

# M.Sc. Chemistry-2014 (Annual Scheme)

## SCHEME OF EXAMINATION (Annual Scheme)

Each Theory Paper

3 Hrs. duration

1. The number of papers and the maximum marks for each paper/Practical shall be shown in the syllabus for the subject concerned. It will be necessary for a candidate to pass in theory part as well as in the Practical part (Wherever prescribed) of a subject/paper separately.
2. A candidate for a pass at each of the Previous and the Final Examination shall be required to obtain (i) atleast 36% marks in the aggregate of all the papers prescribed for the examination and (ii) at least 36% marks in practical (s) wherever prescribed at the examination , provided that if a candidate fails to secure atleast 25% marks in each individual paper at the examination, and also in the test Dissertation /Survey report/Field Work, wherever prescribed, he shall be deemed to have failed at the examination notwithstanding his having obtained the minimum percentage of marks required in the aggregate for the examination. No division will be awarded at the Previous Examination. Division shall be awarded at the end of the Final Examination on the combined marks obtained at the Previous and the Final Examinations taken together, as noted below :

First Division 60 % } of the aggregate marks taken together of  
Second Division 48% } the Previous and the Final Examinations.

3. All the rest will be declared to have passed the examination.
4. If a candidate clears any paper (s)/Practical (s) Dissertation prescribed at the Previous and/or Final examination after a continuous period of three years, then for the purpose of working out his division the minimum pass marks only viz. 25% (36%) in the case of practical) shall be taken into account in respect of such Paper (s) Practical(s)/Dissertation as are cleared after the expiry of the aforesaid period of three years : Provided that in case where a candidate requires more than 25% marks in order to reach the minimum aggregate as many marks out of those actually secured by him will be taken into account as would enable him to makeup the deficiency in the requisite minimum aggregate.
5. The Thesis/Dissertation/Serve Report/Field work shall be typewritten and submitted triplicate so as to reach the office of the Registrar at least 3 weeks before the commencement of the theory examination. Only such candidates shall be permitted to offer Dissertation/Field Work/Survey Report/Thesis (If provided in the scheme of Examination) in lieu of a paper as have secured atleast 55% marks in the aggregate of all the paper prescribed for the previous examination in the case of annual scheme irrespective of the number of paper in which a candidate actually appeared at the examination.

**N.B.:** Non-collegiate candidates are not eligible to offer dissertation as per provisions of 0.170-A.

## Distribution of Marks

### M.Sc. (Previous) Examination 2014

Paper	Course No.	Course	Duration	Max. Marks	Min. Marks
Paper-I	CH-401	Inorganic Chemistry	3 Hrs.	100	36
Paper-II	CH-402	Organic Chemistry	3 Hrs.	100	36
Paper-III	CH-403	Physical Chemistry	3 Hrs.	100	36
Paper-IV	CH-404	Group Theory & Spectroscopy	3 Hrs	50	18
	CH-405A	Mathematics for chemists* or			
Paper-V		Biology for Chemists**	1.5 Hrs.	25	09
	CH-405B	Computers for Chemists	1.5 Hrs	25	09
Practical			14 Hrs.	200	72
Seminar				25	09
			<b>Total Marks</b>	<b>625</b>	

Note : \*For students without Mathematics in B.Sc.  
\*\* For students without Biology in B.Sc.

## M.Sc. (Prev.) – CHEMISTRY- 2014 Paper-I : INORGANIC CHEMISTRY

Duration : 3 hours

Max. Marks – 100

**Note :** The question paper will contain three sections as under –

- Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 10
- Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 50
- Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 40

#### Unit-I

**Stereochemistry and Bonding in Main Group Compounds :** VSEPR, Walsh diagram (tri- and penta-atomic molecules),  $d_{\pi}-p_{\pi}$  bonds, Bent rule and energetics of hybridization, some simple reactions of covalently bonded molecules.

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

#### Unit-II

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

#### Unit-III

**Metal-Ligand bonding** Limitation of crystal field theory, molecular orbital theory, octahedral, tetrahedral and square planar complexes,  $\pi$ -bonding and molecular orbital theory.

#### Unit-IV

**Electronic Spectra and Magnetic Properties of Transition Metal Complexes :** Spectroscopic ground states, correlation. Orgel and Tanabe-Sugano diagrams for transition metal complexes ( $d^1-d^9$  states), calculations of  $Dq$ ,  $\beta$  and  $\beta$  parameters, charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

#### Unit-V

**A. Metal  $\pi$ -Complexes** Metal carbonyl, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls; preparation, bonding structure and important reaction of transition metal nitrosyl, dinitrogen and dioxygen complexes; tertiary phosphine as ligand.

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

#### Books Suggested :

Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley.

Inorganic Chemistry, J.E. Huhey, Harpes & Row.

Chemistry of the Elements. N.N. Greenwood and A. Earnshaw, Pergamon.

Inorganic Electronic Spectroscopy, A.B.P. Lever, Elsevier.

Magneto chemistry, R.1. Carlin, Springer Verlag.

Comprehensive Coordination Chemistry eds., G. Wilkinson, R.D. Gillars and J.A. McCleverty, Pergamon.

## Paper-II -ORGANIC CHEMISTRY

Duration : 3 hours

Max. Marks – 100

**Note :** The question paper will contain three sections as under –

**Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 10

**Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 50

**Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 40

### Unit-I

- A. **Nature of Bonding in Organic Molecules :** Delocalized chemical bonding-conjugation, cross conjugation, resonance hyperconjugation, bonding in fullerenes, tautomerism. Aromaticity in benzenoid and non-benzenoid compounds, alternate and non-alternate hydrocarbons. Hückel's rule, energy level of  $\pi$ -molecular orbitals, annulenes, anti-aromaticity,  $\psi$ aromaticity, homo-aromaticity, PMO approach. Bonds weaker than covalent-addition compounds, crown ether complexes and cryptands, inclusion compounds, catenanes and rotaxanes.
- B. **Stereochemistry :** Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity, conformation of sugars, strain due to unavoidable crowding Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis, Asymmetric synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spirane chirality due to helical shape. Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

### Unit-II

- A. **Reaction Mechanism : Structure and Reactivity :** Type of mechanisms, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotopes effects Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. Effect of structure on reactivity, resonance and field effects, steric effect, quantitative treatment. The Hammett equation and linear free energy relationship, substituent and reaction constants, Taft equation.
- B. **Aliphatic Nucleophilic Substitution** The  $S_N2$ ,  $S_N1$  mixed  $S_N1$  and  $S_N2$  and SET mechanisms. The neighbouring group mechanism, neighbouring group participation by  $\pi$  and  $\sigma$  bonds, anchimeric assistance. Classical and nonclassical carbocations, phenonium ions, norbornyl systems, common carbocation rearrangements. Application of NMR spectroscopy in the detection of carbocations. The

$S_N1$  mechanism. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity.

### Unit-III

**Aliphatic Electrophilic Substitution** Bimolecular mechanisms  $S_E2$  and  $S_E1$ , The  $S_E1$  mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving groups and the solvent polarity on the reactivity.

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

**Aromatic Nucleophilic Substitution** The  $S_NAr$   $S_N1$ , benzyne and  $S_{RN}1$  mechanism, Reactivity effect of substrate structure, leaving group and attacking nucleophile. The Von Richter, Sommelet-Hauser, and Smiles rearrangements.

**Free Radical Reactions** : Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts, Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction.

### Unit-IV

**Addition to Carbon-Carbon Multiple Bonds** : Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity. Addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration, Michael reaction, Sharpless asymmetric epoxidation.

**Addition to Carbon-Hetero Multiple bonds** Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acid esters and nitriles. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Wittig reaction. Mechanism of condensation reactions involving enolates-Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions. Hydrolysis of esters and amides, ammonolysis of esters.

### Unit-V

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

**Pericyclic Reactions** Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reactions-conrotatory and disrotatory motions,  $4n$   $4n+2$  and ally systems. Cycloadditions-antarafacial and suprafacial additions,  $4n$  and  $4n+2$  systems,  $2+2$  addition of ketenes, 1,3 dipolar cycloadditions and cheletropic reactions.

Sigmatropic rearrangements-suprafacial and antarafacial shifts of H, sigmatropic involving carbon moieties, 3,3- and 5,5 sigmatropic rearrangements. Claisen, Cope and aza-Cope rearrangements. Fluxional tautomerism. Ene reaction.

### Book Suggested

Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.

Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Plenum.

A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.

Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.

Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentice-Hall.

Modern Organic Reactions, H.O. House, Benjamin.

Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic &\* Professionsl.

Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh, McMillan.

Pericyclic Reactions, S.M. Mukherji, McMillan, India

Stereochemistry of Organic Compounds, D.Nasipuri, New Age International.

Stereochemisty of Organic Compounds, P.S. Kalsi, New Age International.

Pericyclic Reactions: Ameta, Sharma, Vardia, Vyas, Sadguru Publications

## Paper-III -PHYSICAL CHEMISTRY

Duration : 3 hours

Max. Marks – 100

**Note :** The question paper will contain three sections as under –

**Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 10

**Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 50

**Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 40

### Unit-I

#### 1. Quantum Chemistry

- A. Introduction to Exact Quantum Mechanical Results** the Schrodinger equation and the postulates of quantum mechanics. Discussion of solutions of the Schrodinger equation to some model systems viz., particle in a box, the harmonic oscillator, the rigid rotor, the hydrogen atom.
- B. Approximate Methods** The variation theorem, linear variation principle. Perturbation theory (First order and nondegenerate). Applications of variation method and perturbation theory to the Helium atom.
- C. Angular Momentum** Ordinary angular momentum, generalized angular momentum, eigenfunctions for angular momentum, eigenvalues of angular momentum, operator using ladder operators addition of angular momentum, spin, antisymmetry and Pauli's exclusion principle.
- D. Molecular Orbital Theory** Hückel theory of conjugated systems bond and charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical cyclobutadiene etc. Introduction to extended Hückel theory.

### Unit-II

#### Thermodynamic

- A. Classical Thermodynamics** Brief resume of concepts of laws of thermodynamics, free energy, chemical potential and entropies. Partial molar free energy, partial molar volume and partial molar heat content and their significance. Determinations of these quantities. Concept of fugacity and determination of fugacity.  
**Non-ideal systems :** Excess functions for non-ideal solutions. Activity, activity coefficient, Debye Hückel theory for activity coefficient of electrolytic solutions; determination of activity and activity coefficients; ionic strength. Application of phase rule to three component systems; second order phase transitions.
- B. Statistical Thermodynamics** Concept of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical, grand

canonical and microcanonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers). Partition functions-translation, rotational, vibrational and electronic partition functions, Calculation of thermodynamic properties in terms of partition. Application of partition functions.

**Heat capacity behaviour of solids**-chemical equilibria and equilibrium constant in terms of partition functions, Fermi-Dirac statistics, distribution law and applications to metal. Bose-Einstein statistics, distribution law and application to helium.

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

### Unit-III

**Chemical Dynamics** Methods of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory, Arrhenius equation and the activated complex theory; ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, treatment of unimolecular reactions.

Dynamic chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogen-bromine and hydrogen-chlorine reactions) and homogenous catalysis, kinetics of enzyme reactions, general features of fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis and the nuclear magnetic resonance method, dynamics of unimolecular reactions (Lindemann Hinshelwood and Rice-Ramsperger-Kassel-Marcus (RRKM) theories of unimolecular reactions).

### Unit-IV

#### Surface Chemistry

- A. Adsorption** Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation of surface area (BET equation), Surface films on liquids (Electro-kinetic phenomenon), catalytic activity at surfaces.
- B. Micelles** Surface active agents, classification of surface active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization-phase separation and mass action models, solubilization, micro emulsion, reverse micelles.
- C. Macromolecules** Polymer-definition, types of polymers, electrically conducting, fire resistant, liquid crystal polymers, kinetics of polymerization, mechanism of polymerization. Molecular mass, number and mass average molecular mass, molecular mass determination (Osmometry, viscometry, diffusion and light scattering methods), sedimentation, chain configuration of macromolecules, calculation of average dimension of various chain structures.

