PARISHKAR COLLEGE OF GLOBAL EXCELLENCE (AUTONOMOUS), JAIPUR

SCHEME OF EXAMINATION COURSE STRUCTURE & SYLLABUS

AS PER UGC

ज्ञान-विज्ञान विमुक्तये

CHOICE BASED CREDIT SYSTEM (CBCS)

FOR

BACHELOR OF SCIENCE WITH

CHEMISTRY HONOURS

Department Members

- Dr Nidhi Sogani
- Dr Nisha Sharma
- Dr Kavita Yadav
- Mrs. Sapna Chaudhary
- Mrs. Hema Jain

1. SEMESTER WISE DISTRIBUTION OF CREDITS AND COURSES

PROPOSED SCHEME FOR CHOICE BASED CREDIT SYSTEM IN B.Sc. HONOURS CHEMISTRY

Semester	Core Course (CC) (14 Papers) (6 credit each)	Ability Enhancement Compulsory Course (AECC) (2 Papers) (4 credit each)	Skill Enhancement Course (SEC) (2 Papers) (4 credit each)	Discipline Specific Elective (DSE) (4 Papers) (6 credit each)	Generic Elective (GE) (4 Papers) (6 credit each)	Total Credit per semester
I	Chemistry CC I	AECC I (English / Hindi Communication)	SEC I			**20**
	Chemistry CC II					
II	Chemistry CC III			Chemistry DSE I	GE-1	**24**
	Chemistry CC IV					
III	Chemistry CC V			Chemistry DSE II	GE-2	**24**
	Chemistry CC VI					
IV	Chemistry CC VII		SEC II		GE-3	**28**
	Chemistry CC VIII					
	Chemistry CC IX					
V	Chemistry CC X			Chemistry DSE III	GE-4	**24**
	Chemistry CC XI					
VI	Chemistry CC XII	AECC II (EVS)		Chemistry DSE IV / Project / Dissertation		**28**
	Chemistry CC XIII					
	Chemistry CC XIV					
Total Credits	**14 x 6 = 84**	**2 × 4 = 8**	**2 × 4 = 8**	**4 × 6 = 24**	**4 × 6 = 24**	**148**

Note: -

- **Switch Dissertation with either of the Elective Paper (Only One).**
- **Freedom of selection of various subjects for industrial exposure.**
- **Student can opt any SEC offered by any Department.**

Consolidated Scheme for B.Sc. Honours

Semester	Paper	Nomenclature of Paper	Credit per paper	Total Credit per semester
I	AECC I	English / Hindi Communication	**4**	**20**
	SEC I	Skill Enhancement Course I	**4**	
	CHEMISTRY CC I	INORGANIC CHEMISTRY – I (Atomic Structure, Chemical Bonding & Oxidation-Reduction)	**4 (T) + 2 (P)**	
	CHEMISTRY CC II	PHYSICAL CHEMISTRY - I (States of Matter and Ionic Equilibrium)	**4 (T) + 2 (P)**	
II	CHEMISTRY CC III	ORGANIC CHEMISTRY-I (Basics And Hydrocarbons)	**4**	**24**
	CHEMISTRY CC IV	PHYSICAL CHEMISTRY - II (Chemical Thermodynamics, Equilibrium, Solution & Colligative Properties)	**4 (T) + 2 (P)**	
	Chemistry DSE A	Chemistry Discipline Specific Elective A	**4 (T) + 2 (P)**	
	GE I	GENERIC ELECTIVE I	**4 (T) + 2 (P)**	
III	CHEMISTRY CC V	INORGANIC CHEMISTRY - II (s - And p-Block Elements, Inorganic Polymers & Chromatographic Analysis)	**4**	**24**
	CHEMISTRY CC VI	ORGANIC CHEMISTRY- II (Halogen And Oxygen Contaning Functional Groups)	**4 (T) + 2 (P)**	
	Chemistry DSE B	Chemistry Discipline Specific Elective B	**4 (T) + 2 (P)**	
	GE II	GENERIC ELECTIVE II	**4 (T) + 2 (P)**	
IV	SEC II	Skill Enhancement Course IV	**4**	**28**
	CHEMISTRY CC VII	PHYSICAL CHEMISTRY - III (Phase Equilbrium, Chemical Kinetics And Surface Chemistry)	**4 (T) + 2 (P)**	
	CHEMISTRY CC VIII	Inorganic Chemistry- III (Coordination Chemistry, Lanthanoids & Actinoids & Bioinorganic Chemistry)	**4 (T) + 2 (P)**	
	CHEMISTRY CC IX	Organic Chemistry- III (Heterocyclic Chemistry)	**4 (T) + 2 (P)**	
	GE III	Generic Elective III	**4 (T) + 2 (P)**	
V	CHEMISTRY CC X	Physical Chemistry - IV (Electrochemistry)	**4 (T) + 2 (P)**	**24**
	CHEMISTRY CC XI	Organic Chemistry-IV (Biomolecules)	**4 (T) + 2 (P)**	
	Chemistry DSE C	Chemistry Discipline Specific Elective C	**4 (T) + 2 (P)**	
	GE IV	Generic Elective IV	**4 (T) + 2 (P)**	

