preparation, properties and commercial importance): polyethylene, polypropylene, polystyrene, polymethylmethacrylate, polyvinyl chloride, polytetrafluoroethylene. Polyesters: poly(ethylene terephthalate). Polyamides: aramides (Kevlar and Nomex), polyimides, polysulphone, polyurethanes, polyureas. Natural polymers: polyisoprenes, chitosan.

**(12 Hours)**  
**Total 48 Hours**

***Recommended Books:***

1. Statistical Mechanics–N. Davidson, McGraw–Hill, 1962
2. Introduction to Statistical Thermodynamics–M. Dole, Prentice Hill. 1954
3. Statistical Thermodynamics–R. H. Fowler and E. A. Guggenheim, Cambridge University Press, 1939.
4. An Introduction to Statistical Mechanics–T. L. Hall, Addison Wesley, 1960.
5. Introduction to Statistical Mechanics–G. S. Rushbrook, Oxford University Press, 1949.
6. Statistical Mechanics–J. E. Mayer and M. G. Mayer, John Willey, 1940.
7. Textbook of Physical Chemistry by A. Singh and R. Singh, Campus Books International, New Delhi
8. Polymer Chemistry: An Introduction- Malcolm P. Stevens, Oxford University Press, 1999.
9. Contemporary Polymer Chemistry–Harry R. Allcock and Frederick W. Lampe, Printice-Hall, 1981.
10. Principles of Polymer Chemistry–P. Bahadur and N. V. Shastri, Narosa Publisher, 2002
11. Polymer Chemistry Properties and Applications–Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
12. Text Book of Polymer Chemistry–Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
13. Polymer Science–V.R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age International Publisher, 2001
14. Polymer Modifiers and Additives–John T. Lutz, Jr., Richard F. Grossman, (eds.), Marcel-Dekker, NY, 1989.
15. An Introduction to the Mechanical Properties of Solid Polymers–I. M. Ward, D. W. Hadley, John Wiley & Sons, 1993.
16. Polymer Chemistry Properties and Applications, Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
17. Text Book of Polymer Chemistry, Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
18. Polymer Science, V. R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age International Publisher, 2001
19. Dendrimers and Dendron: Concepts, Synthesis and Applications, G. R. Newkome, C. N. Moorefield and F. Vogtle, Wiley–VCH Publisher, 2001.
20. Special Polymers for Electronics and Optoelectronics, J. A. Chilton and M. T. Goosey, (eds.), Chapman and Hall, 1992
21. Nonlinear Optics of Organic Molecules and Polymers, Hari Singh Nalwa and Seizo Miyata (eds.), CRC Press, 1997.
22. Introduction to Nonlinear Optical Effects in Molecules and Polymers, P. N. Prasad and David J. Williams, Wiley and Sons, 1990.
23. Liquid Crystalline Polymers, A. M. Donald, A. H. Windle, Cambridge University Press, 1992.
24. Nonlinear Properties of Organic Molecules and Crystals Vol. 1, D. S. Chemla, J. Zyss (eds), Academic Press, Inc. (London), 1987.

25. A text book of Physical Chemistry, A. Singh and R. Singh, Campus Books, New Delhi.
26. Comprehensive Physical Chemistry, New Age International, New Delhi.
27. Ion exchange membranes, methods and processes for production thereof and uses in specific application–T. Amimbhavi, P.V. Kulkarni, M.Y. Karidurganavar, **US Patent 6,814,865B1**
28. Ion Exchange Membranes: Preparation, Properties and Applications–M. Y. Karidurganavar, A. A. Kittur, S. S. Kulkarni, Ion Exchange Technology–I, Springer.

### **CHP(Pr)–3.6: Lab Course In Physical Chemistry**

1. Solubility: Study the effect of addition of an electrolyte (NaCl, KCl, Na<sub>2</sub>SO<sub>4</sub> and K<sub>2</sub>SO<sub>4</sub>) on the solubility of an organic acid (Benzoic acid or salicylic acid).
2. Phase equilibria: Construction of phase diagram of three component system (water, benzene and ethanol or acetic acid, water and chloroform or benzene).
3. Conductance: Studying the kinetics of saponification of ethyl acetate by conductance method and hence determine the rate constant.
4. Thermochemistry: Determination of step wise heat of neutralization of a polybasic acid.
5. Reaction Kinetics: Reaction kinetics of H<sub>2</sub>O<sub>2</sub> and HI: Clock reaction.
6. Potentiometry: Potentiometric determination of stability constant of Cu<sup>2+</sup>–EDTA complex.
7. Cryoscopy: Determination of degree of dissociation of given electrolytes (KCl, urea) using cryoscopy method.
8. Refractometry: Molar refraction of a solid substance by dissolving it in a solvent.
9. Solid state: Determine the curie temperature of ferromagnetic material.
10. X-ray diffraction: Determine the linear position and inter planar spacing using X-Ray diffraction patterns.

#### ***Recommended Books:***

1. Findlay's Practical Physical Chemistry, 9th edition, revised by B.P. Levitt.
2. Practical Physical Chemistry by A.M. James and F.E. Prichard
3. Experiments in Physical Chemistry by Shoemaker and Garland
4. Experiments in Physical Chemistry by Daniels, Alberty and Williams et.al.
5. Laboratory Physical Chemistry by Oelke/ M.A.C.T.L.A.C.
6. Experimental Physical Chemistry by W.G. Palamer
7. Advanced Physico–chemical experiments by J.Rose
8. Experimental Physical Chemistry by V.D. Athwale and Paul Mathur, New Age International Publishers.
9. Text book of Physical Chemistry by S. Glasstone
10. Text book of quantitative analysis by A.I. Vogel
11. Advanced Practical Physical Chemistry by J.B. Yadhav, Goel Publishing house, Meerut.

#### **Scheme of Examination:**

- i. Duration of examination : 04 hours
- ii. Experiment : 35 marks
- iii. Viva-Voce & Journal : 05 marks

iv. Internal assessment : 10 marks  
Total : 50 marks

### CHEOT-3.1: APPLIED ORGANIC CHEMISTRY (ELECTIVE)

#### UNIT-I

##### **Molecular Parameters, Isomerism and Prochirality:**

Molecular Parameters: bond lengths, bond angles, bond energies, bond polarity and dipole moment.

Geometrical and optical isomerism: E/Z, R/S nomenclature, Fischer, Sawhorse, Newmann projections. Enantiomers, diastereomers and epimers,

Prochirality: Homotopic, enantiotopic, diastereotopic groups & faces and their reactivity.

**(12 Hours)**

#### UNIT-II

##### **Organic Reactions:**

Classification of organic reactions, Methods of identification, kinetic, non-kinetic methods, isotopic labeling techniques, intermediates, cross over products and product proportions in different types of reactions.

Named Reactions: Classification, aldol, dieckmann, Claisen-Schmidt and similar carbanion addition reactions.

**(12 Hours)**

#### UNIT-III

##### **Chemistry of Heterocycles:**

Structure, synthesis, reactivity of the following heterocycles and their biologically important derivatives: (i) indole (ii) thiazole (iii) pyrimidine (iv) quinoline (v) furan (vi) thiophene and (vii) pyrrole.

**(12 Hours)**

#### UNIT-IV

##### **Functional group Transformations:**

Multi step organic functional group inter conversions involving substitution, addition, eliminations, oxidation, reduction, etherification, hydrolysis and diazocoupling reactions.

**(12 Hours)**

**Total: 48 Hours**

***Recommended Books:***

1. Organic Chemistry–P.Y. Bruice, Pearson Education Pvt. Ltd., New Delhi (2002).
2. Organic Chemistry–S. H. Pine, McGraw-Hill, London (1987).
3. Organic Chemistry–R.T. Morrison and R.T. Boyd, Prentice Hall New Delhi (1994).
4. Organic Chemistry–T.W. Graham Solomons, 4<sup>th</sup> Edition, John Wiley and Sons, (1988).
5. Organic Chemistry volume I, II–I. L. Finar, 6<sup>th</sup> Edition, ELBS London (2004).
6. Organic Chemistry–F.A. Carey, 4<sup>th</sup> Edition, McGraw Hill, (2000).
7. Advanced Organic Chemistry, Reactions, Mechanism and Structure–J March, 4<sup>th</sup> Edition, Wiley Eastern Ltd (2004).
8. Stereochemistry–Conformation and Mechanism P. S. Kalsi, Wiley– Eastern Ltd, New Delhi (1992).
9. Heterocyclic Chemistry–T. L. Gilchrist, Butterworths (London), 1985.
10. Heterocyclic Chemistry –J.A. Joule and G.F. Smith, 2<sup>nd</sup> Edition, Van Nostrand (London), 1978.

**CHEPT–3.1: APPLIED PHYSICAL CHEMISTRY (ELECTIVE)**

**UNIT–I**

**Reaction Kinetics:**

A critical account of collision and transition state theories.

Kinetics and Mechanism: Steady state approximation and simple examples relating kinetics to mechanism. Theories of unimolecular reactions: RRKM theory. Isomerisation of methyl isocyanide.

General features of fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis and the nuclear magnetic resonance method.

**(12 Hours)**

**UNIT–II**

**Thermodynamics:**

Thermodynamic criteria for spontaneous chemical changes, standard free energies and their determination, relation between free energy change and equilibrium constant. The pressure dependence of free energy of non-ideal gases and fugacity. Standard state for non-ideal gas, equilibrium constants in non-ideal systems. Temperature dependence of free energy and equilibrium constants.

**(12 Hours)**

### UNIT-III

#### **Electrochemistry:**

Introduction to electrochemistry, electrical Double Layer: Lippman equation, theories of electrical double layer-Helmholtz-Perrin, Gouy-Chapman and Stern theories. Effect of ions on zeta potential. Activity of ions in solution: ion-solvent interactions, ion-ion interactions and free energy of ions in solution. Born model and modifications, solvation number and their determination. triple ion formation and conductance minima.

(12 Hours)

### UNIT-IV

#### **Introduction to Polymers:**

Basic Concepts: Monomers, repeat units, polymers and degree of polymerization. General classification of polymers, homopolymers, copolymers, terpolymers, addition polymers and condensation polymers with examples, tacticity, comparison between thermoplastics and thermosetting polymers.

Methods of polymer fabrications: Fabrication of polymer films, solution casting, melt pressing, melt extrusion and bubble blown. Fabrication of shaped polymer objects: compression molding, injection molding, reaction injection molding, blow molding extrusion molding and calendaring. Spinning industrial polymers: solution spinning and melt spinning.

Preparation, properties and commercial importance;

Vinyl polymers: polyethylene, polypropylene, polystyrene, polytetrafluoroethylene, polyvinyl chloride and polymethylmethacralate

Polyesters: poly(ethylene terephthalate). Polyamides: aramides (kevlar and nomex). Polyimides, Polysulphone, Polyurethanes and polyureas.

Natural polymers: polyisoprenes, chitosan,

(12 Hours)

**Total 48 Hours**

#### ***Recommended Books:***

1. Physical Chemistry–G.M.Barrow, McGraw Hill
2. Physical Chemistry–R.A. Alberty, Wiley Eastern Ltd.
3. Elements of Physical Chemistry–P.W.Atkins, Oxford
4. Physical Chemistry–P.W. Atkins, ELBS.
5. Modern Electrochemistry Vol I and II–J.O.M,Bokris and A.K.N.Reddy,Plenum, 2006.
6. An Introduction to Electrochemistry–S.Glasstone, Van Norstrand, 1942.
7. A Text Book of Electrochemistry–G.F.A.Kortum and J.O.M. Bokris, Elsevier, 1951.
8. Electrolyte Solutions–R.A.Robinson and R.H.Stokes, Acedemic Press, 1959.
9. Chemical Kinetics–K.J.Laidler, Pearson Education 2004
10. Kinetics and mechanism of chemical transformations–J.Rajaraman and J. Kuriacose, McMillan.
11. Theory of rate processes-S. Glasstone, K.J.Laidler and H.Eyring, McGraw–Hill,1941.
12. Thoeries of chemical reaction rates–K.J.Laidler, MacGraw-Hill, 1969.
13. Fast Reactionss–D.N. Hague, Wiley-Interscience, New York, 1971.

14. Techniques of Organic Chemistry- Weissberger(ed.), Interscience, 1963, Vol.VIII
15. Kinetics of Chemical Changes in Solution–E.S.Amis, McMillan, 1948
16. The Foundations of Chemical Kinetics–S.W. Benson, McGraw–Hill, 1960.
17. Polymer Chemistry: An Introduction, Malcolm P. Stevens, Oxford University Press, 1999.
18. Contemporary Polymer Chemistry, Harry R. Allcock and Frederick W. Lampe, Printice–Hall, 1981.
19. Principles of Polymer Chemistry–P. Bahadur and N. V. Shastri, Narosa Publisher, 2002
20. Polymer Chemistry Properties and Applications, Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
21. Text Book of Polymer Chemistry–Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
22. Polymer Science–V.R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age International Publisher, 2001
23. Principles of Polymer Chemistry–A. Ravve, Plenum Press, New York, 19
24. Polymer Synthesis and Processing–M. Y. Karidurganavar, A. A. Kittur, R. R. Kamble, edited by S. G. Kumbar, C. T. Laurencin and M. Deng, Elsevier (2014)

#### IV SEMESTER

#### CHIT–4.1: INSTRUMENTAL METHODS OF ANALYSIS

#### UNIT–I

##### **Optical methods:**

Atomic absorption spectrometry: Theory, instrumentation, different types of nebulizers, non flame techniques, electrothermal vapourisers, cold vapour AAS determination of mercury, interferences, differences between AAS and flame photometry and analytical applications of AAS.

Emission spectroscopy: Inductively coupled plasma optical emission spectrometry, theory and applications.

Molecular luminescence spectroscopy: Theoretical basis for fluorescence and phosphorescence, instrumentation, factors affecting fluorescence, its applications in quantitative analysis and in the study of biomolecules.

X–ray fluorescence elemental analysis.

**(12 Hours)**

## UNIT-II

### **Analytical methods-I**

Coulometric methods of analysis: General discussion, coulometry at controlled potential, apparatus and general technique, applications, coulometric titrations (amperometric coulometric): Principles, apparatus, comparison of coulometric titrations with conventional titrations, automatic coulometric titrations and applications.

Amperometry: Principle, titrations, advantages and limitations. Applications.

Ion selective electrodes: Glass ion selective electrodes, crystalline solid state ion selective electrodes, liquid-based ion selective electrodes and gas sensing electrodes.

Supercritical fluid chromatography (SFC): Properties of supercritical fluids, instrumentation and operating variables, comparison of SFC with other types of chromatography. Applications.

**(12 Hours)**

## UNIT-III

### **Analytical methods-II**

Polarography: Theory of classical polarography, polarograms, polarographic currents. Halfwave potential, oxygen interference, advantages and limitations. Pulse polarography. Applications of polarography.

Electrogravimetric analysis: Theory, apparatus, deposition and separation, electrolytic separation of metals, applications.

Electrophoresis: Theory and classification. Factors influencing the mobility-macromolecular size and charge, interaction with supporting electrolyte, pH and concentration discontinuities. Factors affecting electrophoretic phenomena-electrolysis, Electroosmosis, temperature and supporting media. Instrumentation. Methodology-preparation of gels-staining and destaining. Capillary electrophoresis methods - capillary zone electrophoresis, capillary gel electrophoresis.

Light-Scattering methods: Nephelometry and turbidometry-Principle, instrumentation and applications.

**(12 Hours)**

## UNIT-IV

### **Analytical methods-III**

Thermal method of analysis: Introduction. Thermogravimetric analysis (TGA): Types of thermogravimetric analysis, principles, factors affecting the results, heating rate, furnace, instrument control/data handling. Instrumentation and applications.

Differential thermal analysis (DTA): Theory, variables affecting the DTA curves. Differences between TGA and DTA. General principles, instrumentation and applications.

Differential scanning calorimetry (DSC): Basic principle, differences between DTA and DSC. Instrumentation, power compensated DSC, Heat flux DSC. Applications.

Thermomechanical analysis. Dynamic mechanical analysis.

Voltammetry: Fundamentals of voltammetry. Cyclic voltammetry: Principles and applications. Stripping analysis: Stripping voltammetry, basic principles, electrodes used for stripping analysis, apparatus for stripping analysis, applications, determination of lead in water by voltammetry.

**(12 Hours)**

**Total: 48 Hours**

### ***Recommended Books:***

1. Instrumental Analysis, D. A. Skoog, F. J. Holler and S.R. Crouch, Cengage Learning (2007).
2. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8<sup>th</sup> edition, Saunders College Publishing, New York (2005).
3. Analytical Chemistry, G.D. Christian, 6<sup>th</sup> edition, Wiley–India (2007).
4. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, PHI Learning Pvt Ltd.New Delhi (2009).
5. Vogel’s Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6<sup>th</sup> edition, Third Indian Reprint, Pearson Education Pvt.Ltd.(2007).
6. Analytical Chemistry Principles, John H. Kennedy, 2<sup>nd</sup> edition, Saunders College Publishing, California (1990).
7. Instrumental Methods of Analysis by H.H. Willard, L.L. Merritt and J.A. Dean, 7<sup>th</sup> Edition, CBS Publishers, New Delhi, 1988.

### **CHI(Pr)–4.5: Lab course in Inorganic Chemistry**

1. Determination of available K/Na in soil by flame photometry
2. Nephelometric/Turbidimetric determination of sulphate/phosphate.
3. Cyclic voltammetric studies on potassium ferrocyanide/ potassium ferricyanide.
4. TG–DTA studies of various hydrated solids-CuSO<sub>4</sub>.5H<sub>2</sub>O, CaC<sub>2</sub>O<sub>4</sub>.H<sub>2</sub>O and MgC<sub>2</sub>O<sub>4</sub> mixture.
5. Determination of fluoride in drinking water by spectrophotometry.
6. Estimation of total cation concentration in water by ion-exchange method.
7. Determination of iron in mustard seed by spectrophotometry.
8. Determination of copper by potentiometric titration using EDTA.
9. Conductometric determination of total acidity of waste water.
10. Analysis of copper/calcium by PFHS method
11. Analysis of Na<sub>2</sub>CO<sub>3</sub> and NaHCO<sub>3</sub> in baking soda by acid base titration

### **Scheme of Examination**

- |                            |            |
|----------------------------|------------|
| 1. Duration of Examination | : 04 hours |
| 2. Experiment              | : 35 marks |
| 3. Viva-voce and Journal   | : 05 marks |
| 4. Internal assessment     | : 10 marks |
| Total                      | : 50 marks |

### ***Recommended Books:***

1. Vogel’s Text Book of Quantitative Inorganic Analysis-J. Bassett, R. C. Denney, G. H. Jaffery and J. Mandham, Longmans, Green and Company Ltd.
2. Chemical analysis of foods and food products-Morris B. Jacobs (3rd Edn.), D. Van Nostrand Company, inc.
3. Standard methods of chemical analysis-F. J. Welcher (6th Edn., Vol. 3 Part-B), D. Van Nostrand Company, Inc. Indian, United States and European Pharmacopea.
4. General Chemistry Experiments-A. J. Elias, University Press.