### Unit-V

#### Electrochemistry

**Electrochemistry of solutions.** Debye-Huckel-Onsager treatment and its extension, ion solvent interactions. Debye-Hückel-Jerum mode. Thermodynamics of electrified interface equations. Derivation of electro capillarity, Lippmann equations (surface excess), methods of determination. Structure of electrified interfaces. Guoy-Chapman, Stern, Grahm Devanatham-Mottwatts, Tobin, Bockris, Devanathan models, Overpotentials, exchange current density, derivation of Butler Volmer equation, Tafel plot.

**Quantum aspects of charge transfer at electrodes**-solution interfaces, quantization of charge transfer, tunneling. Semiconductor interfaces-theory of double layer at semiconductor, electrolyte solution interfaces, structure of double layer interfaces. Effect of light at semiconductor solution interface.

**Electrocatalysis** : Influence of various parameters. Hydrogen electrode.

Bioelectrochemistry, threshold membrane phenomena, Nernst-Planck equation, hodes-Huxley equation; core conductor models, electrocardiography.

Polarography theory, Ilkone equation; half wave potential and its significance. Introduction to corrosion, homogenous theory, forms of corrosion monitoring and prevention methods.

### Books Suggested

Physical Chemistry, P.W. Atkins, ELBS.

Introduction to Quantum Chemistry, A.K. Chandra, Tata Mc Graw Hill.

Quantum Chemistry, Ira N. Levine, Prentice Hall.

Coulson's Valence, R.Mc Weeny, ELBS.

Chemical Kinetics. K.J. Laidler, McGraw-Hill.

Kinetics and Mechanism of Chemical Transformation J.Rajaraman and J. Kuriacose, Mc Millan.

Micelles, Theoretical and Applied Aspects, V. Moroi, Plenum.

Modern Electrochemistry Vol. 1 and Vol II J.O.M. Bockris and A.K.N. Reddy, Planum.

Introduction to Polymer Science, V.R. Gowariker, N.V. Vishwanathan and J. Sridhar, Wiley Eastern.

## Paper-IV -Group Theory, Spectroscopy and Diffraction Methods

Duration : 3 hours

Max. Marks – 50

**Note :** The question paper will contain three sections as under –

**Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05

**Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25

**Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

### Unit-I

A. **Symmetry and Group Theory in Chemistry** Symmetry elements and symmetry operation, definition of group, subgroup, relation between orders of a finite group all its subgroup. Conjugacy relation and classes. Point symmetry group. SchÖnflies symbols, representations of groups by matrices (representation for the  $C_n$ ,  $C_{nv}$ ,  $C_{nh}$ ,  $D_{nh}$ , etc, group to be worked out explicitly). Character of representation. The great orthogonality theorem (without proof) and its importance. Character tables and their use; spectroscopy

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

### Unit-II

A. **Microwave Spectroscopy** Classification of molecules, rigid rotator model, effect of isotopic substitution on the transition frequencies, intensities, non-rigid rotor. Stark effect, nuclear and electron spin interaction and effect of external field applications.

### B. Vibrational Spectroscopy

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

2. **Raman Spectroscopy** Classical and quantum theories of Raman effect. Pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, mutual exclusion principle, Resonance Raman Spectroscopy. Coherent Antistokes Raman Spectroscopy (CARS).

### Unit-III

## A. Electronic Spectroscopy

1. **Atomic Spectroscopy** Energies of atomic orbitals, vector representation of momenta and vector coupling, spectra of hydrogen atom and alkali metal atoms.
2. **Molecular Spectroscopy** Energy levels, molecular orbitals, vibronic transitions, vibrational progressions and geometry of the excited states, Franck-Condon principle, electronic spectra of polyatomic molecules. Emission spectra; radiative and non-radiative decay, internal conversion, spectra of transition metal complexes, charge-transfer spectra.
3. **Photoelectron Spectroscopy** Basic principles; photo-electric effect, ionization process, Koopman's theorem. Photoelectron spectra of simple molecules, ESCA, chemical information from ESCA. Auger electron spectroscopy-basic idea.

### Unit-IV

## Magnetic Resonance Spectroscopy

- A. **Nuclear Magnetic Resonance Spectroscopy** Nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements, factors, influencing chemical shift, deshielding, spin-spin interactions, factors influencing coupling constant "j" Classification (AVB, AMX, ABC, A<sub>2</sub>B<sub>2</sub> etc.). spin decoupling; basic ideas about instrument, NMR studies of nuclei other than proton-<sup>13</sup>C, <sup>19</sup>F and <sup>31</sup>P. FT NMR, advantages of FT NMR, use of NMR in medical diagnostics.
  - B. **Electron Spin Resonance Spectroscopy** Basic principles, zero field splitting and Kramer's degeneracy, factors affecting the 'g' value. Isotropic and anisotropic hyper fine coupling constants, spin Hamiltonian, spin densities and Mc Connell relationship, measurement techniques, applications.
- Nuclear Quadrupole Resonance spectroscopy** Quadrupole nuclei, quadrupole moments, electric field gradients, coupling constant, splitting, applications.

### Unit-V

- A. **X-ray Diffraction** Bragg condition, Miller indices, Laue Method, Bragg method, Debye Scherrer method of X-ray structural analysis of crystals, index reflections, identification of unit cells from systematic absences in diffraction pattern, Structure of simple lattices and X-ray intensities, structure factor and its relation to intensity and electron density, phase problem. Description of the procedure for an X-ray structure analysis, absolute configuration of molecules.
- B. **Electron Diffraction** Scattering intensity vs. scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules. Low energy electron diffraction and structure of surfaces.
- C. **Neutron Diffraction** Scattering of neutrons by solids and liquids, magnetic scattering measurement techniques. Elucidation of structure of magnetically ordered unit cell.

## Books suggested

1. Modern Spectroscopy, J.M. Hollas, John Wiley.
2. Applied Electron Spectroscopy for chemical analysis ed. H. Windawi and F.L. Ho, Wiley Interscience.
3. NMR, NQR, EPR and Mössbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood.
4. Physical Methods in Chemistry, R.S. Drago, Saunders College.
5. Chemical Applications of Group Theory, F.A. Cotton.
6. Introduction to Molecular Spectroscopy, G.M. Barrow, Mc Graw Hill.
7. Basic Principles of Spectroscopy, R. Chang, Mc Graw Hill.
8. Theory and Application of UV Spectroscopy, H.H. Jaffe and M. Orchin, IBH-Oxford.
9. Introduction to Photoelectron Spectroscopy, P.K. Ghosh, John Wiley.
10. Introduction to Magnetic Resonance. A Carrington and A.D. McLachalan, Harper & Row.

## Paper-V (a 1)- MATHEMATICS FOR CHEMISTS

(For students without Mathematics in B.Sc.)

Duration : 1.1/2 hours

Max. Marks – 25

**Note :** The question paper will contain three sections as under –

- Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 2.5
- Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 150 words. Total marks : 12.5
- Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 300 words, 2 questions to be attempted. Total marks : 10

### Unit-I

#### Vectors

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

### Unit-II

Matrix Algebra **Addition and multiplication; inverse, adjoint and transpose of matrices, special matrices (Symmetric, skew-symmetric, Hermitian, Skey-Harmitian, unit, diagonal, unitary etc.) and their properties. Matrix equations: Homogeneous, non-homogeneous linear equations and conditions for the solution, linear dependence and independence. Introduction to vector spaces, matrix eigenvalues and eigenvectors, diagonalization, determinants (examples from Hückel theory). Introduction to tensors; polarzability and magnetic susceptibility as examples.**

### Unit-III

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

Integral calculus, basic rules for integration, integration by parts, partial fractions and substitution. Reduction formulae, applications of integral calculus. Functions of several variables, partial differentiation, co-ordinate transformations (e.g. cartesian to spherical polar) curve sketching.

### Unit-IV

**Elementary Differential equations** Variables-separable and exact first-order differential equations, homogenous, exact and linear equations. Applications to chemical kinetics, secular equilibria, quantum chemistry etc. solution of differential equations by the power series method, Fourier series, solutions of harmonic oscillator and legendre equation etc., spherical harmonics, second order differential equation and their solutions.

### Unit-V

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

**Book Suggested** The Chemistry Mathematics Book, E.Steiner, Oxford University Press.

Mathematics for Chemistry, Doggett and Sucliffe, Longman.

Mathematical for Physical Chemistry : F. Daniels, Mc Graw Hill.

Chemical Mathematics D.M. Hirst, Longman.

Applied Mathematics for Physical Chemistery, J.R. Barrnte, Prentice Hall.

Basic Matchematics for Chemists, Tebbutt, Wiley.

**OR**

## **Paper-V (a 2) : BIOLOGY FOR CHEMISTS**

(For students without Biology in B.Sc.)

Duration : 1.1/2 hours

Max. Marks – 25

**Note :** The question paper will contain three sections as under –

- Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 2.5
- Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 150 words. Total marks : 12.5
- Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 300 words, 2 questions to be attempted. Total marks : 10

### Unit-I

**Cell Structure and Functions** Structure prokaryotic and eukaryotic cells, intracellular organelles and their functions, comparisons of plant and animal cells. Overview of metabolic processes-catabolism and anabolism. ATP - the biological energy currency. Origin of life-unique properties of carbon chemical evolution and rise of living systems. Introduction to biomolecules, building blocks of bio-macromolecules.

### Unit-II

#### Carbohydrates

Conformation of monosaccharides, structure and functions of important derivatives of monosaccharides like glycosides, deoxy sugars, myoinositol, amino sugars. N-acetylmuramic acid, sialic acid. **Disaccharides and polysaccharides.** Structural polysaccharides-cellulose and chitin. Storage polysaccharides-starch and glycogen.

Structure and biological functions of glucosaminoglycans or mucopolysaccharides. Carbohydrates of glycoproteins and glycolipids. Role of sugars in biological recognition. Blood group substances. Ascorbic acid.

Carbohydrate metabolism-Kreb's cycle, glycolysis, glycogenesis and glycogenolysis, gluconeogenesis, pentose phosphate pathway.

### Unit-III

#### Lipids

Fatty acids, essential fatty acids, structure and function of triacylglycerols, glycerophospholipids, sphingolipids, cholesterol, bile acids, prostaglandins. Lipoproteins-composition and function, role in atherosclerosis. Properties of lipid aggregates-micelles, bilayers, liposomes and their possible biological functions. Biological membranes. Fluid mosaic model of membrane structure. Lipid metabolism- $\beta$ -oxidation of fatty acids.

### Unit-IV

#### Amino-acids, Peptides and Proteins

Chemical and enzymatic hydrolysis of proteins to peptides, amino acid sequencing. Secondary structure of proteins, force responsible for holding of secondary structures.  $\alpha$ -helix,  $\beta$ -sheets, super secondary structure, triple helix structure of collagen. Tertiary structure of protein-folding and domain structure. Quaternary structure.

Amino acid metabolism-degradation and biosynthesis of amino acids, sequence determination: chemical/enzymatic/mass spectral, racemization / detection. Chemistry of oxytocin and tryptophan releasing hormone (TRH).

### Unit-V

#### Nucleic Acids

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

#### Book Suggested

1. Principles of Biochemistry, A.L. Lehninger, Worth Publishers.
2. Biochemistry, L. Stryer, W.H. Freeman.

3. Biochemistry, J. David Rawn, Neil Patterson.
4. Biochemistry, Voet and Voet, John Wiley.
5. Outlines of Biochemistry E.E. Conn and P.K. Stumpf, John Wiley.

## **Paper-V (b) : COMPUTER FOR CHEMISTS**

Duration : 1.1/2 hours

Max. Marks – 25

**Note :** The question paper will contain three sections as under –

- Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 2.5
- Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 150 words. Total marks : 12.5
- Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 300 words, 2 questions to be attempted. Total marks : 10

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

### **Unit-I**

#### **Introduction to computers and Computing**

Basic structure and functioning of computer with a PC as an illustrative example. Memory, I/O devices. Secondary storage Computer languages. Operating systems with DOS as an example Introduction to UNIX and WINDOWS. Data processing, principles of programming, Algorithms and flow-charts.

### **Unit-II**

#### **Computer Programming in FORTRAN/C/BASIC**

(the language features are listed here with reference to FORTRAN. The instructor may choose another language such as BASIC or C the features may be replaced appropriately). Elements of the computer language. Constants and variables. Operations and symbols Expressions. Arithmetic assignment statement. Input and output Format statement. Termination statements. Branching statements such as IF or GO TO statement.