VI	AECC II	EVS	**4**	**28**
	CHEMISTRY CC XII	Inorganic Chemistry- IV (Organometallic Chemistry)	**4 (T) + 2 (P)**	
	CHEMISTRY CC XIII	Physical Chemistry - V (Quantum Chemistry, Molecular Spectroscopy & Photochemistry & Nuclear Chemistry)	**4 (T) + 2 (P)**	
	CHEMISTRY CC XIV	Organic Chemistry- V (Spectroscopy)	**4 (T) + 2 (P)**	
	Chemistry DSE D	Chemistry Discipline Specific Elective D		
Total Credits			**132**	**132**

Chemistry Discipline Specific Elective Paper offered in B.Sc. Honours

Semester	Paper	Papers Name	Semester	Paper	Papers Name
II Semester Chemistry DSE A	CHEMISTRY DSE I	Analytical Methods in Chemistry	**III Semester Chemistry DSE C**	CHEMISTRY DSE VII	Research Methodology for Chemistry
	CHEMISTRY DSE II	Instrumental Methods for Analysis		CHEMISTRY DSE VIII	Computational Chemistry
	CHEMISTRY DSE III	Polymer Chemistry		CHEMISTRY DSE IX	Food and Beverage Industry
III Semester Chemistry DSE B	CHEMISTRY DSE IV	Environmental Chemistry	**IV Semester Chemistry DSE D**	CHEMISTRY DSE X	Dissertation / Project
	CHEMISTRY DSE V	Green Chemistry		CHEMISTRY DSE XI	Pharmaceutical and Drug Chemistry
	CHEMISTRY DSE VI	Agrochemical and Fertilizer		CHEMISTRY DSE XII	Metallurgy and its Industrial Importance

Chemistry Skill Enhancement Course Offered in B.Sc. Honours

S.No.	Papers	Papers Name	S.No.	Papers	Papers Name
1	CHEMISTRY SEC I	Basic Analytical Chemistry	3	CHEMISTRY SEC III	Chemistry of Cosmetics & Perfumes
2	CHEMISTRY SEC II	Pharmaceutical Chemistry	4	CHEMISTRY SEC IV	Pesticide Chemistry

SEMESTER I

CORE COURSE I: CHEMISTRY CC I
INORGANIC CHEMISTRY – I
(ATOMIC STRUCTURE, CHEMICAL BONDING & OXIDATION-REDUCTION)

CREDIT: 04
LECTURE: 60

Course Objectives:

INORGANIC CHEMISTRY: Acquire knowledge of atomic structure. Provide an in-depth knowledge about different types of bonding in main group elements to be acquainted with the concept of hybridization and geometry of covalent molecules, shapes of atomic and molecular orbitals. Recall the general trends in the periodic table of s and p block elements. learn the concepts of various diagrammatic presentations i.e., Latimer, Frost, Pourbaix and Ellingham diagrams of potential data along with metallurgy and volumetric analysis.

Course Learning Outcome:

Comparison b/w classical and quantum mechanics. Solve Schrodinger's wave equation of electron for calculating the energy of atom and discuss the concepts of quantum numbers. Describe the periodicity in properties, structures, applications and chemical reactivity of the s-block elements. Concept of Born-Haber cycle and predict the lattice energy, ionization energy and stability of the ionic compounds. Describe the various types of hybridization and geometry of molecules. Molecular orbital diagrams of homo and hetero nuclear diatomic molecules and determine the bond order with the help of M.O. diagram. Interpret and apply Frost and Latimer diagrams to predict chemical behaviour and relative strengths of species as reductants and oxidants. Explain the basic concepts of volumetric analysis and apply them to demonstrate types of titrations and related calculations.

