

CHEMISTRY (HONOURS)

SEMESTER-I**CC-1: INORGANIC CHEMISTRY-I****(Credits-6: Theory-4, Practical-2)-Max. Marks: 100****THEORY (Each class 1 hr.): Marks-70 (50+20)****PRACTICAL (Each class 2 hrs.): Marks-30****Lectures: 60 (40 Theory + 20 Practical classes)****Unit-I: Atomic structure**

(14 Lectures)

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenbergs Uncertainty Principle and its significance, Schrdingers wave equation, significance of ψ and ψ^2 . Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Paulis Exclusion Principle, Hunds rule of maximum multiplicity, Aufbaus principle and its limitations. Variation of orbital energy with atomic number.

Unit-II: Periodicity of elements

(16 Lectures)

Periodicity of Elements : s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s & p-block. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (vander Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. (f) Electron gain enthalpy, trends of electron gain enthalpy. (g) Electronegativity, Paulings/ Mulliken's Allred Rachow's/ and Mulliken-Jaffe's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sandersons electron density ratio.

Unit-III: Chemical bonding-I

(16 Lectures)

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Lande equation with derivation. Madelung constant, Born-Haber cycle and its application, Solvation energy. (ii) Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2 ; O_2 ; C_2 ; B_2 ; F_2 ; CO; NO; and their ions; HCl, BeF_2 , CO_2 , (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajans rules and consequences of polarization. Ionic character in covalent

compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

Unit-IV: Chemical Bonding-II (10 Lectures)

Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators defects in solids. (ii) Weak Chemical Forces : vander Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

Oxidation-reduction (4 Lectures)

Redox equations, standard electrode potential and its application to inorganic reactions. Principles involved in some volumetric analyses (iron, copper and manganese).

Reference Books:

- Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
- Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970.
- Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
- Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.

PRACTICAL: C-1 LAB.

Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

(A) Titrimetric Analysis:

- (i) Calibration and use of apparatus.
- (ii) Preparation of solutions of different Molarity/Normality of titrants.

(B) Acid-Base Titrations:

- (i) Estimation of carbonate and hydroxide present together in mixture.
- (ii) Estimation of carbonate and bicarbonate present together in a mixture.
- (iii) Estimation of free alkali present in different soaps/detergents.

(C) Oxidation-Reduction Titrimetry:

- (i) Estimation of Fe(II) and oxalic acid using standardized KMnO_4 solution.
- (ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
- (iii) Estimation of Fe(II) with $\text{K}_2\text{Cr}_2\text{O}_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference text:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.

SEMESTER-I

CC-2: PHYSICAL CHEMISTRY

(Credits-6: Theory-4, Practical-2)-Max. Marks: 100

THEORY (Each class 1 hr.): Marks-70

PRACTICAL (Each class 2 hrs.): Marks-30

Lectures: 60 (40 Theory + 20 Practical classes)

Unit-I: Gaseous state (18 Lectures)

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η ; variation of viscosity with temperature and pressure.

Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z , and its variation with pressure for different gases. Causes of deviation from ideal behaviour. van der Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dieterici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

Unit-II: Liquid state (6 Lectures)

Qualitative treatment of the structure of the liquid state; radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.

Ionic equilibria- I (6 Lectures)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono- diprotic and triprotic acids (exact treatment).

Unit- III : Solid state (16 Lectures)

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.

Unit-IV: Ionic equilibria – II

(14 Lectures)

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Solubility and solubility product of sparingly soluble salts applications of solubility product principle. Qualitative treatment of acid base titration curves (calculation of pH at various stages). Theory of acidbase indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

Reference Books:

- Atkins, P. W. & Paula, J. de Atkins Physical Chemistry Ed., Oxford University Press (2006).
- Ball, D. W. Physical Chemistry Thomson Press, India (2007).
- Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
- Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
- Principles of Physical Chemistry, Puri, Sharma, Pathania, Vishal Pub. Co.

PRACTICAL: C-2 LAB.**Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)**

1. Surface tension measurements.
 - a) Determine the surface tension by (i) drop number (ii) drop weight method.
 - b) Study the variation of surface tension of detergent solutions with concentration.
2. Viscosity measurement using Ostwalds viscometer.
 - a) Determination of viscosity of aqueous solutions of (i) polymer, (ii) ethanol, and (iii) sugar at room temperature.
 - b) Study the variation of viscosity of sucrose solution with the concentration of solute.
3. pH metry.
 - a) Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
 - b) Preparation of buffer solutions of different pH (i) Sodium acetate-acetic acid, (ii) Ammonium chloride-ammonium hydroxide.
 - c) pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
 - d) Determination of dissociation constant of a weak acid.

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co., New Delhi (2011).
- Garland, C. W., Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill, New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co., New York (2003).

SEMESTER-II

CC-3: ORGANIC CHEMISTRY I

(Credits-6: Theory-4, Practical-2)-Max. Marks: 100

THEORY (Each class 1 hr.): Marks-70

PRACTICAL (Each class 2 hrs.): Marks-30

Lectures: 60 (40 Theory + 20 Practical classes)

Unit-I : BASICS OF ORGANIC CHEMISTRY (12 Lectures)

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.

Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

CARBON-CARBON SIGMA BONDS

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

Unit-II: STEREOCHEMISTRY (18 Lectures)

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis-trans and, syn-anti isomerism E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

Unit-III: CHEMISTRY OF ALIPHATIC HYDROCARBONS

A. Carbon-Carbon pi bonds: (12 Lecturers)

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. 15 Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

B. Cycloalkanes and Conformational Analysis (12 Lecturers)

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

C. Chromatography (4 Lectures)

Basic ideas on principles of chromatography, column chromatography, paper chromatography, GLC, TLC.