## CHIT-4.2: Material Chemistry, Nuclear Chemistry and Environmental Chemistry

### UNIT-I

#### **Nanomaterials and Electron Microscopies.**

Nanomaterials: Introduction, terminology, novel optical properties, nanolayers, carbon nanotubes, nanowires, quantum dots, nanocomposites, thin films, nanofoam, nanoclusters, smart nanostructures. Top-down and bottom-up fabrication: Solution-based and vapour-phase synthesis of nanomaterials, physical vapour deposition, chemical vapour deposition, sol-gel synthesis, combustion method and hydrothermal method.

One-dimensional control (CNT's and inorganic nanowires), two-dimensional control (quantum wells and solid-state superlattices) and three-dimensional control.

Electron microscopies: Scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning transmission electron microscopy (STEM). Scanning probe microscopies: Scanning tunneling microscopy (STM) and atomic force microscopy (AFM).

Nanosensors: Electrochemical sensors and biosensors.

(12 Hours)

### UNIT-II

#### **Nuclear Chemistry:**

Nuclear reactions, nuclear fission and fusion, nuclear reactor, units of radiation energy, G-value. Chemical Dosimetry: Fricke and ceric sulphate dosimeters. Radiation chemistry of water. A brief introduction to radiolysis of liquids and solids.

Health and safety aspects: Biological effects of radiation, permissible exposure of radiation dose and radioactive waste management.

Radioanalytical techniques and isotopes: Radioactive techniques, tracer technique, neutron activation analysis, applications of radiation chemistry/isotopes (radiation synthesis, polymerization, medicine & food irradiation). Radiometric titrations and  $^{14}\text{C}$  dating.

(12 Hours)

### UNIT-III

#### **Air pollution and Water Pollution:**

Air pollutants, prevention and control, green house effect and acid rain. Carbon monoxide: Industrial and transportation sources.  $\text{SO}_x$ -sources, control technique, scrubbing, limestone injection process. Ozone hole and CFC's. Photochemical smog and PAN.  $\text{NO}_x$ : sources and  $\text{NO}_x$  control techniques. Particulates: Size distribution. Bhopal gas tragedy. Noise pollution.

Origin of waste water, types, water pollutants and their effects. Sources of water pollution: Domestic, industrial, agricultural soil and radioactive wastes as source of pollution. Measurement of colour, turbidity, total solids, acidity, alkalinity, hardness, sulphate, fluoride, phosphate and different forms of nitrogen in natural and polluted water. Determination and significance of BOD, COD and TOC. Pesticides as water pollutants and analysis.

Toxic chemicals in the environment, impact of toxic chemicals on enzymes. Heavy metal pollution. Chemical speciation: Biochemical effects of heavy metals (Hg, As, Pb, Se).

(12 Hours)

### UNIT-IV

#### **Chemistry of Selective Materials:**

Glasses, oxide glasses, bond type, viscosity, Zachariasen's rules, criteria of Sun and Rawson, chalcogenide glass, the photocopying process, glass ceramics, applications, ceramics–structures, mechanical properties and application, clay products, refractories, characterisation properties and applications.

LED: Principle, types, advantages and disadvantages of LED displays.

Liquid crystal display (LCD): Properties, twisted nematic field display, advantages and disadvantages of LCD, comparison of LCD & LED.

Shape memory alloys (SMA): Classification, working principles, non–linear optical materials and second harmonic generators.

**(12 Hours)**

**Total: 48 Hours**

***Recommended Books:***

1. T. Pradeep, 'Nano: The essentials', Tata Mcgraw – Hill, 2007.
2. Chemical Reviews–Recent Advances in the Liquid-Phase Syntheses of Inorganic Nanoparticles, Brian L. Cushing, Vladimir L. Kolesnichenko, and Charles J. O'Connor *Chem. Rev.*, 2004, 104 (9), 3893-3946 • DOI: 10.1021/cr030027b.
3. Solid state Chemistry, D. K. Chakrabarty (New Age) 1996.
4. Principles of the solid state, H.V. Keer (Wiley Eastern) 1993.
5. Solid state chemistry and its applications, A.R.West, Wiley–India (2007).
6. Environmental Chemistry–A. K. De (Wiley Eastern).
7. Environmental Chemistry–S. K. Banerji, ( Prentice Hall India), 1993.
8. Essentials of Nuclear Chemistry–H.J.Arnikaar, 4<sup>th</sup> Edn. New Age International (2011).
9. Nuclear and Radiation Chemistry–Friedlander, Kennedy Macias & Miller, Wiley, (1981).

**CHI(Pr)-4.6: Lab course in Inorganic chemistry**

1. Determination of COD of a water sample.
2. Determination of phosphates in detergents.
3. Determination of dissolved oxygen (DO) by Winkler's method.
4. Determination of nitrate & nitrite in water samples and sea water.
5. Analysis of heavy metals in waste water and sea water (Pb, Hg etc. by spectrophotometry).
6. Determination of alkalinity of water samples.
7. Determination of phosphoric acid content in soft drinks.
8. Hardness of water by soap solution method
9. Determination of TDS in water samples.
10. Preparation and characterization of nanoparticles.
11. Analysis of glass and ceramics

**Scheme of Examination**

1. Duration of Examination : 04 hours
2. Experiment : 35 marks

- |                          |            |
|--------------------------|------------|
| 3. Viva-voce and Journal | : 05 marks |
| 4. Internal assessment   | : 10 marks |
| Total                    | : 50 marks |

**References:**

1. Vogel's Text Book of Quantitative Inorganic Analysis–J. Bassett, R. C. Denney, G. H. Jaffery and J. Mandham, Longmans, Green and Company Ltd.
2. Chemical analysis of foods and food Products-Morris B. Jacobs (3rd Edn.), D. Van Nostrand Company, Inc.
3. Standard methods of chemical analysis–F. J. Welcher (6th Edn., Vol. 3 Part–B), D. Van Nostrand Company, Inc. Indian, United States and European Pharmacopea.
4. General Chemistry Experiments–A. J. Elias, University Press.

### CHIT–4.3: ORGANOMETALLIC CHEMISTRY AND SOLID STATE CHEMISTRY

#### UNIT–I

**Organometallic Chemistry:**

Chemistry of organometallic compounds with  $\pi$ -bonding ligands: Synthesis, structure, spectroscopy, reactions and bonding in metal-carbon  $\pi$ -bonded systems involving di-hapto to hexa-hapto ligands viz, olefins, acetylenes, allylic moieties, butadienes, cyclobutadienes, cyclopentadienes and arenes. Organometallic polymers.

**(12 Hours)**

#### UNIT–II

**Fluxional behaviour of Organometallic Compounds:**

Rates of rearrangement and techniques of study. Stereochemical non-rigidity in organometallic compounds, ring whizzing in  $\eta^1$ -Cp complexes, interchange of  $\eta^1$ -and  $\eta^5$ -Cp rings, allyl and allene complexes. Scrambling of carbonyl groups in metal carbonyls.

**2 Hours**

Homogeneous and heterogeneous catalysis involving metal complexes and organometallic complexes. Terminology in catalysis, oxidative additions and oxidative coupling reductive elimination, insertion reactions, hydrogenation of alkenes and related reactions, hydroformylation (Monsanto, Cativa and Wacker Processes), carbonylation, isomerisation and olefin polymerisation oligomerisation reactions. Water gas shift reaction.

**8 Hours**

Organometallic reagents in organic synthesis: Organo-iron, organo-copper and organo-palladium compounds.

**2**

**Hours**

**(12 Hours)**

#### UNIT–III

**Solid State Chemistry:**

Electrical properties: Survey of electrical properties and materials.

1

**Hour**

Super conductivity: Nature and properties of super conductivity materials, Meisner effect, type-I and II super conductors, theories, high temperature oxide super conductors, junction involving metal, super conductor and super conductor. Applications.

4

**Hours** Ionic conductivity: Alkali halides–vacancy conduction. Silver chloride–interstitial conduction. Solid electrolytes:  $\beta$ -alumina, AgI and  $\text{Ag}^+$  ion solid electrolytes. Anion conductors, requirements for conductivity. Applications.

**2 Hours**

Magnetic properties: Mechanism of ferro– and anti–ferro magnetic ordering, selected examples of magnetic materials, their structures and properties, metals and alloys, transition metal oxides, spines, garnets, ilmenites, perovskites, magneto plumbites, applications and structure–property relation.

**3 Hours**

Optical properties: Luminescence and phosphors, configurational coordinate model, some phosphor material, antistokes, phosphors and lasers.

**2 Hours**

**(12 Hours)**

#### UNIT–IV

##### **Mechanical Properties and Structural Transformation of Solids:**

Mechanical properties & dislocations in solids: Edge dislocations & screw dislocations.

Structural transformation of solids: Solid solutions, Hume–Rothery rules, substitutional solid solutions and interstitial solid solutions, solid solution mechanism, experimental methods for studying solid solutions (X–ray powder diffraction and density measurements).

Alloy systems: Phase diagrams, two and three component systems, study of alloy systems, steels with reference to iron, carbon systems and copper– zinc system.

**(12 Hours)**

**Total 48 Hours**

##### ***Recommended Books:***

1. Organometallic Chemistry–R. C. Mehrotra and A. Singh New Age International.
2. Basic Organometallic Chemistry–B D Gupta and A J Elias, Universities Press (2013)
3. Principles of Organometallic Chemistry–G. E. Coates, M. L. H. Green, P. Powell & K. Wade.
4. Metallo–organic Chemistry–A. J. Pearson, Wiley.
5. The Organometallic Chemistry of the Transition Metals–R. H. Crabtree John. Wiley and Sons.
6. Principles and Applications of Organotransition Metal Chemistry–J. P. Collman, L. S. Heagsdus, J. R. Norton & R. G. Finks. University science books.
7. Inorganic Chemistry, 4th Edition–J. E. Huheey, E. A. Keiter and R. C. Keiter. Addition– Wiley.
8. Advanced Inorganic Chemistry 6 th Edn–F. A. Cotton, G. Wilkinson, C. A. Murillo & M. Bochman John–Wiley & sons.

9. Organometallic Reagents in Synthesis--P. R. Jenkins, Oxford chemistry, Primer, Oxford University Press.
10. Solid State Chemistry--N. B. Hannay, Prentice – Hall of India Pvt. Ltd. New Delhi.
11. Solid State Chemistry and its Applications--A. R. West, John –Wiley & sons.
12. New Direction in Solid State Chemistry--C.N.R Rao and J. Gopalkrishnan, Cambridge University Press.
13. Introduction to Solids--L. V. Azaroffs. McGraw Hill.
14. Principles of the Solid State--H. V. Keer, Wiley Eastern.
15. Material Science and Engineering- A First Course--V. Raghavan, Prentice--Hall of India Pvt. Ltd.

#### **CHI(Pr)-4.7: Lab course in Inorganic chemistry**

1. Determination of total acidity of vinegar and wines by acid-base titration.
2. Determination of calcium in calcium gluconate/calcium carbonate tablets/injections and of calcium in milk powder by EDTA titration.
3. Determination of aluminium and magnesium in antacids by EDTA titration.
4. Determination of saccharin in tablets by precipitation titration.
5. Analysis of cement.
6. Analysis of Type metal--Sn gravimetrically and Sb titrimetrically using  $\text{KBrO}_3$
7. Determination of magnesium in milk of magnesium tablets by ion-exchange chromatography.
8. Conductometric titration of sodium acetate with HCl and  $\text{NH}_4\text{Cl}$  with NaOH.
9. Analysis of urine for (i) urea and uric acid by titrimetric and spectrophotometry (ii) Sulphate by precipitation titration after ion-exchange separation (iii) Sugar by Benedict's reagent.
10. Analysis of blood for (i) cholesterol by spectrophotometry and (ii) bicarbonate by acid--base titration

#### **Scheme of Examination**

- |                            |            |
|----------------------------|------------|
| 1. Duration of Examination | : 04 hours |
| 2. Experiment              | : 35 marks |
| 3. Viva-voce and Journal   | : 05 marks |
| 4. Internal assessment     | : 10 marks |
| Total                      | : 50 marks |

#### **Recommended Books:**

1. Vogel's Text Book of Quantitative Inorganic Analysis-J. Bassett, R. C. Denney, G. H. Jaffery and J. Mandham, Longmans, Green and Company Ltd.
2. Chemical analysis of foods and food products-Morris B. Jacobs (3rd Edn.), D. Van Nostrand Company, inc.
3. Standard methods of chemical analysis--F. J. Welcher (6th Edn., Vol. 3 Part-B), D. Van Nostrand Company, Inc. Indian, United States and European Pharmacopea.
4. General Chemistry Experiments--A. J. Elias, University Press.

## CHIP-4.4: PROJECT WORK

The project work may include in-plant training in industries/short term work in the department/other educational institutions/R&D organizations/data mining/review of current literature/theoretical methods/computer applications. Experimental work may involve studies on synthesis/measurements/study of properties/characterization by physical methods/activities for reported/unreported research or any suitable combination thereof.

In case of the students who would work outside the campus, the supervising staff member may visit to the work place at least once during the period and may be eligible for TA-DA as per the University rules.

## CHOT-4.1: ORGANIC SYNTHESIS UNIT – I

### **Synthetic Design and retrosynthetic analysis:**

Protecting groups in organic synthesis: Principle of protection, protection of hydroxyl (–OH), amino (–NH<sub>2</sub>, –NH), carboxylic (–COOH), carbonyl (RCOR') groups, their synthetic applications and methods of deprotection.

Retrosynthetic analysis: Terminology, synthon, synthetic equivalent, functional group interconversion and disconnection approach, one group C–X and two group disconnections. Applications of C–C disconnection in the synthesis of substituted 1,1-, 1,2-, 1,3- and 1,4-bifunctional compounds. Retrosynthetic analysis and forward synthesis for alcohols, benzocaine, acetone cyanohydrin, *p*-methoxy acetophenone, 6-methyl quinoline, pirindol, 6-methoxy indole –3-acetic acid. Application to the synthesis of juvabione, taxol, longifolene, Prelog-Djerassi lactone.

**(12 Hours)**

## UNIT-II

### **Oxidations and Reductions:**

Oxidations: Oxidation of organic compounds using KMnO<sub>4</sub>, PCC, OsO<sub>4</sub>, CrO<sub>3</sub>, K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>, SeO<sub>2</sub>, Pb(OAc)<sub>4</sub>, HIO<sub>4</sub>, oxygen, Oppenauer oxidation, Swern oxidation, ozonolysis. Hydroboration- isomerisation and oxidation. Application in the synthesis of esters, E–Z alkenes, conjugated dienes, alkynes.

Conditions: Catalytic oxidation and Pt, photosensitized oxidation of alkenes, oxidation with molecular oxygen, aromatization, silver based reagents.

Reductions: Reduction of organic compounds using the following reagents: LiAlH<sub>4</sub>, NaBH<sub>4</sub>, lithium hydridoalkoxyaluminates, MPV reduction, catalytic hydrogenation, dissolving metal reduction (including acylion condensation), Clemmensen reduction. Birch Reduction, Wolf-Kishner reduction (Huang-Minlon modification), Raney-Ni desulphurisation.

**(12 Hours)**

### UNIT-III

#### **Newer Reactions:**

Mechanism and strategic applications of the following named reactions: Suzuki coupling, Prins reaction, Shapiro reaction, Mitsunobu reaction, Robinson annulation, Junjappa-Ila aromatic and heteroaromatic annulations, Pauson-Khand reaction, Simon-Smith reaction, Huisgen 1,3-dipolar cycloaddition reaction, O'Donnell Aminoacid synthesis, Heck arylation, Desmartin reaction, Houben-Hoesch reaction, Sonogashira reaction, Buchwald-Hartwig reaction.

(12 Hours)

### UNIT-IV

#### **Newer Reagents:**

Methods of preparation, mechanism of action and application of the following reagents in Organic synthesis: DCC, 1,3-dithiane (Corey-Seebach reaction), LDA, DDQ, Wilkinson catalyst, crown ethers, trimethyl silyl iodide, trimethyl silyl cyanide, hydrosilane, Iwanov reagent, Peterson reaction, Julia olefination, Woodward and Prevost hydroxylations, Lawesson's reagent.

(12 Hours)

**Total 48 Hours**

#### ***Recommended Books:***

1. Organic Synthesis-The Disconnection Approach - Stuart Warren
2. Designing Organic Synthesis-Stuart Warren.
3. Modern Synthetic Organic Chemistry-H. O. House, W. A. Benjamin INC, New York (1969).
4. Principles of Organic Synthesis-R. O. C. Norman and J. M. Coxon, 3<sup>rd</sup> Edition, Nelson Thrones, UK (2003).
5. Synthetic Approaches in Organic Chemistry-Raj K. Bansal, Narosa Publishing House (1998).
6. Modern Methods of Organic Synthesis-Willian Carruthers and Lain Coldham, Cambridge University Press, 2009.
7. Organic Reactions and Their Mechanisms-P.S. Kalsi, 2<sup>nd</sup> Edition, New Age International publishers (2002).
8. M. B. Smith, Jerry March, Advanced Organic Chemistry-Reaction, Mechanism and Structure, 6 Ed., Wiley, 2006.
9. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry (Part A and B) 5<sup>th</sup> Ed., Springer, India.
10. Modern Methods of Organic Synthesis-Willian Carruthers and Lain Coldham, Cambridge University Press, 2009.

#### **CHO(Pr)-4.5: Lab Course In Organic Chemistry**

Multi-step preparation of organic compounds involving various reactions like addition, elimination, oxidation, hydrolysis etc. and purification methods like distillation and crystallization.

#### ***Recommended Books:***

1. Vogel's Textbook of Practical Organic Chemistry Revised-B.S. Furniss, A. J. Hannaford, P.W.G. Smith, A. R. Tatchell, 5<sup>th</sup> Edition, Addison Wesley Longman Limited, UK, 1997.
2. A Hand book of Organic Chemistry-H. T. Clarke.
3. A Laboratory Manual of Organic Chemistry-B. B. Dey and M. V. Govindachari.
4. Lab Experiments in Organic Chemistry-Arun Sethi, New Age International Ltd. New Delhi. 2006.

### Scheme of Examination

Duration of examination	: 04 hours
Experiments	: 35 marks
Journal and Viva	: 05 marks
Internal Assessment	: 10 marks
Total	: 50 marks

## CHOT-4.2: PHOTOCHEMISTRY AND PERICYCLIC REACTIONS

### UNIT-I

#### Organic Photochemistry:

Bonding and antibonding orbitals, principles of photochemistry, photochemical processes, singlet and triplet states, energy transfer and photosensitisation, photochemical reactions, photoreduction, Photochemical fragmentation reactions: Norish type-I, type – II cleavages (Yang cyclisation)–di- $\pi$  methane rearrangement, optical pumping, photochemistry of cyclohexadienones, photo-Fries rearrangement, Paternò-Büchi reaction, photochemistry of alkenes, benzenes, cyclohexanes and photochemistry of vision.

(12 Hours)

### UNIT-II

#### Pericyclic Reactions:

Pericyclic reactions: Classification and features, molecular orbital symmetry, frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl systems.