### **Unit-III**

LOGICAL variables. Double precision variables. Subscripted variables and DIMENSION. DO statement FUNCTION AND SUBROUTINE. COMMON and DATA statement (Student learn the programming logic and these language feature by hands on experience on a personal computer from the very beginning of this topic.)

### **Unit-IV**

#### **Programming in Chemistry**

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

### **Unit-V**

#### **Use of Computer programmes**

The student will learn how to operate a PC and how to run standard programmes and packages, execution of linear regression, X-Y plot, Numerical Integration and differentiation as well as differential equation solution programmes. Monte Carlo and Molecular dynamics, programmes with data preferably from physical chemistry laboratory. Further the student will operate one or two or the packages such as MATLAB, EASYPLOT, LOTUS, FOXPRO and word processing software such as WORDSTAR / MS WORD.

**Book Suggested :**

1. Fundamentals of Computer : V. Rajaraman (Prentice Hall)
2. Computers in Chemistry : K.V. Raman (Tata Mc Graw Hill)
3. Computer Programming in FORTRAN IV-V Rajaraman (Prentice Hall)
4. Computational Chemistry, A.C.Norris.

## M.Sc. (Pre.) PRACTICAL

Practical      Duration : 18 Hrs. (spread in 3 days)

Max. Marks : 200

### Inorganic Chemistry

#### Qualitative and Quantitative Analysis

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

#### Chromatography Separation of cations and anions by

- a. Paper Chromatography.
- b. Column Chromatography : Ion exchange.

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

1. VO (acac)<sub>2</sub>
2. TiO (C<sub>9</sub>H<sub>8</sub>NO)<sub>2</sub>·2H<sub>2</sub>O
3. cis-K[Cr(C<sub>2</sub>O<sub>4</sub>)<sub>2</sub>(H<sub>2</sub>O)<sub>2</sub>]
4. Na[Cr(NH<sub>3</sub>)<sub>2</sub>(SCN)<sub>4</sub>]
5. Mn(acac)<sub>3</sub>
6. K<sub>3</sub>[Fe(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub>]
7. Prussian Blue, Turnbull's Blue.
8. [Co(NH<sub>3</sub>)<sub>6</sub>] [Co(NO<sub>2</sub>)<sub>6</sub>]
9. cis-[Co(trien) (NO<sub>2</sub>)<sub>2</sub>] Cl·H<sub>2</sub>O
10. Hg[Co(SCN)<sub>4</sub>]
11. [Co(Py)<sub>2</sub>Cl<sub>2</sub>]
12. [Ni(NH<sub>3</sub>)<sub>6</sub>]Cl<sub>2</sub>
13. Ni(dm<sub>g</sub>)<sub>2</sub>
14. [Cu(NH<sub>3</sub>)<sub>4</sub>]SO<sub>4</sub>·H<sub>2</sub>O

### Organic Chemistry

#### Qualitative Analysis

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

## Organic Synthesis

Acetylation : Acetylation of cholesterol and separation of cholesteryl acetate by column chromatography.

Oxidation : Adipic acid by chromic acid oxidation of cyclohexanol

Grignard reaction : Synthesis of triphenylmethanol from benzoic acid

Aldol condensation : Dibenzal acetone from benzaldehyde.

Sandmeyer reaction : p-Chlorotoluene from p-toluidine.

Acetoacetic ester Condensation : Synthesis of ethyl-n-butylacetoacetate by A.E.E. condensation.

Cannizzaro reaction : 4-Chlorobenzaldehyde as substrate.

Friedel Crafts reaction :  $\beta$ -Benzoyl propionic acid from succinic anhydride and benzene. Aromatic

electrophilic substitutions : Synthesis of p-nitroaniline and p-bromoaniline.

The Products may be Characterized by Spectral Techniques.

## Quantitative Analysis

Determination of the percentage or number of hydroxyl groups in an organic compound by acetylation method.

Estimation of amines/phenols using bromate bromide solution/or acetylation method. Determination of Iodine and Saponification values of an oil sample.

Determination of DO, COD and BOD of water sample.

## Physical Chemistry

Number of hours for each experiment : 3-4 hours.

A list of experiment under different headings is given below, Typical experiments are to be selected from each type. Students are required to perform at least 30 experiments.

## Error Analysis and Statistical Data Analysis

Errors, types of errors, minimization of errors distribution curves precision, accuracy and combination; statistical treatment for error analysis, student 't' test, null hypothesis, rejection criteria, F & Q test; linear regression analysis, curve fitting.

Calibration of volumetric apparatus, burette, pipette and standard flask.

## Adsorption

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

## Phase Equilibria

- i. Determination of congruent composition and temperature of a binary system (e.g. diphenylamine-benzophenone system).
- ii. Determination of transition temperature of given salt (e.g.,  $\text{CaCl}_2$ ) conductmetrically.
- iii. To construct the phase diagram for three component system (e.g. chloroform-acetic acid-water).

## Chemical Kinetics

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

- i. Determination of the velocity constant of hydrolysis of an ester/ionic reaction in micellar media.
- ii. Determination of the velocity constant for the oxidation of iodide ions by hydrogen peroxide studying the kinetics as an iodine clock reactions.
- iii. Flowing clock reactions (Ref : Experiments in Physical Chemistry by Showmaker)
- iv. Determination of the primary salt effect on the kinetics of ionic reaction and testing of the Bronsted relationship (iodide ion is oxidised by persulphate ion).
- v. Oscillatory reaction.

## Solution :

1. Determination of molecular weight of non-volatile and non-electrolyte/electrolyte by cryoscopic method and to determine the activity coefficient of an electrolyte.
2. Determination of the degree of dissociation of weak electrolyte and to study the deviation from ideal behavior that occurs with a strong electrolyte.

## Electrochemistry

### A. Conductometry

- i. Determination of the velocity constant, order of the reaction and energy of activation for saponification of ethyl acetate by sodium hydroxide conductometrically.
- ii. Determination of solubility and solubility product of sparingly soluble salts e.g.  $\text{PbSO}_4$ ,  $\text{BaSO}_4$ ) conductometrically.
- iii. Determination of the strength of strong and weak acid in a given mixture conductometrically.
- iv. To study the effect of solvent on the conductance of  $\text{AgNO}_3$ /acetic acid and to determine the degree of dissociation and equilibrium constant in different solvents and in their mixtures (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Hückel-Onsager theory.
- v. Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Hückel's limiting law.

### B. Potentiometry/pH metry

1. Determination of strengths of halides in a mixture potentiometrically.
2. Determination of the valency of mercurous ions potentiometrically.
3. Determination of the strength of strong and weak acids in a given mixture using a potentiometer/pH meter.
4. Determination of temperature dependence of EMF of a cell.
5. Determination of the formation constant of silver-ammonia complex and stoichiometry of the complex potentiometrically.
6. Acid-base titration in a non-aqueous media using a pH meter.
7. Determination of activity and activity coefficient of electrolytes.
8. Determination of the dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by titrating it with KOH.
9. Determination of the dissociation constant of monobasic/dibasic acid by albert-Serjeant method.
10. Determination of thermodynamic constants,  $\Delta G$ ,  $\Delta S$ , and  $\Delta H$  for the reaction by e.m.f. method.  $\text{Zn} + \text{H}_2\text{SO}_4 \longrightarrow \text{ZnSO}_4 + 2\text{H}$

## Polarimetry

1. Determination of rate constant for hydrolysis/inversion of sugar using a polarimeter.
2. Enzyme kinetics-inversion of sucrose.

## Books Suggested

1. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R.C. Denney, G.H. Jeffery and J. Mendham, ELBS.
2. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly. Prentice Hall.
3. Experiments and Techniques in Organic Chemistry, D.P. Pasto, C. Johnson and M. Miller, Prentice Hall.
4. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Health.
5. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
6. Handbook of Organic Analysis-qualitative and Quantitative. H. Clark, Adward Arnold.
7. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
8. Practical Physical Chemistry, A.M. James and F.E. Prichard, Longman.

9. Findley's Practical Physical chemistry, B.P. Levitt, Longman.  
 10. Experimental Physical Chemistry, R.C. Das and B. Behera, Tata McGraw Hill.

## M.Sc. (Pre.) PRACTICAL Laboratory Course

### Scheme of Marks

Duration : 18 Hrs. (i.e 30 periods of 40 min per week teaching)

Max. Marks : 200

#### **Inorganic Chemistry**

##### **Qualitative and Quantitative Analysis**

1. Analysis of mixture contain 8 radicals including two radicals of rare elements. 24
2. Separation and determination of two metal ions Cu-Ni, Ni-Zn, Cu-Fe etc. involving volumetric and gravimetric methods. 6
3. Separation of cations and anions by Paper Chromatography or Column Chromatography.

*or*

Preparation of selected inorganic compounds and their studies by I.R. electronic spectra, Mössbauer, E.S.R. and magnetic susceptibility measurements. 10

#### **Organic Chemistry**

- i) **Qualitative Analysis** Separation, purification and identification of compounds of binary mixture (one liquid and one solid) using chromatography, chemical tests. IR spectra to be used for functional group identification. 20
- ii) **Organic Synthesis** Perform one of the 9 organic syntheses as mentioned in the syllabus and Products may be Characterized by Spectral Techniques. 15
- iii) **Quantitative Analysis**
  - a. Estimation of amines/phenols using bromate bromide solution/or acetylation method.
  - b. Determination of the percentage or number of hydroxyl groups in an organic compound by acetylation method.
  - c. Determination of iodine and Saponification values of an oil sample.
  - d. Determination of DO, COD and BOD of water sample. 15

#### **Physical Chemistry**

Perform any two physical experiments(both experiments should not be from same topic) 25+25 A list of experiment under different headings is given in the syllabus, Typical experiments are to be selected from each type. Students are required to perform at least 30 experiments. 50

**Viva** 30

**Record** 20

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**200**

## M.Sc. (FINAL) – CHEMISTRY Exam. - 2014

### Distribution of Marks

Paper	Course No.	Course	Duration	Max. Marks	Min. Marks
Paper-I	CH-501	(A) Applications of Spectroscopy (B) Photochemistry	3 Hrs.	75	27

Paper-II	CH-502	(C) Solid State Chemistry (A) Bioinorganic Chemistry (B) Bioorganic Chemistry (C) Biophysical Chemistry	3 Hrs.	50	18
Paper-III	CH-503	Environmental Chemistry	3 Hrs.	50	18
Paper-IV	CH-504	Elective Paper	3 Hrs.	50	18
Paper-V	CH-505	Elective Paper	3 Hrs.	50	18
Paper-VI	CH-506	Elective Paper	3 Hrs.	50	18
Paper-VII	CH-507	Elective Paper	3 Hrs.	50	18
Seminars	Internal	-	-	25	9
Practical			14 Hrs.	200	72
<b>Total Marks :</b>				<b>600</b>	

Note : The candidate has to answer five questions out of ten questions selecting one from each unit.

**Grand Total (M.Sc. - Previous & Final) : 1200**

### **M.Sc. (Final)**

The following alternative groups of elective papers are approved for M.Sc. final course.

#### **Group-I**

CH-504 : Organotransition Metal Chemistry.

CH-505 : Bioinorganic and Supramolecular Chemistry.

CH-506 : Photo inorganic Chemistry.

CH-507 : Polymers

#### **Group-II**

CH-504 : Organic Synthesis-I

CH-505 : Organic Synthesis-II

CH-506 : Heterocyclic Chemistry

CH-507 : Chemistry of Natural Products

#### **Group-III**

CH-504 : Analytical Chemistry

CH-505 : Physical Organic Chemistry

CH-506 : Chemical Dynamics

CH-507 : Electrochemistry

## **Paper-I: APPLICATION OF SPECTROSCOPY PHOTOCHEMISTRY AND SOLID STATE CHEMISTRY**

Duration : 3 Hrs.