Unit-IV: AROMATIC HYDROCARBONS (10 Lectures)

Aromaticity: Hckels rule, aromatic character of arenes, cyclic carbocations/carbanions and hetero-cyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitra-tion, sulphonation and Friedel-Crafts alkylation/acylation with their mechanism. Directing effects of the groups.

Reference Books:

- Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Educa-tion).
- Finar, I. L. Organic Chemistry (Volume 2): Stereochemistry and the Chemistry of Natural Prod-ucts), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.
- Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

PRACTICAL: C-3 LAB.

Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

1. Checking the calibration of the thermometer.
2. Purification of organic compounds by crystallization using the following solvents:
 - Water
 - Alcohol
 - Alcohol-Water
3. Determiation of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus).
4. Effect of impurities on the melting point mixed melting point of two unknown organic com-pounds.
5. Determiation of boiling point of liquid compounds. (boiling point lower than and more than 100C by distillation and capillary method)
6. Chromatography
7. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography.
8. Separation of a mixture of two sugars by ascending paper chromatography.
9. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).

Reference Books:

- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
- Furniss, B.S., Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).

SEMESTER-II**CC-4: PHYSICAL CHEMISTRY-II****(Credits-6: Theory-4, Practical-2)-Max. Marks: 100****THEORY (Each class 1 hr.): Marks-70****PRACTICAL (Each class 2 hrs.): Marks-30****Lectures: 60 (40 Theory + 20 Practical classes)****Unit-I: Chemical thermodynamics** (14 Lectures)

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. First law: Concept of heat, q , work, w , internal energy, U , and statement of first law; enthalpy, H , relation between heat capacities, calculations of q , w , U and H for reversible, irreversible and free expansion of gases (ideal and vander Waals) under isothermal and adiabatic conditions. Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoffs equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature.

Unit-II: (14 Lectures)

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

Free Energy Functions: Gibbs and Helmholtz energy; variation of S , G , A with T , V , P ; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell 17 relations; thermodynamic equation of state.

Unit-III: Systems of variable composition (18 Lectures)

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

Chemical equilibrium : Criteria of thermodynamic equilibrium, degree of advancement of re-action, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p ; K_c and K_x : Le Chatelier principle (quantitative treatment) equilibrium between ideal gases and a pure condensed phase.

Unit-IV: Solutions and Colligative Properties (14 Lectures)

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Reference Books:

- Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).
- Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
- Levine, I. N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010). Metz, C.R. 2000 solved problems in chemistry, Schaum Series (2006).

PRACTICAL: C-4 LAB.

Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

THERMOCHEMISTRY

1. Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
2. Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Calculation of the enthalpy of ionization of ethanoic acid.
4. Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
5. Determination of basicity/proticity of a polyprotic acid by the thermo chemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
6. Determination of enthalpy of hydration of copper sulphate.
7. Study of the solubility of benzoic acid in water and determination of H.

Reference Books;

- Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi (2001).

SEMESTER-III**CC-5: INORGANIC CHEMISTRY-II****(Credits-6: Theory-4, Practical-2)-Max. Marks: 100****THEORY (Each class 1 hr.): Marks-70****PRACTICAL (Each class 2 hrs.): Marks-30****Lectures: 60 (40 Theory + 20 Practical classes)****UNIT-I: General Principles of Metallurgy** (8 Lectures)

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel de Boer process and Mond's process, Zone refining.

Acids and Bases (8 Lectures)

Bronsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, leveling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

UNIT-II: Chemistry of s and p Block Elements-I (14 Lectures)

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements. Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate.

UNIT-III: Chemistry of s and p Block Elements-II (14 Lectures)

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes. Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

UNIT-IV: Noble Gases (8 Lectures)

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2 ; XeF_4 and XeF_6 ; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2). Molecular shapes of noble gas compounds (VSEPR theory).

Inorganic Polymers: (8 Lectures)

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.

Reference Books:

- Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
- Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
- Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.
- Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
- Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.
- Shriver & Atkins, Inorganic Chemistry 5th Ed.

PRACTICAL: C-5 LAB.

Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

(A) Iodo / Iodimetric Titrations

- i. Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).
- ii. Estimation of available chlorine in bleaching powder iodometrically.

(B) Inorganic preparations

- i. Cuprous chloride, Cu_2Cl_2 :
- ii. Preparation of manganese (III) phosphate, $MnPO_4 \cdot H_2O$.
- iii. Preparation of aluminium potassium sulphate $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$ (Potash alum).

Reference Books:

- Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. 1978

SEMESTER-III

CC-6: ORGANIC CHEMISTRY-II

(Credits-6: Theory-4, Practical-2)-Max. Marks: 100

THEORY (Each class 1 hr.): Marks-70

PRACTICAL (Each class 2 hrs.): Marks-30

Lectures: 60 (40 Theory + 20 Practical classes)

UNIT-I: Chemistry of Halogenated Hydrocarbons (16 Lectures)

Alkyl halides: Methods of preparation, nucleophilic substitution reactions SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts, nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li Use in synthesis of organic compounds.

UNIT-II: Alcohols, Phenols, Ethers and Epoxides (16 Lectures)

Alcohols: preparation, properties and relative reactivity of 1^o, 2^o, 3^o alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement;

Phenols: Preparation and properties; Acidity and factors affecting it, Ring substitution reactions, Reimer Tiemann and Kolbes Schmidt Reactions, Fries and Claisen rearrangements with mechanism;

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and LiAlH₄.

UNIT-III: Carbonyl Compounds (14 Lectures)

Structure, reactivity and preparation: Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisan-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, substitution reactions, oxidations and reductions (Clemmensen, Wolf -Kishner, LiAlH₄, NaBH₄, MPV, PDC and PGC); Addition reactions of unsaturated carbonyl compounds: Michael addition.