Electrocyclic processes: Introduction, Woodward-Hoffmann rules for  $4n-$  and  $(4n+2)-\pi$  systems, stereochemistry under thermal and photochemical conditions.

Cycloaddition reactions: Introduction, supra facial and antra facial addition, [2+2] and [4+2] cycloaddition reaction (Diels-Alder reaction) FMO analysis under thermal and photochemical conditions.

Sigmatropic rearrangements: Classification, FMO approach for [1,3], [1,5] and [3,3] sigmatropic rearrangements, supra and antra facial hydrogen shifts. Walk, Claisen-Cope, oxy-Cope and aza-Cope rearrangements. Vitamin-D group isomerizations.

(12 Hours)

### UNIT-III

#### Molecular Rearrangement:

Molecular Rearrangement: Classification and general mechanistic pattern for electrophile, free radical and nucleophile rearrangement.

Mechanisms of the following rearrangement:

- (i) C-C migration: Wagner-Meerwein, pinacol-pinacolone, dienone-phenol, benzilic, Favorskii, Sommelet-Hauser, Stevens, Smiles, Fritsch-Butenberg-Wiechell.
- (ii) C-N migration: Benzidine rearrangement, Neber, Beckmann, Hofmann, Curtius, Lossen, Schmidt.

- (iii) C–O migration: Baeyer-Villiger, Dakin, Payne (including *aza* and *thia*), hydroperoxide, Crigee, Rupe, Ferrier, Petasis, Bamford–Stevens.
- (iv) O–C migration: Baker–Venkataraman, Fries and Wittig rearrangements.

(12 Hours)

#### UNIT–IV

##### Organo–Lithium, –Magnesium, –Zinc, and –Tin Compounds:

Organolithium and organomagnesium: Preparation, properties of organolithium and organomagnesium compounds and their uses in organic synthesis and in the preparation of organometallic compounds, Gilman reaction, LDA.

Organozinc compounds: Preparation, structure and bonding, applications in C–C bond forming reactions *viz.*, Simmons–Smith reaction, Negishi coupling, Fukuyama coupling, Barbier reaction and zinc acetylides.

Organotin Compounds: Synthesis of organostannanes and their utility in C–C bond forming reactions, tributyltinhydride, Barton decarboxylation, Barton deoxygenation, Stille–Kelly coupling reactions.

(12 Hours)

Total: 48 Hours

##### Recommended Books:

1. Modern Molecular Photochemistry–N. J. Turro, University Science Books, (1991).
2. Molecular Reactions and Photochemistry–C. H. Depuy and D. Chapman, Pearson Education, (1972).
3. Organic Photochemistry–J. M. Coxan and B. Halton, Cambridge University Press, London (1974).
4. Photochemistry and Pericyclic Reactions, Jagadamba Sing and Jaya Singh, New Age Intl Publishers, 2008.
5. Frontier Orbital and Symmetry Controlled Pericyclic Reactions, R. K. Kar, Books and Allied (P) Ltd. 2010.
6. Principles of Organic Synthesis–R. O. C. Norman and J. M. Coxon, 3<sup>rd</sup> Edition, Nelson Thrones, UK (2003).
7. Organic Reaction Mechanism–R. K. Bansal, 3<sup>rd</sup> Edition, Tata McGraw Hill (2006).
8. Molecular rearrangements I and II–P.de. Mayo.
9. Mechanisms of Molecular Migrations. Volume–I and II B. S. Thyagarajan, 1<sup>st</sup> Edition, Wiley–Interscience, London (1979).
10. Molecular Transformations in Organic Chemistry–D. Ranganathan and S. Ranganathan, 1<sup>st</sup> Edition, McMillan India, New Delhi (1975).
11. Organic Chemistry Volume I, II–I. L. Finar, 6<sup>th</sup> Edition, ELBS London (2007).
12. Advanced Organic Chemistry, 7<sup>th</sup> Ed, J. March, Wiley and Sons, 2015.
13. Organic Chemistry, J. Clayden, N. Greeves, S. Warren, and P. Wothers. Oxford University Press, (2001).
14. Modern Methods of Organic Synthesis–William Carruthers and Lain Coldham, Cambridge University Press, 2009.

#### CHO(Pr)–4.6: LAB COURSE IN ORGANIC CHEMISTRY

Ternary mixture analysis (without derivatives). Qualitative analysis of three component mixture containing amino acids, low boiling liquids, nitrophenols etc.

***Books Recommended:***

1. Vogel's Textbook of Practical Organic Chemistry Revised–B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell, 5<sup>th</sup> Edition, Addison Wesley Longman Limited, UK, 1997.
2. A Hand book of Organic Chemistry–H. T. Clarke.
3. A Laboratory Manual of Organic Chemistry–B. B. Dey and M.V. Govindachari.
4. Lab Experiments in Organic Chemistry–Arun Sethi, New Age International Ltd. New Delhi. 2006

**Scheme of Examination**

Duration of examination	: 04 hours
Experiments	: 35 marks
Journal and Viva	: 05 marks
Internal Assessment	: 10 marks
Total	: 50 marks

**CHOT-4.3: HETEROCYCLIC AND MEDICINAL CHEMISTRY**

**UNIT-I**

**Heterocyclic Chemistry-I**

Chemistry of three, four, and seven membered heterocycles with one heteroatom.

Three membered: oxiranes, aziridines and thiranes.

Four membered: oxetanes, azetidines and thietanes.

Seven membered: oxepines, azepines and thiepinines.

**(12 Hours)**

**UNIT-II**

**Heterocyclic Chemistry-II**

Transformations, Photochemistry and rearrangement in heterocycles.

Transformations of: (i) coumarins to benzofurans, (ii) sydnones to pyrazoles, (iii) chromones to pyrazoles (iv) furans to pyridines and (v) pyrroles to pyridines.

Heterocycles in functional group transformations: (i) alkanes from thiophenes, (ii) cycloalkanes from pyrazolines, (iii) dienes from pyrroles (iv) alcohols from isoxazolidines (v) esters from trichlorocyanuric acid, (vi) acetylenes from 1,2,3-selenadiazoles and (vii) deoxygenation of phenols tetrazoles.

Rearrangements in heterocycles: (i) Dimroth rearrangement, (ii) Boulton–Katritzky rearrangement and (iii) Fischer Indole cyclisation.

**(12 Hours)**

**UNIT-III**

**Medicinal Chemistry-I:**

Modern theories of drug action, concept of receptors, computer aided drug design, qualitative and quantitative SAR.

Sulfa drugs: Sulfadiazines, sulfamethazines, sulfaguanidines, sulfaisoxozoles and sulfamerazine.

Analgesics: Classification of narcotic and non-narcotic analgesics.

Narcotic: Opium alkaloids, morphine, metopon, benzomorphan and phenazocine.

Non-Narcotic: 4-Phenylpiperidines, pethidine, di-isopropylamines, methadone, pyrazolones and antipyrine.

Anti-Fertility Drugs: Steroidal and non-steroidal compounds, norethindrone, mestranil, norgestrol and non-steroidal antifertility drugs.

**(12 Hours)**

#### UNIT – IV

##### **Medicinal Chemistry–II:**

Antineoplastic agents: Nitrogen mustards, chlorabucil, sarcolycin dopan and cyclophosphomide. Pteridines: Amethopterin, pyrimidines, 5-fluorouracil, cis-platines, anti-platines, etc.

Antibiotics: Structure, synthesis, stereochemistry and spectral features of the following antibiotics: natural penicillins, semisynthetic penicillins, patulin, chloramphenicol, streptomycin, structural features and uses of common antibiotic drugs. Norfloxacin, rifamycin and amoxycillin.

**(12 Hours)**

**Total: 48 Hours**

##### ***Recommended Books:***

1. An Introduction of the Chemistry of Heterocyclic Compounds–R. M. Achenson, 4<sup>th</sup> Edition, John Wiley and Sons.
2. Heterocyclic Chemistry–A.R. Katritzky and J. J. Logowskii.
3. Heterocyclic Chemistry–T. L. Gilchrist, 3<sup>rd</sup> Edition, Pearson Education Delhi (2005).
4. Modern Heterocyclic Chemistry –Joules and Smith.
5. Heterocyclic Chemistry–R. K. Bansal, 3<sup>rd</sup> Edition, New Age International Publishers (2002).
6. Medicinal Chemistry Volume I and II–A. Burger, Wiley–Interscience New York (1988).
7. Progress in Medicinal Chemistry Volume 1–8. Edited G.P. Ellis and G.B. West. North Holland New York (1974).
8. Organic Chemistry volume–I, II, I. L. Finar, 6<sup>th</sup> Edition, ELBS London (2007).
9. Heterocyclic Chemistry–J. A. Joule and K. Mills, 5<sup>th</sup> Edition, Wiley, (2010)

#### CHO(Pr) –4.7: LAB COURSE IN ORGANIC CHEMISTRY

##### **Preparation of Derivatives / Spectral Analysis**

##### ***Recommended Books:***

1. Vogel's Textbook of Practical Organic Chemistry Revised - B. S. Furniss, A. J. Hannaford, P.W.G. Smith, A.R. Tatchell, 5<sup>th</sup> Edition, Addison Wesley Longman Limited, UK, 1997.
2. A Hand book of Organic Chemistry–H. T. Clarke.
3. A Laboratory Manual of Organic Chemistry - B. B. Dey and M. V. Govindachari.
4. Lab Experiments in Organic Chemistry– y Arun Sethi, New Age International Ltd. New Delhi. 2006.

### Scheme of Examination

Duration of examination	: 04 hours
Experiments	: 35 marks
Journal and Viva	: 05 marks
Internal Assessment	: 10 marks
Total	: 50 marks

### CHOP-4.4: PROJECT WORK

The project work may include in-plant training in Industries/short term work in the department/other educational institutions/R&D organizations/data mining/review of current literature/theoretical methods/computer applications. Experimental work may involve studies on synthesis/measurements/study of properties/characterization by physical methods/activities for reported/unreported research or any suitable combination thereof.

In case of the students who would work outside the campus, the supervising staff member may visit to the work place at least once during the period and may be eligible for TA-DA as per the University rules.

### CHPT-4.1: QUANTUM MECHANICS AND SOLID STATE CHEMISTRY

#### UNIT-I

#### Chemical Bonding-I:

Electronic structure of diatomic molecules. The Born-Oppenheimer approximation. Valence bond and molecular orbital theories of chemical bonding, comparison of the two theories. Applications of valence bond and molecular orbital theories to hydrogen molecule and hydrogen molecule ion. Improvements in the Heitler-London wave functions.

Bonding and antibonding molecular orbitals. Molecular orbital theory applied to homonuclear and heteronuclear diatomic molecules, molecular electron configuration and calculation of bond order.

Slater orbitals, Hartree-Fock self-consistent field method for many electron atoms. Configuration interaction and Roothaan equations.

(12 Hours)

#### UNIT-II

#### Chemical Bonding-II:

Localized and non-localized molecular orbitals, hybridization and direct valence. Quantum mechanical treatment to  $sp$ -,  $sp^2$ - and  $sp^3$ -hybridization and the geometry associated with  $sp$ -,  $sp^2$ - and  $sp^3$ -orbitals.

Conjugated and aromatic molecules: Huckel molecular orbital theory and MO description of normal and cyclic butadienes, ethylene and aromatic molecules (benzene as an example), calculation of delocalization energies, fractional bond orders, charge density calculations and extended Huckel theory.

(12 Hours)

### UNIT-III

#### Solid State Chemistry-I

Introduction, properties of Solids: Malleability, ductility, elasticity, plasticity, brittleness hardness, enantiotropy, monotropy and isomorphism. Allotropy and polymorphism of solids. Bonding in solids: Ionic, covalent, metallic, molecular and hydrogen bonded crystals. Lattice energy of ionic crystals. Numerical problems.

Imperfection in solids: Types of defects including Frenkel and Schottky defects, thermodynamics of Frenkel and Schottky defects.

Reactivity in solid state: Introduction, thermodynamics, classification, experimental methods for the study, kinetic equation, energy of activation of solid state reactions, diffusion mechanism in solid state reactions, factors affecting the reactivity of solids.

(12 Hours)

### UNIT-IV

#### Solid State Chemistry-II:

Semiconductors: Bonding and conductivity, mechanism of conductivity, energy bands in semiconductors, impurity conductors, p-n and n-p-n junctions and importance of semiconductors.

Superconductors: Occurrence of super conductivity, its destruction by magnetic fields, effect of I.R. and isotope effect, B.C.S. theory of superconductivity applications.

(12 Hours)

Total 48 Hours

#### *Recommended Books:*

1. Quantum Mechanics-L.T.Schiff, Prentice-Hall.
2. Quantum Chemistry-H. Eyring, J. Walter and G. E. Kimball, John Wiley.
3. Quantum Mechanics-An Introduction- H. L. Strauss, Prentice Hall of India.
4. Quantum Mechanics-L. Pauling and E.B.Wilson, McGraw Hill.
5. Contemporary Quantum Chemistry-J. Goodisman, Plenum/Rosetta.
6. Quantum Chemistry-K. S. Pitzer, Prentice-Hall
7. Introductory Quantum Mechanics-Valdimir Rojanstry.
8. Quantum Chemistry- John P.Lowe.
9. Quantum Chemistry-Ira N. Levine, Prentice Hall of India Pvt. Ltd.
10. Quantum Chemistry-Donald A. McQuarrie, Viva Book Pvt. Ltd.
11. Physical Chemistry-P.W. Atkins, Clarendon Press, Oxford, 1970.
12. Molecular Quantum Mechanics-P.W.Atkins, Clarendon Press, Oxford, 1970.
13. Introduction to Quantum Chemistry-J. M. Anderson.
14. Introduction to Quantum Mechanics-R. H. Dicke, J. P. Wittke.
15. Introductory Quantum Chemistry-A. K. Chandra, Tata McGraw Hill, New Delhi 1994.
16. Quantum Mechanics in Chemistry-M.W. Hanna.
17. Quantum Chemistry-R .K. Prasad, New Age International Publishers, New Delhi.
18. Solid State Chemistry-N.B.Hanna

19. Solid State Physics–A.J.Dekkar, Mac Millon, India Ltd.1993
20. Solid State Chemistry–C.N.R.Rao, Cambridge, CUP
21. Solid State Physics, Edited by R. Kube and Takeo Nagamiya McGraw Hill Book Co. Inc.
22. Introduction to Solids–L.V.Azaroff, McGraw Hill, New York.
23. Solid State Chemistry and its Applications–A. R. West, John Wiley 1998

#### **CHP(Pr)–4.5: Lab Course in Physical Chemistry**

1. Viscosity: Viscosity of air by Rankine's method.
2. Solubility: Variation of solubility of  $\text{Ca}(\text{OH})_2$  in NaOH solution and hence determination of the solubility product of  $\text{Ca}(\text{OH})_2$ .
3. Thermochemistry: (i) Heat of reaction (precipitation/formation) of  $\text{BaSO}_4$ . (ii) Heat of transition of Glauber's salt ( $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ )
4. Surface Tension: Critical micelle concentration of a soap molecule. (e.g., Potassium laureate).
5. Potentiometry: Determination of degree of hydrolysis and  $K_h$  of aniline hydrochloride
6. Polarimetry: Kinetics of inversion of sucrose and determination of catalytic coefficient.
7. Cryoscopy: Determination of activities of electrolytes and non-electrolytes using cryoscopy method.
8. Spectrophotometry: Investigation of complex formation between  $\text{Fe}^{+3}$  and salicylic acid and determination of empirical formula, stability,  $\Delta G$  value calculation and pH effects.
9. Glass transition temperature: Determination of glass transition temperature by dilatometer.
10. Solid state: To determine the electron–phonon coupling constant of copper

#### ***Recommended Books:***

- 1) Findlay's Practical Physical chemistry, 9th edition, revised by B.P. Levitt.
- 2) Practical Physical Chemistry by A.M. James and F.E. Prichard
- 3) Experiments in Physical Chemistry by Shoemaker and garland
- 4) Experiments in Physical Chemistry by Daniels, Alberty and Williams et.al.
- 5) Laboratory Physical Chemistry by Oelke / M.A.C.T.L.A.C.
- 6) Experiments in Physical Chemistry by W.G. Palmer
- 7) Advanced Physico–Chemical experiments by J.Rose
- 8) Experimental Physical Chemistry by V.D. Athwale and Paul Mathur, New Age International Publishers.
- 9) Text Book of Physical Chemistry by S. Glasstone
- 10) Text Books of quantitative analysis by A.I. Vogel
- 11) Advanced Practical Physical Chemistry by J.B. Yadhav, Goel Publishing House, Meerut.
- 12) Computers and their applications to Chemistry, Ramesh Kumari, Narosa.
- 13) A Lab Manual of Polymers, S. M. Ashraf, Sharif Ahmed, Ufana Riaz, I.K. International New Delhi.

#### **Scheme of Examination:**

- i. Duration of examination : 04 hours

ii. Experiment	: 35 marks
iii. Viva-Voce & Journal	: 05 marks
iv. Internal assessment	: 10 marks
Total	: 50 marks

## CHPT-4.2: Catalysis and Polymer Chemistry

### UNIT-I

#### Homogeneous Catalysis:

Homogeneous Catalysis: Introduction, general catalytic mechanism: equilibrium treatment and steady-state treatment, activation energies for catalyzed reactions. Acid-Base catalysis: General acid-base catalysis, mechanism of acid-base catalysis, catalytic activity and acid-base strength, salt effects in acid-base catalysis and specific acid-base catalysis: Bronsted relation and linear free energy changes. Acidity functions: Zucker-Hammett hypothesis and Bunnett hypothesis.

Enzyme Catalysis: Influence of substrate concentration, pH, temperature and inhibitors, transient-phase kinetics. Mechanism of enzyme catalysis: Michaelis-Menten mechanism and Lineweaver-Burk plot.

(12 Hours)

### UNIT-II

#### Adsorption and Heterogeneous Catalysis:

Adsorption: The phenomenon of adsorption and thermodynamics of adsorption, adsorption isotherms, Langmuir adsorption isotherm, Langmuir constant and Gibbs energy of adsorption, Langmuir adsorption with lateral interaction, BET adsorption isotherm, Freundlich isotherm and adsorption on heterogeneous surface.

Heterogeneous catalysis: Catalysis at surfaces, mechanism of heterogeneous catalysis: Langmuir-Hinshelwood mechanism and Eley-Rideal mechanism. Transition-state theory of heterogeneous surface reaction: Rates of chemisorptions, rates of desorption, unimolecular and bimolecular surface reactions. Industrial applications of heterogeneous catalysis. Comparison of homogenous and heterogeneous reaction rates.

(12 Hours)

### UNIT-III

#### Polymer Rheology and Molecular Weight Determination:

Rheological Properties: Introduction, Hook's law, Newton's equation and stress-strain behavior in polymers.

4

#### Hours

Measurements of average molecular weights: Osmometry, viscometry, light scattering, and gel permeation chromatography. Practical significance of polymer molecular weight and related numerical problems.