Max. Marks : 75

**Note :** The question paper will contain three sections as under –

- Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 10
- Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 35
- Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 30

## Inorganic Chemistry

### Unit-I

- A. **Vibrational Spectroscopy** Symmetry and shapes of  $AB_2$ ,  $AB_3$ ,  $AB_4$ ,  $AB_5$  and  $AB_6$ , mode of bonding of ambidentate ligands, ethylenediamine and diketonato complexes, application of resonance Raman spectroscopy particularly for the study of active sites of metalloproteins.  
**Electron Spin Resonance Spectroscopy** Hyperfine coupling, spin polarization for atoms and transition metal ions, spin-orbit coupling and significance of g-tensors, application to transition metal complexes (having one unpaired electron) including biological systems and to inorganic free radicals such as  $PH_4$ ,  $F_2^-$  and  $(BH_3)^-$ .
- B. **Nuclear Magnetic Resonance of Paramagnetic Substances in Solution** The contact and Pseudo contact shifts, factors affecting nuclear relaxation, some applications including biochemical systems, an overview of NMR of metal nuclide with emphasis on  $^{195}Pt$  and  $^{119}Sn$  NMR.  
**Mossbauer Spectroscopy** Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (1) bonding and structures of  $Fe^{+2}$  and  $Fe^{+3}$  compounds including those of intermediate spin, (2)  $Sn^{+2}$   $Sn^{+4}$  compounds nature of M-L bond, coordination number, structure and (3) detection of oxidation state and inequivalent MB atoms.

### Unit-II

#### Organic Chemistry

- A. **Ultraviolet and Visible spectroscopy** Various electronic transitions (185-800 nm) Beer-Lambert law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes, Fieser Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic compounds. Steric effect in biphenyls.
- B. **Infrared Spectroscopy Instrumentation and Sample handling** Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and fermi resonance.
- Optical Rotatory Dispersion(ORD) and Circular Dichroism(CD)**  
 Definition, deduction of absolute configuration, octan rule for ketones.

### Unit-III

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

- B. **Carbon-13 NMR Spectroscopy** General considerations, chemical shift (aliphatic olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants. Two dimension NMR spectroscopy-COSY, NOESY, DEPT, INEPT, APT and INADEQUATE techniques.

**Mass Spectrometry** Introduction ion production E1, C1 FD and FAB, factors affecting fragmentation, ion analysis, ion abundance Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak. McLafferty rearrangement. Nitrogen rule. High resolution mass spectrometry. Example of mass spectral fragmentation of organic compounds with respect to their structure determination.

## Unit – IV

### PHOTO CHEMISTRY

- A. **Photochemical Reactions** Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry.

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

**Miscellaneous Photochemical Reactions.** Photo-Fries reactions of anilides, Photo-Fries rearrangement. Barton reaction. Singlet molecular Oxygen reaction. Photochemical formation of smog. Photodegradation of polymers. Photochemistry of vision.

- B. **Photochemistry of Alkene** Intramolecular reactions of the olefinic bond-geometrical isomerism, cyclisation reactions, rearrangement of 1,4- and 1,5-dienes.

**Photochemistry of Carbonyl Compounds** Intramolecular reactions of carbonyl compounds-saturated, cyclic and acyclic,  $\beta,\gamma$  unsaturated and  $\alpha, \beta$  unsaturated compounds, cyclohexadienones. Intermolecular cycloaddition reactions-dimerisations and oxetane formation.

**Photochemistry of Aromatic Compounds** Isomerisations, additions and substitutions.

## Unit-V

### SOLID STATE CHEMISTRY

- A. **Solid State Reactions** General principles, experimental procedure, co-precipitation as a precursory to solid state reactions, kinetics of solid state reactions. **Crystal Defects and Non-Stoichiometry** Perfect and imperfect crystals, intrinsic and extrinsic defects-point defects, line and plane defects, vacancies-Schottky defects and Frenkel defects. Thermodynamics of Schottky and Frenkel defect formation, colour centres, non-stoichiometry and defects.
- B. **Electronic Properties and Band Theory** Metals, insulators and semiconductors, electronic structure of solids band theory, band structure of metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, doping semiconductors, p-n junctions, super conductors. Optical properties-Application of optical and electron microscopy. Magnetic Properties-Classification of materials : Effect of temperature calculation of magnetic moment, mechanism of ferro and anti ferromagnetic ordering super exchange. **Organic Solids** Electrically conducting solids. organic charge transfer complex, organic metals, new superconductors.

## Book Suggested

1. Physical Methods for Chemistry, R.S. Drago, Saunders Compnay.
2. Structural Methods in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S. Cradock, ELBS.
3. Infrared and Raman Spectral : Inorganic and Coordination Compounds K. Nakamoto, Wiley.
4. Progress in Inorganic Chemistry vol., 8, ed., F.A. Cotton, vol., 15 ed. S.J. Lippard, Wiley.
5. Transition Metal Chemistry ed. R.L. Carlin vol. 3 Dekker.
6. Inorganic Electronic Spectroscopy, A.P.B. Lever, Elsevier.
7. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, .V. Parish, Ellis Haywood.
8. Practical NMR Spectroscopy, M.L. Martin. J.J. Deepish and G.J. Martin, Heyden.
9. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler adn T.C. Morrill, John Wiley.
10. Introduction to NMR spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Wiley.
11. Application of Spectroscopy of Organic Compounds, J.R. Dyer Prentice Hall.
12. Spectroscopic Methods in Organic Chemistry D.H. Williams, I. Fleming, Tata McGraw-Hill.
13. Fundamentals of photochemistry, K.K. Rothagi-Mukheriji, Wiley-Eastern.
14. Essentials of Molecular Photochemistry, A Gilbert and J. Baggott, Blackwell Scientific Publication.
15. Molecular Photochemistry, N.J. Turro, W.A. Benjamin.
16. Introductory Photochemistry, A. Cox and t. Camp, McGraw Hill.
17. Photochemistry, R.P. Kundall and A. Gilbert. Thomson Nelson.
18. Organic Photochemistry, J. Coxon and B.halton, Cambridge University Press.
19. Solid state chemistry and its applications, A.R. West. Peenum.
20. Principles of the Solid State, H.V. Keer, Wiley Eastern.
21. Solid State Chemistry, N.B. Hannay.
22. Solid State Chemistry, D.K. Chakrabarty, New Wiley Eastern.
23. Organic Photochemistry: Ameta, Mehta, Sharma, Sadguru Publications

## Paper-II

# BIO-INORGANIC, BIO-ORGANIC & BIO-PHYSICAL CHEMISTRY

Duration : 3 Hrs.

Max. Marks : 50

**Note :** The question paper will contain three sections as under –

**Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05

**Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25

**Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

### Unit-I

**A. Metal Ions in Biological Systems** Bulk and trace metals with special reference to Na, K, Mg, Ca, Fe, Cu, Zn, Co, and  $K^+$ ,  $Na^+$  pump.

**Bioenergetics and ATP Cycle.** DNA polymerisation, glucose storage, metal complexes in transmission of energy; chlorophylls, photosystem I and photosystem II in cleavage of water.

**Nitrogen fixation** Biological nitrogen fixation, and its mechanism, nitrogenase, Chemical nitrogen fixation.

**B. Transport and Storage of Dioxygen** Heam proteins and oxygen uptake structure and function of haemoglobin, myoglobin, haemocyanin and hemerythrin, model synthetic complexes of iron, cobalt and copper.

**Electron Transfer in Biology** Structure and function of metal of proteins in electron transport, processes cytochromes and ion-sulphur proteins, synthetic models.

### Unit-II

- A. **Introduction** Basic considerations, Proximity effects and molecular adaptation.  
**Enzymes** Introduction and historical perspective, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Nomenclature and classification, extraction and purification. Fischer's lock and key and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labelling and enzyme modification by site-directed mutagenesis. Enzyme kinetics, Michaelis-Menten and Lineweaver Burk plots, reversible and irreversible inhibition.
- B. **Mechanism of Enzyme Action** Transition-state theory, orientation and Steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Examples of some typical enzyme mechanisms for chymotrypsin, ribonuclease, lysozyme and carboxypeptidase.

### Unit-III

- A. **Kinds of Reactions Catalysed by Enzymes** Nucleophilic displacement on a phosphorus atom, multiple displacement reactions and the coupling of ATP cleavage to endergonic processes. Transfer of sulphate, addition and elimination reactions, enolic intermediates in isomerisation reactions,  $\beta$ -cleavage and condensation, some isomerization and rearrangement reactions. Enzyme catalyzed carboxylation and decarboxylation. Mechanism of enzyme action of Isomerase and Synthetase.
- B. **Enzyme Models** Host-guest chemistry, chiral recognition and catalysis, molecular recognition, molecular asymmetry and prochirality. Biometric chemistry, crown ether, cryptates. Cyclodextrins, cyclodextrin-based enzyme models, clixarenes, ionospheres, micelles synthetic enzymes or synzymes.

### Unit IV

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

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

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

### Unit-V

- A. **Biological Cell and its Constituents** Biological cell, structure and functions of proteins, enzymes, DNA and RNA in living systems. Helix coil transition.  
**Bioenergetics** Standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP.  
**Cell Membrane and Transport of Ions** Structure and functions of cell membrane, ion transport through cell membrane, Irreversible thermodynamic treatment of membrane transport. Nerve conduction.
- B. **Statistical Mechanics in Biopolymers** Chain configuration of macromolecules, statistical distribution end to end dimensions, calculation of average dimensions for various chain structures. Polypeptide and protein structures, introduction to protein folding problem.

**Thermodynamics of Biopolymers Solutions** Thermodynamics of biopolymer solutions, osmotic pressure, membrane equilibrium, muscular contraction and energy generation in mechanochemical system.

### Book Suggested

1. Bioorganic Chemistry : A Chemical Approach to Enzyme Action, Hermann Dugas and C. Penny, Springer Verlag.
2. Understanding Enzymes, Trevor Palmer, Prentice Hall.
3. Enzyme Chemistry : Impact and Applications, Ed. Collin J Suckling, Royal Society of Chemistry.
4. Enzyme Mechanisms Ed. M.I. Page and A Williams, Royal Society of Chemistry.
5. Fundamentals of Enzymology, N.C. Price and L. Stevens. Oxford University Press.
6. Immobilized Enzymes : An Introduction and Applications in Biotechnology, Michael ID. Trevan, John Wiley.
7. Enzymatic Reaction Mechanisms. C. Walsh. W.H. Freeman.
8. Enzyme Structure and Mechanism, A Fersht, W.H. Freeman.
9. Biochemistry : The Chemical Reactions of Living Cells, D.E. Metzler, Academic Press.
10. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.
11. Bioinorganic Chemistry, I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentine, University Science Books.
12. Inorganic Biochemistry vol. I and II ed. G.L. Eichhorn, Elsevier.
13. Progress in Inorganic Chemistry, Vol 18 and 38 ed J.J. Lippard, Wiley.
14. Macromolecules Structure and Function, F.Wold, Prentice Hall.

## Paper-III: ENVIRONMENTAL CHEMISTRY

Duration : 3 Hrs.

Max. Marks : 50

**Note :** The question paper will contain three sections as under –

- Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05
- Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25
- Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

### Unit-I

**Atmosphere** Atmospheric layers, Vertical temperature profile, heat/radiation budget of the earth atmosphere systems. Biogeochemical cycles of carbon, nitrogen, sulphur, phosphorus oxygen. Residence times.

**Atmospheric Chemistry** Sources of trace atmospheric constituents : Nitrogen oxides, Sulphur dioxide and other sulphur compounds, carbon dioxides, chlorofluorocarbons and other halogen compounds, methane and other hydrocarbons. Mechanism of photochemical decomposition of NO<sub>2</sub> and formation of ozone atoms, hydroxyl, hydroperoxy and organic radicals and hydrogen peroxide and their reactions

### Unit-II

**Air Pollution** Air pollutants and their classifications. Aerosols-sources, size distribution and effect on visibility, climate and health.

**Acid Rain** Definition, Acid rain precursors and their aqueous and gas phase atmospheric oxidation reactions. Damaging effects on aquatic life, plants, buildings and health. Monitoring of SO<sub>2</sub> and NO<sub>x</sub>. Acid rain control strategies.

**Stratospheric Ozone Depletion** Mechanism of Ozone formation, Mechanism of catalytic Ozone depletion, Discovery of Antarctic Ozone hole and Role of chemistry and meteorology. Control Strategies.

**Green House Effect** Terrestrial and solar radiation Spectra, Major green house gases and their sources and Global warming potentials. Climate change and consequences.