Active methylene compounds: Ketoenol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

UNIT-IV: Carboxylic Acids and their Derivatives (10 Lectures)

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen

condensation, Dieckmann and Reformatsky reactions, Hofmann-bromamide degradation and Curtius rearrangement.

Sulphur containing compounds

(4 Lectures)

Preparation and reactions of thiols, thioethers and sulphonic acids.

Reference Books:

- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.

PRACTICAL: C-6 LAB.

Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
2. Organic preparations:
 - i. Acetylation of one of the following compounds: amines (aniline, o-, m-, p-toluidines and o-, m-, p-anisidine) and phenols (α and β -naphthol, vanillin, salicylic acid) by any one method:
 - a) Using conventional method.
 - b) Using green approach.
 - ii. Benzoylation of one of the following amines (aniline, o-, m-, p-toluidines and o-, m-, p-anisidine) and one of the following phenols (α and β -naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction.
 - iii. Bromination of any one of the following:
 - a) Acetanilide by conventional methods.
 - b) Acetanilide using green approach (Bromate-bromide method).
 - iv. Nitration of any one of the following:
 - a) Acetanilide/nitrobenzene by conventional method.
 - b) Salicylic acid by green approach (using ceric ammonium nitrate).

The above derivatives should be prepared using 0.5-1gm. of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.

Reference Books:

- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

SEMESTER-III

CC-7: PHYSICAL CHEMISTRY-III

(Credits-6: Theory-4, Practical-2)-Max. Marks: 100

THEORY (Each class 1 hr.): Marks-70

PRACTICAL (Each class 2 hrs.): Marks-30

Lectures: 60 (40 Theory + 20 Practical classes)

UNIT-I: Phase Equilibria-I (14 Lectures)

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications (H₂O and sulphur system). Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions (Pb-Ag system, desilverisation of lead)

UNIT-II: Phase Equilibria-II (14 Lectures)

Three component systems, water-chloroform-acetic acid system, triangular plots. Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

UNIT-III: Chemical Kinetics (18 Lectures)

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of orders, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

UNIT-IV: Catalysis (8 Lectures)

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Surface chemistry (6 Lectures)

Physical adsorption, chemisorption, adsorption isotherms (Langmuir, Freundlich and Gibbs isotherms), nature of adsorbed state.

Reference Books:

- Peter Atkins & Julio De Paula, Physical Chemistry 9th Ed., Oxford University Press (2010).
- Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004).
- McQuarrie, D. A. & Simon, J. D., Molecular Thermodynamics, Viva Books Pvt. Ltd.: New Delhi (2004).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
- Zundhal, S.S. Chemistry concepts and applications Cengage India (2011).
- Ball, D. W. Physical Chemistry Cengage India (2012).
- Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
- Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
- Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).

PRACTICAL: C-7 LAB.**Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)**

1. Distribution of acetic/ benzoic acid between water and cyclohexane.
2. Study the equilibrium of at least one of the following reactions by the distribution method:

$$I_2(aq) + I^- \rightarrow I_3^-(aq)$$

$$Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n^{2+}$$
3. Study the kinetics of the following reactions.
 - i. Integrated rate method:
 - a) Acid hydrolysis of methyl acetate with hydrochloric acid.
 - b) Saponification of ethyl acetate.
 - ii. Compare the strengths of HCl and H₂SO₄ by studying kinetics of hydrolysis of methyl acetate.

Adsorption

1. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

SEMESTER- IV

CC-8: INORGANIC CHEMISTRY-III

(Credits-6: Theory-4, Practical-2)-Max. Marks: 100

THEORY (Each class 1 hr.): Marks-70

PRACTICAL (Each class 2 hrs.): Marks-30

Lectures: 60 (40 Theory + 20 Practical classes)

UNIT-I: Coordination Chemistry (20 Lectures)

Werners theory, valence bond theory (inner and outer orbital complexes), electro neutrality principle and back bonding. Crystal field theory, measurement of CFSE weak and strong fields, pairing energies, factors affecting the magnitude of $10 Dq$ in octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar geometry. Qualitative aspect of ligand field and MO Theory. IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, Labile and inert complexes.

UNIT-II: Transition Elements-I (12 Lectures)

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series.

UNIT-III: Transition Elements-II (12 Lectures)

Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy).

UNIT-IV: Lanthanoids and Actinoids (6 Lectures)

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only). General features of actinoids, separation of Np, Pm, Am from U.

Bioinorganic Chemistry (10 Lectures)

Metal ions present in biological systems, classification of elements according to their action in biological system. Na/K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.

Reference Books:

- Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977.
- Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.
- Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
- Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. Wiley-VCH, 1999.
- Basolo, F, and Pearson, R.C., Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
- Greenwood, N.N. & Earnshaw A., Chemistry of the Elements, Butterworth-Heinemann, 1997.

PRACTICAL: C-8 LAB.

Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

Gravimetric Analysis:

- i. Estimation of nickel(II) using Dimethylglyoxime (DMG).
- ii. Estimation of copper as CuSCN .
- iii. Estimation of iron as Fe_2O_3 by precipitating iron as $\text{Fe}(\text{OH})_3$:
- iv. Estimation of Al(III) by precipitating with oxine and weighing as $\text{Al}(\text{oxine})_3$ (aluminium oxinate).

Chromatography of metal ions

Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

- i. Ni(II) and Co(II)
- ii. Fe(III) and Al(III)

Reference Book:

1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.

SEMESTER-IV

CC-9: ORGANIC CHEMISTRY-III

(Credits-6: Theory-4, Practical-2)-Max. Marks: 100

THEORY (Each class 1 hr.): Marks-70

PRACTICAL (Each class 2 hrs.): Marks-30

Lectures: 60 (40 Theory + 20 Practical classes)

UNIT-I: Nitrogen Containing Functional Groups (12 Lectures)

Preparation and important reactions of nitro compounds, nitriles and isonitriles.

Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1^o, 2^o and 3^o amines with Hinsberg reagent and nitrous acid.

UNIT-II: Diazonium Salts (8 Lectures)

Preparation and their synthetic applications.

Polynuclear Hydrocarbons (12 Lectures)

Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene. Polynuclear hydrocarbons.

UNIT-III: Heterocyclic Compounds (20 Lectures)

Classification and nomenclature, Structure, aromaticity in 5-membered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine structure elucidation of indole, Fischer indole synthesis and Madelung synthesis, structure of quinoline and isoquinoline. Derivatives of furan: Furfural and furoic acid (preparation only).

UNIT-IV: Alkaloids (8 Lectures)

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine. (6 Lectures)
Terpenes Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and α -terpineol.

Reference Books:

- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976).
- Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
- Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Parakashan (2010).

PRACTICAL: C-9 LAB.

Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

1. Detection of extra elements (N, X, S).
2. Functional group test for nitro, amine and amide groups.
3. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds).

Reference Books:

- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

SEMESTER-IV

CC-10: PHYSICAL CHEMISTRY-IV

(Credits-6: Theory-4, Practical-2)-Max. Marks: 100

THEORY (Each class 1 hr.): Marks-70

PRACTICAL (Each class 2 hrs.): Marks-30

Lectures: 60 (40 Theory + 20 Practical classes)

UNIT-I: Conductance-I (12 Lectures)

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Waldens rules.

UNIT-II: Conductance-II (16 Lectures)

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

UNIT-III: Electrochemistry-I (18 Lectures)

Quantitative aspects of Faradays laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry. Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and $\text{SbO/Sb}_2\text{O}_3$ electrodes.

UNIT-IV: Electrochemistry-II (14 Lectures)

Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). Electrical properties of atoms and molecules Basic ideas of electrostatics, Electrostatics of dielectric media. Clausius-Mosotti equation and Lorenz-Laurentz equation (no derivation)

Reference Books:

- Atkins, P.W & Paula, J.D. Physical Chemistry, 9th Ed., Oxford University Press (2011).
- Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
- Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).

- Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- Rogers, D. W. Concise Physical Chemistry Wiley (2010).
- Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).

PRACTICAL: C-10 LAB.

Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

Conductometry

1. Determination of cell constant.
2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Perform the following conductometric titrations:
 - i. Strong acid vs. strong base
 - ii. Weak acid vs. strong base
 - iii. Strong acid vs. weak base

Potentiometry

1. Perform the following potentiometric titrations:
 - i. Strong acid vs. strong base
 - ii. Weak acid vs. strong base
 - iii. Dibasic acid vs. strong base

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co., New York (2003).

SEMESTER- V

CC-11: ORGANIC CHEMISTRY-IV

(Credits-6: Theory-4, Practical-2)-Max. Marks: 100

THEORY (Each class 1 hr.): Marks-70

PRACTICAL (Each class 2 hrs.): Marks-30

Lectures: 60 (40 Theory + 20 Practical classes)

UNIT-I: Nucleic Acids (9 Lectures)

Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

Enzymes (8 Lectures)

Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereo specificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

UNIT-II: Amino Acids, Peptides and Proteins (16 Lectures)

Amino acids, peptides and their classification. -Amino acids - Synthesis, ionic properties and re-actions. Zwitterions, pKa values, isoelectric point and electrophoresis. Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis

UNIT-III: Lipids (8 Lectures)

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

Concept of Energy in Biosystems (7 Lectures)

Cells obtain energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism (catabolism and anabolism). Overview of catabolic pathways of fat and protein. Interrelationship in the metabolic pathways of protein, fat and carbohydrate. Calorific value of food, standard calorific content of food types.

UNIT-IV: Pharmaceutical Compounds: Structure and Importance (12 Lectures)

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

Reference Books:

- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VIth Edition. W.H. Freeman and Co.
- Nelson, D.L., Cox, M.M. and Lehninger, A.L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.
- Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harpers Illustrated Biochem-istry. XXVIII edition. Lange Medical Books/ McGraw-Hill.

PRACTICAL: C-11 LAB.

Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

1. Preparations of the following compounds:
 - i. Aspirine,
 - ii. Phenacetin,
 - iii. Milk of magnesia,
 - iv. Aluminium hydroxide gel,
 - v. Divol.
2. Saponification value of an oil or a fat.
3. Determination of Iodine number of an oil/ fat.

Reference Books:

- Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
- Arthur, I. Vogel, Quantitative Organic Analysis, Pearson.

SEMESTER-V**CC-12: PHYSICAL CHEMISTRY-V****(Credits-6: Theory-4, Practical-2)-Max. Marks: 100****THEORY (Each class 1 hr.): Marks-70****PRACTICAL (Each class 2 hrs.): Marks-30****Lectures: 60 (40 Theory + 20 Practical classes)****UNIT-I: Quantum Chemistry** (18 Lectures)

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and particle-in-a-box (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, nodal properties. Extension to three dimensional boxes, separation of variables, degeneracy. Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wave functions. Vibrational energy of diatomic molecules and zero-point energy. Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables (Preliminary treatment). Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

UNIT-II: Chemical Bonding (12 Lectures)

Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+ : Bonding and antibonding orbitals. Qualitative extension to H_2 : Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH_2 , H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules.

UNIT-III: Molecular Spectroscopy-I (16 Lectures)

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

UNIT-IV: Molecular Spectroscopy-II (6 Lectures)

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation.

Photochemistry (8 Lectures)

Characteristics of electromagnetic radiation, Lambert-Beers law and its limitations, physical significance of absorption coefficients. Laws of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

Reference Books:

- Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
- Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
- House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
- Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
- Kakkar, R. Atomic & Molecular Spectroscopy, Cambridge University Press (2015).

PRACTICAL: C-12 LAB.

Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

Colourimetry

1. Determine the concentration of HCl against 0.1 N NaOH spectrophotometrically.
2. To find the strength of given ferric ammonium sulfate solution of (0.05 M) by using EDTA spectrophotometrically.
3. To find out the strength of CuSO₄ solution by titrating with EDTA spectrophotometrically.
4. To determine the concentration of Cu(II) and Fe(III) solution photometrically by titrating with EDTA.

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).
- Experimental Physical Chemistry by J. N. Gurtu, R. Kapoor.

SEMESTER- VI**CC-13: INORGANIC CHEMISTRY-IV****(Credits-6: Theory-4, Practical-2)-Max. Marks: 100****THEORY (Each class 1 hr.): Marks-70 (50+20)****PRACTICAL (Each class 2 hrs.): Marks-30****Lectures: 60 (40 Theory + 20 Practical classes)****UNIT-I: Organometallic Compounds-I** (14 Lectures)

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π -acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding. Zeises salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

UNIT-II: Organometallic Compounds-II (14 Lectures)

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler Natta Catalyst). Species present in ether solution of Grignard reagent and their structures. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation), structure and aromaticity, comparison of aromaticity and reactivity with that of benzene.

UNIT-III: Theoretical Principles in Qualitative Analysis (H₂S Scheme) (10 Lectures)

Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (uride, borate, oxalate and phosphate) and need to remove them after Group II.

Catalysis by Organometallic Compounds

Study of the following industrial processes and their mechanism:

1. Alkene hydrogenation (Wilkinsons Catalyst).
2. Hydroformylation (Co salts).
3. Wacker Process.
4. Synthetic gasoline (Fischer Tropsch reaction). (8 Lectures)

UNIT-IV: Reaction Kinetics and Mechanism (14 Lectures)

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans-effect and its applications, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes. Thermodynamic and kinetic stability, Kinetics of octahedral substitution (classification of metal ions based on water exchange rate), General mechanism of substitution in octahedral complexes (D, I, Id, Ia).

Reference Books:

- Vogel, A.I. Qualitative Inorganic Analysis, Longman, 1972.
- Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Edition, Prentice Hall, 1996-03-07.
- Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.
- Sharpe, A.G. Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005.
- Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, 3rd Ed., John Wiley and Sons, NY, 1994.
- Greenwood, N.N. & Earnshaw, A. Chemistry of the Elements, Elsevier 2nd Ed, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
- Lee, J.D. Concise Inorganic Chemistry 5th Ed., John Wiley and sons 2008. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
- Shriver, D.D. & P. Atkins, Inorganic Chemistry 2nd Ed., Oxford University Press, 1994.
- Basolo, F. & Person, R. Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution 2nd Ed., John Wiley & Sons Inc; NY.
- Purcell, K.F. & Kotz, J.C., Inorganic Chemistry, W.B. Saunders Co. 1977.
- Miessler, G. L. & Donald, A. Tarr, Inorganic Chemistry 4th Ed., Pearson, 2010.
- Collman, James P. et al. Principles and Applications of Organotransition Metal Chemistry. Mill Valley, CA: University Science Books, 1987.
- Crabtree, Robert H. The Organometallic Chemistry of the Transition Metals, New York, NY: John Wiley, 2000.
- Spessard, Gary O., & Gary L. Miessler. Organometallic Chemistry. Upper Saddle River, NJ: Prentice-Hall, 1996.
- Mehrotra R.C. and Singh, A. Organometallic Chemistry, New Age International Publishers, 2nd Edn, 2000.

PRACTICAL: C-13 LAB.**Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)**

Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of 26ie rent reactions. The following radicals are suggested:

CO_3^{2-} , NO_2^- , S^- , SO_3^- , $S_2O_3^{2-}$, CH_3COO^- , F^- , Cl^- , Br^- , I^- , NO_3^- , BO_3^- , $C_2O_4^{2-}$, PO_4^{3-} , NH_4^+ , K^+ , Pb_2^+ , Cu_2^+ , Cd_2^+ , Bi_3^+ , Sn^{2+} , Sb^{3+} , Fe^{3+} , Al^{3+} , Cr^{3+} , Zn^{2+} , Mn^{2+} , Co^{2+} , Ni^{2+} , Ba^{2+} , Sr^{2+} , Ca^{2+} , Mg^{2+} . Mixtures should preferably contain one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) or combination of anions e.g. CO_3^{2-} and SO_3^{2-} , NO_2^- and NO_3^- , Cl^- and Br^- , Cl^- and I^- , Br^- and I^- , NO_3^- and Br^- , NO_3^- and I^- . Spot tests should be done whenever possible.

Reference Books:

1. Vogels Qualitative Inorganic Analysis, Revised by G. Svehla.
2. Marr & Rockett Inorganic Preparations.

SEMESTER-VI**CC-14: ORGANIC CHEMISTRY-IV****(Credits-6: Theory-4, Practical-2)-Max. Marks: 100****THEORY (Each class 1 hr.): Marks-70****PRACTICAL (Each class 2 hrs.): Marks-30****Lectures: 60 (40 Theory + 20 Practical classes)****UNIT-I: Organic Spectroscopy-I** (18 Lectures)

UV Spectroscopy: Types of electronic transitions, λ max (Lamda max), Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward rules for calculation of λ max for the following systems: , the unsaturated aldehydes: ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.

UNIT-II: Organic Spectroscopy-II (12 Lectures)

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin-spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, alde-hydes and aromatics; Interpretation of NMR spectra of simple compounds.

Mass Spectroscopy-Basic principle, Fragmentation pattern, Instrumentation, Determination of m/e ratio. Application of Mass Spectroscopy on CH₄, C₂H₆, n-butane and neo-pentane. Applications of IR, UV and NMR for identification of simple organic molecules.

