Class: M.Sc. Chemistry
Semester: I
Subject: Chemistry -I

Title of Paper: Inorganic Chemistry I

Unit-I

Stereochemistry and Bonding in Main Group Compounds:

VSEPR theory, Walsh diagram (triatomic and penta-atomic molecules), dπ-pπ bonding, Bent rule and energetic of hybridization, some simple reactions of covalently bonded molecules.

Unit-II

Metal-Ligand Equilibrium 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 potentiometry and spectrophotometry.

Unit-III

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. 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-IV

Metal-Ligand bonding

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

Unit-V

HSAB Theory

Classification of acids and bases as hard and soft; HSAB principle, theoretical basis of hardness and softness; Lewis-acid base reactivity approximation; donor and acceptor numbers, E and C equation; applications of HSAB concept.

Books Suggested

1. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley.
2. Inorganic Chemistry, J.E. Huhey, Harpes & Row.
3. Chemistry of the Elements. N.N. Greenwood and A. Earnshow, Pergamon.
4. Inorganic Electronic Spectroscopy, A.B.P. Lever, Elsevier.
5. Magnetiochemistry, R.1. Carlin, Springer Verlag.
6. Comprehensive Coordiantion Chemistry eds., G. Wilkinson, R.D. Gillars and J.A. Mc Cleverty, Pergamon.

Class: M.Sc. Chemistry
Semester: I
Subject: Chemistry –II

Title of Paper: Organic Chemistry I

Unit-I

Chirality, Absolute and relative configuration, The terms chiral, achiral, stereogenic center (stereocenter), representations of three dimensional molecules, stereoisomerism resulting from more than one stereogenic unit, Pi-diastereoisomerism and torsional chirality in carbon-carbon double bonds, some stereochemical reactions near a stereocenter (formation of diastereomers) stereoselective and stereospecific reactions, stereoisomerism in compounds without a stereogenic carbon, optical activity due to stereoplane (planar chirality)- paracyclophanes and trans-cyclooctene, optical activity of compounds due to helicity, asymmetric synthesis.

Unit-II

Aromaticity, NMR spectroscopy and aromaticity, aromatic compounds, antiaromatic compounds, nonaromatic compounds, annulenes, ions, metallocenes, Crown ether complexes and cryptates, phase transfer catalysis, The Hammett equation- linear free energy relationship, Taft equation, steric effects, strain and Bredt rule.

Unit III

Aliphatic nucleophilic substitution, S_N2 reaction as a stereospecific reaction, SN1 Mechanism-Ion Pairs and other aspects, S_Ni and SET mechanisms, neighbouring group participation-anchimeric assistance, non-classical carbocations, Conformations and stereoisomerism of acyclic and cyclic systems, conformation and chemical reactivity.

Unit-IV

Stereochemistry of elimination reactions, E1, E2 and E1cB mechanisms, elimination versus substitution, Free radical reactions, Structure, stability and geometry, properties of free radicals

Unit-V

Aliphatic Nucleophilic Substitution, S_N2, S_N1 mixed S_N1 and S_N2 and SET mechanism. The neighboring group mechanism, neighboring group participation by σ and π bonds, Classical and nonclassical carbocations, phenomium ions, norbornyl systems, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes.

Book Suggested

1. J. March., Advanced Organic Chemistry: Reactions, Mechanisms and Structure, John Wiley
2. P. S. Kalsi. Stereochemistry, Conformation and Mechanism, New Age International
3. Peter Sykes, A guide book to mechanism in Organic chemistry, Orient-Longmans
4. E. L. Eliel, Stereochemistry of Carbon Compounds, McGraw-Hill
5. S. M. Mukherji and S. P. Singh, Reaction Mechanism in Organic Chemistry, Macmillan
6. F. A. Carey and R. J Sundberg, Advanced Organic Chemistry, Part A and B, Plenum
7. P. S. Kalsi., Organic Reactions and their Mechanisms, New Age International
8. Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentice-Hall.
9. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh,Macmillan.
10. Pericyclic Reactions, S.M. Mukherji, Macmillan, India
11.

Class: M.Sc. Chemistry
Semester: I
Subject: Chemistry –III

Title of Paper: Physical Chemistry-I

Unit-I

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, Hydrogen Molecule.

Unit-II

Approximate Methods

Variational and perturbation methods. Applications of variation method and perturbation theory to the Helium atom.

Molecular Orbital Theory

Huckel theory of conjugated systems bond and charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical cyclobutadiene.

UNIT III

Angular Momentum

Ordinary angular momentum, generalized angular momentum, eigen fucntions for angular momentum, eigen values of angular momentum operator using ladder operators addition of angular momenta, spin, anti-symmetry and Pauli exclusion principle.

Unit-IV

Chemical Thermodynamics

Partial molar Quantities: Partial molar free energy, partial molar volume and partial molar heat content, Chemical Potential 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 Huckel theory for activity coefficient for electrolytic solutions; determination of activity and activity coefficients; ionic strength.

Unit-V

Statistical Thermodynamics

Partition functions-translation, rotational, vibrational and electronic partition functions, Application of partition functions. Equilibrium constant in terms of partition functions, Fermi-Dirac Statistics and Bose-Einstein statistics

Books Suggested

1. J. P. Lowe and K.Peterson, Quantum Chemistry Academic Press.
2. D. A. McQuarrie, Quantum Chemistry Viva Books Pvt. Ltd.: New Delhi.
3. R. G. Mortimer, Mathematics for Physical Chemistry Elsevier.
4. F. L. Pilar, Elementary Quantum Chemistry, Dover Publication Inc.: New York.
5. P. W. Atkins and J. de Paula, Atkin's Physical Chemistry, Oxford University Press.
6. I. L. Levine, Quantum Chemistry, Prentice-Hall Inc., New Jersey.
7. T. Engel and P. Reid, Physical Chemistry, Benjamin-Cummings.

8. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, Univ. Science Books.
9. R. J. Silbey, R. A. Alberty and M. G. Bawendi, Physical Chemistry, Wiley.
10. A.K. Chandra, Introduction to Quantum Chemisty, Tata Mc Graw Hill.
11. K.J. Laidler, Chemical Kinetics. Mc Graw-Hill.
12. J.O.M. Bockris and A.K.N. Reddy, Modern Electrochemistry Vol. 1 and Vol II, Planum.
13. R.K. Prasad, Introduction to Quantum Chemistry, New Age Publication.

Class: M.Sc. Chemistry
Semester: I
Subject: Chemistry –IV
Title of Paper: : Group Theory & Spectroscopy I

Unit-I

Symmetry and Group theory in Chemistry:

Symmetry elements and symmetry operation, definition of group, subgroup, Conjugacy relation and classes. Point symmetry group, Schonfilies symbols, representations of groups by matrices (representation for the C_n, C_{nv}, C_{nh}, D_{nh} etc), Character of a representation, The great orthogonality theorem (without proof) and its importance, Character tables and their use; spectroscopy. Derivation of character table for C_{2v} and C_{3v} point group, Symmetry aspects of molecular vibrations of H_2O molecule, Symmetry, shapes and molecular vibrations of AB_2, AB_3, AB_4, AB_5 and AB_6

Unit-II

Infrared-Spectroscopy:

Electromagnetic Radiation, basic principle of IR spectroscopy, Review of linear harmonic oscillator, Selection rules, force constant and bond strengths, normal modes of vibration, group frequencies, overtones, combination bands and Fermi resonance, factors affecting the band positions and intensities, Far IR region, metal ligand vibrations

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.