8

#### Hours

(12 Hours)

## UNIT-IV

### **Thermal and Polymer Fabrication Techniques:**

Thermal method of analysis: Introduction, thermal characterization techniques: Thermogravimetric analysis (TGA) and differential thermal analysis (DTA), introduction, experimental procedure, advantages and disadvantages of TGA/DTA. Differential scanning calorimetry (DSC): Introduction, experimental setup, heat capacity, glass transition temperature, crystallization, melting and determination of percent crystallinity.

**6 Hours**

Methods of Polymer Fabrications: Fabrication of polymer films, solution casting, melt pressing, melt extrusion and bubble blown. Fabrication of shaped polymer objects: compression molding, injection molding, reaction injection molding, blow molding, extrusion molding and calendaring. Spinning industrial polymers: Solution spinning and melt spinning.

**6 Hours**

**(12 Hours)**

**Total 48 Hours**

### ***Books recommended:***

1. Physical Chemistry by G. M. Barrow, McGraw Hill, New York, 1996.
2. Fundamentals of Physical Chemistry by Maron and Lando.
3. Physical Chemistry by P. W. Atkins, ELBS, London, 1990 (Ed. 4).
4. Physical Chemistry by K. Vamulapalli, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
5. Physical Chemistry by Daniels and Alberty, Wiley, New York.
6. Physical Chemistry Through Problems by S. K. Dogra and S Dogra, Wiley Eastern, New Delhi.
7. A Text Book of Physical Chemistry by Samuel Glasstone, McMillan, London.
8. Atomic Structure and Chemical Bonding by Manas Chanda, Tata McGraw Hill Publishing Co., New Delhi.
9. Chemical Kinetics by K. J. Laidler, Tata McGraw Hill Publishing Co., New Delhi.
10. Kinetics and Reaction Mechanisms by Frost and Pearson, Wiley, New York.
11. Chemical Kinetics, K. J. Laidler. Mcgraw-Hill 1950.
12. Theory of rate processes, S. Glasstone, K. J. Laidler and H. Eyring Mcgraw-Hill 1941.
13. Kinetics and Mechanism, A Frost and R. G. Pearson, John Wiley, 1953.
14. The foundations of Chemical Kinetics, S. W. Benson, McGraw-Hill, 1960.
15. Kinetics of Chemical Changes in Solution, E. S. Amis, McMillan, 1948.
16. The Kinetics of Chemical Change, C. N. Hinshelwood, Oxford, 1942.
17. Free Radical Mechanisms, E.W.R. Steacies, Reinhold, 1946.

18. Techniques of Organic Chemistry, Weissberger (Ed) Vol VIII, Investigations of Rates and Mechanism of Reactions Interscience, 1963.
19. Theories of Chemical Reactions Rates, K.J. Laidler, McGraw-Hill, 1969.
20. Comprehensive Physical Chemistry, New Age International, New Delhi.
21. Polymer Chemistry: An Introduction, Malcolm P. Stevens, Oxford University Press, 1999.
22. Contemporary Polymer Chemistry, Harry R. Allcock and Frederick W. Lampe, Printice–Hall, 1981.
23. Principles of Polymer Chemistry, P. Bahadur and N. V. Shastri, Narosa Publisher, 2002
24. Polymer Chemistry: Properties and Applications, Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
25. Text Book of Polymer Chemistry, Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
26. Polymer Science, V. R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age International Publisher, 2001.
27. Membrane Technology in the Chemical Industry-S. P. Nunes and K. V. Peinemann (Eds.), Wiley–VCH Publisher, 2001.
28. Membranes for Industrial Wastewater Recovery and Reuse–Simon Judd and Bruce Jefferson (Eds.), Elsevier.
29. Membrane Processes, R. Rautenbach and R. Albrecht, Wiley and Sons, 1989.
30. A text book of Physical Chemistry, A. Singh and R. Singh, Campus Books, New Delhi.

#### **CHP(Pr)–4.6: LAB. COURSE IN PHYSICAL CHEMISTRY**

1. Surface Tension: Comparison of cleansing powers of two detergent samples.
2. Phase Equilibria: Phase diagram of naphthalene & diphenyl system, acetamide & salicylic acid and picric acid and benzene systems.
3. Conductance: Determination of the ionic conductance of  $\text{Cu}^{2+}$  at infinite dilution by Hittorf's method.
4. Reaction Kinetics: Studying the kinetics of photodegradation of indigocarmine (IC) using  $\text{ZnO/TiO}_2$  as photocatalyst and study the effect of  $\text{ZnO/TiO}_2$  and IC on the rate of photodegradation.
5. Potentiometry: Stability of the complex  $\text{Ag}(\text{NH}_3)_2$  (concentration cells)
6. Solubility: Influence of ionic strength on the solubility of  $\text{CaSO}_4$  and determination of its thermodynamic solubility product and mean ionic activity.
7. Cryoscopy: A study of complex formation between mercury and potassium halides using cryoscopy method.
8. Mobilities of ions: Determination of the ionic conductance of  $\text{Cu}^{2+}$  at infinite dilution by Hittorf's method.
9. Solid State: To determine the energy gap of semiconductor by resistivity measurement using four probe method.
10. Potentiometry: Determination of Hammett constant of ortho-, meta- and para-amino/nitro benzoic acid by pH measurements.

#### ***Books Recommended:***

- 1) Findlay's Practical Physical chemistry, 9th edition, revised by B.P. Levitt.
- 2) Practical Physical Chemistry by A. M. James and F. E. Prichard
- 3) Experiments in Physical Chemistry by Shoemaker and Garland
- 4) Experiments in Physical Chemistry by Daniels, Alberty and Williams.
- 5) Laboratory Physical Chemistry by Oelke / M.A.C.T.L.A.C.
- 6) Experiments in Physical Chemistry by W.G. Palmer
- 7) Advanced Physico-Chemical Experiments by J. Rose

- 8) Experimental Physical Chemistry by V. D. Athwale and Paul Mathur, New Age International Publishers.
- 9) Text Book of Physical Chemistry by S. Glasstone
- 10) Text Books of Quantitative Analysis by A. I. Vogel
- 11) Advanced Practical Physical Chemistry by J. B. Yadhav, Goel Publishing House, Meerut.
- 12) Computers and their applications to Chemistry, Ramesh Kumari, Narosa.
- 13) A Lab Manual of Polymers, S.M. Ashraf, Sharif Ahmed, Ufana Riaz, I.K. International New Delhi.

**Scheme of Examination:**

i. Duration of examination	: 04 hours
ii. Experiment	: 35 marks
iii. Viva-Voce & Journal	: 05 marks
iv. Internal assessment	: 10 marks
Total	: 50 marks

**CHPT-4.3: SPECTROSCOPY AND MICROSCOPY**

**UNIT-I**

**Raman Spectroscopy:**

Introduction to scattering phenomenon, Raman effect: Theories of Raman effect (Classical and quantum theory). Concept of polarizability and polarizability ellipsoid. Rotational-Raman Spectra and vibrational-Raman spectra of Molecules.

Symmetry selection rule and prohibition of inter-combination, influence of nuclear spin in case of homonuclear diatomic molecules, ortho- and para-modifications. Rotational-vibrational-Raman spectra, rule of mutual exclusion. Polarization of Raman lines and depolarization ratio. An introduction to Laser resonance Raman spectroscopy. Structure elucidation using combined Raman and infrared spectroscopy (e.g. H<sub>2</sub>O, N<sub>2</sub>O and CO<sub>2</sub>). Numerical problems.

**(12 Hours)**

**UNIT-II**

**Mass Spectrometry:**

Mass Spectrometry: Introduction, theoretical principles and instrumentation: ionization and ionization methods (electron ionization, chemical ionization, desorption ionization and electron spray ionization techniques). Mass analyzer (magnetic deflection and time of flight mass analyzer).

Metastable ions. Ionization and appearance potentials, experimental determination of ionization and appearance potential and applications in mass spectrometry.

Fragmentation: Principles, Stevenson rule, odd electron (OE<sup>+</sup>) and even electron (EE<sup>+</sup>) ions, molecular ion and base peak, fragmentation pattern and correlation with structure. Isotope effects in chloro and bromo compounds. McLafferty rearrangement.

Nitrogen Rule. Application of mass spectrometry in structure diagnosis and determination of empirical molecular formula from the peak intensities of molecular ion and isotopic peaks. Numerical problems.

**(12 Hours)**

### UNIT-III

#### **Photoelectron and Mössbauer Spectroscopy:**

Photoelectron Spectroscopy: Introduction, photoelectric effect, instrumentation. Valence and binding energies, molecular term symbols, shift in energies due to chemical effects. Auger electron spectroscopy (AES), its advantages and limitations. Electron spectroscopy for chemical analysis (ESCA). Applications to free molecules and surfaces.

**6 Hours**

Mössbauer Spectroscopy: Theoretical principles, Mössbauer effect, conditions for Mössbauer spectroscopy and instrumentation. Resonance line shifts, chemical shifts, electric quadrupole interactions and magnetic interactions. Applications of Mossbauer Spectroscopy.

**6 Hours**

**(12 Hours)**

### UNIT-IV

#### **Microscopy:**

Introduction to Microscopy.

Scanning electron microscopy (SEM): Introduction, principle and instrumentation, sample preparation, scanning process, image formation and applications of SEM.

**3 Hours**

Transmission electron microscopy (TEM): Introduction, principle and instrumentation, sample preparation, advantages/disadvantages and applications of TEM.

**2**

**Hours**

Atomic force microscopy (AFM): Introduction, principle, imaging modes, topographic image, advantages/disadvantages and applications of TEM.

**2**

**Hours**

Attenuated total reflectance (ATR) spectroscopy: Introduction, principle, sampling method, crystal methods for ATR, factors affecting the spectrum, sampling: liquid and solid sampling. Applications.

**3 Hours**

Photoacoustic spectroscopy: Introduction, principle, photoacoustic effect, advantages and limitations of photoacoustic spectroscopy, examples and applications of photoacoustic spectroscopy.

**2 Hours**

**(12 Hours)**

**Total 48 Hours**

#### ***Recommended Books:***

1. Introduction to Molecular Spectroscopy–G. M. Barrow, McGraw Hill, New York.
2. Physical Methods in Inorganic Chemistry–R. S. Drago, East-West Press, New Delhi
3. Molecular Spectroscopy–J. D. Graybeal, McGraw Hill.
4. Spectroscopy, Vol. I, II and III. Ed.–Walker and Straughan, Chapman Hall, 1976.
5. Infrared and Raman Spectra of Polyatomic Molecules–G. Herzberg, Van Nostrand, New York, 1954.
6. Absorption Spectroscopy–R.P.Bauman, Wiley New York,1952.
7. Introduction to Photoelectron Spectroscopy–P.K.Ghosh., John Wiley

8. Photoelectron Spectroscopy–T.H.D. Eland. Butterworth, London, 1974.
9. Fundamentals of Molecular spectroscopy–C.N.Banwell, Tata McGraw Hill, New York,1985.
10. Magneto chemistry–P.Selwood , Interscience, New York, 1956.
11. Techniques in Organic Chemistry, Vol.I. Interscience, 1963
12. Mass Spectroscopy: Organic Applications-K. Beiman, McGraw Hill.
13. Introduction to Mass Spectroscopy and its Applications–R.W. Kiser, Prentice Hall, Englewood–Cliff (NJ) 1965.
14. Basic Principle of Spectroscopy–Raymond Chang, McGraw Hill Kogakusha, Tokyo, 1971.
15. Physical Chemistry G.M.Barrow–McGraw Hill, New York, 1991.
16. Instrumental Methods of Analysis–Willard, Merritt and Dean, Tata MacGraw Hill, New Delhi, 1993.
17. Molecular Interpretation of Mass Spectroscopy–F. W. Mclafferty and W. A. Benzamin.
18. Molecular Spectroscopy–I.N.Levin, Interscience.

#### **CHP(Pr)–4.7: Lab Course In Physical Chemistry**

1. Surface Tension: Molecular surface energy and association factor.
2. Phase Equilibria: Formula of the complex formed between copper ions and ammonia by distribution method.
3. Refractometry: Ionization constant of bromphenol blue.
4. Reaction Kinetics: Kinetics of oxidation of 2-propanol by chromic acid and determination of effect of addition of Mn(II) on the reaction rate.
5. Reaction Kinetics: Studying the kinetics of reaction between CAT and indigocaramine spectrophotometrically and determination of rate constant
6. Potentiometry: Transport number of  $\text{Ag}^+$  and  $\text{NO}_3^-$  in solution (concentration cells)
7. Viscosity: Effect of temperature on the viscosity of the liquid Viscosity of air by Rankine`s method.
8. Solid state: Determination of magnetic susceptibility of paramagnetic substance by Quinke`s method
9. Solid state: Determine the relative integrated intensities of ZnS by Debye Scherrer pattern.

Computer applications: The students will be taught to operate a PC and how to run standard programs and packages such as MS-WORD, EXCEL, ORIGIN, SIGMA PLOT, CHEM SKETCH etc. and solve chemistry problems. Problems will be taken preferably from physical chemistry for plotting first and second derivative curves, linear plots etc. Problems from chemical kinetics, polymer chemistry, analytical chemistry, electrochemistry, spectroscopy etc. will be solved.

#### ***Recommended Books:***

1. Findlay's Practical Physical chemistry, 9th edition, revised by B.P. Levitt.
2. Practical Physical Chemistry by A.M. James and F.E. Prichard.
3. Experiments in Physical Chemistry by Shoemaker and garland.

4. Experiments in Physical Chemistry by Daniels, Alberty and Williams et.al.
5. Laboratory Physical Chemistry by Oelke / M.A.C.T.L.A.C.
6. Experiments in Physical Chemistry by W.G. Palmer.
7. Advanced Physico–Chemical experiments by J.Rose.
8. Experimental Physical Chemistry by V.D. Athwale and Paul Mathur, New Age International Publishers.
9. Text Book of Physical Chemistry by S. Glasstone.
10. Text Books of quantitative analysis by A.I. Vogel.
11. Advanced Practical Physical Chemistry by J.B. Yadhav, Goel Publishing House, Meerut.
12. Computers and their applications to Chemistry, Ramesh Kumari, Narosa.
13. A Lab Manual of Polymers, S.M. Ashraf, Sharif Ahmed, Ufana Riaz, I.K. International New Delhi.

**Scheme of Examination:**

- |                            |            |
|----------------------------|------------|
| i. Duration of examination | : 04 hours |
| ii. Experiment             | : 35 marks |
| iii. Viva-Voce & Journal   | : 05 marks |
| iv. Internal assessment    | : 10 marks |
| Total                      | : 50 marks |

**CHPP–4.4: Project Work**

The project work may include in–plant training in industries/short term work in the Department/other educational institutions/R&D organizations/data mining/rReview of current literature/theoretical methods/computer applications. Experimental work may involve studies on synthesis/measurements/study of properties/characterization by physical methods/activities for reported/unreported research or any suitable combination thereof.

In case of the students who would work outside the campus, the supervising staff member may visit to the work place at least once during the period and may be eligible for TA–DA as per the University rules.

KARNATAK UNIVERSITY, DHARWAD  
POST-GRADUATE DEPARTMENT OF STUDIES IN CHEMISTRY

SYLLABUS FOR M.Sc. CHEMISTRY

CHOICE BASED CREDIT SYSTEM

(CBCS)  
(With effect from 2019-20)

SEMESTER-I

CHAT-1.1 INORGANIC CHEMISTRY-I

UNIT-I

Structures and Energetics of Ionic Crystals and Covalent Bonds:

Ionic Bond: Properties of ionic compounds, crystal lattices, closed packed structures, coordination number of an ion, radius ratio rule, structures of crystal lattices- NaCl, CsCl, ZnS and rutile. Lattice energy: Born Lande equation, Born-Haber cycle, uses of Born-Haber type of calculations. Covalent character in ionic bonds, Fajan's rules, hydration energy and solubility of ionic solids.

Covalent Bond: Valence bond theory, resonance, hybridization and energetics of hybridization. VSEPR theory: Deduction of molecular shapes. MOT of homo and heteronuclear molecules and MO treatment for the molecules involving delocalized  $\pi$ -bonding ( $\text{CO}_3^{2-}$ ,  $\text{NO}_3^-$  and  $\text{CO}_2$ ). Walsh diagrams and Bent's rule.

(12 Hours)

## UNIT-II

### Coordination Chemistry:

Coordination numbers 2–10 and their geometries. Crystal field theory of coordination compounds: octahedral, square planar, tetrahedral, trigonal bipyramidal and square pyramidal fields, measurement of  $10 Dq$  and factors affecting it, CFSE, Spectrochemical series and Jahn–Teller effect.

Structural evidences for ligand field splitting: hydration, ligation and lattice energies. Evidences for covalency in M–L bonding. MO theory of coordination compounds: MO energy level diagrams for octahedral and tetrahedral complexes without and with  $\pi$ -bonding.

Electronic Spectra: Spectroscopic ground terms, Orgel diagrams for transition metal complexes ( $T_d$  &  $O_h$ ).

Magnetism: Types, spin moment, spin–orbit coupling.

(12 Hours)

## UNIT-III

### Stability of Metal Complexes, Concepts of Acids and Bases and Non-Aqueous Solvents:

Stability of complexes: Step-wise and overall formation constants, factors affecting stability of metal complexes, determination of stability constants of metal complexes by spectrophotometric and polarographic methods.

Concept of acids and bases: Theories of acids and bases, Bronsted and Lewis acids and bases, Lux–Flood theory, leveling effect of solvents, hardness and softness, HSAB concept and its applications.

Non-aqueous solvents: Classification of solvents, properties of non-aqueous solvents. Reactions in non-aqueous media: Liquid ammonia, anhydrous sulphuric acid, anhydrous HF, liquid sulphur dioxide. Super acids.

(12 Hours)

## UNIT-IV

### Solid State Chemistry:

Crystal lattice: Unit Cell, Miller indices and planes, X-ray diffraction method, molecular solids, hydrogen bonding, metallic, covalent and ionic solids; structural classification of binary and tertiary compounds, determination simple structure, spinel and perovskite structures. Band theory, conductors, semiconductors and insulators, energy bands, intrinsic and extrinsic semiconductors. Perfect and imperfect crystals, intrinsic and extrinsic defects, point, line and plane- defects. Vacancy, Schottky and Frenkel defects. Schottky and Frenkel defect formation, colour centres, non-stoichiometry.

(12 Hours)

Total 48 Hours

***Recommended Books:***

- 1 Inorganic Chemistry–Principles of Structure and Reactivity, 4<sup>th</sup>Edn–J. E. Huheey, E.A. Keiter, R. L. Keiter and O.K. Medhi. Pearson Education (2009).
- 2 Shriver & Atkins' Inorganic Chemistry, 5<sup>th</sup> Edn–P. Atkins, Tina Overton, J. Rourke, Mark Weller and F. Armstrong.Oxford University Press (2010)
- 3 Inorganic Chemistry, 2<sup>nd</sup> Edn. Catherine E. Housecroft and A.G. Sharpe, Pearson Prentice Hall (2005)
- 4 Concise Inorganic Chemistry–J. D. Lee, 5<sup>th</sup> Edn, New Age International (1996).
- 5 Solid State Chemistry and its Applications–A. R. West, John-Wiley and sons.
- 6 Solid state Chemistry–N. B. Hannay, Prentice-Hall of India Pvt. Ltd. New Delhi.