SYLLABUS:

UNIT – I : ATOMIC STRUCTURE **Lecture : 14**

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's 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.

Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number. Electronic configuration of elements.

Research approach: applications of quantum mechanics in daily life.

UNIT – II : PERIODICITY OF ELEMENTS **Lecture : 16**

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 and p-block; (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (van der Waals), (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral), (e) Ionization enthalpy, (f) electron gain enthalpy, (g) Electronegativity.

Research approach: applications of elements in biological system, Use of Radioactive elements.

UNIT – III : CHEMICAL BONDING **Lecture: 20**

IONIC BOND: General characteristics. Born-Landé equation with derivation for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

COVALENT BOND: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy. 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. Fajan's rules and consequences of polarization.

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

MOLECULAR ORBITAL THEORY: Molecular orbital diagrams of diatomic (N_2, O_2, C_2, B_2, F_2, CO, NO) and simple polyatomic molecules (HCl, BeF_2, CO_2) (idea of s-p mixing and orbital interaction to be given). Bond order, Bond strength and Bond length, Comparison of VBT and MOT.

WEAK CHEMICAL FORCES: van der 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.

Research approach: Effect of solvation energy on any chemical reaction.

UNIT – IV : OXIDATION-REDUCTION **Lecture : 10**

Reduction potentials – redox half reactions, concept of over potential; diagrammatic presentation of potential data (Latimer, Frost and Pourbaix diagrams); redox stability in water, disproportionation, oxidation by atmospheric oxygen; elements extracted by reduction – Ellingham diagrams.

Principles involved in volumetric analysis (Acid base titrations, Iodometric & iodimetric titrations, Redox titrations) to be carried out in class.

Reference Books:

- Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
- Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970
- Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
- Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
- Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002**.**

CORE COURSE I PRACTICAL: CHEMISTRY LAB CC I
INORGANIC CHEMISTRY – I
(ATOMIC STRUCTURE, CHEMICAL BONDING & OXIDATION-REDUCTION)

CREDIT: 02
LECTURE: 60

Course Objectives:

INORGANIC CHEMISTRY: Acquire knowledge of conductometric titrations and their calculations. Make the students to get an insight on the use of apparatus used in volumetric analysis and correct titrimetric procedure along with standard and nonstandard solutions. Perform all sorts of gravimetric calculations.

Course Learning Outcome:

Develop the analytical skills to carry out different types of volumetric and gravimetric analysis.

SYLLABUS:

1. Titrimetric Analysis
   (i) Calibration and use of apparatus
   (ii) Preparation of solutions of different Molarity/Normality of titrants
2. Acid-Base Titrations
   (i) Estimation of carbonate and hydroxide present together in mixture.
   (ii) Estimation of carbonate and bicarbonate present together in a mixture.
3. 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 $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference Books:

- Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.

CORE COURSE II: CHEMISTRY CC II
PHYSICAL CHEMISTRY - I
(STATES OF MATTER AND IONIC EQUILIBRIUM)

CREDIT: 04
LECTURE: 60

Course Objectives:

PHYSICAL CHEMISTRY: Enhance the knowledge on principles and bulk properties of matter. Understanding homogenous and heterogeneous equilibrium and equilibrium constant.

Course Learning Outcome:

Explain kinetic theory of gases and Maxwell distribution of Molecular velocities to describe the behaviour of gases. Discuss structure and application of liquid crystal. Describe laws of crystallography and apply these laws. Deduce the thermodynamic relations of equilibrium constant with other thermodynamic properties.

SYLLABUS:

UNIT – I : GASEOUS STATE	**Lecture : 18**

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; Deviations from ideal gas behavior, compressibility factor, *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behavior. Van der Waals equation of state, its derivation and application in explaining real gas behavior. Maxwell distribution and its use in evaluating molecular velocities and average kinetic energy.
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, 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	**Lecture : 8**

LIQUID STATE: physical properties of liquids: vapor pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Temperature variation of viscosity liquids and comparison with that of gases.