Unit-III

Electron Spin Resonance Spectroscopy:

Basic principles, Hyperfine coupling, Isotropic and anisotropic hyperfine coupling constants, spin polarization for atoms and transition metal ions, spin-orbit coupling and significance of g-tensors, factors affecting the 'g' value. Zero field splitting and Kramer's degeneracy; spin Hamiltonian, spin densities and Mc Connell relationship. Applications

Unit-IV

Raman Spectroscopy

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

Unit-V

Electronic Spectroscopy

Molecular Spectroscopy Energy levels, molecular orbitals, vibronic transitions, vibrational progressions and geometry of the excited states, Franck-Condon principle, electronic spectra of polyatomic molecules.

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.

Books suggested

1. Modern Spectroscopy, J.M. Hollas, John Viley.
2. Applied Electron Spectroscopy for chemical analysis d. H. Windawi and F.L. Ho, Wiley Interscience.
3. NMR, NQR, EPr and Mossbauer 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, IBHOxford.
9. Introduction to Photoelectron Spectroscopy, P.K. Ghosh, John Wiley.
10. Introduction to Magnetic Resonance. A Carrington and A.D. Maclachalan, Harper & Row.

Class: M.Sc. Chemistry
Semester: I
Subject: Chemistry –V
Title of Paper: : **Mathematics For Chemists**

(For students without Mathematics in B.Sc.)

Unit-I

Vectors

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

Matrix Algebra

Addition and multiplication; inverse, adjoint and transpose of matrices.

Unit-II

Differential Calculus

Functions, continuity and differentiability, rules for differentiation, applications of differential calculus including maxima and minima ,Bohr's radius and most probable velocity from Maxwell's distribution etc.).

Unit-III

Integral calculus

Basic rules for integration, integration by parts, partial fractions and substitution. Reduction formula, applications of integral calculus.

Unit-IV

Elementary Differential equations

First-order and first degree differential equations, homogenous, exact and linear equations. Applications to chemical kinetics.

Unit-V

Permutation and Probability

Permutations and combinations, probability and probability theorems average, variance root means square deviation examples from the kinetic theory of gases etc., fitting (including least squares fit etc with a general polynomial fit.

Book Suggested

1. The chemistry Mathematics Book, E.Steiner, Oxford University Press.
2. Mathematics for chemistry, Doggett and Suiclific, Logman.
3. Mathematical for Physical chemistry: F. Daniels, Mc. Graw Hill.
4. Chemical Mathematics D.M. Hirst, Longman.
5. Applied Mathematics for Physical Chemistry, J.R. Barante, Prentice Hall.
6. Basic Mathematics for Chemists, Tebbutt, Wiley.

Class: M.Sc. Chemistry
Semester: I
Subject: Chemistry –V

Title of Paper: Biology for Chemists

(For students without Biology in B.Sc.)

Unit-I

Cell Structure and Functions

Structure prokaryotic and eukaryotic cells, intracellular organelles and their functions, comparison of plant and animal cells. Ove4rview and their functions, comparison of plant and animal cells. Overview of metabolic processes-catabolism and anabolism. ATP – the biological energy currency.

Unit-II

Carbohydrates

Conformation of monosaccharides, structure and functions of important derivatives of mono-saccharides like glycosides, deoxy sugars, myoinositol, amino sugars, Structural polysaccharides of cellulose and chitin. Storage polysaccharides-starch and glycogen. Carbohydrates of glycoporteins and glycolipids. Role of sugars in biological recognition. Blood group substances. Ascorbic acid.

Unit-III

Lipid

Fatty acids, essential fatty acids, structure and function of triacylglycerols, glycerophospholipids, sphingolipids, cholesterol, bile acids, prostaglandins. Liproproteins-compositiion and function, role in atherosclerosis., liposomes and their possible biological functions. Fluid mosaic model of membrane structure. Lipid metabolism boxidation 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. ahelix, -b-sheets, super secondary structure, Quaternary structure. Amino acid metabolism-degradation and biosynthesis of amino acids,

Unit-V

Nucleic Acids

Purine and pyrimidine bases of nucleic acids, base pairing via H-bounding. Structure of ribonucleic acids (RNA) and deoxyribonucleic acid (DNA), double helix model of DNA and forces responsible for holding it.

Book Suggested

1. Principles of Biochemistry, A.L. Lehninger, Worth Publishers.
2. Biochemistry, L. Stryer, W.H. Freeman.
3. Biochemistry, J. David Rawan, Neil Patterson.
4. Biochemistry, Voet and Voet, John Wiley.
5. Outlines of Biochemistry E.E. Conn and P.K. Stumpf, John Wiley.

Class: M.Sc. Chemistry
Semester: I
Subject: Chemistry –I

Title of Paper: Inorganic Chemistry Practical

Practical examination shall be conducted separately for each branch.

Inorganic Chemistry

1. Quantitative and qualitative analysis
2. Chromatography
3. Preparation
4. Record
5. Viva Voce

Quantitative and qualitative analysis

(a) Separation and determination of two metal ions Cu-Ni, Ni-Zn, Cu-Fe etc. involving volumetric and gravimetric methods.

(b) Chromatography: Separation of cations and anions by Paper Chromatography.

(c) Preparations: Preparation of selected inorganic compounds and their studies by IR, electronic spectra, Mossbauer, ESR and magnetic susceptibility measurements.

(d) Handling of air and moisture sensitive compounds.

1. $VO(acac)_2$
2. cis-$K[Cr(C_2O_4)_2(H_2O)_2]$
3. $Na[Cr(NH_3)_2(SCN)_4]$
4. $Ni(acac)_2$
5. $K_3[Fe(C_2O_4)_3]$
6. Prussian Blue, Turnbull's Blue.
7. Oxalate Complexes of Copper-II

Class: M.Sc. Chemistry
Semester: I
Subject: Chemistry –II
Title of Paper: Organic Chemistry Practical

Organic Chemistry

1. Qualitative Analysis
2. Organic Synthesis
3. Record
4. Viva Voce

Qualitative Analysis

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

Organic Synthesis

Acetylation, Nitration, Halogenations, Oxidation, Reduction, Polymerization

Class: M.Sc. Chemistry
Semester: I
Subject: Chemistry –III
Title of Paper: Physical Chemistry Practical

Physical Chemistry

1. Error Analysis and Statistical Data Analysis
2. Chemical Kinetics
3. Solution
4. Record
5. Viva Voce

Error Analysis and Statistical Data Analysis

(a) Errors, types of errors, minimization of errors, distribution curves precision, accuracy and combination; statistical treatment for error analysis, student's test, null hypothesis, rejection criteria. F & Q test; linear regression analysis, curve fitting. Calibration of volumetric apparatus, burette, pipette and standard flask.

(b) Adsorption Experiment.

Phase Equilibria

i. Determination of congruent composition and temperature of a binary system (e.g. diphenylamine-benzophenone system).
ii. Determination of glass transition temperature of a given salt (e.g., $CaCl_2$) conductometrically.
iii. To construct the phase diagram for three component system (e.g. chloroform-acetic acid-water).