**CHA(Pr)–1.5: Lab Course in Inorganic Chemistry**

- 1 Determination of iron in hematite ore using cerium(IV) solution (0.02M) as the titrant and gravimetric determination of insoluble residue.
- 2 Determination of calcium and magnesium carbonates in dolomite ore using EDTA titration and gravimetric analysis of insoluble residue.
- 3 Quantitative analysis of copper-nickel in alloy/mixture:
  - ii. Copper volumetrically using  $\text{KIO}_3$
  - iii. Nickel gravimetrically using DMG
- 4 Determination of lead and tin in a mixture: Analysis of solder using EDTA.
- 5 Determination of Cr(III) and Fe(III) in a mixture: Kinetic masking.
- 6 Quantitative determination of iron(III) gravimetrically and calcium(II) volumetrically in a mixture.

- 7 Determination of iron(II) and nickel (II) in a mixture:  
iv. Iron(II) volumetrically using  $K_2Cr_2O_7$  solution  
v. Nickel gravimetrically using DMG solution
- 8 Quantitative analyses of chloride and iodide in a mixture:  
vi. Iodide volumetrically using  $KIO_3$   
vii. Total halide gravimetrically
- 9 Preparation of complexes:  
i) Tris (thiourea) copper(I)sulphate monohydrate and  
ii) Tris (oxalato) aluminate (III)

**Scheme of Examination:**

1	Duration of Examination	: 4 hours
2	Experiment	: 35 marks
3	Viva-voce and Journal	: 05 marks
4	Internal assessments	: 10 marks
	Total	: 50 marks

**Recommended Books:**

- 1 Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.
- 2 Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc, India.
- 3 Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D
- 4 Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003, Pearson Education Pvt. Ltd., New Delhi.
- 5 Practical Inorganic Chemistry– G. Pass and H. Sutcliff, Chapman and Hall Ltd (1968)

**CHAT-1.2: ORGANIC CHEMISTRY-I**

**UNIT-I**

**Bonding in Organic Molecules:**

Localized chemical bonding: Bond distances, bond angles, bond energies, bond polarity, dipole moment and calculation of heat of reactions.

Delocalised chemical bonding: Conjugation, cross conjugation, steric inhibition of resonance, hyperconjugation, tautomerism, valence tautomerism.

Structure and reactivity: Brönsted-Lowry concept of organic acids, conjugate acids and bases, pH, pKa values. Electronic, steric, and solvent effects on their strengths. General and specific acid base catalysis, running scale of acidity. Lewis acids and bases. HSAB concept.  
(12 Hours)

## UNIT-II

### Organic Reaction Mechanisms:

Classification of organic reactions: Meaning and importance of reaction mechanism.

Non-kinetic methods of Determination of Reaction Mechanism: Product identification, cross over experiments, study of intermediates, isotopic labeling, kinetic isotope effects and stereochemical studies.

Nucleophilic substitutions (aliphatic): Mechanisms of  $S_N2$ ,  $S_N1$  (rearrangements in  $S_N1$  reactions) and  $S_{Ni}$ ,  $S_{RN}1$  pathways. Effects of structure, leaving groups and ambident nucleophiles.

Elimination Reactions:  $E_2$ ,  $E_1$ ,  $E_1CB$  pathways. Stereochemistry, product proportions in dehydration of alcohols, alkyl halides (chiral and achiral), Hoffmann and Saytzeff rules. Substitution v/s elimination and pyrolytic eliminations.

(12 Hours)

## UNIT-III

### Stereochemistry and Conformational Analysis:

Elements of symmetry and chirality, optical isomerism, optical activity, specific rotation. molecules with one asymmetric center. Fischer, Wedge and 3D representations, DL and RS systems indicating configuration. Ring compounds, molecules with two chiral centers: Fischer, Saw-Horse, Newmann projections and their transformations.

Enantiomers, diastereomers, epimers, racemization, resolution. Stereochemical correlation.

Geometrical isomerism: E-Z nomenclature, configuration of geometrical isomers and *syn*- & *anti*- isomers.

Conformational analysis: Conformational study of n-Butane, ethylene, glycol, chlorohydrin.

(12 Hours)

## UNIT-IV

### Aromaticity:

Aromaticity and Huckel's rule: HMO theory, energy level diagrams, möbius systems, benzenoid and non-benzenoid aromatic compounds. Tropones, tropolones, borazine and azulene.

Heterocyclic Systems: Systems of the type pyrrole, pyridines, pyrilium cation, ferrocene. alternant and non-alternant hydrocarbons.

Aromaticity of charged rings (3-8 membered), non aromatic, anti-aromatic and homo aromatic systems.

Ring current as criteria for aromaticity. Annulenes and heteroannulenes [10-18].

(12 Hours)

**Total 48 Hours**

***Recommended Books:***

- 1 Organic Chemistry–P. Y. Bruice, 7<sup>th</sup> Edition, Pearson Education Pvt. Ltd., New Delhi (2013).
- 2 Organic Chemistry–S. H. Pine, McGraw-Hill, London (1987).
- 3 Mechanism and Structure in Organic Chemistry–1965, by E.S. Gould.
- 4 Organic Chemistry–R. T. Morrison and R.T. Boyd, Prentice Hall, New Delhi (1994).
- 5 Organic Chemistry–T. W. Graham Solomons, 4<sup>th</sup> Edition, John Wiley and Sons (1988).
- 6 Organic Chemistry–G. M. Loudon, 4<sup>th</sup> Edition, Oxford University Press, New York (2002).
- 7 Organic Chemistry Volume–I, II–I. L. Finar, 6<sup>th</sup> Edition, ELBS London (2004).
- 8 Organic Chemistry–F.A. Carey, 4<sup>th</sup> Edition, McGraw Hill (2000).
- 9 Advanced Organic Chemistry, Reactions, Mechanism and Structure–J. March, 3<sup>rd</sup> Edition, Wiley Eastern Ltd. (2004).
- 10 Stereochemistry–Conformation and Mechanism–P. S. Kalsi, Wiley–Eastern Ltd, New Delhi (1992).
- 11 Guidebook to Mechanism in Organic Chemistry–P. Sykes. Orient Longman, London (2002).
- 12 Aromaticity–P. J. Garratt, McGraw Hill Book company (1971).

**CHA(Pr)–1.6 : LAB COURSE IN ORGANIC CHEMISTRY**

**Preparation of the following organic compounds:**

- 1 Benzoic acid and benzyl alcohol from benzaldehyde (Cannizarro reaction).
- 2 Cyclohexanone from cyclohexanol.
- 3 Reduction of *p*-nitrobenzaldehyde to *p*-nitrobenzylalcohol.
- 4 2,4-Dinitrophenol from chlorobezene.
- 5 Benzil from benzaldehyde.
- 6 *m*-Nitroaniline from nitrobenzene.
- 7 *m*-Nitro benzoic acid from ethyl benzoate.
- 8 Benzanilide from benzophenone (Beckmann rearrangement).
- 9 *p*-Bromoaniline from acetanilide.
- 10 *p*-Nitroaniline from acetanilide.

***Recommended Books:***

1. Vogel's Textbook of Practical Organic Chemistry Revised–B.S.Furniss, A. J. Hannaford, P.W.G. Smith, A. R. Tatchell, 5<sup>th</sup> Edition, Addison Wesley Longman Limited, UK, 1997.
2. A Hand book of Organic Chemistry–by H. T. Clarke.
3. A Laboratory Manual of Organic Chemistry by B. B. Dey and M. V. Govindachari.
4. Lab Experiments in Organic Chemistry–by Arun Sethi, New Age International Ltd. New Delhi. 2006.

**Scheme of Examination:**

v. Duration of examination	: 04 hours
vi. Experiments	: 35 marks
vii. Viva-Voce & Journal	: 05 marks
viii. Internal assessment	: 10 marks
Total	: 50 marks

**CHAT–1.3: PHYSICAL CHEMISTRY–I**

**UNIT–I**

**Quantum Mechanics:**

Review of classical mechanics: Equation of motion for a particle, Newtonian, Lagrangian and Hamiltonian equations of motion, elementary wave motion. Operators, eigen values and expectation values, commuting operators, linear operator and hermitian operators. Solutions of Schrödinger equations of a free particle, particle in a box problem: in one and three dimensions, degeneracy, reflection and penetration of a particle in a one dimensional box of semi-infinite barrier, a particle in a box of finite walls.

Rigid rotator, derivation of selection rules for transitions in rotating molecule, linear harmonic oscillator, Hermite polynomials. Equation for the hydrogen atom in spherical polar coordinates and an indication of the method of its solution, the quantum numbers and their significance.

Hydrogen-like atoms, properties of the H–atom wave functions. Electronic energy states of H–atom. Many electron systems and the self consistent field method. Electronic configurations in the periodic table. Pauli exclusion principle.

**(12 Hours)**

**UNIT–II**

**Reaction Kinetics:**

A critical account of collision and transition state theories.

Kinetics and mechanism: Steady state approximation and simple examples relating kinetics to mechanism. Theories of Unimolecular reactions: RRKM theory. Isomerisation of methyl isocyanide. Chain Reactions, examples of chain reactions, general aspects of chain reactions. Chain-length, chain transfer reactions, chain inhibition, kinetics of branching chain reactions and explosion limits.

**(12 Hours)**

### UNIT-III

#### **Thermodynamics:**

Thermodynamic criteria for spontaneous chemical changes. Systems at (i) constant volume and temperature and (ii) constant pressure and temperature (derivation of  $dA \leq 0$  &  $dG \leq 0$ ). Dependence of free energy on pressure and temperature. Standard free energies and their determination. Relation between free energy change and equilibrium constant. Gibbs-Helmholtz equation and their different forms. The pressure dependence of free energy of non-ideal gases and fugacity. Standard state for non-ideal gas. Equilibrium constant for system of non-ideal gases. Lewis and Randall rule. Temperature dependence of free energy and equilibrium constants. Partial miscibility, activity and activity coefficients of components of solutions, partial molar quantities and their determinations. Gibbs-Duhem equation and the calculation of activity of a component in solutions. Duhem-Margules equation. Ternary systems and phase diagram of ternary systems.

### UNIT-IV

#### **Polymers:**

Review on basic concepts of polymers and their classifications. Basic concepts in polymer. Comparison between addition polymers and condensation polymers. Tacticity. Elastomers, difference between elastomer and thermoplastic, approaches to increase processability. Techniques of free-radical polymerization: Bulk, solution, suspension, emulsion and precipitation polymerization. Reactions of vinyl polymers: Functional group reactions, ring-forming reactions and block & graft copolymer formation. Crosslinking reactions: peroxide crosslinking, sulphur vulcanization, radiation crosslinking, photo crosslinking, electron beam crosslinking and miscellaneous crosslinking reactions. Polymer degradation: Chemical, thermal and radiation degradations.

**(12 Hours)**

**Total: 48 Hours**

#### ***Books Recommended:***

- 1 Introduction to Quantum Chemistry by A. K. Chandra, Ed. 3, Tata McGraw Hill, New Delhi, 1988.
- 2 Quantum Chemistry by R. K. Prasad, New Age International Publications, New Delhi, 1997.
- 3 Quantum Chemistry by Eyring, Walter and Kimball, John-Wiley, New York.

- 4 Physical Chemistry by G. M. Barrow, McGraw Hill, New York, 1996.
- 5 Fundamentals of Physical Chemistry by Maron and Lando.
- 6 Physical Chemistry by P. W. Atkins, ELBS, London, 1990 (Ed. 4).
- 7 Physical Chemistry by K. Vamulapalli, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
- 8 Physical Chemistry by Daniels and Alberty, Wiley, New York.
- 9 Physical Chemistry Through Problems by S. K. Dogra and S Dogra, Wiley Eastern, New Delhi.
- 10 A Text Book of Physical Chemistry by Samuel Glasstone, McMillan, London.
- 11 Atomic Structure and Chemical Bonding by Manas Chanda, Tata McGraw Hill Publishing Co., New Delhi.
- 12 Chemical Kinetics by K. J. Laidler, Tata McGraw Hill Publishing Co., New Delhi.
- 13 Kinetics and Reaction Mechanisms by Frost and Pearson, Wiley, New York.
- 14 Polymer Chemistry: An Introduction, Malcolm P. Stevens, Oxford University Press, 1999.
- 15 Contemporary Polymer Chemistry, Harry R. Allcock and Frederick W. Lampe, Printice-Hall, 1981.
- 16 Principles of Polymer Chemistry, P. Bahadur and N. V. Shastri, Narosa Publisher, 2002
- 17 Polymer Chemistry: Properties and Applications, Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
- 18 Text Book of Polymer Chemistry, Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
- 19 Polymer Science, V. R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age International Publisher, 2001.

#### **CHA (Pr)–1.7: LAB COURSE IN PHYSICAL CHEMISTRY**

- 1 General Information and Chemical mathematics: Calibration of glasswares, concentration measures of solutions- concept of normality, molarity, molality and mole fraction, preparation of standard solution. Treatment of Experimental data – Errors, type of errors, Accuracy and precision. Mean deviation, standard deviation, significant figures, Methods of average and least squares.
- 2 Spectrophotometry: To obtain the absorption curve of  $\text{KMnO}_4$  solution on a colorimeter and hence verify Beer–Lamberts law.
- 3 Potentiometry: Determination of the dissociation constant of dibasic acids (minimum two acids and titration with NaOH)
- 4 Conductance: Simultaneous estimation of  $\text{H}_2\text{C}_2\text{O}_4$  and HCl in the mixture conductometrically by titrating with NaOH.
- 5 Distribution law: Studying the distribution of benzoic acid between water and benzene and hence determine the degree of association of benzoic acid in benzene.
- 6 Viscosity: Determination of viscosity average molecular weight of polystyrene in toluene by Ubbelohde Viscometer
- 7 Thermochemistry: Determine the relative strength of  $\text{CH}_3\text{COOH}$  and  $\text{ClCH}_2\text{COOH}$  by calorimetric method.
- 8 Reaction Kinetics: Determination of activation parameters of the reaction of acid hydrolysis of methyl acetate at two different temperatures.
- 9 Cryoscopy: Determination of cryoscopic constant of benzene and nitrobenzene
- 10 Refractometry: Analysis of a binary mixture (glycerol and water) by refractive indices measurement.

### ***Recommended Books:***

- 1 Practical Physical Chemistry by A. M. James and F. E. Prichard, Longmans, London.
- 2 Experiments in Physical Chemistry by Shoemaker and Garland, McGraw Hill, New York.
- 3 Experiments in Physical Chemistry by Daniels, Alberty and Willams, McGraw Hill, New York.
- 4 Experimental Physical Chemistry by W. G. Palmer, Cambridge University Press, London.
- 5 Advanced Physico-Chemical experiments by J. Rose.
- 6 Text Book of Physical Chemistry by S. Glasstone, , McGraw Hill, London.
- 7 Text book of Quantitative Analysis by A. I. Vogel, ELBS, Harlow.
- 8 Advanced Practical Physical Chemistry by J. B. Yadav, Goel Publishing House.
- 9 Experimental Physical Chemistry by V. D. Athawale and Parul Mathur, New Age International Publishers.
- 10 Advanced Physical Chemistry Experiments by Gurtu and Gurtu, Pragati Prakashan Educational Publishers, 3rd Edition 2007.

### **Scheme of Examination:**

- i. Duration of examination: 04 hours
  - ii. Experiment : 35 marks
  - iii. Viva-Voce & Journal : 05 marks
  - iv. Internal assessment : 10 marks
- Total : 50 marks

## **CHAT-14: ANALYTICAL CHEMISTRY**

### **UNIT-I**

#### **Language of Analytical Chemistry, Data Treatment and Gravimetric Analysis:**

Language of analytical chemistry: Definition of analysis, determination, measurement, techniques and methods. Classification of analytical techniques. Selection of an analytical method: Accuracy, precision, sensitivity, selectivity, robustness and ruggedness. Figures of merit of analytical methods: Sensitivity, detection limit and linear dynamic range.

Errors and Treatment of analytical Data: Limitations of analytical methods–Errors: determinate and indeterminate errors, minimization of errors. Statistical treatment of finite samples, measures of central tendency and variability, mean, median, range, standard deviation and variance. Student's t-test, confidence interval of mean. Testing for significance and comparison of two means and two standard deviations.

Comparison of an experimental mean and a true mean. Criteria for the rejection of an observation, Q-test. External standard calibration, the least squares methods, regression equation and correlation coefficient.

Gravimetric analysis: Mechanism of precipitation, factors influencing precipitation, coprecipitation, postprecipitation and organic reagents used in gravimetry (oxime and dmg).

(12 Hours)

## UNIT-II

### **Titrimetric Methods:**

Titrimetric Analysis: Principles of titrimetric analysis. Classification of reactions in titrimetry. Titrations based on acid-base reactions: Titration curves for strong acid and strong base, weak acid and strong base and weak base and strong acid titrations. Titration curves, quantitative applications, selecting and standardizing a titrant, inorganic analysis, alkalinity, acidity and ammonium salts.

Complexometric titrations: Indicators for EDTA titrations, theory of common indicators, titration methods employing EDTA, direct, back and displacement titrations, indirect determinations, titration of mixtures using masking and demasking agents.

Redox Titrations: Balancing redox equations, calculation of the equilibrium constant of redox reactions, titration curves, theory of redox indicators, calculation of standard potentials, determination of chemical oxygen demand (COD) in natural and waste waters.

Precipitation titrations: Titration curves, titrants and standards, indicators for precipitation titrations involving silver nitrate, the Volhard, the Mohr and the fajan's methods

(12 Hours)

## UNIT-III

### **Separation Methods-I:**

Fundamentals of chromatography: General description, definition, terms and parameters used in chromatography, classification of chromatographic methods, criteria for selection of stationary and mobile phase and nature of adsorbents.

Column chromatography: Theories, plate theory, rate theory, band broadening-eddy diffusion, longitudinal diffusion and resistance to mass transfer, column efficiency, Van Deemter's equation and its modern version, interrelationships, capacity factor, selectivity factor, column resolution, distribution constant and applications of conventional column chromatography, advantages and limitations.

Thin layer chromatography (TLC): Definition, mechanism, efficiency of TLC plates, methodology, selection of stationary and mobile phases, development, spray reagents, identification and detection, reproducibility of  $R_f$  values, qualitative and quantitative analysis.

High performance liquid chromatography (HPLC): Instrumentation, pumps, column packing, characteristics of liquid chromatographic detectors, UV and fluorescence detectors, advantages and applications.

(12 Hours)

## UNIT-IV

### **Separation methods-II**

Gas chromatography (GC): Principle, instrumentation, columns, study of detectors, thermal conductivity, flame ionization and mass spectrometry, factors affecting separation, retention volume, retention time and applications.

Ion exchange chromatography (IEC): Definition, principle, requirements for ion-exchange resin, types of ion-exchange resins, resin properties-ion-exchange capacity and its determination, resin selectivity and factors affecting the selectivity, applications of IEC in purification and recovery processes.