UNIT-III: Carbohydrates (8 Lectures)

Occurrence, classification and their biological importance. Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruffdegradation; Disaccharides Structure elucidation of maltose. Polysaccharides Elementary treatment of starch, cellulose.

Dyes

Classification, colour and constitution; Mordant and Vat dyes; Chemistry of dyeing. Synthesis and applications of: Azo dyes Methyl orange and Congo red (mechanism of Diazo Coupling); Triphenyl methane dyes - Malachite Green, and crystal violet; Phthalein dyes Phenolphthalein and Fluorescein; Natural dyes Alizarin and Indigo; Edible dyes with examples. (8 Lectures)

UNIT-IV: Polymers (14 Lectures)

Introduction and classification including di-block, tri-block and amphiphilic polymers; Number average molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity Index. Polymerisation reactions -Addition and condensation -Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes; Preparation and

applications of plastics thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene); Fabrics natural and synthetic (acrylic, polyamido, polyester); Rubbers natural and synthetic: Buna-S chloroprene and Neoprene; Vulcanization; Polymer additives; Biodegrad-able and conducting polymers with examples.

Reference Books:

- Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.
- Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub.
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
- Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Pragati Prakashan (2010).
- Kemp, W. Organic Spectroscopy, Palgrave.

PRACTICAL: C-14 LAB.

Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
4. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
5. Qualitative analysis of unknown organic compounds containing mono-functional groups (car-bohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols etc.

Reference Books:

- Vogel, A.I. Quantitative Organic Analysis, Part 3, Pearson (2012).
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
- Furniss, B.S., Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

SKILL ENHANCEMENT COURSES (SEC)

SEMESTER- IV

SEC-2 : PESTICIDES & FUEL CHEMISTRY

(Credits: 04)- Max. Marks: 100

60 Lectures (Each Lecture 1 hr.)

Unit-I :

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).

Unit-II :

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value Coal: Uses of coal (fuel and non-fuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Unit-III:

Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining and different types of petroleum products and their applications. Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

Unit-IV :

Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pore point) and their determination.

Reference Books:

- R. Cremlyn : Pesticides, John Wiley.
- E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
- P.C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
- B.K. Sharma: Industrial Chemistry, Goel Publishing House, Meerut.

DISCIPLINE SPECIFIC ELECTIVE(DSE)

SEMESTER-V

DSE-1: POLYMER CHEMISTRY

(Credits-6: Theory-4, Practical-2)-Max. Marks: 100

THEORY (Each class 1 hr.): Marks-70

PRACTICAL (Each class 2 hrs.): Marks-30

Lectures: 60 (40 Theory + 20 Practical classes)

UNIT-I: Introduction and history of polymeric materials:

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers. (4 Lectures)

Functionality and its importance:

Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi-functional systems, Poly-functional systems. (8 Lectures)

UNIT-II: Kinetics of Polymerization:

Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques. (8 lectures)

Crystallization and crystallinity:

Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. (4 Lectures)

Nature and structure of polymers-Structure property relationships. (2 Lectures)

UNIT-III: Determination of molecular weight of polymers

(M_n , M_w , etc.) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index. (8 Lectures)

Glass transition temperature (T_g) and determination of T_g

WLF equation, Factors affecting glass transition temperature (T_g). (8 Lectures)

UNIT-IV: Polymer Solution

Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions. (8 Lectures)

Properties of Polymers

(Physical, thermal & mechanical properties). Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins,

polystyrene and styrene copolymers, poly(vinyl chloride) poly(vinyl acetate), polyacrylamide, fluoro polymers (Te on), polyamides (nylon-6 and nylon 6,6). Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers (polysiloxane), Polycarbonates, Conducting Polymers, (polyacetylene, polyaniline). (10 Lectures)

Reference Books:

- Seymours Polymer Chemistry, Marcel Dekker, Inc.
- G. Odian: Principles of Polymerization, John Wiley.
- F.W. Billmeyer: Text Book of Polymer Science, John Wiley.
- P. Ghosh: Polymer Science & Technology, Tata Mcgraw-Hill.
- R.W. Lenz: Organic Chemistry of Synthetic High Polymers.

PRACTICAL: DSE-1 LAB.

Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

Polymer synthesis

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
 - a) Purification of monomer.
 - b) Polymerization using benzoyl peroxide (BPO) / 2,2-azo-bis-isobutyronitrile (AIBN).
2. Preparation of nylon 66/6.
3. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein.
 - a) Preparation of IPC.
 - b) Purification of IPC.
 - c) Interfacial polymerization.
4. Redox polymerization of acrylamide.
5. Precipitation polymerization of acrylonitrile.
6. Preparation of urea-formaldehyde resin.
7. Preparations of novalac resin/resold resin.
8. Microscale Emulsion Polymerization of poly(methylacrylate).

Polymer characterization

1. Determination of molecular weight by viscometry:
 - a) Polyacrylamide-aq. NaNO₂ solution
 - b) (Poly vinyl propylidene (PVP) in water
2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of head-to-head monomer linkages in the polymer.
3. Determination of molecular wt. by end group analysis: Polyethylene glycol (PEG) (OH group).
4. Determination of hydroxyl number of a polymer using colorimetric method.

Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. Instrumental Techniques
3. IR studies of polymers

*at least 5 experiments to be carried out.