Chemical Kinetics

i. Determination of the effect of (a) Change of temperature (b) Charge of concentration of reactant and catalyst and (c) Ionic strength of the media on the velocity constant of hydrolysis of an ester/ionic reaction.
ii. Determination of the velocity constant of hydrolysis of an ester/ionic reaction in micellar media.
iii. Determination of the velocity constant for the oxidation of iodide ions by hydrogen peroxides. Study the kinetics as an iodine clock reaction.

Solution

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

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.

Class: M.Sc. Chemistry
Semester: II
Subject: Chemistry –I

Title of Paper: Inorganic Chemistry II

Unit-I

Electronic Spectral Studies of Transition Metal Complexes:

Spectroscopic ground states, correlation. Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), Selection rule for electronic spectroscopy. Intensity of various type electronic transitions. Calculations of 10Dq, B and β parameters, charge transfer spectra.

Unit-II

Magnetic Properties of Transition Metal Complexes

Anomalous magnetic moments, Quenching of orbital contribution. Orbital contribution to magnetic moment, magnetic exchange coupling and spin crossover.

Unit-III

Metal π-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 dioxgen complexes; tertiary phosphine as ligand.

Unit-IV

Metal Clusters

Higher boranes, carboranes, metalloboranes and metallo-carboranes compounds with metal metal multiple bonds.

Unit-V

Optical Rotatory Dispersion and Circular Dichroism

Linearly and circularly polarized lights; optical rotatory power and circular birefringence, elipticity and circular dichroism; ORD and Cotton effect, Faraday and Kerr effects; Assignment of electronic transitions; applications of ORD and CD for the determination of (i) absolute configuration of complexes and (ii) isomerism due to non-planarity of chelate rings.

Books Suggested :

1. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley.
2. Inorganic Chemistry, J.E. Huhey, Harpes & Row.
3. Chemistry of the Elements. N.N. Greenwood and A. Earnshow, Pergamon.
4. Inorganic Electronic Spectroscopy, A.B.P. Lever, Elsevier.
5. Magnetiochemistry, R.1. Carlin, Springer Verlag.
6. Comprehensive Coordiantion Chemistry eds., G. Wilkinson, R.D. Gillars and J.A. Mc Cleverty, Pergamon.

Class: M.Sc. Chemistry
Semester: II
Subject: Chemistry –II

Title of Paper: Organic Chemistry II

Unit-I

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, Vilsmeir reactiion, Gatterman-Koch reaction

Aromatic Nucleophilc Substitution

The S_NAr S_N1, benzyne and S_N1 mechanism, Reactivity effect of substrate structure, leaving group and attacking nucleophile. The Von Richte, Sommelet-Hauser, and Smiles rearrangements.

Unit-II

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 carboyxlic acids, autooxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts, Sandmeyer reaction, Free radical rearrangement, Hunsdiecker reaction.

Unit III

Addition Reactions

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 bounds, hydrogenation of aromatic rings. Hydroboration, Michael reaction, sharpless asymmetric epoxidation.

Unit-IV

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 usaturated carbonyl compounds, Witting reaction, Mechanism of condensation reactions involving enolates-Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions. Hydrolysis of esters and amides, ammonolysis of esters.

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.

Unit-V

Pericyclic Reactions

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

Book Suggested

1. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sunderg, Plenum.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Comell University Press.
5. Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentice-Hall.
6. Modern Organic Reactions, H.O. House, Benjamin.
7. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic &* Professionsl.
8. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh, Macmillan.
9. Pericyclic Reactions, S.M. Mukherji, Macmillan, India
10. Stereochemistry of Organic Compounds, D.Nasipuri, New Age International.
11. Stereochemisty of Organic Compounds, P.S. Kalsi, New Age International.

Class: M.Sc. Chemistry
Semester: II
Subject: Chemistry –III

Title of Paper: Physical Chemistry II

Unit-I

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. Dyamic chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogenbromine 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 ad the nuclear magnetic resonance method, dynamics of unimolecular reactions (Lindemann Hinshelwood and Rice-Ramsperger- Kassel- Marcus (RRKM) theories for unimolecular reactions).

Unit-II

Surface Chemistry

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), and Surface films on liquids (Electro-kinetic phenomenon).

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, solublization, micro emulsion, reverse micelles.

Unit-III

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-IV

Non Equilibrium Theromodynamics

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.

Unit-V

Electrochemistry

Electrochemistry of solutions. Debye-Huckel-Onsager treatment and its extension, ion solvent interactions. Debye-Huckel-Jerum mode. Thermodynamics of electrified interface equations. Derivation of electro capillarity, Lippmann equations (surface excess), methods of determination. Structure of electrified interfaces. 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. Polarography theory, Ilkovic equation; half wave potential and its significance.

Books Suggested

1. Physical Chemistry, P.W. Atkins, ELBS.
2. Introduction to Quantum Chemistry, A.K. Chandra, Tata Mc Graw Hill.
3. Quantum Chemistry, Ira N. Levine, Prentice Hall.
4. Coulson's Valence, R.Mc Ween y, ELBS.
5. Chemical Kinetics. K.J. Laidler, McGraw-Hill.
6. Kineties and Mechanism of Chemical Transformation J.Rajaraman and J. Kuriacose, Mc Millan.
7. Micelles, Theoretical and Applied Aspects, V. MOraoi, Plenum.
8. Modern Electrochemistry Vol. 1 and Vol II J.O.M. Bockris and A.K.N. Reddy, Planum.
9. Introduction to Polymer Science, V.R. Gowarikar, N.V. Vishwanathan and J. Sridhar, Wiley Eastern.

Class: M.Sc. Chemistry
Semester: II
Subject: Chemistry –IV

Title of Paper: Group theory and Spectroscopy-II

Unit-I

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 (AXB, AMX, ABC, A_2B_2 etc.). Spin decoupling; basic ideas about instrument, NMR studies of nuclei other than protin-^{13}C, ^{19}F and ^{31}P. FT-NMR, advantages of FT-NMR.

Unit II

Nuclear Quadrupole Resonance Spectroscopy

Quadrupole nuclei, quadrupole moments, electric field gradient, coupling constant, splitting. Applications.

Unit-III

Electron Spin Resonance Spectroscopy

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

Unit-IV

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.

Unit-V

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.

Neutron Diffraction

Scattering of neutrons by solids measurement techniques, Elucidation of structure of magnetically ordered unit cells.

Books suggested

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

Class: M.Sc. Chemistry
Semester: II
Subject: Chemistry –V

Title of Paper: Computers for Chemists

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

Unit-I

Introduction to computers and Computing

Basic structure and functioning of computer with a PC as illustrative example. Memory I/O devices. Secondary storage Computer languages. Operating systems with DOS as an example Introduction to UNIX and WINDOWS. Principles of programming Alogrithms 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 compute language. Constants and variables. Operations and symbols Expressions. Arithmetic assignment statement. Input and output Format statement. Termination statements. Branching statements as IF or GO TO statement. LOGICAL variables. Double precession 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 beginning of this topic.)

Unit-III

Programming in Chemistry

Developing of small computer codes using any one of the languages FORTRAN/C/BASIC involving simple formulae in Chemistry, such as Van der Waals equation. Chemical kinetics (determination of Rate constant) Radioactive decay (Half Life and Average Life). Determination Normality, Molarity nd Molality of solutions. Evaluation Electronegativity of atom and Lattice Energy from experimental determination of molecular weight and percentage of element organic compounds using data from experimental metal representation of molecules in terms of elementary structural features such as bond lengths, bond angles.