Solvent extraction: Nernst partition law, efficiency and selectivity of extraction. Extraction systems: Extraction of covalent neutral molecules, extraction of uncharged metal chelates and synergic extraction, extraction of ion-association complexes-non chelated complexes and chelated complexes. Use of salting out agents. Methods of extraction—batch and continuous extractions. Applications (special emphasis on extraction of iron and copper).

(12 Hours)

Total: 48 Hours

***Recommended Books:***

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8<sup>th</sup> edition, Saunders College Publishing, New York (2005).
2. Analytical Chemistry, G.D. Christian, 6<sup>th</sup> edition, Wiley–India (2007).
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, PHI Learning Pvt Ltd. New Delhi (2009).
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6<sup>th</sup> edition, Third Indian Reprint, Pearson Education Pvt. Ltd.(2007).
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California (1990).

**CHA(Pr)–1.8: Lab Course in Analytical Chemistry**

**III. Organic Chemistry Practical**

**Quantitative analysis**

- 1 Titrimetric Estimation of amino acids.
- 2 Estimation of glucose by Bertrand's method.
- 3 Estimation of keto group.
- 4 Iodine value of oil (Chloramine - T method)
- 5 Estimation of Nitro group by reduction using SnCl<sub>2</sub>.

**Qualitative Analysis**

Separation of binary mixture of organic compounds using ether and identification of separated compounds by systematic qualitative organic analysis.

Please Note: 1) Individual organic compounds are to be given after the candidate reports the nature of the mixture.

2) Ether insoluble acids and ether insoluble Neutral organic compounds may be given.

3) Low boiling liquids and Amino acids need not be given.

The following mixtures may be given:

- 1 Acid + Base
- 2 Acid + Neutral
- 3 Base + Neutral
- 4 Phenol + Acid
- 5 Base + Phenol

#### IV. Physical Chemistry Practicals

- 1 Determination of molecular radius of glycerol molecule by viscosity method.
- 2 Estimation of metal ions of ferric-thiocyanate and cupric-ammonia complexes by spectrophotometrically.
- 3 Determination of relative strength of acids (HCl and H<sub>2</sub>SO<sub>4</sub>) by studying the hydrolysis of methyl acetate.
  
- 4 Determination of dissociation constants of weak monobasic acids potentiometrically by titrating against NaOH.
- 5 Comparison of strengths of chloroacetic acid and acetic acid using conductometric method.
- 6 Determine the dissociation constant of acetic acid pH-metrically by titrating against NaOH.

#### ***Recommended Books:***

- 1 Practical Physical Chemistry by A. M. James and F. E. Prichard, Longmans, London.
- 2 Experiments in Physical Chemistry by Shoemaker and Garland, McGraw Hill, New York. Experiments in Physical Chemistry by Daniels, Alberty and Williams, McGraw Hill, New York.
- 3 Experimental Physical Chemistry by W. G. Palmer, Cambridge University Press, London.
- 4 Advanced Physico-Chemical experiments by J. Rose.
- 5 Text Book of Physical Chemistry by S. Glasstone, , McGraw Hill, London.
- 6 Text book of Quantitative Analysis by A. I. Vogel, ELBS, Harlow.
- 7 Advanced Practical Physical Chemistry by J. B. Yadav, Goel Publishing House.
- 8 Experimental Physical Chemistry by V. D. Athawale and Parul Mathur, New Age International Publishers.
- 9 Advanced Physical Chemistry Experiments by Gurtu and Gurtu, Pragati Prakashan Educational Publishers, 3rd Edition 2007.

#### **Scheme of Examination:**

- i. Duration of examination: 04 hours
- ii. Experiment : 35 marks
- iii. Viva-Voce & Journal : 05 marks

iv. Internal assessment : 10 marks  
Total : 50 marks

**SEMESTER-II**  
**CHAT-2.1: INORGANIC CHEMISTRY-II**

**UNIT-I**

**Chemistry of Non-Transition Elements:**

Alkali and alkaline earth metal complexes of crown ethers, cryptands and calixarenes and their biological importance. Synthesis, properties and structures of boron, carbon and silicon compounds: Chemistry of higher boranes, classification, structures and MO description of bonding, framework electron counting, Wade's rules, chemistry of  $B_5H_9$ ,  $B_{10}H_{14}$  and  $B_nH_n^{2-}$ , boron nitride, borazines, carboranes, metalloboranes, metallocarboranes; silicates, silicones, graphite, graphene, carbon nanotubes and zeolites. Hydrogen bonding and its influence on properties.

**(12 Hours)**

**UNIT-II**

**Chemistry of Main Group Elements:**

Nitrogen, phosphorous and sulphur compounds: Hydrides, oxides and oxy acids of nitrogen, phosphorous, sulphur and halogens. Phosphazines, phosphazene polymers, sulphur-nitrogen compounds: Binary sulphur nitrides:  $S_4N_4$ ,  $S_2N_2$  and  $(SN)_x$ . P-O and P-S cage compounds. Chemistry of halogens and xenon: Interhalogens, pseudohalogens, polyhalide ions, oxyhalogen species. Xenon oxides and fluorides.

**(12 Hours)**

**UNIT-III**

**Symmetry and Group Theory:**

Molecular symmetry, representation of symmetry operation as matrices. Definition of groups, set of symmetry operations of molecules satisfying the condition of point groups. Representation, basis of representation, reducible and irreducible representation. The great orthogonality theorem, character tables. The direct product. Applications of group theory: Molecular vibrations; molecular vibration in symmetrical  $AB_2$ . Hybridisation (tetrahedral and trigonal planar geometries)

(12 Hours)

#### UNIT-IV

##### Organometallic Chemistry:

Organometallic compounds: Introduction, classification of organometallic compounds by bond type, nomenclature, classification of ligands  $\sigma$  and  $\pi$  ligands, hapticity of ligands, 18 and 16 electron rules, electron counting schemes. Ferrocene and ruthenocene: Preparation, structure and bonding. Complexes containing alkene and alkyne ligands: Preparation, structure and bonding. Carbene (Fischer and Schrock type) complexes: Synthesis, structure and bonding. The isolobal principles.

Use of organometallic reagents in hydrogenation, hydroformylation, isomerisation and polymerization reactions.

(12 Hours)

Total: 48 Hours

##### *Recommended Books:*

- 1 Inorganic Chemistry–Principles of Structure and Reactivity, 4<sup>th</sup>Edn–J. E. Huheey, E.A. Keiter, R. L. Keiter and O.K. Medhi. Pearson Education (2009).
- 2 Shriver & Atkins' Inorganic Chemistry, 5<sup>th</sup> Edn–P. Atkins, Tina Overton, J. Rourke, Mark Weller and F.Armstrong.Oxford University Press (2010)
- 3 Inorganic Chemistry, 2<sup>nd</sup> Edn. Catherine E. Housecroft and A.G. Sharpe, Pearson Prentice Hall (2005)
- 4 Concise Inorganic Chemistry–J. D. Lee, 5<sup>th</sup> Edn, New Age International (1996).
- 5 Chemical Applications of Group Theory, 2<sup>nd</sup> Edn-F. A. Cotton, Wiley Eastern Ltd ( ).
- 6 Symmetry and Spectroscopy of Molecules–K. Veera Reddy, New Age International, (2011).
- 7 Group Theory in Chemistry–M. S. Gopinathanan and V. Ramakrishnan, Vishal Publishing Co. (2007)
- 8 Organometallic Chemistry–A unified Approach, R.C. Mehrotra and A. Singh, 2<sup>nd</sup> Edn. New Age International (2011).
- 9 F.A. Cotton and G. Wilkinson: Advanced Inorganic Chemistry, Wiley, 1991.
- 10 Basic Organometallic Chemistry – B D Gupta and A J Elias, Universities Press (2013)

#### CHA(Pr)–2.4: Lab Course in Inorganic Chemistry

1. Semimicro qualitative inorganic analysis of a mixture containing three cations (including one less common cation such as W, Mo, Ti, Zr, Ce, V and Li) and two anions (one of them may or may not be interfering anion such as  $PO_4^{3-}$ ,  $BO_3^{3-}$ ,  $C_2O_4^{2-}$ ,  $F^-$  and  $CH_3COO^-$ ).
2. Separation and determination of Zn and Mg on an anion exchanger.

3. Demonstration experiment: Determination of iron as the 8-hydroxy quinolate by solvent extraction.

**Scheme of Examination:**

5. Duration of Examination	: 4 hours
6. Experiment	: 35 marks
7. Viva-voce and Journal	: 05 marks
8. Internal assessment	: 10 marks
Total	: 50 marks

***Recommended Books:***

- 1 Vogel's Text Book of Quantitative Chemical Analysis (5<sup>th</sup> Ed), G.H. Jeffrey, J. Bassette, J. Mendham and R.C. Denny, Longman, 1999.
- 2 Vogel's Qualitative Inorganic Analysis (7<sup>th</sup> Ed), G. Svehla, Longman (2001)

**CHAT-2.2: ORGANIC CHEMISTRY-II**

**UNIT-I**

**Reaction Mechanism:**

Aliphatic electrophilic substitutions:  $S_E2$ ,  $S_E1$  and  $S_{Ei}$  mechanisms. Reactions involving double bond shifts,  $\alpha$ -halogenation of carbonyl compounds, nitrosation at carbon bearing active hydrogen, mercury exchange reactions.

Aromatic electrophilic substitutions: Mechanisms of aromatic, nitration, sulphonation, halogenation, isotope effects, energy profile diagrams. Kinetic and thermodynamic control, sulphonation, Hammond's Postulate, o/p ratio, ipso-substitution, Vilsmeier Haack and Fries rearrangement.

Aromatic nucleophilic substitutions:  $S_NAr$ ,  $S_N1$  and aryne pathways. Meisenheimer complexes, mechanism and synthetic applications of vicarious nucleophilic substitution (VNS), Von-Richter, Goldberg, Bucherer, Shiemann reactions and Smiles rearrangement.

**(12 Hours)**

**UNIT-II**

**Advanced Stereochemistry:**

Prochirality: Homotopic, enantiotopic and diastereotopic atoms, groups and faces.

Stereochemical descriptors: Application to reduction of carbonyl compounds, cyanohydrin formation, addition of water to alkenes.

Optical activity due to molecular dissymmetry: Allenes, spiranes, biphenyls, atropisomerism, molecular crowding.

Conformational analysis of cyclohexane, mono substituted cyclohexanes. Chirality of cyclohexanes.

(12 Hours)

### UNIT-III

#### Carbohydrates:

Monosaccharides: Conformational representation of monosaccharides and their transformations. Determination of configuration of the monosaccharides, mechanism of mutarotation–base catalyzed isomerisation of aldoses and ketoses. Epimerisation, anomeric effect, glycosides, ether and ester derivatives of carbohydrates. Acetone, amino and deoxysugars. Oxidation and reduction reactions of carbohydrates.

Disaccharides: Structure elucidation of maltose, lactose, sucrose.

Polysaccharides: Structure and degradation of starch, cellulose and glycogen.

(12 Hours)

### UNIT-IV

Chemistry of heterocycles: Nomenclature of heterocyclic compounds including fused heterocycles.

Synthesis and chemical reactions of indole, quinoline, isoquinoline, thiazole, imidazole, benzimidazole, coumarin, flavones and isoflavones.

(12 Hours)

**Total 48 Hours**

#### ***Recommended Books:***

- 1 Advanced Organic Chemistry part A and B–F. A. Carey and R. J. Sundberg, 4<sup>th</sup> Edition, Plenum Publishers (2000).
- 2 Advanced Organic Chemistry, Reactions, Mechanism and Structure–J March, 3<sup>rd</sup> Edition, Wiley Eastern Ltd. (2004).
- 3 Guide Book to Mechanism in Organic chemistry–Peter Sykes Oriant- Longman (1985).
- 4 Stereochemistry of Carbon Compounds–Eliel, Tata McGraw Hill, New Delhi (1976).
- 5 Stereochemistry of Organic Compounds, Principles and Applications – D. Nasipuri, Wiley Eastern Ltd (1992).
- 6 Organic Chemistry Vol–I, II, III–S. M. Mukherji, S. P. Singh and R. P. Kapoor, New Age International Ltd, New Delhi (2000).
- 7 Organic Chemistry Volume–I, II– I. L. Finar, 6<sup>th</sup> Edition, ELBS London (2004).
- 8 Chemistry of Carbohydrates–G. C. Percival.
- 9 Carbohydrates –Chemistry and Biochemistry –Pigman and Harton.
- 10 Heterocyclic Chemistry–T. L. Gilchrist, 3<sup>rd</sup> Edition, Pearson Education Delhi, (2005).
- 11 Heterocyclic Chemistry –J.A. Joule and G.F. Smith, 2<sup>nd</sup> Edition, Van Nostrand London (1978).

- 12 Heterocyclic Chemistry–R. K. Bansal, 3<sup>rd</sup> Edition, New–Age International, New Delhi, 2004.  
13 [https://profiles.uonbi.ac.ke/sdereese/files/upc\\_213nomenclature\\_of\\_heterocyclic\\_compounds\\_0.pdf](https://profiles.uonbi.ac.ke/sdereese/files/upc_213nomenclature_of_heterocyclic_compounds_0.pdf)

### CHA(Pr)–2.5 : Lab Course In Organic Chemistry

1. Quantitative Estimation of the following Organic compounds: (i) Acid (ii) Acid + Amide (iii) Acid + Ester (iv) Molecular weight determination by base hydrochloride method (v) Phenol (Bromometric method).
2. Preparations of derivatives of heterocycles like coumarins, quinolines, benzimidazoles, benzoxazines, pyrazoles by convention, microwave and by sonication.
3. Preparations based on functional group reactions of organic compounds like aldehydes, ketones, esters, phenols etc.

Note: Any two of the above experiments will be prescribed for the examination.

#### Scheme of Examination

I	Duration of examination	: 04 hours
ii	Experiments	: 35 marks
iii	Viva-Voce & Journal	: 05 marks
iv	Internal assessment	: 10 marks
	Total	: 50 marks

#### *Recommended Books:*

- 1 Vogel's Textbook of Practical Organic Chemistry Revised–B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell, 5<sup>th</sup> Edition, Addison Wesley Longman Limited, UK, 1997.
- 2 A Hand book of Organic Chemistry–H.T. Clarke.
- 3 A Laboratory Manual of Organic Chemistry–B. B. Dey and M.V. Govindachari.
- 4 Lab Experiments in Organic Chemistry–Arun. Sethi, New Age International Ltd. New Delhi. 2006.
- 5 Experimental Organic Chemistry–L. M. Harwood, and C. J. Moody, Blackwell Scientific, London, 1989.
- 6 Practical Organic Chemistry–W. Kemp, McGraw Hill, London, 1967.

## CHAT–2.3: PHYSICAL CHEMISTRY–II

### UNIT–I

### **Microwave Spectroscopy and X-ray Diffraction:**

Microwave spectroscopy: Gaseous microwave spectra and rotational transitions: Study of inversion of ammonia and hindered rotations in molecules. Instrumentation. Stark effect in molecular spectra, first and second order Stark effects.

X-ray diffraction: Origin and production of X-rays, interaction of X-rays with matter: Absorption, scattering and diffraction. Reciprocal lattice: Bragg's law in reciprocal space. Instrumentation: Sources, filters, monochromatic detectors. Crystal structure: Unit cell, lattices, planes and miller indices. Debye-Scherrer powder methods and Weissenberg camera. Numerical problems.

**(12 Hours)**

## **UNIT-II**

### **Reaction Kinetics:**

Kinetics in Solution: Effect of solvent, pressure and ionic strength for ion-ion, ion-neutral molecule type reactions and cage effects.

Potential energy surfaces, methods employed in the construct of potential surfaces, calculating reactions.

Fast Reactions: Techniques for fast reactions, flow methods, stopped flow technique, relaxation methods and flash photolysis. Numerical problems.

**(12 Hours)**

## **UNIT-III**

### **Electrochemistry:**

Introduction to electrochemistry, Debye-Huckel and Bjerrum models and the corresponding theoretical expression for activity coefficient and Debye-Huckel-Onsager theory of conductance of strong electrolytes.

Electrochemistry of Solution: Activity of ions in solution, solvation number and their determination, ion-solvent interactions, ion-ion interactions and free energy of ions in solution and triple ion formation, conductance minima and free energy of ions in solution. Born model for calculating the free energy of ion-solvent interaction and its modifications. The enthalpy and entropy of ion-solvent interaction.

Electrical double layer: Electrocapilarity, Lippman equation (surface excess), theories of electrical double layer: Helmholtz-Perrin, Gouy-Chapman and Stern theories. Effect of ions on zeta potential. Over potentials, exchange current density, derivation of Butler-volmer equation and Tafel plot.

**(12 Hours)**

## UNIT-IV

### Polymer Chemistry:

Transitions in polymers: Definition of glass transition temperature ( $T_g$ ) and flow temperature ( $T_f$ ) and melting temperature ( $T_m$ ), thermal behaviour of amorphous and crystalline polymers, factors affecting the  $T_g$ . Plasticizers, properties and their effect on  $T_g$  of PVC and diethylhexylsuccinate, efficiency of plasticizers, comparison of  $T_g$  and  $T_m$ .  $T_g$  of copolymers and polymer blends, relation between  $T_g$  and  $T_m$ .

Polymer molecular weight: Number average and weight average molecular weights, polydispersity and molecular weight distribution in polymers. Numerical problems on determination of molecular weights.

Kinetics of polymerization: Kinetics of free-radical addition polymerization, cationic polymerization, anionic polymerization, copolymerization and determination of reactivity ratios.

Polymer synthesis: Ziegler-Natta polymerization (isotactic and syndiotactic) and its limitations. Metallocene catalysis polymerization (isotactic). Metathesis polymerization: Acyclic diene metathesis polymerization (ADMET) and ring opening metathesis polymerization (ROMP). Group transfer polymerization (GTP) and advantages of GTP.

(12 Hours)

**Total 48 Hours**

### *Recommended Books:*

- 1 Fundamentals of Molecular Spectroscopy by C. N. Banwell, Tata McGraw Hill Publishing Co., New Delhi.
- 2 An introduction to Molecular Spectroscopy by G. M. Barrow, McGraw Hill, New York.
- 3 Molecular Spectra and Molecular Structure: I Spectra of Diatomic Molecules by G. Herzberg, Van Nostrand, Princeton.
- 4 Physical Chemistry by P. W. Atkins, ELBS, London.
- 5 Physical Chemistry by G. M. Barrow, McGraw Hill, New York.
- 6 Atomic and Molecular Spectroscopy by M. C. Gupta, New Age International Publishers, New Delhi.
- 7 Chemical Kinetics by K. J. Laidler, Tata McGraw Hill Publishing Co., New Delhi.
- 8 Kinetics and Reaction Mechanisms by Frost and Pearson, Wiley, New York.
- 9 Chemical Kinetics by K. J. Laidler, McGraw Hill, 1950.
- 10 Kinetics and mechanism of chemical transformations by J. Rajaraman and J. Kuriacose, McMillan.
- 11 Theory of rate processes by S. Glasstone, K. J. Laidler and H. Eyring, McGraw-Hill, 1941.
- 12 Theories of Chemical reaction Rates by K. J. Laidler, McGraw-Hill, 1969.