UNIT – III : SOLID STATE	**Lecture : 16**

SOLID STATE: Natute of solid states, types of ions, size effects, radius ratio rule and its limitations, 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, ZnS, KCl.

METALLIC BOND: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids

UNIT – IV : IONIC EQUILIBRIUM **Lecture : 18**

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; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action, 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 acid-base indicators; selection of indicators and their limitations.

Reference Books:

- Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 10th Ed., Oxford University Press (2014).
- 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).
- Engel, T. & Reid, P. *Physical Chemistry* 3rd Ed. Pearson (2013).

CORE COURSE II PRACTICAL: CHEMISTRY LAB CC II
PHYSICAL CHEMISTRY - I
(STATES OF MATTER AND IONIC EQUILIBRIUM)

CREDIT: 02
LECTURE: 60

Course Objectives:

PHYSICAL CHEMISTRY: Learn about the determination of the percent composition of binary solutions by using a viscometer and stalagmometer.

Course Learning Outcome:

Determine the percentage composition of non-interacting systems by viscosity and surface tension method

SYLLABUS:

1. Surface tension measurements.
   a. Determine the surface tension by stalagmometer.
   b. Study the variation of surface tension with different concentration of detergent solutions.
2. Viscosity measurement using Ostwald's 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 meter
   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

CORE COURSE III: CHEMISTRY CC III
ORGANIC CHEMISTRY-I
(BASICS AND HYDROCARBONS)

CREDIT: 04
LECTURE: 60

Course Objectives:

ORGANIC CHEMISTRY: Understand the core concepts of organic chemistry i.e. resonance, hyperconjugation, inductive effect, etc. and their qualitative and quantitative treatment. Provide an in-depth knowledge about alkanes, alkenes & alkynes and their reactions. Provide an in-depth knowledge about the organic-chemical reactions with a focus on aromaticity & stereochemistry.

Course Learning Outcome:

Identify different electronic effects, their role and impact on molecules. Explain the behavior of different aliphatic hydrocarbons. Identify various organic reaction mechanisms including free radical substitution, electrophilic and nucleophilic addition reactions. **T**o solve problems based on the concept of electronic effect. Apply the fundamental concepts of stereochemistry on simple molecules. **I**llustrate the mechanism of organic reactions on hydrocarbons depending upon the reactants involved. Identify the different aromatic, non-aromatic, homoaromatic & antiaromatic compounds and interpret their properties. **L**earn and identify many organic reaction mechanisms including electrophilic aromatic substitution. **P**redict and describe various types of reactive intermediates, reactivity and factors affecting the reactivity and stability of aromatic substrates

SYLLABUS:

UNIT – I : BASICS OF ORGANIC CHEMISTRY **Lecture: 10**

Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties 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; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals, Carbenes, Nitrene and Benzyne. Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions. Method of determination of reaction mechanism (intermediates, isotopic effect, kinetic and stereochemical studies).

Research approach: Determine the stability of product on the basis of intermediates.

UNIT – II : STEREOCHEMISTRY **Lecture: 18**

Concept of isomerism, types of isomerism, Difference between configuration and conformation, Representation and interconversion of wedge-dash, Newmann-sawhorse and Fischer projection formula.

Optical Isomerism: optical activity, specific rotation, concept of chilarity (elements of symmetry, molecular chirality, stereogenic centers), Enantiomerism, Diastereomerism and Meso compounds. Threo and erythro; Relative and absolute configuration, D and L and R/S nomenclature. Resolution of enantiomers, concept of inversion, retention and racemization.

Geometrical Isomerism: Determination of configuration of geometrical isomerism, syn-anti, cis-trans and E-Z nomenclature.

Conformational Isomerism: Conformation analysis of alkanes (ethane, propane & butane): Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams. Conformation of mono substituted cyclohexane derivatives.

Research approach: Use of stereoisomers to determine the major product in any reaction.