Unit-IV

Use of Computer programmes

Operation of PC. Data Processing. Running of standard Programs and Packages such as MS WORD, MS EXCEL special emphasis on calculations and chart formations. X-Y plot.

Simpson's Numerical Integration method. Programmes with data preferably from physical chemistry laboratory.

Unit V

Internet

Application of Internet for Chemistry with search engines, various types of files like PDF, JPG, RTF and Bitmap. Scanning, OMR, Web camera.

Book Suggested :

Fundamentals of Computer : V. Rajaraman (Prentice Hall)

Computers in Chemistry : K.V. Raman (Tata Mc Graw Hill)

Computer Programming in FORTRAN IV-V Rajaraman (Prentice Hall)

Class: M.Sc. Chemistry
Semester: II
Subject: Chemistry –I
Title of Paper: Inorganic Chemistry Practical
Practical examination shall be conducted separately for each branch.

Inorganic Chemistry

1. Quantitative Analysis
2. Chromatography
3. Preparation
4. Record
5. Viva Voce

Quantitative Analysis:

Separation and determination of two metal ions Cu-Ni, Ni-Zn, Cu-Fe and other suitable combination involving volumetric and gravimetric methods.

Less Common Element metal ions, analysis of insoluble.

Chromatography

Separation of cations and anions by Column Chromatography: Ion exchange/TLC.

Preparations

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

1. $[Co(NH3)_6]$ $[Co(NO_2)_6]$
2. cis-$[Co(trien)\ (NO_2)_2]Cl.H_2O$
3. $Hg[Co(SCN)_4]$
4. $[Co(Py)_2Cl_2]$
5. $[Ni(NH3)_6]Cl_2$
6. $Ni(dmg)_2$
7. $[Cu(NH_3)_4]SO_4.H_2O$
8. $[Cu_3[CS\ NH_2]_2\ SO_4.2H_2O$
9. $K_3[Cr(SCN)_6]_4.H_2O$

Class: M.Sc. Chemistry
Semester: II
Subject: Chemistry –II
Title of Paper**: Organic Chemistry Practical**

Organic Chemistry

1. Organic Synthesis
2. Quantitative Analysis
3. Record
4. Viva Voce

Organic Synthesis

(A) Synthesis involving name reaction:

(ii) Aldol condensation
(iii) Connizzaro reaction
(iiii) Sandmeyer reaction
(iiv) Diel's Alder reaction
(iv) Knoevenagel reaction

(B) Synthesis of dyes:

(ii) Phenolphthalein
(iii) Fluoroscein
(iiii) Diazotization followed by coupling

Quantitative Analysis

(ii) Determination of the percentage or number of hydroxyl groups in an organic compound by acetylation method.
(iii) Estimation of amines/phenols using bromate bromide solution/or acetylation method.
(iiii) Saponification value, iodine value and acid values of an oil or fat.

Class: M.Sc. Chemistry
Semester: II
Subject: Chemistry –III
Title of Paper**: Physical Chemistry Practical**

Physical Chemistry

1. Conductometry
2. Potentiometry/pH metry
3. Polarimetry
4. Record
5. Viva Voce

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. $PbSO_4$, $BaSO_4$) conductometrically.

iii. Determination of the strength of strong and weak acid in a given mixture conductometrically.

iv. To study of the effect of solvent on the conductance of $AgNO_3$/acetic acid and to determine the degree of dissociation and equilibirum constant in different solvents and in their mixtures (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Huckel-Onsager theory.

v. Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Huckel's limiting law.

Potentiometry/pH metry

1. Determination of strengths of halides in a mixture potentiometrically.
2. Determination of the strength of strong and weak acids in a given mixture using a potentiometer/pH meter.
3. Determination of temperature dependence of EMF of a cell.
4. Determination of the formation constant of silver-ammonia complex and
5. stoichiometry of the complex potentiometrically.
6. Acid-base titration in a non-aqueous media using a pH meter.

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.

Class: M.Sc. Chemistry
85+15=100
Semester: III

Title of Paper: MOLECULAR SPECTROSCOPY (301)

Unit-I

Ultraviolet and Visible spectroscopy: Fundamentals, effect of solvent and extending conjugation on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes, Fiesher Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic compounds. Steric effect in biphenyls

Unit-II

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 of spin systems,(AXB, AMX, ABC, A2B2 etc.). First-order and Second-order spectra Basic idea about instrument, FT NMR, 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), spin decoupling(double resonance), chemical exchange, effect of deuteration, stereochemistry, hindered rotation, NMR shift reagents, Solvent effect, Nuclear Overhauser effect (NOE).

Unit-III

Carbon-13 NMR Spectroscopy: General considerations, chemical shift (aliphatic olefinic , alkyne, aromatic, heteroaromatic and carboynl carbon), NMR studies of nuclei other than proton and carbon-^{19}F and ^{31}P. Two dimensional NMR spectroscopy: COSY, HETCOR, NOESY, DEPT, HMBC and HMQC techniques.

Unit-IV

Mass Spectrometry : Introduction, ion production EI, CI, FD, ESI and FAB, ion analysis, ion abundance, Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable ion peak, Mc Lafferty rearrangement , Nitrogen rule, High resolution mass spectrometry. Combined problems based on UV, IR, NMR and Mass spectral techniques

Unit-V

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} and Sn^{+4} compounds-nature of M-L bond, coordination number, structure and (3) detection of oxidation state and inequivalent MB atoms.

Books Suggested

1. R.M. Silverstein, G.C. Bassler and T.C. Morrill, Spectrometric Identification of Organic Compounds, John Wiley
2. R.J. Abraham, J. Fisher and P. Loftus, Introduction to NMR spectroscopy, Wiley
3. J.R. Dyer, Application of Spectroscopy of Organic Compounds, Prentice Hall
4. D.H. Williams, I. Fleming, Spectroscopic Methods in Organic Chemistry, Tata McGraw-Hill
5. Banwell, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill
6. G. Aruldhas, Molecular Structure and Spectroscopy, Prentice Hall

Class: M.Sc. Chemistry
85+15=100
Semester: III

Title of Paper: PHOTOCHEMISTRY (302)

Unit-I

Photochemical Reactions

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

Unit-II

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.

Unit III

Photochemistry of Alkene

Intramolecular reactions of the olefinic bond-geometrical isomerism, cyclisation reactions, rearrangement of 1,4- and 1,5-dienes. Photochemistry of Aromatic Compounds Isomerisations, Additions and Substitutions.

Unit-IV

Photochemistry of Carbonyl Compounds

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

Unit-V

Miscellaneous Photochemical Reactions

Photo-Fries reactions of anilides, Photo-Fries rearrangement. Barton reaction. Singlet molecular oxygen reaction. Photochemical formation of smog. Photodegration of polymers. Photochemistry of vision

Book Suggested

1. K.K. Rothagi-Mukheriji, Fundamentals of photochemistry, Wiley-Eastern.
2. A Gilbert and J. Baggott, Essentials of Molecular Photochemistry, Blackwell Scientific Publication.
3. N.J. Turro, Molecular Photochemistry, Benjamin.
4. A. Cox and T. Camp, Introductory Photochemistry, McGraw Hill.
5. R.P. Kundall and A. Gilbert, Photochemistry, Thomson Nelson.
6. J. Coxon and B.Holtom, Organic Photochemistry, Cambridge University Press.