Reference Books:

- Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed.
- Harry R. Allcock, Frederick W. Lampe and James E. Mark, Contemporary Polymer Chemistry, 3rd ed. Prentice-Hall (2003).
- Fred W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984). Joel R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003).
- Petr Munk and Tejraj M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John Wiley & Sons (2002).
- L.H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005).
- Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd ed. Oxford University Press (2005).
- Seymour/ Carrahers Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

SEMESTER-V

DSE-2: GREEN CHEMISTRY

(Credits-6: Theory-4, Practical-2)-Max. Marks: 100

THEORY (Each class 1 hr.): Marks-70

PRACTICAL (Each class 2 hrs.): Marks-30

Lectures: 60 (40 Theory + 20 Practical classes)

UNIT-I: Introduction to Green Chemistry

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry. (4 Lectures)

Principles of Green Chemistry and Designing a Chemical synthesis-I

Twelve principles of Green Chemistry with their explanations and examples with special emphasis on: Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions. Prevention/ minimization of hazardous/ toxic products reducing toxicity. risk = (function) hazard exposure; waste or pollution prevention hierarchy. Green solvents supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents. (12 Lectures)

UNIT-II: Principles of Green Chemistry and Designing a Chemical synthesis-II

Explanation of principles with special emphasis on: Energy requirements for reactions alternative sources of energy: use of microwaves and ultrasonic energy. Selection of starting materials; avoidance of unnecessary derivatization careful use of blocking/protecting groups. Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis. Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD What you don't have cannot harm you, greener alternative to Bhopal Gas Tragedy (safer route to carbonyl) and Flixborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation. Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes. (14 Lectures)

UNIT-III: Examples of Green Synthesis/ Reactions and some real world cases-I

Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis) Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents: Diels-Alder reaction and Decarboxylation reaction. Ultrasound assisted reactions: sonochemical Simmons-Smith

Reaction (Ultrasonic alternative to Iodine). Surfactants for carbon dioxide replacing smog producing and ozone depleting solvents with CO₂ for precision cleaning and dry cleaning of garments. Designing of Environmentally safe marine antifoulant. (14 Lectures)

UNIT-IV: Examples of Green Synthesis/ Reactions and some real world cases-II

Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting (6 Lectures)

Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C₂S₃); Green chemistry in sustainable development. (10 Lectures)

Reference Books:

1. V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry, Anamalaya Publishers (2005).
2. P.T. Anastas & J.K. Warner: Oxford Green Chemistry- Theory and Practical, University Press (1998).
3. A.S. Matlack: Introduction to Green Chemistry, Marcel Dekker (2001).
4. M.C. Cann & M.E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
5. M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington (2002).

PRACTICAL: DSE-2

Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

1. Safer starting materials.
 - The Vitamin C clock reaction using Vitamin C tablets, tincture of iodine, hydrogen peroxide and liquid laundry starch.
 - Effect of concentration on clock reaction.
 - Preparation and characterization of nanoparticles (Ag, Au) using plant extract.
2. Using renewable resources
 - Preparation of biodiesel from vegetable oil.
3. Avoiding waste
 - Principle of atom economy.
 - Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.
 - Preparation of propene by two methods can be studied.
 - (i) Triethylamine ion + OH⁻ $\xrightarrow{H_2SO_4/\Delta}$! propene + trimethylpropene + water
 - (ii) 1-propanol → propene + water
 - The other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy.

4. Use of enzymes as catalysts
 - Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide
5. Alternative Green solvents

Diels Alder reaction in water

- Reaction between furan and maleic acid in water and at room temperature rather than in benzene and reflux.
 - Extraction of D-limonene from orange peel using liquid CO₂ prepared from dry ice. Mechanochemical solvent free synthesis of azomethines
5. Alternative sources of energy
 - Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of Cu(II).
 - Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Reference Books:

- Anastas, P.T & Warner, J.C. Green Chemistry: Theory and Practice, Oxford University Press (1998).
- Kircho, M. & Ryan, M.A. Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC (2002).
- Ryan, M.A. Introduction to Green Chemistry, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
- Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi. Bangalore ISBN 978-93-81141-55-7 (2013).
- Cann, M.C. & Connelly, M. E. Real world cases in Green Chemistry, American Chemical Society (2008).
- Cann, M. C. & Thomas, P. Real world cases in Green Chemistry, American Chemical Society (2008).

SEMESTER-VI

DSE-3: INDUSTRIAL CHEMICALS AND ENVIRONMENT

(Credits-6: Theory-4, Practical-2)-Max. Marks: 100

THEORY (Each class 1 hr.): Marks-70

PRACTICAL (Each class 2 hrs.): Marks-30

Lectures: 60 (40 Theory + 20 Practical classes)

UNIT-I: Industrial Gases and Inorganic Chemicals (10 Lectures)

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, sulphur dioxide. Inorganic Chemicals: Manufacture, application and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, potassium dichromate and potassium permanganate.

Industrial Metallurgy

Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology. (4 Lectures)

UNIT-II: Environment and its segments (14 Lectures)

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur. Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone. Major sources of air pollution. Pollution by SO₂; CO₂; CO; N O_x; and H₂S and control procedures. Effects of air pollution on living organisms and vegetation. Greenhouse effect and global warming, Ozone depletion by oxides of nitrogen, chloro fluorocarbons and halogens, removal of sulphur from coal.

UNIT-III: Water Pollution: (16 Lectures)

Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, fertilizer. Sludge disposal. Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

UNIT-IV: Energy & Environment (10 Lectures)

Sources of energy: Coal, petrol and natural gas. Nuclear fusion/ fission, solar energy, hydrogen, geothermal, tidal and hydel. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

Biocatalysis: Introduction to biocatalysis: Importance in green chemistry and chemical industry. (6 Lectures)

Reference Books:

- E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
- R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
- A. Kent: Riegels Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
- S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
- De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
- S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.
- S.E. Manahan, Environmental Chemistry, CRC Press (2005).
- G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
- Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

PRACTICAL: DSE-3

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD).
3. Determination of Biological Oxygen Demand (BOD).
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method (AgN O₃ and potassium chromate).
6. Estimation of total alkalinity of water samples (CO₃²⁻ ; HCO₃⁻) using double titration method.
7. Measurement of dissolved CO₂:
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples.
10. Preparation of borax/ boric acid.