**Urban Air Pollution** Exhaust emissions, damaging effects of carbon monoxide. Monitoring of CO. Control strategies.

### **Unit-III**

**Aquatic Chemistry and Water Pollution** Redox chemistry in natural waters. Dissolved oxygen, biological oxygen demand, chemical oxygen demand, determination of DO, BOD and COD. Aerobic and anaerobic reactions of organic sulphur and nitrogen compounds in water. Acid-base chemistry of fresh water and sea water. Aluminum, nitrate and fluoride in water. Eutrophication . Sources of water pollution. Treatment of waste and sewage. Purification of drinking water, techniques of purification and disinfection.

### **Unit-IV**

**Soil and Environmental Disasters** Composition, micro and macronutrients, soil pollution by fertilizers, plastic and metals. Methods of re-mediation of soil. Bhopal gas tragedy, Chernobyl, three mile island, Minimata Disease, Seveso (Italy), London smog.

### **Unit-V**

**Industrial Pollution :** Cement, sugar, distillery, drug, paper and pulp, thermal power plants, nuclear power plants. Metallurgy, polymers, etc.. radionuclide analysis, disposal of wastes and their managements.

### **Books Suggested**

Environmental Chemistry, Colin Baird, W.H. Freeman Co. New York, 1998.

Chemistry of Atmospheres, R.P. Wayne, Oxford.

Environment Chemistry, A.K. De, Wiley Eastern, 2004.

Environmental Chemistry, S.E. Manahan, Lewis Publishers.

Introduction to Atmospheric Chemistry, P.V. Hobbs, Cambridge.

### **Group-I**

Organotransition Metal Chemistry.

Bioinorganic and Supramolecular Chemistry.

Photoinorganic Chemistry.

Polymers.

### **Group II**

Organic synthesis-I

Organic Synthesis-II

Heterocyclic Chemistry

Chemistry of Natural Products

### **Group III**

Analytical Chemistry

Physical Organic Chemistry

Chemical Dynamics

Electrochemistry

## **ELECTIVE PAPER-I (Group-I)** **Organotransition Metal Chemistry**

Duration : 3 Hrs.

Max. Marks : 50

**Note :** The question paper will contain three sections as under –

**Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05

**Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25

**Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

### **Unit-I**

**Alkyls and Aryls of Transition Metals** Types, routes of synthesis, stability and decomposition pathways organocopper in organic synthesis. Transition metal compounds with bonds to hydrogen.

### **Unit-II**

**Compounds of Transition Metal-Carbon Multiple Bonds** Alkylidenes, alkylidyne, low valent carbenes and carbynes-synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligands, role in organic synthesis.

### **Unit-III**

**Transition Metal  $\pi$ -Complexes** Transition metal  $\pi$ -Complexes with unsaturated organic molecules, alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes, preparation, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligands and to organic synthesis.

### **Unit-IV**

**Homogeneous Catalysis** Stoichiometric reactions for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxoreaction), oxopalladation reactions, activation of C-H bond.

### **Unit-V**

**Fluxional Organometallic Compounds** Fluxionality and dynamic equilibrium in compounds such as  $\eta^2$ -olefine,  $\eta^3$ -allyl and dienyl complexes.

**Books Suggested**

Principles and Application of Organotransition Metal Chemistry, J.P. Collman, L.S. Hegsdus, J.R. Norton and R.G. Finke, University Science Books.

The Organometallic Chemistry of the Transition Metals, R.H. Crabtree. John Wiley.

Metallo-organic Chemistry, A.J. Pearson, Wiley.

Organometallic Chemistry, R.C. Mehrotra and A. Singh New Age International.

## **ELECTIVE PAPER-2 (Group-I)**

### **Bioinorganic and Supramolecular Chemistry**

Duration : 3 Hrs.

Max. Marks : 50

**Note :** The question paper will contain three sections as under –

**Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05

**Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25

**Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

#### **Unit-I**

**Metal Storage and Transport and Biomineralization** Ferritin transferrin, and siderophores.

**Calcium in Biology** Calcium in living cells, transport and regulation, molecular, aspects of intramolecular processes, extracellular binding proteins.

#### **Unit-II**

##### **Metalloenzymes**

Zinc enzymes – carboxypeptidase and carbonic anhydrase. Iron enzymes-catalase, peroxidase and cytochrome P-450.

**Metallo enzyme-II** Copper enzymes-superoxide dismutase. Molybdenum oxatransferase enzymes-xanthine oxidase. Coenzyme vitamin B<sub>12</sub>.

#### **Unit-III**

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

**Metal-Nucleic Acid Complexes** Metal ions and metal complex interactions. Metal complex nucleic acids.

#### **Unit-IV**

##### **Supramolecular Chemistry-I**

Molecular recognition : Molecular receptors for different types of molecules including arisonic substrates, design and synthesis of co receptor molecules and multiple recognition.

Supramolecular reactivity and catalysis.

#### **Unit -V**

##### **Supramolecular Chemistry-II**

Transport processes and carrier design.

Supramolecular devices. Supramolecular photochemistry, supramolecular electronic, ionic and switching devices.

### Books Suggested

1. Principles of Bioinorganic Chemistry. S.J. Lippard and J.M. Berg University Science Books.
2. Bioinorganic Chemistry, I Bertini, H.B. Gray. S.J. Lippard and J.S. Valentine, University Science Books.
3. Inorganic Biochemistry Vols I and II Ed.G.L. Eichhorn, Elsevier.
4. Progress in Inorganic Chemistry Vols. 18 G.L. Eichhorn, Elsevier and 38 Ed J.J. Lippard Wiley.
5. Supramolecular Chemistry, J.M Lehn, VCH

## ELECTIVE PAPER-3 ( Group-I) Photoinorganic Chemistry

Duration : 3 Hrs.

Max. Marks : 50

**Note :** The question paper will contain three sections as under –

**Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05

**Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25

**Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

### Unit-I

**Basic of Photochemistry** Absorption, excitation, photochemical laws, quantum yield, electronically excited states-life times-measurements of the times. Flash photolysis, stopped flow techniques Energy dissipation by radiative and non-radiative processes, absorption spectra, Frank-Condon principle, photochemical stages-primary and secondary processes.

### Unit-II

**Properties of Excited States** Structure, dipole moment, acid-base strengths, reactivity. Photochemical kinetics-calculation of rates of radiative processes. Bimolecular deactivation-quenching.

### Unit-III

**Excited States of Metal Complexes** Excited states of metal complexes : Comparison with organic compounds, electronically excited states of metal complexes, charge transfer spectra, charge transfer excitations.

**Metal Complex Sensitizers** Metal complex sensitizer, electron relay, metal colloid systems, semiconductor supported metal or oxide systems, water photolysis, nitrogen fixation and carbon dioxide reduction.

### Unit-IV

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

### Unit-V

**Redox Reactions by Excited Metal Complexes** Energy transfer under conditions of weak interaction and strong interaction-exciplex formation; condition of the excited states to be useful as redox reactants, excited electron transfer, metal complexes as attractive candidates, (2,2-bipyridine and 1,10-phenanthroline complexes), illustration of reducing and oxidising character of Ruthenium<sup>+2</sup> (bipyridal complex, comparison with Fe (bipy)<sub>3</sub>; role of spin-orbit coupling-life time of these complexes. Application of redox processes of

electronically excited states for catalytic purposes, transformation of low energy reactants into high energy products, chemical energy into light.

### Book Suggested

Concepts of Inorganic Photochemistry, A.W. Adamson and P.D. Fleischauer, Wiley.

Inorganic Photochemistry, J.Chem. Educ. vol. 60 No. 10, 1983.

Progress in Inorganic Chemistry, Vol. 30ed. S.J. Lippard. Wiley.

Coordination Chem. Revs. 1981, vol. 39, 121, 131; 1975, 15, 321; 1990 97, 313.

Photochemistry of Coordination Compounds, V. Balzari and V. Carassiti, Academic Press.

Elements in Inorganic Photochemistry, G.J. Ferraudi, Wiley.

## ELECTIVE PAPER-4 (Group-I)

Duration : 3 Hrs.

Max. Marks : 50

**Note :** The question paper will contain three sections as under –

**Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05

**Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25

**Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

### Unit-I

#### Polymers

##### Basics

Importance of polymers. Basic concepts : Monomers, repeat units, degree of polymerization Linear, branched and network polymers. Classification of polymers. Polymerization : condensation, addition/radical chain-ionic and co-ordination and copolymerization. Polymerization conditions and polymer reactions. Polymerization in homogeneous and heterogeneous systems.

### Unit-II

#### Polymer Characterization

Polydispersion-average molecular weight concept. Number, weight and viscosity average molecular weights. Polydispersity and molecular weight distribution. The practical significance of molecular weight. Measurement of molecular-weights, end-group, viscosity, light scattering, osmotic and ultracentrifugation methods.

**Analysis and testing of polymers** Chemical analysis of polymers, spectroscopic methods, X-ray diffraction study. Microscopy.

**Thermal analysis and physical testing** tensile strength. Fatigue, impact. Tear resistance, hardness and abrasion resistance.

### Unit-III

**Inorganic Polymers** A general survey and scope of Inorganic Polymers special characteristics, classification, homo and hetero atomic polymers.

### Unit-IV

#### Structure, Properties and Application of

A. Polymers based on Phosphorous-Phosphazenes, Polyphosphates

B. Polymers based on Sulphure-Tetrasulphur tetranitride and related compounds.

#### Structure, Properties and Applications of

A. Polymers based on boron-borazines, boranes and carboranes.

B. Polymers based on Silicon, silicones polymetalloxanes and polymetallosiloxanes, silazanes.

## Unit-V

### Structure, Properties and Applications of

Metal clusters.

Co-ordination and metal chelate polymers.

### Book Suggested

Inorganic Chemistry, J.E. Huheey, Harper Row.

Developments in Inorganic polymer Chemistry, M.F. Lappert and G.J. Leigh.

Inorganic polymers- N.H. Ray.

Inorganic polymers, Graham and Stone.

Inorganic Rings and Cages : D.A. Armitage.

Textbook of Polymers Science, F.W. Billmeyer Jr. Wiley.

Contemporary Polymer Chemistry, H.R. Alcock and F.W. Lambe, Prentice Hall.

Polymer science, V.R.Gowariker, N.V.Viswanthan and J.Shreedhar Wiley-Eastern.

## ELECTIVE PAPER-5 (Group-II) Organic Synthesis I

Duration : 3 Hrs.

Max. Marks : 50

**Note :** The question paper will contain three sections as under –

**Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05

**Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25

**Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

### Unit-I

**Organometallic Reagents** Principle, preparations, properties and applications of the following in organic synthesis with mechanistic details. **Group I and II metal organic compounds** Li, Mg, Hg, Cd, Zn and Ce Compounds.

**Transition metals** Cu, Pd, Ni, Fe, Co, Rh, Cr, and Ti compounds. **Other elements** S, Si, B and I compounds.

### Unit-II

#### Oxidation

Introduction, Different oxidative processes. Hydrocarbons-alkenes, aromatic rings, saturated C-H groups (activated and unactivated) alcohols, diols, aldehydes, ketones, ketals and carboxylic acids. Amines, hydrazines, and sulphides. Oxidations with ruthenium tetroxide, iodobenzene diacetate and thallium. (III) Nitrate.

### Unit-III

#### Reduction

Introduction, Different reductive processes. Alkanes, alkenes, alkynes, and aromatic rings. **Carbonyl compounds**-aldehydes, ketones, acids and their derivatives. Epoxides. Nitro, nitroso, azo and oxime groups. Hydrogenolysis.

### Unit-IV

#### Rearrangements

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

A detailed study of the following rearrangements.

Pinacol-pinacolone, Wagner-Meerwein, Demjanov, Benzil-Benzilic acid. Favorskii, Arndt-Eistert synthesis, Neber, Beckmann, Hoffmann, Curtius, Schmidt, Baeyer-Villiger, Shapiro reaction.

### Unit-V

**Metallocenes, Nonbenzenoid Aromatics and Polycyclic Aromatic Compounds** General consideration. Synthesis and reactions of some representative compounds. (Tropone, tropolone, azulene, ferrocene, phenanthrene and fluorine).

#### Books Suggested

1. Modern Synthetic Reactions. H.O. House, W.A. Benjamin.
2. Some Modern Methods of Organic Synthesis, W. Carruthers, Cambridge Univ. Press.
3. Advanced Organic Chemistry, Reactions Mechanisms and Structure, J. March. John Wiley.
4. Principles of Organic synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic & Professional.
5. Advanced Organic Chemistry Part B.F.A. Carey and R.J. Sundberg Plenum Press.
6. Rodd's Chemistry of Carbon Compounds. Ed. S. Coffey, Elsevier.