7. C H Dupuoy and O L Chapman Molecular Reactions and Photochemistry, Prentice Hall
8. J Kagan, Organic Photochemistry, Academic Press.

Class: M.Sc. Chemistry
85+15=100
Semester: III

Title of Paper: BIO-INORGANIC CHEMISTRY (303)

Unit-I

Electron Transfer in Biology

Structure and function of metal of proteins in electron transport processes cytochrome's and ion-sulphure proteins, synthetic models.

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

Unit-II

Metalloporphyrins

Structure and optical spectra; heme proteins: magnetic susceptibility, epr and electronic spectra; hemoglobin and myoglobin: molecular structures, thermodynamics and kinetics of oxygenation, electronic and spatial structures, synthetic oxygen carriers, model systems; iron enzymes, peroxidase, catalase and cytochrome P-450

UNIT III

Metalloenzymes

Copper enzymes, superoxide dismutase, cytochrome oxidase and ceruloplasmin; Coenzymes; Molybdenum enzyme: xanthine oxidase; Zinc enzymes: carbonic anhydrase, carboxy peptidase and interchangeability of zinc and cobalt in enzymes; Vitamin B12 and B12 coenzymes; Iron storage, transport, biomineralization and siderophores, ferritin and transferrins.Hemocyanin and Hemerithrin.

Unit-IV

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.

Unit-V

Enzyme models: Host guest chemistry, chiral recognition and catalysis, molecular recognition, molecular asymmetry and prochirality, biomimetic chemistry, crown ethers, cryptates, cyclodextrins, cyclodextrin-based enzyme models, calixarenes, ionophores, micelles, synthetic enzymes or synzymes.

Books Suggested

1. S. J. Lippard & J. M. Berg. Principles of Bioorganic Chemistry, Panima Publ. Corpn.
2. E.-I. Ochiai. Bioinorganic Chemistry – An Introduction, Allyn and Bacon Inc.
3. M. N. Hughes. The Inorganic Chemistry of Biological Processes, Wiley .
4. R.P. Hanzlik. Inorganic Aspects of Biological and Organic Chemistry, Academic Press.

5. H. Kraatz & N. Metzler-Nolte (Eds.). Concepts and Models in Bioinorganic Chemistry, Wiley.
6. I. Bertini, H. B. Gray, S. J. Dippard & J. S. Valentine, Bioinorganic Chemistry, Viva Books Pvt. Ltd.
7. A.W. Addison, W.R. Cullen, D. Dolphin & B.R. James (eds.). Biological Aspects of Inorganic Chemistry, John Wiley .

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Class: M.Sc. Chemistry
85+15=100
Semester: III

Title of Paper: DIFFRACTION METHODS & PHOTOELECTRON SPPECTROSCOPY (304)

Unit-I

X-ray Diffraction

Bragg condition, Miller indices, X-Ray emission, Moseley Law, Duane Hunt Law, Laue Method and Debye Scherrer method of X-ray structural analysis of crystals,

Unit -II

Crystel density, 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.

Unit-III

Electron Diffraction

Electron diffraction vs X-Ray diffraction, Resolution and operating voltage of electron microscope, Measurement techniques: SEM and TEM , Sample preparation and elucidation of structure .

Unit-IV

Difference between Neutron Diffraction and X-Ray Diffraction, Neutron Spectrometer: Instrumentation and Applications, Elucidation of structure of Ferro- and Antiferro- magnetic structures.

Unit-V

Photoelectron Spectroscopy

Basic principles; photo-electric effect, ionization process, X-Ray Photoelectron Spectroscopy (XPS): Features, Advantages, Limitations and Applications. Photoelectron spectra of simple molecules. ESCA: Chemical information from ESCA

Books suggested

1. L.V. Azaroff, Elements of X-Ray Crystalography, McGraw-Hill/ Wiley, New York.
2. S. K. Chatterjee, X-Ray Diffraction,: Itys Theory and Applications, PHI Learning Pvt. Ltd. New Delhi.
3. K. Ramakanth Hebber, Basics of X-Ray Diffractions and its Applications, I.K. International Pulishing House, Banglore.
4. Paulvan der Heide, X-ray Photoelectron Spectroscopy: An introduction to Principles and Practices , Wiley.
5. A.R. West, Solid State Chemistry and its Applications, Plenum.
6. John F. Watts, John Wolstenholme, An Introduction to Surface Analysis by XPS and AES, Wiley.
7. P.K. Ghosh, Introduction of Photoelectron Spectroscopy.

Class: M.Sc. Chemistry
85+15=100
Semester: III

Title of Paper: : MEDICINAL CHEMISTRY (305)

Unit-I

Antineoplastic agents

Introduction, cancer chemotherapy, role of alkylating agents and antimetabolite in treatment of cancer, carcinolytic antibiotics, and mitotic inhibitors, Synthesis of mechlorethamine, cyclophosphamide, melphalan, uracil, mustards and 6-mercaptopurine, recent development in cancer chemotherapy.

Unit-II

Psychoactive drugs-The chemotherapy of mind

Introduction, neurotransmitters, CNS depressants, general anesthetics, mode of action of hypnotics, sedatives, anti-anxiety drugs, benzodiazipines, buspirone, neurochemistry of mental diseases, Anti psychotic drugs the neuroleptics, anti-depressants, butyro phenones, stereo chemical aspects of psychotropic drugs. Synthesis of diazepam, oxazepam, chlorazepam, alprazolam, phenytoin, ethosuximide, trimethadione, barbiturates, thiopental sodium, gluthemide.

Unit-III

Tranquilizers:-

Phenothiazine derivatives - structure- activity relationship, metabolism and mode of action; other tranquilizers. Synthesis of chlorpromazine.

Unit-IV

Diuretics (Drugs acting on renal system): Classification, structure-activity relationships and mode of action of organomercurials, phenoxy acetic acids, purines carbonic anhydrase inhibitors, benzothiadiazines , ulphamoyl benzoic acid derivatives, endocrine antagonists.

Unit-V

Sulpha Drugs:

Classification, structure-activity-relationship, Mode of action. Synthesis: Sulphadiazine, Sulphaisoxazole, Sulphadimethoxine.

Book Suggested

1. Robert F.dorge Wilson and Gisvod. Textbook of organic Medicinal and Pharmaceu-tical Chemistry.
2. Ed. M.E. Wolff, John wiley. Berger's Medicinal Chemistry and drug discovery, Vol-I.
3. J.Faprhop and G.Penzillin. Organic synthesis-concept, method and starting material.
4. Eds.Korolkovas and Burkhattar J.H. John Wiley & sons. Essentials of medicinal Chemistry.
5. Graham & Patrick, Introduction to Medicinal Chemistry OUP
6. Goodman and Gilman's Pharmacological Basis of Therapeutics, McGraw-Hill.
7. Wilson and Gisvold's Text Book of Organic Medicinal and Pharmaceutical Chemistry, Ed Robert F. Dorge.

Class: M.Sc. Chemistry
85+15=100
Semester: III

Title of Paper: : POLYMER (306)

Unit-I

Basic concepts: Monomers, repeat units, degree of polymerization, Linear, branched and network polymers, Classification of polymers. Inorganic Polymers special characteristics, classification, homo and hetero atomic polymers.