UNIT – III : CHEMISTRY OF ALIPHATIC HYDROCARBONS **Lecture: 20**

Alkanes: Preparation: Wurtz reaction, Kolbe's synthesis, Corey house reaction. REACTIONS: Physical and chemical reaction of alkanes, Free radical Substitution: Halogenation – relative reactivity and selectivity;

Cycloalkanes: Types of cycloalkanes and their relative stability, Baeyer strain theory, Ring strain in small rings, theory of strainless rings The case of cyclopropane ring banana bonds

Alkenes: Method of formation by elimination reactions, Mechanism of E_1, E_2, E_1cb reactions. Saytzeff and Hofmann eliminations. REACTIONS: Physical properties and relative stability of alkenes, Electrophilic additions their mechanisms (Markownikoff/Anti-Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration oxidation, ozonolysis, reduction, syn and anti- hydroxylation (oxidation). Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene;

Diene: Nomenclature and classification of dienes, isolated, conjugated, and cumulated dienes, structure of allenes, method of formation of butadiene, polymerization. 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction

Alkynes: Method of formation, Acidity, Electrophilic and Nucleophilic additions, Hydration to form carbonyl compounds, Alkylation of terminal alkynes. Metal ammonia reduction, Oxidation and polymerization

UNIT – IV : AROMATIC HYDROCARBONS **Lecture: 12**

Aromaticity: Huckel rule. Structure of benzene: molecular formula and Kekule structure, stability and carbon-carbon bond lengths of benzene, resonance structure and MO diagram. Nomenclature: Benzene derivatives, aryl group, aromatic nucleus and side chain. Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions: Electrophilic substitution reaction, general pattern of the mechanism, role of σ and π complexes, Mechanism of nitration, halogenation, Sulphonation and Friedel-Craft's reaction. Side-chain oxidation of alkyl benzene (mercuaration and demercuration reaction), Birch reduction. Energy profile diagrams, Activating and Deactivating substituents, Directive influence - orientation and ortho/para ratio, ipso effect. Method of formation of benzene, alkyl benzenes and biphenyl.

Polynuclear Hydrocarbons: Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons

Research approach: Use of aromatic hydrocarbons in industry (medicine, pesticide, plastics.

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 Education).
- Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, 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.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition.

CORE COURSE III PRACTICAL: CHEMISTRY LAB CC III
ORGANIC CHEMISTRY-I
(BASICS AND HYDROCARBONS)

CREDIT: 02
LECTURE: 60

Course Objectives:

ORGANIC CHEMISTRY: Provide an in-depth knowledge purification of organic compounds and organic stereochemistry**.**

Course Learning Outcome:

Provide an in-depth knowledge about the organic stereochemistry

SYLLABUS:

1. **Checking the calibration of the thermometer.**
2. **Purification of organic compounds by sublimation**
3. **Purification of organic compounds by recrystallization using the following solvents: a) Water; b) Alcohol; c) Alcohol-Water**
4. **Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus).**
5. **Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.**
6. **Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation and capillary method).**
7. *Stereochemical study of organic compounds via models:*
   a) *R and Z configuration of optical isomers*
   b) *E, Z configuration of geometrical isomers*
   c) *Conformational analysis of cyclohexanes and substituted cyclohexanes.*

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)

CORE COURSE IV: CHEMISTRY CC IV
PHYSICAL CHEMISTRY - II
(CHEMICAL THERMODYNAMICS, EQUILIBRIUM, SOLUTION & COLLIGATIVE PROPERTIES)

CREDIT: 04
LECTURE: 60

Course Objectives:

PHYSICAL CHEMISTRY: Learn various laws of thermodynamics and their applications. Be acquainted with the laws of thermodynamics in understanding homogenous and heterogenous equilibrium. Understand the concept of ideal, non-ideal and partially miscible liquids. learn about thermodynamic functions and thermodynamic conditions for equilibrium. Understand the concept of colligative properties of dilute solutions.

Course Learning Outcome:

Describe the basic concepts of laws of thermodynamics and apply them to calculate thermodynamic properties. Calculate reaction enthalpy for different chemical processes. Criteria of Thermodynamic equilibrium. Equilibrium constant and its dependence on temperature, pressure, and concentration. Explain the concept of thermodynamic for open system Compile the properties of solutions of solids and gases in liquids, miscible liquids, partially miscible liquids, and immiscible liquids, appraise the concept of colligative properties and apply for molecular weight determination.

SYLLABUS:

UNIT – I : CHEMICAL THERMODYNAMICS **Lecture:20**

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 van der 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; Hesse's Law, calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equation) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion tem.