## ELECTIVE PAPER-6 (Group-II) Organic Synthesis II

Duration : 3 Hrs.

Max. Marks : 50

**Note :** The question paper will contain three sections as under –

**Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05

**Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25

**Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

### Unit-I

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

### Unit-II

**Protecting Groups** Principle of protection of alcohol, amine, carbonyl and carboxyl groups.  
**One Group C-C Disconnections** Alcohols and carbonyl compounds, regioselectivity. Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.

### Unit-III

**Two Group C-C Disconnections** Diels-Alder Reaction, 1,3-difunctionalised compounds,  $\alpha$ - $\beta$ - unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds. Micheal addition and Robinson annelation.

#### Unit-IV

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

#### Unit-V

**Synthesis of Some Complex Molecules** Application of the above in the synthesis of following compounds : Camphor, Longifoline, Cortsone, Reserpine, Vitamin D, Juvabione, Aphidicolin and Fredericamycin A.

#### Books Suggested

Designing Organic Synthesis, S. Warren. Wiley.

Organic Synthesis-Concept, Methods and Starting Materials, J. Fuhrhop.

Some Modern Methods of Organic Synthesis. W. Carruthers, Cambridge Univ. Press.

Modern Synthetic Reactions H.O. House, W.A Benjamin.

Advanced Organic Chemistry : Reactions, Mechanisms and Structure, J. March. Wiley.

Principles, of Organic Chemistry Part B, F.A. Carey and R.J. Sundberg, Plenum Press.

Disconnection Approach: Ameta, Punjabi, Ameta, Jain, Sadguru Publications

## ELECTIVE PAPER-7 (Group-II) Heterocyclic Chemistry

Duration : 3 Hrs.

Max. Marks : 50

**Note :** The question paper will contain three sections as under –

**Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05

**Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25

**Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

#### Unit-I

**Nomenclature of Heterocycles** Replacement and systematic nomenclature (Hantzsch-Widman system) for monocyclic fused and bridged heterocycles.

**Aromatic Heterocycles** General chemical behaviour of aromatic heterocycles, classification (structural type), criteria of aromaticity (bond lengths, ring current and chemical shifts in  $^1\text{H}$  NMR-spectra. Empirical resonance energy, delocalization energy and dewar resonance energy, diamagnetic susceptibility escalations). Heteroaromatic reactivity and tautomerism in aromatic heterocycles.

#### Unit-II

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

interactions. **Heterocyclic Synthesis** Principles of heterocyclic synthesis involving cyclization reactions and cycloaddition reactions.

### Unit-III

**Small Ring Heterocycles** Three-membered and four-membered heterocycles-synthesis and reactions of aziridines, oxiranes, thiranes, azetidines, oxetanes and thietanes.

**Benzo-Fused Five-Membered Heterocycles** Synthesis and reactions including medicinal applications of benzopyrroles, bezofurans and benzothiophenes.

### Unit-IV

**Meso-ionic Heterocycles** General classification, chemistry of some important meso-ionic heterocycles of type-A and B and their applications.

**Six-Membered Heterocycles with one Heteroatom** Synthesis and reactions of pyrylium salts and pyrones and their comparison with pyridinium & thiopyrylium salts and pyridones. Synthesis and reactions of quinolizinium and benzopyrylium salts, coumarins and chromones.

### Unit-V

**Six Membered Heterocycles with Two or More Heteroatoms** Synthesis and reactions of diazoles, triazines, tetrazines and thiazines.

**Seven-and Large-Membered Heterocycles** Synthesis and reactions of azepines, oxepines, thiepinines, diazepines thiazepines, azocines, diazocines, dioxocines and dithiocines.

**Heterocyclic Systems Containing P, As, Sb and B** Heterocyclic rings containing phosphorus : introduction, nomenclature, synthesis and characteristics of 5- and 6-membered ring systems phosphorinanes, phosphorines, phospholanes and phospholes.

### Books Suggested :

Heterocyclic Chemistry Vol. 1-3, R.R. Gupta, M. Kumar and V.Gupta, Springer Verlag.

The Chemistry of Heterocycles, T. Eicher and S. Hauptmann, Thieme.

Heterocyclic Chemistry J.A. Joule, K. Mills and G.F. Smith, Chapman and Hall.

Heterocyclic Chemistry, T.L. Gilchrist, Longman Scietific Techinal.

Contemporary Hetrocyclic Chemistry, G.,R. Newkome and W.W. Paudler, Wiley-Inter Science.

An Introductiion to the Heterocyclic Compounds, R.M. Acheson, John Wiley.

Comprehensive Heterocyclic Chemistry, A.R. Katritzky and C.W. Rees, eds. Pergamon Press.

## ELECTIVE PAPER-8 (Group-II) Chemistry of Natural Products

Duration : 3 Hrs.

Max. Marks : 50

**Note :** The question paper will contain three sections as under –

**Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05

**Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25

**Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

### Unit-I

**Terpenoids and Carotenoids** Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules : Citral, Gerniol  $\alpha$ -Terpeneol, Menthol, Farnesol, Zingiberene, Santonin, Phytol, Abietic acid and  $\beta$ -Carotene.

#### Unit-II

##### Alkaloids

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

#### Unit-III

##### Steroids

Occurrence, nomenclature, basic skeleton, Diels hydrocarbon and stereochemistry, Isolation, Structure determination and synthesis of Cholesterol, Bile acids, Androsterone, Testosterone, Estrone, Progesterone, Aldosterone, Biosynthesis of Steroids.

#### Unit-IV

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

**Porphyryns** Structure and synthesis of Haemoglobin and Chlorophyll.

#### Unit-V

##### Prostaglandins

Occurrence, nomenclature, classification, biogenesis and physiological effects. Synthesis of PGE<sub>2</sub> and PGF<sub>2 $\alpha$</sub> .

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

#### Books Suggested

Natural Products : Chemistry and Biological Significance, J. Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope and J.B. Harborne, Longman, Essex.

Organic Chemistry : Vol. 2 IL. Finar, ELBS

Stereoselective Synthesis : A Practical Approach, M. Ngoradi, VCH.

Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.

Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the Americas, Ed. Kurt Hostettmann, M.P. Gupta and A. Marston. Harwood Academic Publishers.

Introduction to Flavonoids, B.A. Bohm. Harwood Academic Publishers.

New Trends in Natural Product Chemistry, Ata-ur-Rahman and M.L. Choudhary, Harwood Academic Publishers.

Insecticides of Natural Origin, Sukh Dev, Harwood Academic Publishers.

Chemistry of Natural Products: B. C. Joshi, S. C. Ameta, Himanshu Publication

## ELECTIVE PAPER-9 (Group-III)

# Analytical Chemistry

Duration : 3 Hrs.

Max. Marks : 50

**Note :** The question paper will contain three sections as under –

- Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05
- Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25
- Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

## Unit-I

### Introduction

Role of analytical chemistry. Classification of analytical methods classical and instrumental. Types of instrumental analysis. Selecting an analytical method. Neatness and cleanliness. laboratory operations and practices. Analytical balance. Techniques of weighing, errors. Volumetric glassware cleaning and calibration of glassware. Sample preparation-dissolution and decompositions. Gravimetric techniques. Selecting and handling of reagents. Laboratory notebooks. Safety in the analytical laboratory.

## Unit-II

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

## Unit-III

**Food analysis** Moisture, ash, crude protein, fat crude fiber, carbohydrates, calcium, potassium, sodium and phosphate. Food adulteration-common adulterants in food, contamination of foods stuffs. Microscopic examination of foods for adulterants. Pesticide analysis in food products. Extraction and purification of sample. HPLC. Gas chromatography for organophosphates. Thin-layer chromatography for identification of chlorinated pesticides in food products.

## Unit-IV

**Analysis of Water Pollution** Origin of Waste water, types, water pollutants and their effects. Sources of water pollution-domestic, industrial, agricultural soil and radioactive wastes as sources of pollution. Objectives of analysis-parameter for analysis-colour, turbidity, total solids, conductivity, acidity, alkalinity, hardness, chloride, sulphate, fluoride, silica, phosphates and different forms of nitrogen, Heavy metal pollution-public health significance of cadmium, chromium, copper, lead, zinc, manganese, mercury and arsenic. General survey of instrumental technique for the analysis of heavy metals in aqueous systems. Measurements of DO, BOD, and COD. Pesticides as water pollutants and analysis.

## Unit-V

### Analysis of Soil, Fuel, Body Fluids and Drugs

**Analysis of Soil :** moisture pH total nitrogen, phosphorus, silica, lime, magnesia, manganese, sulphur and alkali salts.

**Fuel analysis :** liquid and gas. Ultimate and proximate analysis-heating values-grading of coal. Liquid fuels-flash point, aniline point, octane number and carbon residue. Gaseous fuels-produced gas and water gas-calorific value.

- B. **Clinical Chemistry :** Composition of blood-collection and preservation of samples. **Clinical analysis.** Serum electrolytes, blood glucose, blood urea nitrogen, uric acid, albumin, globulins, barbiturates, acid and alkaline phosphates. **Immunoassay :** principles of radio immunoassay (RIA) and applications. The blood gas analysis trace elements in the body.
- C. **Drug analysis :** Narcotics and dangerous drug. Classification of drugs. Screening by gas and thin-layer chromatography and spectrophotometric measurements.

## Book Suggested

Analytical Chemistry, G.D. Christian, J.Wiley.

Fundamentals of Analytical Chemistry. D.A. Skoog. D.M. West and F.J. Hooper, W.B. Saunders.

Analytical Chemistry-Principles. J.H. Kennedy. W.B. Saunders.

Analytical Chemistry-Principles and Techniques. LG. Hargis. Prentice Hall.

Principles of Instrumental analysis D.A. Skoog and J.L. Loary, W.B. Saunders.

Principles of Instrumental Analysis D.A. Skoog W.B. Saunders.

Quantitative Analysis, R.A. Day, Jr. and A.L. Underwood, Prentice Hall.

Environmental Solution, S.M. Khopkar, Wiley Eastern.

Basic Concepts of Analyticals Chemistry, S.M. Khopkar, Wiley Eastern.

Handbook of Instrumental Techniques for Analytical Chemistry, F. Settle, Prentice Hall.

## ELECTIVE PAPER-10 (Group-III) Physical Organic Chemistry

Duration : 3 Hrs.

Max. Marks : 50

**Note :** The question paper will contain three sections as under –

**Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05

**Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25

**Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

### Unit-I

**Concepts in Molecular Orbital (MO) and Valence Bond (VB) Theory** Introduction to Huckel molecular orbital (MO) method as a mean to explain modern theoretical methods. Advanced techniques in PMO and FMO theory. Molecular mechanics, semi empirical methods and *ab initio* and density functional methods. Scope and limitations of several computational programmes. **Quantitative MO theory** : Hückel molecular orbital (HMO - method as applied to ethene, ally and butadiene. Qualitative MO theory ionisation potential. Electron affinities. MO energy levels. Orbital symmetry. Orbital interaction diagrams. MO of simple organic systems such as ethene, ally, butadiene, methane and methylol group. Conjugation and hyperconjugation. Aromaticity. Valence bond (B) configuration mixing diagrams. Relationship between VB configuration mixing and resonance theory. Reaction profiles. Potential energy diagrams. **Curve-crossing model**-nature of activation barrier in chemical reactions.

### Unit-II

**Principles of Reactivity** Mechanistic significance of entropy, enthalpy and Gibb's free energy. Arrhenius equation. Transition state theory. Uses of activation parameters, Hammond's postulate, Bell-Evans-Polanyi

Principle. Potential energy surface model. Marcus theory of electron transfer. Reactivity and selectivity principles.

**Kinetic Isotope Effect** Theory of isotope effects. Primary and secondary kinetic isotope effects. Heavy atom isotope effects. Tunneling effect. Solvent effects.

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

### Unit-III

**Structural Effects on Reactivity** Linear free energy relationships (LFER). The Hammett equation, substituent constants, theories of substituent effects. Interpretation of values. Reaction constant. Deviations from Hammett equation. Dual parameter correlation, inductive substituent constant. The Taft model,  $\sigma_1$  and  $\sigma_R$  scales.