Unit III

Polymerization: condensation, addition, radical chain-ionic and co-ordination and copolymerization. Polymerization conditions and polymer reactions. Polymerization in homogeneous and heterogeneous systems.

Unit-III

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, Xray diffraction study, Microscopy. Thermal analysis and physical testing-tensile strength. Fatigue, impact, Tear esistance, Hardness and abrasion resistance.

Unit-IV

Polymer Processing

Plastics, elastomers, fibers. Compounding. Processing techniques. Clendering, die casting, rotational casting, film casting, injection moulding, blow moulding, extrusion moulding, thermoforming, foaming, reinforcing and fire spining

Unit-V

Structure, Properties and Application of Polymers
Structure, Properties and Applications of:
[A] Functional polymers: Fire retarding polymers and Electrically conducting polymers.
[B] Biomedical polymers: Contact lens, dental polymers, artificial heart and kidney,
[C] Polymers based on boron-borazines, boranes , carboranes,
[D] Polymers based on Silicon, silicone's polymetalloxanes and polymetallosiloxanes,
[E] Polymers based on Phosphorous-Phosphazenes, Polyphosphates

Book Suggested

1. Polymer Science, V. R. Gowariker, N. V. Viswanathan and J. Sreedhar, Wiley- Eastern
2. Textbook of Polymers Science, F.W. Billmeyer Jr., Wiley.
3. Contemporary Polymer Chemistry, H.R. Al cock and F.W. Lambe, Prentice Hall.
4. Developments in Inorganic polymer Chemistry, M.F. Lappert and G.J. Leigh.
5. Inorganic polymers- N.H. Ray.
6. Inorganic polymers, Graham and Stone.
7. Inorganic polymers, J. E. Mark, H. R. Allcok and R. West

Class: M.Sc. Chemistry
85+15=100
Semester: III

Title of Paper: ORGANIC SYNTHESIS (307)

Unit-I

The disconnection approach (Retrosynthetic analysis):Guidelines to choose disconnection, Synthons and synthetic equivalents, Functional group interconversion, the order of events and its guidelines, One-group C-X disconnections, Two-group C-X disconnections, Chemoselectivity, reversal of polarity, cyclization reactions and summary of strategy.Amine synthesis, Stereoselectivity, stereoselective reactions, stereospecific reactions

Unit-II

One group C-C disconnections: Alcohols, carbonyl compounds, regioselectivity. Use of acetylenes

Two-group C-C disconnections:Diels-Alder reactions (stereospecificity, stereoselectivity, endo-selectivity, regioselectivity), 1,3-Difunctionalised and , unsaturated carbonyl compounds, 1,5-Difunctionalised compounds, Michael addition and Robinson Annelation.

Unit-III

Oxidation Processes Introduction, Different oxidative processes. Mn(VII) oxidants:Oxidation of alcohols,alkenes,alkynes,aldehydes,ketones,aromatic side chains and rings, amines Cr (VI) oxidants:Oxidation of alcohols /phenols(Jones reagent, Collins reagent, PCC,PDC), alkanes,alkenes,aromatic side chain and aromatic nucleus.

Unit IV

Oxidation with peracids: oxidation of alkenes ,ketones. Other oxidants: Oxidation with ruthenium tetraoxide, lead tetra acetate, thallium. (III) nitrate,potassium periodate,aluminium tri-isopropoxide and aluminium tri-t-butoxide, hydrogen peroxide, t-Butyl hydroperoxide

Unit-V

Reduction Processes Introduction, Different reductive processes. Catalytic hydrogenation: Heterogeneous hydrogenation, Homogeneous hydrogenation. Metal hydride reduction :Scope, Mechanism, stereochemical aspects of metal hydride reduction using lithium aluminium hydride,Sodium borohydride, Diboranes Reduction by dissolving metals: Scope and basic mechanism, Clemensen reduction, Birch reduction

Reduction by other reducing agents: Hydrazines, Diimid

Book Suggested

1. S. Warren, Designing Organic Synthesis, Wiley.
2. W.Carruthers,S ome Modren Methods of Organic Synthesis, Cambrige Univ. Press.
3. H.O. House, Modern Synthetic Reactions, W.A. Benjamin
4. V.K.Ahluwalia ,Organic Reaction Mechanisms, Narosa Publishing House
5. S.M.Mukherji and S.P.Singh,Reaction Mechanism in Organic Chemistry, Macmilan
6. J. March, Advanced Organic Synthesis: Reaction, Mechanisms and Structure, Wiley

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Class: M.Sc. Chemistry
Semester: III
Subject: Chemistry –I

Title of Paper: Spectral Interpretation (Practical)

Interpretation of the spectra of the followings:

- UV-Visible
- IR Spectra
- NMR Spectra
- ESR Spectra

Class: M.Sc. Chemistry
85+15=100
Semester: IV

Title of Paper: ANALYTICAL CHEMISTRY (401)

Unit-I

Electronic Spectral Studies of Transition Metal Complexes:

Spectroscopic ground states, correlation. Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), Selection rule for electronic spectroscopy. Intensity of various type electronic transitions. Calculations of 10Dq, B and β parameters, charge transfer spectra.

Statistical tests and Error Analysis:

Accuracy, precision, classification of errors, significant figures and computation, mean deviation and standard deviation, Least square methods, regression coefficient , F-test, t test and Chi-test.

Sampling and Sample Treatment:

Factors involved in effective sampling, good samples; Representative and homogeneous, samples of mixtures.

Unit-II

Spectrochemical and Thermal Methods:

Spectrophotometry: Quantities principles of absorption, instrumentation, single beam, double beam, determination of pKa value of an indicator, detectors, applications. Atomic spectroscopy: Principles of emissions, atomic emission spectroscopy and flame emission spectroscopy, monochromator, detector, types of interferences,

Unit-III

Electroanalytical Methods:

Theory of electrogravimetric analysis, electrode reactions, over potential, Cyclic voltammetry, Linear-scan voltammetry, Pulse voltammetric methods, stripping methods. Coulometry: Coulometrc titrations and controlled- potential electrolysis.

Unit-IV

Separation Techniques:

Classification of chromatographic separations. Theory of chromatography. Applications of chromatographic methods: Adsorption and partition chromatography. Ion exchange chromatography , LC, HPLC and GC, Column matrices, Detectors. Affinity and chiral columns. Principles of analytical separations, liquid –liqid extraction : Distribution coefficient, distribution ratio, solvent extraction of metals, analytical separations, multiple batch extractions, countercurrent distribution., multiple extractions.

Unit-V

Thermal methods of analysis: Principles and instrumentation of TG and DTA. Complementary nature of TG and DTA. Differential scanning calorimeter (DSC). Applications of thermal methods in analytical chemistry.

Books Suggested:

1. Gary D.Christian, Analytical Chemistry, John-Wiley
2. H.A.Willard, L.L.Merrit, and J.A.Dean, Instrumental Methods of Analysis, Van Nostrand, New York, 1986.
3. D.A.Skoog & D.M.West Principles of Instrumental Analysis. Holt Rinahart Winston, New York, 1988.
4. K A Robinsons Chemical Analysis, Harper Collins Publishers, NewYork.
5. A.J. Bard and L. R. Faulkner, Electrochemical Methods: Fundamentals and Applications, John Wiley & Sons: New York.