- 13 Techniques of Organic by Weissberger(ed.), Interscience, Vol.VIII, 1963,
- 14 Kinetics of Chemical Changes in Solution by E. S. Amis, MacMillan, 1948
- 15 The Foundations of Chemical Kinetics by S. W. Benson, MacGraw-Hill, 1960.
- 16 An Introduction to Electrochemistry by S. Glasstone, Van Nostrand, London
- 17 A Text book of Electrochemistry by G.F.A. Kortum and J.O.M. Bockris, Elsevier, New York.
- 18 Modern Electrochemistry by J.O.M. Bockris and A.K.N. Reddy Vol. I and Vol. II, Butterworths, London.
- 19 Polymer Chemistry: An Introduction, Malcolm P. Stevens, Oxford University Press, 1999.
- 20 Contemporary Polymer Chemistry, Harry R. Allcock and Frederick W. Lampe, Printice-Hall, 1981.
- 21 Principles of Polymer Chemistry, P. Bahadur and N. V. Shastri, Narosa Publisher, 2002
- 22 Polymer Chemistry: Properties and Applications, Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
- 23 Text Book of Polymer Chemistry, Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
- 24 Polymer Science, V. R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age International Publisher, 2001.

#### **CHA(Pr)–2.6: Lab Course In Physical Chemistry**

- 1 Solubility: Determine the heat of solution of a solute (e.g oxalic acid or benzoic acid) by solubility method.
- 2 Coulometric titration: Titration of I<sub>2</sub> against Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>.
- 3 Cryoscopy: Determination of the degree of dissociation of a given strong electrolyte and the determination of the number of ions present in the solute using cryoscopy method.
- 4 Spectrophotometry: To obtain the absorption spectra of coloured complexes (Ferric-thiocyanate and Cupric–ammonia complexes) and hence verify the Beer–Lambert’s law and estimation of metal ions in solution by spectrophotometry.
- 5 Conductance: (i) Determination of equivalent conductance of a weak electrolyte at different concentrations and the applicability of Ostwald’s law. (ii) Determination of equivalent conductance of a weak electrolyte from Kohlrausch’s law.
- 6 Potentiometry: Potentiometric determination of formal redox potential of Fe<sup>2+</sup>/Fe<sup>3+</sup> and Ce<sup>4+</sup>/Ce<sup>3+</sup> or Cr<sup>6+</sup>/Cr<sup>3+</sup> couples by titrating Fe<sup>2+</sup> solution with Ce<sup>4+</sup> or Cr<sup>6+</sup>.
- 7 Reaction Kinetics: Investigation of autocatalytic reaction between potassium permanganate and oxalic acid in the presence of H<sub>2</sub>SO<sub>4</sub>.
- 8 Viscosity: Determination of limiting viscosity number (Staudinger index) of polystyrene.
- 9 pH metry: Titration of acetic acid against NaOH and hence determine the acid dissociation constant (K<sub>a</sub>).

#### ***Recommended Books:***

- 1 Findlay’s Practical Physical Chemistry, 9th edition, revised by B. P. Levitt, Longman, London.
- 2 Practical Physical Chemistry by A. M. James and F. E. Prichard, Longman, London.
- 3 Experiments in Physical Chemistry by Shoemaker and Garland, McGraw Hill, New York.

- 4 Experiments in Physical Chemistry by Daniels, Alberty and Willams McGraw Hill, New York.
- 5 Laboratory Physical Chemistry by Oelke/M.A.C.T.L.A.C.
- 6 Experimental Physical Chemistry by W. G. Palmer, C.U.P., London.
- 7 Advanced Physico-Chemical Experiments by J. Rose.
- 8 Text Book of Physical Chemistry by S. Glasstone, Macmillon and Co., London.
- 9 Text Book of Quantitative Analysis by A. I. Vogel, ELBS, Harlow.
- 10 Advanced Practical Physical Chemistry by J. B. Yadav. Goel Publishing House.
- 11 Experimental Physical Chemistry by V. D. Athawale and Parul Mathur, New Age International Publishers.
- 12 Advanced Physical Chemistry Experiments by Gurtu and Gurtu, Pragati Prakashan Educational Publishers, 3rd Edition, 2007.

**Scheme of Examination:**

- |                            |            |
|----------------------------|------------|
| i. Duration of examination | : 04 hours |
| ii. Experiment             | : 35 marks |
| iii. Viva-Voce & Journal   | : 05 marks |
| iv. Internal assessment    | : 10 marks |
| Total                      | : 50 marks |

## CHEIT 2.1: APPLIED INORGANIC CHEMISTRY (ELECTIVE)

### UNIT-I

**Data Analysis:**

Types of errors, accuracy and precision, methods of minimization of systematic errors, mean and standard deviation, distribution of random errors, reliability of results, comparison of results-Student t-test, F-test and chi-square test, significant figures, confidence intervals, method of least squares, calibration curve and standard addition method.

**(12 Hours)**

### UNIT-II

**Thermal Methods of Analysis and Inorganic Polymers:**

Thermal methods of analysis: Thermobalance, factors influencing thermogravimetric results, differential thermal analysis: Instrumentation for differential thermal analysis (DTA) and differential scanning calorimetry (DSC). Applications of TG, DTA and DSC.

Inorganic Polymers: Silicones, polyphosphazenes, synthesis, structure and applications.

**(12 Hours)**

### UNIT-III

#### **Bioinorganic Chemistry:**

Metal ions in biological systems, deficiency of trace metal ions (Fe, Zn, Cu and Mn), metal ions and chelating agents in medicine: Treatment of toxicity due to inorganics (chelation therapy) and metal complexes as therapeutic agents.

Proteins and their functions: Heme proteins, oxygen uptake proteins-hemoglobin and myoglobin,

**(12 Hours)**

### UNIT-IV

#### **Chromatography:**

Gas chromatography: Principles, instrumentation, stationary phases and types of carrier gases used in GC. Methods of sample injection, types of detectors, programmed temperature GC, plate and plate height theory in GC. Applications of GC and use of GC-MS in detection of samples.

**(12 Hours)**

**Total 48 hours**

#### ***Recommended Books:***

- 1 Vogel's Textbook of Quantitative Analysis. 6<sup>th</sup> Edition—J. Mendham, R. C. Denney, J. D. Branes and MJK Thomas. Publisher: Pearson Education.
- 2 Contemporary polymer Chemistry, Third edition—H. R. Allcock, F. W. Campe and J. E. Mark, Publisher: Pearson Education.
- 3 Inorganic Chemistry, 4<sup>th</sup> edn—J. E. Huheey, R. L. Keiter and A. L. Keiter, Addison Wesley, 2000.
4. Inorganic Chemistry of Biological Processes, 2<sup>nd</sup> edn. —M. N. Hughes, Wiley, 1988.
- 5 Bioinorganic Chemistry—I. Bertini. H. B. Gray, S. J. Lippard and J. S. Valentine, Viva Books, 1998.
- 6 Bioinorganic Chemistry—A.K. Das, Books and Allied (P) Ltd, 2007.
- 7 Principles of Instrumental Analysis-Skoog, Holler and Nieman, Harcourt Afca, 2001.
- 8 Vogel's Text Book of Quantitative Inorganic Analysis., 4<sup>th</sup> Edn. —J. Bessett, R. C. Denney, G. H. Jeffery and J. Mendham, Longman Green and Company Ltd.

### CHAT-3.1: INSTRUMENTAL METHODS OF ANALYSIS

#### UNIT-I

##### Optical Methods:

Atomic absorption spectrometry: Theory, instrumentation, different types of nebulizers, non flame techniques, electrothermal vapouriser, cold vapour AAS determination of mercury, interferences, differences between AAS and flame photometry and analytical applications of AAS.

Emission Spectroscopy: Inductively coupled plasma optical emission spectrometry-theory and applications.

Molecular Luminescence Spectroscopy: Theoretical basis for fluorescence and phosphorescence, instrumentation, factors affecting fluorescence, its applications in quantitative analysis and in the study of biomolecules. X-ray fluorescence elemental analysis.

(12 Hours)

#### UNIT-II

##### Analytical methods-I

Coulometric methods of analysis: General discussion, coulometry at controlled potential, apparatus and general technique, applications, coulometric titrations (amperometric coulometric): Principles, apparatus, comparison of coulometric titrations with conventional titrations, automatic coulometric titrations and applications.

Amperometry: Principle, titrations, advantages and limitations and applications.

Ion selective electrodes: Glass ion selective electrodes, crystalline solid state ion selective electrodes, liquid-based ion selective electrodes and gas sensing electrodes.

Supercritical fluid chromatography (SFC): Properties of supercritical fluids, instrumentation and operating variables, comparison of SFC with other types of chromatography and applications.

(12 Hours)

#### UNIT-III

### **Analytical methods–II:**

Polarography: Theory of classical polarography, polarograms, polarographic currents. Halfwave potential, oxygen interference, advantages and limitations. pulse polarography and applications of polarography.

Electrogravimetric analysis: Theory, apparatus, deposition and separation, electrolytic separation of metals and applications.

Electrophoresis: Theory and classification, factors influencing the mobility–macromolecular size and charge, interaction with supporting electrolyte, pH and concentration discontinuities. Factors affecting electrophoretic phenomena–electrolysis, electroosmosis, temperature and supporting media. Instrumentation. Methodology: Preparation of gels–staining and destaining. Capillary electrophoresis methods: Capillary zone electrophoresis and capillary gel electrophoresis.

Light–scattering methods: Nephelometry and turbidometry: Principle, instrumentation and applications.

**(12 Hours)**

### **UNIT–IV**

### **Analytical methods–III**

Thermal method of analysis: Introduction.

Thermogravimetric analysis (TGA): Types of thermogravimetric analysis, principles, factors affecting the results, heating rate, furnace, instrument control/data handling. Instrumentation and applications.

Differential thermal analysis (DTA): Theory, variables affecting the DTA curves, differences between TGA and DTA, general principles. Instrumentation and applications.

Differential scanning calorimetry (DSC): Basic principle, differences between DTA and DSC. Instrumentation, power compensated DSC, heat flux DSC and applications.

Thermomechanical analysis and dynamic mechanical analysis.

Voltammetry: Fundamentals of voltammetry. Cyclic voltammetry: Principles and applications.

Stripping analysis: Stripping voltammetry, basic principles, electrodes used for stripping analysis, apparatus for stripping analysis, applications and determination of lead in water by voltammetry.

**(12 Hours)**

**Total 48 hours**

### ***Recommended Books:***

1. Instrumental Analysis, D. A. Skoog, F. J. Holler and S. R. Crouch, Cengage Learning (2007).
2. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8<sup>th</sup> edition, Saunders College Publishing, New York (2005).
3. Analytical Chemistry, G.D. Christian, 6<sup>th</sup> edition, Wiley-India (2007).
4. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, PHI Learning Pvt. Ltd. New Delhi (2009).

- Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J. D. Barnes and M.J.K. Thomas, 6<sup>th</sup> edition, Third Indian Reprint, Pearson Education Pvt.Ltd.(2007).
- Analytical Chemistry Principles, John H. Kennedy, 2<sup>nd</sup> edition, Saunders College Publishing, California (1990).
- Instrumental Methods of Analysis by H.H. Willard, L.L. Merritt and J.A. Dean, 7<sup>th</sup> Edition, CBS Publishers, New Delhi, 1988.

#### **CHA(Pr)-3.4: Lab course in Analytical Chemistry-I**

- Nephelometric/turbidimetric determination of sulphate/phosphate in ground water samples.
- Determination of calcium in milk powder using EDTA.
- Separation and determination of chloride and bromide on an anion exchanger.
- Cation exchange chromatographic separation of cadmium and zinc and their estimation by EDTA titration.
- Analysis of a mixture of iron (II) and iron (III) by EDTA titration using pH control.
- Evaluation of the composition of Fe (II)-1,10-phenanthroline complex by spectrophotometry.
- Colorimetric determination of Ti (IV) using H<sub>2</sub>O<sub>2</sub>.

#### **Scheme of Examination:**

1. Duration of Examination	: 4 hours
2. Experiment	: 35 marks
3. Viva-voce and Journal	: 05 marks
4. Internal assessment	: 10 marks
Total	: 50 marks

#### ***Recommended Books:***

- A text Book of Quantitative Inorganic Analysis-A. I Vogel
- Vogel's Text Book of Quantitative Inorganic Analysis, Basset, Denney, Jeffery & Mendham
- Colorimetric Determination of Traces of Metals-E. B Sandell.
- Analytical Chemistry-G. D Christian, 4<sup>th</sup> ed, Wiley, 1986.

### **CHAT-3.2: MOLECULAR SPECTROSCOPY**

#### **UNIT-I**

**Basic concepts, Electronic Spectroscopy and Mass Spectrometry:**

Properties of electromagnetic radiation.

Wave property: Interference and diffraction. Particle property: Photoelectric effect.

Regions of the electromagnetic spectrum, energies corresponding to various kinds of radiation. Interaction of electromagnetic radiation with matter (absorption, emission, transmission, reflection, dispersion, polarisation and scattering). General application.

Electronic spectroscopy: Molecular electronic absorption spectroscopy (UV-Visible), electronic spectra of diatomic molecules, electronic transitions, selection rules, assignment of transition, band intensities, substituent and solvent effect and charge transfer transitions. Application to organic and inorganic molecules.

Mass Spectrometry: Ionization and mass analysis.

Fragmentation: Principles, odd electron ( $OE^+$ ) and even electron ( $EE^+$ ) ions, molecular ion and base peak, nitrogen rule, metastable ions. Isotope effects in chloro and bromo compounds. Fragmentation of inorganic and organic compounds

## UNIT-II

### Vibrational Spectroscopy:

Vibrational spectroscopy: Infrared spectroscopy: Vibrational energy levels, infrared spectra of diatomic and polyatomic molecules, normal modes of vibration, force constant, selection rules, anharmonicity, the vibration-rotation spectroscopy. Infrared spectra of simple molecules and coordination compounds, changes in infrared spectra of donor molecules upon coordination (N,N-dimethylacetamide, urea, DMSO, pyridine N-oxide, ammine, cyano, cyanato and thiocyanato complexes), mono and multinuclear carbonyl complexes, nitrosyls, phosphine and arsine complexes. Change in spectra accompanying change in symmetry upon coordination ( $NO_3^-$ ,  $SO_4^{2-}$ ,  $NO_2^-$ , and  $ClO_4^-$ ), hydrogen bonding. Instrumentation including FTIR.

Raman spectroscopy: Theory, relation with IR spectroscopy, resonance Raman stimulated hyper and inverse Raman effects. Experimental techniques, structure determination from IR and Raman spectra.

(12 Hours)

## UNIT-III

### Magnetic Resonance spectroscopy:

Nuclear magnetic resonance spectroscopy: Magnetic properties of nuclei, population of energy levels, the Larmor precession, relaxation processes, chemical shift, shielding mechanism, spin-spin interactions, rules governing the interpretation of first order spectra, effect of chemical exchange on spectra. Analysis of complex NMR spectra,  $^1H$ -NMR spectra of organic molecules and complex metal ligands.

Spin-systems: First order and second order patterns. Long range coupling: Spin decoupling, CIDNP and NOE. NMR shift reagents.

NMR studies of nuclei other than proton,  $^{13}C$ -NMR (including heteronuclear coupling with other nuclei viz.,  $^{19}F$  and  $^{31}P$ ),  $^{19}F$ ,  $^{31}P$ ,  $^{11}B$ ,  $^{15}N$ . Spectra of paramagnetic complexes, contact shift, double resonance technique. Instrumentation including FT-NMR.

(12 Hours)

## UNIT-IV

### Electron Paramagnetic Resonance and Mössbauer Spectroscopy:

Electron Paramagnetic Resonance (EPR) Spectroscopy: Basic principles, selection rules, intensity, width, position of spectral line, multiplet structure of EPR spectra, hyperfine interaction, spin-orbit coupling, zero-field splitting and Kramer's degeneracy, rules for interpreting spectra, factors affecting the magnitude of values. Instrumentation. Applications to the study of free radicals, coordination compounds, biological studies and rate of electron exchange reactions.

Mössbauer Spectroscopy: Introduction, principles, conditions for Mössbauer spectroscopy, parameters from Mossbauer spectra, isomer shifts, electric quadrupole interaction, magnetic interactions, Mossbauer spectrometer. Applications in structure determination of  $\text{Fe}_3(\text{CO})_{12}$ , Prussian blue, oxyhemerythrin, hexacyanoferrates, nitropruside, tin halides.

(12 Hours)

Total 48 Hours

### *Books Recommended:*

- 1 Fundamentals of Molecular Spectroscopy - C. N. Banwell.
- 2 Physical Methods in Chemistry - R.S. Drago, Saunder college.
- 3 Structural Methods in Inorganic Chemistry - E. A. Ebsworth, D. W. H. Rankin and S. Craddock, ELBS.
- 4 Infrared Spectra of Inorganic and Coordination Compounds - K. Nakamoto.
- 5 Infrared Spectroscopy - C.N.R. Rao.
- 6 Electron Absorption Spectroscopy and Selected Techniques - D. N. Satyanarayana, University Press India Ltd. Hyderabad.
- 7 Introduction to Spectroscopy – D.L. Pavia, G.M. Lampman and G.S. Kriz, Thomson Learning, Singapore (2001)
- 8 Spectroscopic Identification of organic compounds – R. M. Silverstein and F. X. Webster, 6<sup>th</sup> Edition, Wiley and Sons, India Ltd. (2006).
- 9 Interpretation of Mass Spectroscopy–McLafferty.

## CHA(Pr)-3.5: Lab course in Analytical Chemistry-II

### 1. Chromatography:

- (i) Paper chromatography: Qualitative separation of amino acids in a given mixture
- (ii) Column chromatography: Separation of plant pigments

### 2. Conductometric titrations:

- (i) Sodium acetate with HCl
- (ii)  $\text{NH}_4\text{Cl}$  with NaOH

(iii) HCl, CH<sub>3</sub>COOH and CuSO<sub>4</sub>

3. Estimation of iron in razor-blade by potentiometric & visual titration using sodium vanadate.
4. Assay of iron in pharmaceutical preparation by visual & potentiometric titration by Ce(SO<sub>4</sub>)<sub>2</sub>
5. Determination of aluminium and magnesium in antacids by EDTA titration.
6. Determination of saccharin in tablets by precipitation titration.

**Scheme of Examination:**

- |                            |            |
|----------------------------|------------|
| 1. Duration of Examination | : 4 hours  |
| 2. Experiment              | : 35 marks |
| 3. Viva-voce and Journal   | : 05 marks |
| 4. Internal assessment     | : 10 marks |
| Total                      | : 50 marks |

***Recommended Books:***

1. A text Book of Quantitative Inorganic Analysis–A. I Vogel
2. Vogel's Text Book of Quantitative Inorganic Analysis, Basset, Denney, Jeffery & Mendham
3. Colorimetric Determination of Traces of Metals–E. B Sandell.
4. Analytical Chemistry–G. D Christian, 4<sup>th</sup> ed, Wiley, 1986.