**Acids, Bases, Electrophiles, Nucleophiles and Catalysis** Acid-base dissociation, Electronic and structural effects, acidity and basicity. Acidity functions and their application. Hard and soft acids and bases. Nucleophilicity scales. Nucleofugacity. The  $\alpha$ -effect. Ambivalent nucleophiles. Acid-base catalysis-specific and general catalysis. Brønsted catalysis, Nucleophilic and electrophilic catalysis. Catalysis by noncovalent binding-micellar catalysis.

**Steric and Conformation Properties** Various type of steric strain and their influence on reactivity. Steric acceleration. Molecular measurements of steric effects upon rates. Steric LFER, Conformational barrier to bond rotation-spectroscopic detection of individual conformers. Acyclic and monocyclic systems. Rotation around partial double bonds. Winstein-Holness and Curtin-Hammett principle.

### Unit-IV

**Nucleophilic and Electrophilic Reactivity** Structural and electronic effects on  $S_N^1$  and  $S_N^2$  reactivity. Solvent effect. Kinetic isotope effects. Intramolecular assistance. Electron transfer nature of  $S_N^2$  reaction. Nucleophilicity and  $S_N^2$  reactivity based on curvecrossing mode. Relationship between polar and electron transfer reactions  $S_{RN}^1$  mechanism. Electrophilic reactivity, general mechanism. Kinetic of  $S_E^2$  Ar reaction. Structural effects on rates and selectivity. Curve-crossing approach to electrophilic reactivity.

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

### Unit-V

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

### Book Suggested :

Molecular Mechanics, U. Burkrt and N.L. Allinger, ACS Monograph 177, 1982.

Organic Chemists, Book of Orbitals : L. Salem and W.L. Jorgensen, Academic Press.

Mechanism and Theory in Organic Chemistry, T.H. Lowry and K.C. Richardson, Harper and Row.

Introduction to Theoretical Organic Chemistry and Molecular Modeling.

Physical Organic Chemistry : N.S. Isaacs, ELBS/Longman.

Supramolecular Chemistry : Concepts and Perspective, J.M. Lehn, VCH.

The Physical Basis of Organic Chemistry : H. Maskill, Oxford University Press.

## **ELECTIVE PAPER-11 (Group-III)**

### **Chemical Dynamics**

Duration : 3 Hrs.

Max. Marks : 50

**Note :** The question paper will contain three sections as under –

**Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05

**Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25

**Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

#### **Unit-I**

**Atmospheric Reactions** Physical structure of the atmosphere, chemical composition of the atmosphere, Kinetics and mechanism of  $\text{NO}_x$ ,  $\text{ClO}_x$  cycles and  $\text{H}_2 + \text{O}_2$  reaction. Mechanism of general methane oxidation. Kinetics and mechanism of low temperature oxidation of methane. Concept of global warming.

#### **Unit-II**

**Enzymes and Inhibitions** Kinetics of one enzymes-Two substrate systems and their experimental characteristics. Enzyme inhibitors and their experimental characteristics. Kinetics of enzyme inhibited reactions.

**Micelles catalysis and inhibition** Kinetics and mechanism of micelle catalyzed reactions ( $1^{\text{st}}$  order and second order) Various type of micelle catalyzed reactions. Micelle inhibited reactions.

**Transition State** A brief aspect of statistical mechanics and transition state theory. Application in calculation of second order rate constant for reactions involving collision of (1) atom + atom (2) atom + molecule (3) molecule + molecule reactions. Static solvent effects and thermodynamics formulations. Adiabatic electron transfer reactions, energy surfaces.

#### **Unit-III**

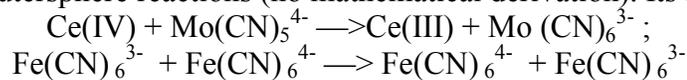
**Radiation Chemistry** Radiation chemistry and photochemistry. Radiation chemistry of water and aqueous solutions. Hydrogen atom and hydroxyl radical-oxidizing and reducing conditions. Kinetics and mechanism of photochemical and photosensitized reactions (One example in each case). Stern-Volmer equation and its application. Hole-concept in the presence of semiconductor type photocatalysts. Kinetics and mechanism of electron transfer reaction in the presence of visible light. Kinetics of exchange reactions (Mathematical analysis)

**Dynamics of Gas-surface Reactions** Adsorption/desorption kinetics and transition state theory. Dissociative adsorption and precursor state. Mechanism of Langmuir's adsorption of the oxidation of carbon monoxide to carbon dioxide. True and apparent activation energies. Industrial importance of heterogeneous catalysis.

#### **Unit-IV**

**Substitution Reactions** Substitution reactions. Classification of ligand substitution mechanism. Anation and base catalyzed kinetics of anation reactions. Aquation and acid catalyzed kinetics of aquation reactions (octahedral complexes). Inner-sphere electron transfer reactions and mechanism. Various types of inner

sphere bridges, adjustment and remote attack. Linkage isomerism. Chemical and resonance mechanism. Marcus-Cross relation in outersphere reactions (no mathematical derivation). Its application in reactions



Bridged outer-sphere electron transfer mechanism. Kinetics of reactions in the presence of cyclodextrines. Considering one full case study, Nucleophilic and electrophilic catalyst and their mode of action.

#### Unit-V

**Metal ion Catalysis and Induced Phenomena** Metal ion catalyzed reactions, their kinetics and reaction mechanism in solutions. Induced reactions, their characteristics. Mechanism of (i) Fe(II) induced oxidation of iodine by Cr(VI). (ii) As(III) induced oxidation of Mn(II) by chromate in acid solutions. Kinetics and mechanism of induced reactions in metal complexes (octahedral complexes of Cobalt (III) only).

**Oscillatory Reactions** Autocatalysis and oscillatory reactions, Kinetics and mechanism of Belousov-Zhabotinski (B-Z) reactions.

#### Book Suggested :

1. Progress in Inorganic Chemistry, Vol. 30.
2. R. Lumry and R.W. Raymond, Electron Transfer Reactions, Interscience.
3. N.L. Bender, Mechanism of Homogeneous Catalysis from protein to protein, Wiley.
4. A.G. Sykes, Kinetics of Inorganic reactions, Pergamon.
5. S.W. Benson, Mechanism of Inorganic Reactions, Academic Press.
6. Physical Chemistry Vol. 2, Ed. Prof Ya Grasimov, Mir publisher.
7. Inorganic Reaction Mechanism, Basolo and Pearson, J.Wiley .
8. Electron Transfer Reactions, H. Taube, Oxford Press.

## ELECTIVE PAPER-12 (Group-III) Electrochemistry

Duration : 3 Hrs.

Max. Marks : 50

**Note :** The question paper will contain three sections as under –

- Section-A :** One compulsory question with 10 parts, having 2 parts from each unit, short answer in 20 words for each part. Total marks : 05
- Section-B :** 10 questions, 2 questions from each unit, 5 questions to be attempted, taking one from each unit, answer approximately in 250 words. Total marks : 25
- Section-C :** 04 questions (question may have sub division) covering all units but not more than one question from each unit, descriptive type, answer in about 500 words, 2 questions to be attempted. Total marks : 20

#### Unit-I

##### Conversion and Storage of Electrochemical Energy

**Present status of energy consumption :** Pollution problem. History of fuel cells, Direct energy conversion by electrochemical means. Maximum intrinsic efficiency of an electrochemical converter. Physical interpretation of the Carnot efficiency factor in Electrochemical energy converters. Power outputs. Electrochemical generators (Fuel Cells) : Hydrogen oxygen cells, Hydrogen Air cell, Hydrocarbon air cell, Alkaline fuel cell, Phosphoric and fuel cell, direct NaOH fuel cells, applications of fuel cells.

**Electrochemical Energy Storage :** Properties of Electrochemical energy stores : Measure of battery performance, Charging and discharging of a battery, Storage Density, Energy Density.

#### Unit-II

**Classical Batteries** : (i) Lead Acid (ii) Nickel-Cadmium, (iii) Zinc-Manganese dioxide. **Modern Batteries** : (i) Zinc-Air (ii) Nickel-Metal Hydride, (iii) Lithium Battery, Future **Electricity storers** : Storage in (i) Hydrogen, (ii) Alkali Metals, (iii) Non aqueous solutions.

**Bioelectrochemistry** : Bioelectrodics, Membrane Potentials, Simplistic theory, Modern theory, Electrical conductance in biological organism: Electronic, Protonic electrochemical mechanism of nervous systems, enzymes as electrodes.

### Unit-III

**Corrosion and Stability of Metals** : Civilization and surface mechanism of the corrosion of the metals; Thermodynamics and the stability of metals, Potential -pH (or Pourbaix) Diagrams; Corrosion current and corrosion potential -Evans diagrams. Measurement of corrosion rate : (i) Weight Loss method, (ii) Electrochemical Method.

**Inhibiting Corrosion** : Cathodic and Anodic Protection. Inhibition(i) by addition of substrates to the electrolyte environment, (ii) by charging the corroding metal from external source, anodic protection. Organic inhibitors. The fuller Story. Green inhibitors.

**Passivation** : Structure of Passivation films, Mechanism of Passivation, Spontaneous Passivation Nature's method for stabilizing surfaces.

### Unit-IV

**Kinetics of Electrode Processes** : Essentials of Electrode reaction. Current Density, Over potential, Tafel Equation, Butler - Volmer equation. Standard rate constant ( $K^0$ ) and Transfer coefficient, Exchange Current.

**Irreversible Electrode processes** : Criteria of irreversibility, information from irreversible wave.

**Methods of determining kinetic parameters for quasi-reversible and irreversible waves** : Koutecky's methods, Meites Israel method, Gelling's method.

**Electrocatalysis** : Chemical catalysts and Electrochemical catalysts with special reference to porphyrins, porphyrin oxides of rare earths. Electrocatalysis in simple redox reactions, in reaction involving adsorbed species. Influence of various parameters.

### Unit-V

**Potential Sweep Method** : Linear sweep Voltammetry, Cyclic Voltammetry, theory and applications. Diagnostic criteria of cyclic voltammetry. Controlled current microelectrode techniques : comparison with controlled potential methods, chronopotentiometry, theory and applications.

**Bulk Electrolysis Methods** : Controlled potential coulometry, controlled coulometry. Electro-organic synthesis and its important applications. **Stripping analysis** : anodic and cathodic modes, pre electrolysis and stripping steps. Applications of stripping analysis.

#### Books Suggested :

1. Modern Electrochemistry Vol. I, IIA, Vol. IIB J'OM Bockris and A.K.N. Reddy, Plenum Publication, New York.
2. Polarographic Techniques by L. Meites, Interscience.
3. "Fuel Cells : Their electrochemistry". McGraw Hill Book Company, New York.
4. Modern Polarographic Methods by A.M. Bond, Marcell Dekker.
5. Polarography and Allied techniques by K. Zutshi, New age International publicatin. New Delhi.
6. Electroanalytical Chemistry by Basil H. Vessor & Galen W. ; Wiley Interscience.
7. Topics in Pure and Applied Chemistry, Ed. S. K. Rangrajan, SAEST Publication, Karaikudi (India)

## M.Sc. (FINAL) CHEMISTRY PRACTICAL

Duration : 14 Hrs. in two days

Max. Marks : 200

### Inorganic Chemistry

#### Preparation

Preparation of selected inorganic compounds and their study by IR, electronic spectra, Moss Bauer. ESR and magnetic susceptibility measurements. Handling of air and moisture sensitive compounds involving vacuum lines. Selection can be made from the following :

Sodium amide. *Inorg. Synth.*, 1946, 2, 128.

Synthesis and thermal analysis of group II metal oxalate hydrate. *J. Chem. Ed.*, 1988, 65, 1024.

Atomic absorption analysis of Mg and Ca.

Trialkoxyboranes-IR and NMR spectra.

PhBce Dichlorophenylborane - Synthesis in vacuum line.

Preparation of Tin (IV) iodide, Tin (IV) chloride and Tin (II) iodide, *Inorg. Synth.*, 1953, 4, 119.

Relative Stability of Tin (IV) and Pb (IV). Preparation of ammonium hexachlorostannate  $(\text{NH}_4)_2 \text{SnCl}_6$  ammonium hexachloroplumbate  $(\text{NH}_4)_2 \text{PbCl}_6$ .

Hexa-bis (4,nitrophenoxy) cyclotriphosphazene.