DR. A. P. J. ABDUL KALAM UNIVERSITY, INDORE

Class: M.Sc. Chemistry
85+15=100
Semester: IV

Title of Paper: ENVIRONMENTAL CHEMISTRY (402)

Unit-I

Environment

Introduction. Composition of atmosphere, vertical temperature, temperature inversion, heat budget of the earth, atmospheric system, vertical stability atmosphere, Biochemical cycles of C, N, P, S and O. Biodistribution of elements.

Unit II

Hydrosphere

Chemical composition of water bodies-lakes, streams, rivers and wetlands etc. Hydrological cycle

Aquatic pollution – Inorganic,organic, pesticide, agriculture, industrial and sewage, detergents, oil spills and oil pollutants. Water quality parameters – dissolved oxygen, biochemical oxygen demand, solids, metals, content of chloride, sulphate, phosphate, nitrate and microorganisms. Water quality standards. Analytical methods of measuring BOD, DO, COD, F, Oils, metals (As, Cd, Cr, Hg, Pb, Se etc.),residual chloride and chlorine demand.

Purification and treatment of water.

Unit-III

Soils

Composition, micro and macro nutrients, pollution – fertilizers, pesticides, plastics and metals. Waste treatment.

Atmosphere

Chemical composition of atmosphere – particles, ions and radicals and their formation. Chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, O and their effect, pollution by chemicals, petroleum, minerals, chlorofluorohydrocarbons. Green house effect, acid rain, air pollution controls and their chemistry. Analytical methods for measuring air pollutants. Continuous monitoring instruments. Urban Air Pollution Exhaust emissions, damaging effects of carbon monoxide. Monitoring of CO. Control strategies.

Unit IV

Industrial Pollution

Cement, sugar, distillery, drug, paper and pulp, thermal power plants, nuclear power plants, metallurgy. Polymers, drugs etc.

Environmental disasters – Cherbonyl, Three mile island, Seveso and minamata disasters, Japan tsunami

Unit-V

Environmental Toxicology

Toxic heavy metals **:** Mercury, lead, arsenic and cadmium. Causes of toxicity. Bioaccumulation, sources of heavy metals. Chemical speciation of Hg, Pb, As, and Cd. Biochemical and damaging effects.

Toxic Organic Compound **:** Pesticides, classification, properties and uses of organochlorine and ionospheres pesticides detection and damaging effects..

Book Suggested

1. Environmental Chemistry, S.E. Mahan, Lewis Publishers.
2. Environmental Chemistry, Sharma & Kaur, Krishna Publishers.
3. Environmental Chemistry, A.K. De, Wiley Eastern
4. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern
5. Standard Method of Chemical Analysis, F.J. Welcher Vol. III, Van Nostrand Reinhold Co.
6. Environmental Toxicology, Ed. S. Landsberger and M. Creatchman, Gordon and Breach Science Publication.
7. Enviromental Chemistry, C. Baird, W.H. Freeman.

Class: M.Sc. Chemistry
85+15=100
Semester: IV

Title of Paper: SOLID STATE CHEMISTRY & MATERIALS SCIENCE (403)

Unit-I

Solid State Reactions

General Principles,Experimental procedure,Coprecipitation as a procedure to solid state reactions,Crystallization of solutions and gels (zeolite synthesis),melts,and glasses, Vapor phase transport methods,Modification of existing structures by intercalation and Ion exchange reactions, preparation of thin films – electrochemical methods,chemical vapour deposition; Growth of single Crystals – Czochralski method, Bridgman & Stokbarger methods, zone melting.

Unit-II

Crystal defects and Non- stoichiometry

Stoichiometric Defects: Perfect and imperfect crystals,Types of defects, Point defects Schottky defect , Frenkel defects ,The concentration of defects:Law of Mass action and statistical thermodynamic approaches, Numericals Non-Stoichiometric Defects: Origin of non-stoichiometry, Colour centers: Fcentre, H-centre,V-centre.

Unit-III

Superconductors

Superconductivity: occurrence of superconductivity, destruction of superconductivity by magnetic fields (Meissner effect), BCS theory of superconductivity, Organic Superconductors.

Unit-IV

Chemistry of Nanomaterials

Basic concepts of Nanoscience -nanotechnology and their role in various fields, Synthesis of nanoparticles (Top-down -Nanolithography, CVD; Bottom-up -Sol-get processing, chemical synthesis) and their characterization techniques, Properties of nanostructured materials: optical, magnetic and chemical properties.

Unit-V

Nanometerials: Introduction, Carbon-based materials-Fullerenes, Carbon nanotubes, Quantum well, Quantum wires, Quantum dots, Dendrimers, Properties and technological advantages of Nanomaterials.

Optical properties: Luminescence and phosphors; Configurational coordinate model, Antistoke phosphors, Lasers — ruby and neodymium

Books Suggested

1. Solid state chemistry and its applications, A.R. West. Plenum
2. Principles of the Solid State, H.V. Keer, Wiley Eastern
3. Solid State Chemistry, N.B. Hannay
4. Solid State Chemistry, D.K. Chakrabarty, New Wiley Eastern.
5. Introduction to nanotechnology: Charles P.Poole, Jr. Frank, J. Owens: Wiley India
6. Chemistry of Advanced Materials: An overview, L.V. Interrate, M.J. Hampden-Smith Wiley-VCH
7. Nanomaterials : A.K. Bandyopadhyay; New Age International Publishers
8. Nanotechnology by Mark Ratner and Daniel Ratner, Pearson Education

DR. A. P. J. ABDUL KALAM UNIVERSITY, INDORE

Class: M.Sc. Chemistry
85+15=100
Semester: IV

Title of Paper: BIOORGANIC CHEMISTRY (404)

Unit-I

Introduction : Basic Consideration, Proximity effects and molecular adoption.

Enzymes: Introduction, Chemical and Biological catalysis, remarkable properties of enzymes, Nomenclature and classification, concept and identification of active site by use of inhibitors, reversible & irreversible inhibition.

Unit II

Kinds of Reactions Catalyzed by Enzymes: B-cleavage and consideration, some isomerization and rearrangement reactions. Enzyme catalyzed carboxylation and decarboxylation.

Mechanism of Enzyme action: Transition state theory, Orientation and steric effect, acid-base catalysis, covalent catalysis.

Unit-III

Enzyme Models : Host guest chemistry, Chiral recognition and catalysis, molecular recognition, molecular asymmetry and prochirality, Biomimetic chemistry, crown ethers, cryptates, cyclodextrins, cyclodextrin based enzyme models, Calixarenes, ionophores, micelles synthetic enzyme or synzymes.

Unit-IV

Biotechnological Application of enzymes: Large scale production and purification of enzymes, techniques and methods of immobilization of enzyme activity, application of immobilized enzymes, effect of immobilization on Enzyme activity, application of immobilized enzymes. Clinical uses of enzymes, enzyme therapy, enzymes and recombinant DNA technology.

Unit-V

Co-Enzyme Chemistry: Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes, Structure and biological functions of coenzyme A.