**CHAT–3.3: SELECTED TOPICS IN ANALYTICAL CHEMISTRY-I**

**UNIT–I**

**Sensors**

Sensors: Membrane electrodes, classification and properties, principle, membrane potential, sensors types: Crystalline, liquid membrane and enzyme electrodes, gas sensors, voltammetric sensors, optical sensors and thermal sensors.

Biosensors: Introduction to biosensors, characteristics of an ideal biosensor. Basic electrochemical principles and measurement system.

Enzyme based electrochemical biosensors: Theory and applications of glucose, urea and alcohol biosensors. Transducer technology, enzyme based calorimetry, enzyme reactors with HPLC. Enzyme based micro electrodes. Analytical and biological applications of sensors.

**(12 Hours)**

**UNIT–II**

**Bioinorganic Chemistry:**

Bioinorganic chemistry: Metal ions in biological systems, essential and trace metals, Transport and storage of dioxygen, haemoglobin, myoglobin, hemerythrin and hemocyanins. Electron transfer proteins: Cytochromes, iron-sulphur proteins.

Metalloproteins as enzymes: Carboxy peptidase, catalases, peroxidases, cytochrome P-450, superoxide dismutase, copper oxidases, vitamin B<sub>12</sub> coenzyme, chlorophyll and its role in photosynthesis, photosystems-I & II, nitrogen fixation and metal complexes in medicine.

**(12 Hours)**

### UNIT-III

#### **Automated methods of analysis:**

Automated methods of analysis: Overview, advantages and disadvantages of automated analyses, types of automatic systems, flow injection analysis, instrumentation, sample and reagent transport systems, sample injectors and detectors, separations in FIA. Dialysis and gas diffusion, principles of FIA, dispersion, applications, stopped flow methods, flow injection titrations, microfluidics, discrete automatic systems, robotics, discrete clinical analyzers and automatic organic elemental analyzers.

**(12 Hours)**

### UNIT-IV

#### **Computational Chemistry:**

Computational Chemistry: Introduction to computers and computing, introduction to computer languages, programming in chemistry, developments in involving simple formulae in chemistry, Van der Waals equation, pH titration, radioactive decay.

Elementary structural features, bond angles and bond lengths, running standard programs and packages: Linear regression, X-Y plot, operational packages, MS word and MS Excel.

**(12 Hours)**

**Total: 48 Hours**

#### ***Recommended Books:***

1. Biosensor-Theory & Applications, Donald G. Burek, (Technomic Publication, Lancaster) 1993
2. Biosensors, ISHA Books, Delhi, Ed: Rajmohan Joshi, 2006
2. Bioinorganic Chemistry-Asim K. Das, Books and Allied (P) Ltd, (2007).
3. Principles of Bioinorganic Chemistry-S. J. Lippard and J. M. Berg, Panima Publishing Corporation.
4. Inorganic Chemistry-Principles of Structure and Reactivity, 4<sup>th</sup>Edn-J. E. Huheey, E.A. Keiter, R. L. Keiter and O.K. Medhi. Pearson Education (2009).
5. Instrumental Analysis, D.A. Skoog, F. J. Holler and Stanley R Crouch, Cengage Learning, 2007.
6. Instrumental Methods of Analysis by H.H. Willard, L.L. Merritt and J.A. Dean, 7<sup>th</sup> Edition, CBS Publishers, New Delhi, 1988.

### CHA(Pr)–3.6: Lab course in Analytical Chemistry–III

1. **Polarimetry:** Determination of specific rotation of (i) cane Sugar solution (ii) cane sugar cane by inversion method (iii) cane sugar solution in presence of other sugar solution.
2. **Potentiometric Titrations:** (i) analysis of mixture of halides (ii) determination of iron using potassium dichromate.
3. **Conductometric Titrations:** (i) analysis of halides, (ii) determination of sulphates.
4. **pH Metric titrations:** (i) Determination of strength of acids (ii) determination of strength of commercial phosphoric acid ( $H_3PO_4$ ) by pH titration (iii) determination of soda ash in washing soda.
5. **Spectrophotometry:** Analysis of waste water for (i) phosphate by molybdenum blue method (ii) ammonia-nitrogen by Nessler's method OR nitrite-nitrogen by NEDA method.

#### Scheme of Examination:

- |                            |            |
|----------------------------|------------|
| 1. Duration of Examination | : 4 hours  |
| 2. Experiment              | : 35 marks |
| 3. Viva-voce and Journal   | : 05 marks |
| 4. Internal assessment     | : 10 marks |
| Total                      | : 50 marks |

#### Recommended Books:

1. A text Book of Quantitative Inorganic Analysis–A. I Vogel
2. Vogel's Text Book of Quantitative Inorganic Analysis, Basset, Denney, Jeffery & Mendham
3. Colorimetric Determination of Traces of Metals–E. B Sandell.
4. Analytical Chemistry–G. D Christian, 4<sup>th</sup> ed, Wiley, 1986.

### SEMESTER–IV

#### CHAT–4.1 Pollution and Analysis

#### UNIT–I

#### Soil pollution and Analysis:

Soil pollution: Acidification, salinisation, sodification, agrochemical pollution, urban and industrial pollution, effects of soil pollution and solutions for soil pollution.

Soil analysis: Preparation of laboratory sample, measurement of pH and conductivity, acidic and alkaline soil. Analysis of major constituents: Organic matter, nitrogen, sulphur, sodium, potassium and calcium. Analysis of trace elements: Copper, molybdenum, zinc and boron.

(12 Hours)

## UNIT-II

### **Air Pollution and Analysis:**

Air pollutants: Classification and properties of air pollutants, emission sources, major emissions from global sources. Behaviour and fate of air pollutants, wet precipitation, dry deposition, interaction at the earth's surface, chemical reactions in the atmosphere, photochemical smog, effects of air pollution on human health, vegetation and materials.

Air pollution sampling and measurement: Ambient air sampling, collection of gaseous and particulate air pollutants. Analysis of air pollutants: SO<sub>2</sub>-ambient air measurements, stack gas measurement chemiluminescent techniques, CO-NDIR, amperometric, FID & catalytic oxidation methods, Coulometric & chemiluminescent methods. Hydrocarbon measurement: Total and individual hydrocarbons by chromatographic methods, particulates optical & mass measurement methods.

**(12 Hours)**

## UNIT-III

### **Water Pollution and Analysis:**

Sources of water pollution, classification of water pollutants: Organic, inorganic, sediment, thermal and radioactive materials, effects and solutions. Analysis of water parameters: Hardness, carbonate, bicarbonate, chloride, sulphate, fluoride, sodium, potassium, iron, chromium, manganese, chlorine demand, dissolved oxygen, biochemical oxygen demand and chemical oxygen demand.

**(12 Hours)**

## UNIT-IV

### **Noise and Radiation Pollution and analysis:**

Noise pollution: Concept of sound, noise and hearing problems, measurement of noise, sources of noise, effects of noise pollution. Regulation and control rules 2000 for noise pollution.

Radiation Pollution: Sources, effects, protection from radiation pollution, disposal of radioactive waste. Analysis of radionuclides.

**(12 Hours)**

**Total: 48 Hours**

### ***Recommended Books:***

1. Environmental Chemistry, S.E. Manahan, CRC Press/ Lewis Publishers, 1994
2. Environmental Chemistry with Green Chemistry, A.K. Das, Books and Allied (P) Ltd, (2012)
3. Environmental Chemistry, A.K. Dey, New Age International, (P) Ltd, Publishers, New Delhi
4. Environmental Chemistry, B.K. Sharma, Goel Publishing House.

5. Environmental Science and Technology, S.E. Manahan, Lewis Publishers, New York
6. Environmental pollution analysis, S.M. Khopkar, New Age International, (P) Ltd, Publishers, New Delhi

#### **CHA(Pr)–4.5: Lab course in Analytical Chemistry**

1. Analysis of water for alkalinity and acidity by pH metric method
2. Determination of strength of commercial phosphoric acid by pH titration
3. Determination of ammonia in household cleaners by conductometric titrations.
4. Determination of sodium and potassium in soil by flame photometry
5. Determination of phosphate in domestic waste water by spectrophotometry.
6. Analysis of mercury/lead in industrial effluents by spectrophotometry
7. Determination of DO, BOD and COD of a waste water sample by titrimetry
8. Determination of fluoride by spectrophotometric method
9. Soil analysis

#### **Scheme of practical examination:**

- |                                      |            |
|--------------------------------------|------------|
| 1. Duration of practical examination | : 4 hrs    |
| 2. Experiment                        | : 35 marks |
| 3. Viva voce and Journal             | : 05       |
| 4. Internal assessment               | : 05       |
| Total                                | : 50       |

#### ***Recommended Books:***

1. A text Book of Quantitative Inorganic Analysis – A.I Vogel
2. Vogel's Text Book of Quantitative inorganic Analysis, Basset, Denney, Jeffery & Mendham
3. Colorimetric Determination of Traces of Metals – E.B Sandell.
4. Analytical Chemistry, G.D. Christian, 5<sup>th</sup> edition, 2001 John Wiley & Sons, Inc. India

#### **CHAT–4.2: Quality Control, Analysis of Food, Beverages and Pharmaceuticals**

#### **UNIT–I**

#### **Quality Control:**

An introduction to quality control and quality assurance: Basic concepts, quality assurance, aspects of specification and tolerance, quality acceptance, sampling, reliability, cost aspects of quality decisions. Importance of quality control: Drugs and pharmaceuticals. Sources of impurities in pharmaceutical chemicals. Quality control in raw materials, production (in process), finished product. Current trends in quality control, ISO-9000 and ISO-14000 series. Laws related to quality control. Case studies of quality control in various industries such as plastics and polymers, fertilizers, agrochemicals, petrochemicals, dyes and pharmaceuticals.

**(12 Hours)**

## UNIT-II

### **Analysis of Beverages, Food Preservatives and Adulterants:**

Introduction: Soft drinks, alcoholic drinks, tea, coffee and fruit juices. Analysis of Caffeine in coffee and tannin in tea, detection of chicory in coffee, chloral hydrate in toddy. Estimation of methyl alcohol in alcoholic beverages, poisonous materials derived from containers. Food preservatives like sodium benzoate, sodium propionate, sodium sulphate, potassium metabisulphate (qualitative and quantitative analysis).

Food Adulterants: Artificial sweeteners like saccharin and dulcin, coal tar dyes and non-permitted colours and trace metals, detection and estimation.

**(12 Hours)**

## UNIT-III

### **Drugs and Pharmaceutical Analysis:**

Antibiotics: Introduction, classification, structure elucidation, stereochemistry and reaction mechanism of penicillins, tetracycline and chloramphenicol.

Analysis of common drugs:

Analgesics: Aspirin and paracetamol. Antihelmentics: Mebendazole. Antiallergies: Chlorpheniramine maleate. Anti-inflammatory agents: Oxyphenbutazone. Antimalarials: primaquine phosphate. Antituberculosists: Isoniazid (INH). Narcotics: Nicotine, morphine. Sedatives: Diazepam. Vitamins: A, B<sub>1</sub>, B<sub>2</sub>, B<sub>6</sub>, C & folic acid.

**(12 Hours)**

## UNIT-IV

### **Analysis of dairy products and edible oils:**

Chemistry, principles and analysis of liquids (edible): (i) general composition of edible oils, qualitative tests to purity, rancidity of fats and oil, estimation of rancidity, hydrogenated fat, tests for common edible oils like groundnut oil, castor oil, cottonseed oil & mustard oil. Tests for adulterants like argemoss oil & mineral oils and (ii) analytical principles in the analysis of dairy products composition of milk and milk products, alcohol test, fermentation, dye reduction. Methylene blue and resaturin tests. Tests to distinguish between buffed oleomargarine, phosphate tests for efficacy of pasteurization. Analysis of fat content, mineral in milk and butter. Estimation of added water in milk.

**(12 Hours)**

Total: 48 Hours

***Recommended Books:***

1. Analysis of Foods, H.E. Cox
2. Chemical Analysis of Foods, H.E. Cox
3. Foods: Facts and Principles; N. Shakuntala Many and S. Swamy, 4<sup>th</sup> Edtn., New Age International (1998)
4. Pharmaceutical analysis: Ed. By T. Higuchi and E.B. Hanssen, Wiley New York
5. Quantitative analysis of drugs: D.C. Garratt, Chappman and Hall, New York
6. Drugs and Pharmaceutical Sciences Series; Marcel Dekkar, Vol. II, INC. New York

**CHAP(Pr)–4.6: Lab course in Analytical Chemistry**

1. Analysis of medicines: APC tablet, paracetamol, sulphadiazine drugs by potentiometry/spectrophotometry/titrimetry
2. Assay of aspirin / caffeine / phenacetin by spectrophotometry
3. Determination of vitamin A in vanaspathi by UV spectrophotometry.
4. Isolation of casein and lactose from milk
5. Food analysis: Determination of iron in mustard sugar, phosphorus in peas, ascorbic acid in tomato, benzoic acid in food products
6. Determination of iodine value of an oil sample
7. Saponification of an oil sample

**Scheme of practical examination:**

- |                                      |            |
|--------------------------------------|------------|
| 1. Duration of practical examination | : 4 hrs    |
| 2. Experiment                        | : 35 marks |
| 3. Viva voce and Journal             | : 05       |
| 4. Internal assessment               | : 05       |
| Total                                | : 50       |

***Recommended Books:***

1. A text Book of Quantitative Inorganic Analysis–A. I. Vogel
2. Vogel's Text Book of Quantitative Inorganic Analysis, Basset, Denney, Jeffery & Mendham
3. Colorimetric Determination of Traces of Metals–E. B. Sandell.
4. Analytical Chemistry, G.D. Christian, 5<sup>th</sup> edition, 2001 John Wiley & Sons, Inc. India

**CHAT–4.3: SELECTED TOPICS IN ANALYTICAL CHEMISTRY–II**

## UNIT– I

### **Analysis of Biomedical samples:**

Composition of body fluids and detection of abnormal levels of certain constituents leading to diagnosis of disease. Sample collection and preservation of physiological fluids, analytical methods for the constituents of physiological fluids (blood, serum, urine). Blood–estimation of glucose, cholesterol, urea, haemoglobin and bilirubin. Urine: Urea, uric acid, creatinine, calcium phosphate, sodium, potassium and chloride. Biological significance, analysis and assay of enzymes (pepsin, monoaminooxidase, tyrosinase), vitamins (thiamine, ascorbic acid, vitamin–A) and hormones (progesterone, oxytocin, insulin). Chemical, instrumental and biological assays to be discussed wherever necessary. Estimation of poisonous materials such as lead, mercury and arsenic in biological materials.

**(12 Hours)**

## UNIT–II

### **Analysis of Ores, Minerals and Fertilizers:**

Composition, properties and analysis of minerals and ores: Hematite, pyrolusite, dolomite, chromate, bauxite, limestone, zirconite, gypsum and epsom.

Fertilizer analysis: Types, analysis of nitrogenous fertilizers, organic nitrogenous, phosphatic and potassic fertilizers.

Pesticide and insecticide analysis: introduction, classification and analysis of DDT, gammexane, endosulphon, zinaf, ziram, malathian, thiram, thiometon, simazine & chloridane.

**(12 Hours)**

## UNIT–III

### **Metals, Alloys and Cement Analysis:**

Steel, Cu–Ni alloy, solder, bronze, brass, aluminum alloy, ferroalloys of silicon, molybdenum, chromium, titanium and vanadium. Analysis of structural materials: Cement and glass. Analysis of refractory materials: Fire clay, fluorspar. Analysis of cement

**(12 Hours)**

## UNIT–IV

### **Analytical procedures in refineries:**

Types of crude oil (sweet and sour), composition of crude oil, causes for corrosion in refinery (sulfidic & naphthenic acid) crude oil refining, fractional distillation (atmospheric and vacuum distillation). Purification processes (merox, alkylation, reformulation,

hydrotreating, cracking etc.). Products of refinery (naphtha, gasoline, diesel, furnace oil, lube oil etc.), residues of refining processes (sulfur, pet coke). Specifications of gasoline, jet fuel and diesel in India and abroad. Paraffins, iso-paraffins, olefins, naphthenes, aromatics. Analytical techniques used in crude oil and products evaluation: True boiling point distillation, spectroscopic evaluation (NIR & FTIR), density, viscosity, cloud point, pour point, PIONA analysis in gasoline, simulated distillation, GC-MS, HPLC, cetane number and octane number .

(12 Hours)  
Total: 48 Hours

***Recommended Books:***

1. Technical methods of analysis: R.C. Griggin
2. Analytical Chemistry: Principles; J.H. Kennedy, 2<sup>nd</sup> Edn., Saunders, 1990
3. Principles of Instrumental methods of analysis: Skoog, Holler and Nieman, 5<sup>th</sup> Edn., Saunders 1998
4. Quantitative analysis: Day and Underwood, Prentice Hall, 1998
5. Fundamentals of petroleum refining: M.A.Fahim, T.A.Alsahhaf and Amal Elkilani, Elsevier Science, ISBN; 978-0-444-52785-1
6. Analytical methods in petroleum upstream applications. Etd., by Cesar Ovalles, Carl E. Rechsteiner Jr., CRC Press, Taylor and Francies Group
7. Industrial Chemistry: B.K. Sharma, Goel Publishing House
8. Quantitative analysis, An instrumental approach: Srivastava and Jain, S. Chand 1997
9. Biochemistry: The chemical reactions of living cells. D.E. Metzler, Academic Press.
10. Enzymes Chemistry: Impact and application Edn. Collin J. Suckling, Academic Press.

**CHAP(Pr)-4.7: Lab course in Analytical Chemistry**

1. Analysis of fertilizers: Urea, super phosphates
2. Analysis of pyrolusite ore
3. Analysis of alloys: cupronickel and bronze
4. Analysis of cement
5. Determination of (i) aluminium and magnesium in a mixture
6. Analysis of Stainless Steel-Ni gravimetrically using DMG, Fe volumetrically using Ce(IV), Cr volumetrically by persulphate oxidation,
7. Analysis of body fluids: Determination of cholesterol, glucose in blood; uric acid, creatinine in urine.

**Scheme of practical examination:**

- |                                      |            |
|--------------------------------------|------------|
| 1. Duration of practical examination | : 4 hrs    |
| 2. Experiment                        | : 35 marks |
| 3. Viva voce and Journal             | : 05       |
| 4. Internal assessment               | : 05       |
| Total                                | : 50       |

***Recommended Books:***

1. A text Book of Quantitative Inorganic Analysis–A. I. Vogel
2. Vogel's Text Book of Quantitative Inorganic Analysis, Basset, Denney, Jeffery & Mendham
3. Colorimetric Determination of Traces of Metals – E.B Sandell.
4. Analytical Chemistry, G.D. Christian, 5<sup>th</sup> edition, 2001 John Wiley & Sons, Inc. India

**CHAP–4.4: Project work**

It may include in–plant training in industries/short term work in other educational institutions/R&D organizations/data mining/review of current literature/theoretical methods/computer applications etc. Experimental work may involve studies on synthesis/characterization/properties/measurements/activities of reported/unreported research or any suitable combination thereof.

In case of students who will work outside the campus, the supervising staff member shall visit the place at least once during the tenure and hence he / she may be eligible for TA/DA as per the University rules.