Synthesis of trichlorodiphenylantimony (V) hydrate. *Inorg. Synth.*, 1985, 23, 194

Sodium tetrathionate  $\text{Na}_2\text{S}_4\text{O}_6$ .

Metal complexes of dimethyl sulfoxide (IR) :  $\text{CuCl}_2 \cdot 2\text{DMSO}$ ,  $\text{PdCl}_2 \cdot 2\text{DMSO}$ ,  $\text{RuCl}_2 \cdot 4\text{DMSO}$ . *J. Chem. Educ.*, 1982, 59, 57.

Synthesis of metal acetylacetonate : Magnetic moment, IR, NMR, *Inorg. Synth.*, 1957, 5, 130, 1963, 1, 183.

Bromination of  $\text{Cr}(\text{acac})_3$ . *J. Chem. Edu.*, 1986, 63, 90.

Magnetic moment of  $\text{Cu}(\text{acac})_2 \cdot \text{H}_2\text{O}$ .

Cis and Trns  $[\text{Co}(\text{en})_2\text{Cl}_2]^+$ .

Separation of optical isomer of cis- $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$ . *J. Chem. Soc.*, 1960. 4369.

Ion exchange separation of oxidation state of vanadium. *J. Chem. Educ.*, 1980, 57, 316; 1978, 55, 55.

Determination of Cr (III) complexes.  $[\text{Cr}(\text{H}_2\text{O})_6]\text{NO}_3 \cdot 3\text{H}_2\text{O}$ ,  $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl} \cdot 2\text{H}_2\text{O}$ ,  $[\text{Cr}(\text{en})_3]\text{Cl}_3$ ,  $\text{Cr}(\text{acac})_3$ . *Inorg. synth.*, 1972, 13, 184.

Preparation of N, N bis (salicylaldehyde) ethylenediamine, silane H<sub>2</sub>.  $\text{Co}(\text{Silane})$  *J. Chem. Educ.*, 1977, 54, 443; 1973, 50, 670.

Preparation of Fe(II) chloride (use it as Friedel-Craft chlorination source) *J. Org. Chem.*, 1978, 43, 2423; *J. Chem. Edu.*, 1984, 61, 645; 1986, 63, 361.

Reaction of Cr(III) with a multidentate ligand; a kinetics experiment (visible spectra Cr-EDTA complex) *J.A.C.S.*, 1953, 75, 6570.

Preparation and use of Ferrocene. *J. Chem. Edu.* 1966, 43, 73; 1976, 53, 730.

Preparation of copper glycine complex-cis and trans bis (glycinato Copper (II)). *J. Chem. Soc. Dalton*, 1979, 1901, *J. Chem. Edu.*, 1982, 59, 1052.

Preparation of phosphine  $\text{Ph}_3\text{P}$  and its transition metal complexes.

Any other experiment such as conversion of p-xylene to terephthalic acid catalyzed by  $\text{CoBr}_2$  (homogeneous catalysis).

Preparation of  $[\text{Co}(\text{phenanthroline-5,6 quinone})]$ .

### **Spectrophotometric Determinations**

Manganese/Chromium/Vanadium in steel sample.

Nickel/molybdenum/tungsten/vanadium/uranium by extractive spectrophotometric method.  
Fluoride/nitrite/phosphate.

Zirconium-alizarin Red-S complex : Mole-ratio method.

Copper-Ethylene diamine complex : Slope-ratio method.

Iron-phenanthroline complex : Job's method of continuous variations.

### **Flame Photometric Determinations**

- Sodium and potassium when present together.
- Lithium/Calcium/barium/strontium.
- Cadmium and magnesium in tap water.

**Quantitative determinations of a three component mixture :** One Volumetrically and two gravimetrically :

- $\text{Cu}^{+2}$ ,  $\text{Ni}^{+2}$ ,  $\text{Zn}^{+2}$
- $\text{Cu}^{+2}$ ,  $\text{Ni}^{+2}$ ,  $\text{Mg}^{+2}$

### **Chromatographic Separations**

- Cadmium and zinc
- Zinc and magnesium.
- Thin-layer chromatography-separation of nickel, manganese, cobalt and zinc. Determination of  $R_f$  values.
- Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of  $R_f$  values.

### **Organic Chemistry**

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

**Multi-step Synthesis of Organic Compounds** The exercise should illustrate the use of organic reagents and may involve purification of the products by chromatographic techniques.

**Photochemical reaction**

Benzophenone → Benzpinacol → Benzpinacolone

**Beckmann rearrangement** : Benzanilide from benzene

Benzene → Benzophenone → Benzophenone oxime → Benzanilide

**Benzilic acid rearrangement** : Benzilic acid from benzoin

Benzoin → Benzil → Benzilic acid

### **Synthesis of heterocyclic compounds**

Skraup synthesis : Preparation of quinoline from aniline

Fisher Indole synthesis : Preparation of 2-phenylindole from phenylhydrazine. **Enzymatic synthesis**

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

Biosynthesis of ethanol from sucrose.

**Synthesis using microwave** : Alkylation of diethyl malonate with benzyl chloride.

**Synthesis using phase transfer catalyst** : Alkylation of diethyl malonate or ethyl acetoacetate with an alkylhalide.

### **Extraction of Organic Compounds from Natural Sources**

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

**Paper Chromatography** Separation of identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of R<sub>f</sub> values.

**Spectroscopy** Identification of organic compounds by the analysis of their spectral data (UV, IR, PMR, CMR & MS) Spectrophotometric (UV/VIS) Estimations

Amino acids

Proteins

Carbohydrates

Cholesterol

Ascorbic acid

Aspirin

Caffeine

## Physical Chemistry

Number of hours for each experiment : 3-4 hours. a list of experiments under different headings are given below. Typical experiments are to be selected from each type.

### Physical chemistry

Number of Hours to each experiment : 3 Hours. A list of experiments under different headings are given below. Typical experiments are to be selected from each type.

#### (A) Thermodynamics

Determination of partial molar volume of solute (e.g. KCl) and solvent in a binary mixture.

Determination of the temperature dependence of the solubility of a compound in two solvents having similar intramolecular interactions (benzoic acid in water and in DMSO-Water mixture and calculate the partial molar heat of solution.

#### (B) Spectroscopy

- i. Determination of pK<sub>a</sub> of an indicator (e.g. methyl red) in (a) aqueous and (b) micellar media.
- ii. Determination of stoichiometry and stability constant of Ferricisothiocyanation complex ion in solution.
- iii. Determination of rate constant of alkaline bleaching of Malachite green and effect of ionic strength on the rate of reaction.

#### iv. (C) Polarography

- i. Identification and estimation of metal ions such as Cd<sup>2+</sup>, Pb<sup>2+</sup>, Zn<sup>2+</sup>, and Ni<sup>+2</sup> etc. polarographically.
- ii. Study of a metal ligand complex polarographically (using Lingane's Method).

#### (D) Chemical Kinetics

- i. Determination of rate constant and formation constant of an intermediate complex in the reaction of Ce(IV) and Hypophosphorous acid at ambient temperature.
- ii. Determination of energy and enthalpy of activation in the reaction of KMnO<sub>4</sub> and benzyl alcohol in acid medium.
- iii. Determination of energy of activation and entropy of activation from a single kinetic run.
- iv. Kinetics of an enzyme catalyzed reaction.

**(E) Electronics** This lab course will have theory as well as practical and the lectures shall be delivered during lab hours.

**Basic Electronics** Notations used in the electronic circuit, study of electronic compounds and colour codes. Conversion of chemical quantities into electronic quantities. transducer, illustration with electrodes, thermocouples and thermistors. Passive components : Resistors, capacitors and inductors with some emphasis on solid state properties of materials. Net works of resistors. Thevenin's theorem, superposition theorem, loop analysis, RC circuits, LR Circuits, LCR circuits. Illustration of the use of circuits in NQR spectroscopy, Mössbauer spectroscopy cyclic voltammetry and in power supplied as filter circuits.

**Active components** Introduction to ordinary diodes and Zener diode with some emphasis on p-n junction as a solid state property. Use of diode as rectifiers, clipping and clamping circuits. Power supplies. Transistors : An extension of p-n-p and n-p-n transistors. Characteristics of transistors, hybrid parameters; transistor circuits as amplifiers, high impedance (preamplifier) circuits. Darlington pairs, differential amplifiers.

**Operational Amplifiers** Ideal characteristics; inverter, summer, integrator, differentiator, voltage follower, illustrative use of operational amplifiers. Introduction to Fourier transformation in instrumentation. List of Experiments in electronics (Do at least five experiments from this section)

1. (a) To plot the diode characteristics and find its dynamic resistance and cut in voltage.  
(b) To plot the characteristics of transistor used as a diode and compare the results with those of (a)
2. (a) To plot the diode characteristics and find its dynamic resistance and cut in voltage.(b) To plot the characteristics of transistor used as a diode and compare the results with those of (a)wave form.
3. To implement a diode damper circuit which damps the positive peak of the input voltage to (a) Zero voltage and (b) a given voltage. Verify the performance.
4. (a) To plot the characteristics of an NPN transistor in CE configuration.  
(b) To find the h-parameter of the transistor from the characteristics.
5. (a) To plot the characteristics of an NPN transistor in CB configuration.  
(b) To find the h-parameter of the transistor from the characteristics and compare it with the results of experiment No. 6.
6. (a) To plot the drain and transfer characteristics of a JEET in CS configuration.  
(b) To find out the pinch off voltage, maximum drain to source saturation current and the transconductance.
7. To obtain the frequency response of an RC coupled amplifier and estimate the bandwidth.
8. (a) To plot the characteristics of Zener diode and find its dynamic resistance under reverse biased condition. To use zener diode for a voltage regulation.  
(i) Plot the line regulation curve.  
  
(ii) Plot the load Regulation curve.
9. (a) To wire a Half wave Rectifier circuit using diode and measure the rms voltage, de voltage and to find Ripple factor.  
  
(b) To study the performance of half way and full wave doubler circuits.
10. To plot the characteristics of UJT and find the peak voltage, peak current and valley voltage and use as a relaxation oscillator.

*Note : A sheet containing 20 questions/diagrams/circuits will be provided to the students to reply. These question based on basic electronics will cover both theory and practical as provided in the syllabi. They will be of objective type for duration of 20 minutes with maximum scoring of 10 marks*

### **Books Suggested**

1. Inorganic Experiments, J. Derek Woolings, VCH.
2. Microscale Inorganic Chemistry, Z. Szafran, R.M, Pike and M.M. Singh, Wiley.
3. Practical Inorganic Chemistry, G. Marr and B. W. Rockett, Van Nostrad.
4. The systematic Identification of Organic Compounds, R.L. Shriner and D.Y. curlin.

## **M.Sc. (Final) PRACTICAL Laboratory Course**

### Scheme of Marks

Duration : 18 Hrs. (i.e 30 periods of 40 min per week teaching)

Max. Marks : 200

### **Inorganic Chemistry**

- i) Preparation of selected inorganic compounds and their study by IR, electronic spectra, Mossbauer. ESR and magnetic susceptibility measurements. Handling of air and moisture sensitive compounds involving vacuum lines.
- ii) Spectrophotometric Determinations of one of the 5 exercises given in the syllabus.
- iii) Flame Photometric Determinations
  - or
  - Chromatographic Separations
    - 1. Cadmium and zinc
    - 2. Zinc and magnesium.
    - 3. Thin-layer chromatography-separation of nickel, manganese, cobalt and zinc. Determination of  $R_f$  values.
    - 4. Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of  $R_f$  values.

### Organic Chemistry

- i) **Qualitative Analysis** Separation, purification and identification of the components of a mixture of three organic compounds (three solids or two liquids and one solid or two solids and one liquid), using test for checking the purity of the separated compounds, chemical analysis, IR, PMR and mass spectral data.
- ii) **Multi-step Synthesis of Organic Compounds** Perform one of the 7 types multi-step synthesis of organic compounds in examination.
- iii) Extraction of Organic Compounds from Natural Sources perform one of the 11 exercises as mentioned in the syllabus.
  - or
  - Spectroscopy** Identification of organic compounds by the analysis of their spectral data (UV, IR, PMR, CMR & MS)

### Physical Chemistry

Perform any two physical experiments(not from the same topics). A list of experiments are to be selected from each topic.

**Viva**

**Record**

**150**

**30**

**20**

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**200**