Books suggested

1. Bioorganic chemistry:A Chemical Approch to Enzyme action,Hermann Dugas and C.Penny, Springer-Verag.
2. Understanding Enzymes, Trevor Palmer, Prentice Hall
3. Enzyme Chemistry: Impact and applications, Ed Collin J Suckling, Chapman and Hall
4. Enzyme mechanism a 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. Enzymattic Reaction Mechanism C. Walsh,W.H. Freeman.
7. Enzyme Structure and Mechanism A Fersht, W.H.Freeman.
8. Biochemistry : The Chemical reaction of leaving cells, D.E.Metzler, Academic Press.
9. Biochemistry(4th edn.) Stryer, L.W.; H.Freeman & Co.(1995)
10. Understanding Enzymes Palmer, T.; Prantice Hall (1995).

Class: M.Sc. Chemistry
85+15=100
Semester: IV

Title of Paper: ORGANOMETALLIC CHEMISTRY (405)

Unit-I

Main Group Organometallics

Synthesis and reactions of organolithium compounds; Synthesis and reactions of organomagnesium compounds; Organometallics of zinc and mercury: preparation, structure, bonding and reactions of aluminum organyls; Thallium(I) organyls (synthesis of TlCp); Organyls of sodium, synthesis of NaCp; Silicon and tin organyls of coordination number 4.

Unit-II

Transition Metal–Carbon Bond

Transition Metal–Carbon σ-Bond: Brief review of metal alkyl compounds; transition metalcarbene and transition metal-carbyne compounds; transition metal vinylidene and transition metal allenylidene compounds. Cyclopropenyl cation ($C_3R_3^+$) as a ligand; C_4R_4 as a ligand (R = H, Me, Ph)

Unit-III

Syntheses of Cyclopentadienyl and Arene Metal Analogues

Synthesis and reactions of cyclopentadienyl metal carbonyls, cyclopentadienyl metal hydrides, cyclopentadienyl metal halides, arene metal carbonyls, η6-arene-chromium tricarbonyl in organic synthesis.

Unit-IV

Applications to Organic Synthesis and Homogeneous Catalysis

(a) In Organic Synthesis: Hydrozirconation of alkenes and alkynes; reagent; η4-diene iron-tricarbonyls in organic synthesis

Unit V

In Catalysis: Asymmetric hydrogenation; synthesis of acetic acid and glycol (Monsanto acetic acid process); Arylation/vinylation of olefins (Heck reaction); Wacker process (olefin oxidation); Asymmetric epoxidation.

Book Suggested :

1. C. Elschenbroich. *Organometallics* (3rd edn.), Wiley-VCH Publication (2006).
2. C. Elschenbroich & A. Salzer. *Organometallics – A Concise Introduction* (2nd edn.),VCH Publication (1992).
3. F. Mathey & A. Sevin. *Molecular Chemistry of the Transition Elements*, John Wiley (1996).
4. F. A. Cotton & G. Wilkinson. *Advanced Inorganic Chemistry* (5th edn.), John Wiley (1988).
5. R. C. Mehrotra & A. Singh. *Organometallic Chemistry: A Unified Approach.*

Class: M.Sc. Chemistry
Semester: IV

Title of Paper: CHEMISTRY OF NATURAL PRODUCTS (406)

Unit I

Terpenoids

Structure determination, stereochemistry, biosynthesis and synthesis of some common terpenopids Citral, α-Terpeneol, Farnesol, Zingiberence, Santonin, Phytol and Abietic acid.

UNIT II

Alkaloids

Structure, stereochemistry, synthesis and biosynthesis of some common alkaloids Ephedrine, Nicotine, Atropine, (+) Conin ,Quinine and Morphine.

UNIT III

Alkaloids

Structure, stereochemistry, synthesis and biosynthesis of some common alkaloids Ephedrine, Nicotine, Atropine, (+) Conin ,Quinine and Morphine.

UNIT III

Steroids: Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry, Isolation, Structure determination and synthesis of: Cholesterol, Bile acids. Harmons: Androsterone, Testosterone, Ostrone, Progesterone, Aldosterone, Biosynthesis of Steroids.

Prostaglandis: Occurrence, nomenclature, classification, biogenesis and physiological effects. Synthesis of PGE2 and PGF2a.

UNIT IV

Plant Pigments

Occurrence, nomenclature and general methods of structure determination. Isolation and

synthesis of Apigenin, Luteolin Quercetin, Myrcetin, Vitexin, Diadzein, Aureusin,

Cyanidin, Hirsutidin, Biosynthesis of flavonoids: Acetate pathway and Shikimic acid

pathway. Prophyrins: Structure and synthesis of Haemoglobin and Chlorophyll.

UNIT V

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:

1. Organic Chemistry : Vol. 1 and 2, I. L. Finar, ELBS
2. Organic Chemistry of Natural Products Vol. I and Vol. II, Gurdeep R. Chatwal, Himalaya Publishing House
3. Stereoselective Synthesis: A Practical Approach, M. Norgradi, VCH.
4. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier. Introduction to Flavonoids, B.A. Bohm. Harwood Academic Publishers.
5. New Trends in Natural Product chemistry, Ataaur Rahman and M.L. Choudhary, Harwood Academic Publishers.
6. Insecticides of Natural Origin, Sukh Dev, Harwood Academic
7. A. R. K. Paturbizliksyh earnsd. C. W. Rees: Comprehensive Heterocyclic Chemistry, Pergamon

Class: M.Sc. Chemistry
Semester: IV

Title of Paper: HETEROCYCLIC CHEMISTRY (407)

Unit I

Nomenclature of Heterocycles

Replacement and systematic nomenclature (Hantzsch-Widman system) for monocyclic, fused , bridged and spiro heterocycles

Unit II

Aromatic Heterocycles

General chemical behaviour of aromatic heterocycles,classification,criteria of aromaticity(bond lengths,ring current and chemical shifts in $_1$HNMR,empirical resonance energy,delocalization energy,and Dewar resonance energy,Diamagnetic susceptibility exaltations)

UNIT III

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

Heterocyclic Synthesis

Principles of heterocyclic synthesis involving cyclization and cycloaddition reactions

UNIT IV

Small Ring Heterocycles

Three- membered and four- membered Heterocycles- synthesis and reactions of aziridines, oxiranes, thiranes, azetidines, and oxetanes

Benzo Fused Five- membered Heterocycles

Synthesis and reactions of benzopyrroles, benzofurans and benzothiophenes

UNIT V

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 coumarins, chromones

Six- membered Heterocycles with two or more Heteroatoms

Synthesis and reactions of diazines and triazines

Seven- membered Heterocycles

Synthesis and reactions of azepines, oxepines, thiepines.and diazepines

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Books Suggested:

1. R. M. Acheson : An Introduction to Chemistry of Heterocyclic Compounds (Interscience)
2. R. K. Bansal: Heterocyclic Chemistry (Wiley E).
3. L. A. Paquitte: Principles of Modern Heterocyclic Chemistry.
4. A. R. Katritzky: Advances in Heterocyclic Chemistry (A.P.).
5. R. R. Gupta, M. Kumar and V. Gupta: Heterocyclic Chemistry, Vol-1-3, Springer Verlag.
6. T. Eicher and S. Hauptmann: The Chemistry of Heterocycles, Thieme
7. J. A. Joule, K. Mills and G. F. Smith: Heterocyclic Chemistry, Chapman and Hall

Class: M.Sc. Chemistry
Semester: IV

Title of Paper: Dissertation (Practical)

Dissertation from any laboratory, industry or research centre for learning the practical work at bulk level.