Reference Books:

- E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
- R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
- Kent: Riegels Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
- S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
- De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
- S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.

SEMESTER-VI

DSE-4: DISSERTATION/PROJECT WORK

Marks:100

GENERIC ELECTIVE (GE)

B.Sc.(Hons.) Students other than Chemistry Honours will opt two Chemistry GE Papers.

SEMESTER-I & III

GE-1 : ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

(Credits-6: Theory-4, Practical-2)-Max. Marks: 100

THEORY (Each class 1 hr.): Marks-70

PRACTICAL (Each class 2 hrs.): Marks-30

Lectures: 60 (40 Theory + 20 Practical classes)

SECTION A: INORGANIC CHEMISTRY-1 (30 Periods)

Unit-I: Atomic Structure (14 Lectures)

Review of: Bohrs theory and its limitations, dual behaviour of matter and radiation, de-Broglies relation, Heisenberg Uncertainty principle. Hydrogen atom spectra.

What is Quantum mechanics ? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2 . Schrödinger equation for hydrogen atom.

Radial and angular parts of the hydrogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s . Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (m_s).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

Unit-II: Chemical Bonding and Molecular Structure (16 Lectures)

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Land equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajans rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding

combination of orbitals, MO treatment of homonuclear diatomic molecules (N_2 ; O_2) and heteronuclear diatomic molecules (CO, NO). Comparison of VB and MO approaches.

Section B: Organic Chemistry-1 (30 Periods)

Unit- III: Fundamentals of Organic Chemistry (8 Lectures)

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Hckels rule.

Stereochemistry (10 Lectures)

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Con guration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). D and L; cisrans nomenclature; CIP Rules: R/S (for one chiral carbon atoms) and E/Z Nomenclature (for up to two C=C systems).

Unit- IV: Aliphatic Hydrocarbons (12 Lectures)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. Alkanes: (Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbes synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogena-tion.

Alkenes: (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydro-halogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markowniko s and anti-Markowniko s addition), Hydration, Ozonolysis,

Alkynes: (Upto 5 Carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by de-halogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline $KMnO_4$.

Reference Books:

- J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
- F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
- Douglas, McDaniel and Alexader: Concepts and Models in Inorganic Chemistry, John Wiley.

- T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
- Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
- E. L. Eliel: Stereochemistry of Carbon Compounds, Tata McGraw Hill. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
- R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
- Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.

PRACTICAL: GE LAB.

Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

Section A: Inorganic Chemistry-Volumetric Analysis

- Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
- Estimation of oxalic acid by titrating it with KMnO_4 :
- Estimation of water of crystallization in Mohr's salt by titrating with KMnO_4 :
- Estimation of Fe (II) ions by titrating it with $\text{K}_2\text{Cr}_2\text{O}_7$ using internal indicator.
- Estimation of Cu (II) ions iodometrically using $\text{Na}_2\text{S}_2\text{O}_3$:

Section B: Organic Chemistry

- Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements).
- Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given).
 - a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography.
 - b) Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

- Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
- Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
- Textbook of Practical Organic Chemistry, A.I. Vogel, Prentice Hall, 5th edition.
- Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960.

SEMESTER-II & IV

GE-2 : CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY-I

(Credits-6: Theory-4, Practical-2)-Max. Marks: 100

THEORY (Each class 1 hr.): Marks-70

PRACTICAL (Each class 2 hrs.): Marks-30

Lectures: 60 (40 Theory + 20 Practical classes)

Section A: Physical Chemistry-1 (30 Lectures)

Unit-I: Chemical Energetics (10 Lectures)

Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature Kirchoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Chemical Equilibrium: (8 Lectures)

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG_0 , Le Chatelier's principle. Relationships between K_p , K_c and K_x for reactions involving ideal gases.

Unit- II: Ionic Equilibria (12 Lectures)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts applications of solubility product principle.

Section B: Organic Chemistry-2 (30 Lectures)

Unit- III: (8 Lectures)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. Aromatic hydrocarbons: Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Crafts reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

Alkyl and Aryl Halides (8 Lectures)

Alkyl Halides (Up to 5 Carbons) Types of Nucleophilic Substitution (SN_1 ; SN_2 and SN_i) reactions. Preparation: from alkenes and alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.

Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Unit- IV: Alcohols, Phenols and Ethers (Upto 5 Carbons) (14 Lectures)

Alcohols: Preparation: Preparation of 1° , 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes and ketones, carboxylic acid and esters. Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation Diols: (Upto 6 Carbons) oxidation of diols Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts.

Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer Tiemann Reaction, Gattermann-Koch Reaction, Houben-Hoesh Condensation. Schotten-Baumann Reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Aldehydes and ketones (aliphatic and aromatic): Formaldehyde, acetaldehyde, acetone and benzaldehyde.

Preparation: from acid chlorides and from nitriles.

Reactions Reaction with HCN, ROH, $NaHSO_3$, NH_2G derivatives. Iodoform test.

Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemmensen reduction and Wolff Kishner reduction. Meerwein-Ponndorf Verley reduction.

Reference Books:

- T. W. Graham Solomons: Organic Chemistry, John Wiley and Sons.
- Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
- I.L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
- R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
- Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
- G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
- G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
- J. C. Kotz, P. M. Treichel & J. R. Townsend: General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
- H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
- R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).

PRACTICAL: GE-II & IV LAB.
Full Mark -30 (Expt.-15, Viva-voce-5 & Record 10)

Section A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO₃, NH₄Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of pH.

Ionic equilibria

- a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
- b) Preparation of buffer solutions:
 - i) Sodium acetate-acetic acid.
 - ii) Ammonium chloride-ammonium hydroxide Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
 - a) Bromination of Phenol/ Aniline.
 - b) Benzoylation of amines/phenols.
 - c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone.

Reference Books:

- A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
- F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.