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics. 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 relations; thermodynamic equation of state. Concept of fugacity. System of Variable Composition: Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs- Duhem equation, chemical potential of ideal mixtures.

Research approach: Joule – thomson effect.

UNIT – II : CHEMICAL EQUILIBRIUM **Lecture:15**

Criteria of thermodynamic equilibrium. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration, thermodynamic derivation of relations between the various equilibrium constants Kp, Kc and Kx. Le Chatelier principle (quantitative treatment). Reaction isotherm and isochore, Clapeyron equation and Clausius Clapeyron equation.

UNIT – III : SYSTEMS OF VARIABLE COMPOSITION **Lecture: 12**

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.

UNIT – IV : SOLUTIONS AND COLLIGATIVE PROPERTIES **Lecture:13**

Methods of expressing concentration of solutions, activity and activity coefficient, dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Vapor pressure-composition and temperature composition curves of ideal and non-ideal solutions, Azeotropes. 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 normally dissociated and associated solutes in solution.

Reference Books:

- Peter, A. & Paula, J. de. *Physical Chemistry* 10th Ed., Oxford University Press (2014).
- 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).

CORE COURSE IV PRACTICAL: CHEMISTRY LAB CC IV
PHYSICAL CHEMISTRY - II
(CHEMICAL THERMODYNAMICS, EQUILIBRIUM, SOLUTION & COLLIGATIVE PROPERTIES)

CREDIT: 02
LECTURE: 60

Course Objectives:

PHYSICAL CHEMISTRY: Develop experimental skills of thermochemistry, Ionic equilibria and phase equilibria.

Course Learning Outcome:

Measure enthalpy of neutralization and ionization for different acid-base combinations. Determine critical solution temperature of partially miscible liquids.

SYLLABUS:

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 thermochemical 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 ΔH.

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).

DISCIPLINE SPECIFIC ELECTIVE (DSE-A)
SEMESTER 2

DISCIPLINE SPECIFIC ELECTIVE I: CHEMISTRY DSE I
ANALYTICAL METHODS IN CHEMISTRY

CREDIT: 04
LECTURE: 60

Course Objectives:

To get in-depth knowledge of analytical methods such as Solvent extraction, Gravimetric, Chromatography and their applications.

Course Learning Outcomes:

Principle of solvent extraction, chromatographic methods, common ion effect and solubility product. Principle of GSC and GLC analysis. Separation mechanism involved in adsorption and partition HPLC. Solve numerical problems.

SYLLABUS:

UNIT – I : QUALITATIVE AND QUANTITATIVE ASPECTS OF ANALYSIS **Lectures: 12**

Sampling, Definition, types of sample, sample preparations – particle size, homogeneity, dissolution technology and decomposition, storage of samples evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t-test, rejection of data, and confidence.

UNIT – II : GRAVIMETRIC ANALYSIS **Lectures: 15**

Common ion effect and solubility product principles, Conditions for good precipitation, Factors affecting precipitation like acid, temperature, nature of solvent, Super saturation and precipitation formation, Precipitation from homogeneous solution and examples, Co-precipitation, post precipitation and remedies for their minimization, Washing of precipitate and ignition of precipitate, Brief idea about method of filtration and drying of precipitate.
INTRODUCTION TO ELECTROGRAVIMETRY: principle, applications, electrolytic separations of Cu and Ni,

UNIT – III : CHROMATOGRAPHY **Lectures: 20**

Introduction and classification of chromatographic methods, Principle of chromatographic analysis, Theoretical plates and column efficiency, Theory, Principle, technique and applications of-Column Chromatography, Ion exchange Chromatography, Thin layer Chromatography, Paper Chromatography
GAS CHROMATOGRAPHY: Introduction, Theory, Principle, GSC and GLC, Separation mechanism involved in GSC and GLC, Instrumentation of Gas chromatography, Working of gas chromatography, Gas chromatogram and qualitative-quantitative analysis, Applications of gas chromatography.
HIGH PERFORMANCE LIQUID CHROMATOGRAPHY: Introduction, Need of liquid chromatography, Separation mechanism involved in adsorption and partition HPLC, Instrumentation and working of HPLC, Applications of HPLC, Introduction to supercritical fluid chromatography

UNIT – IV : SOLVENT EXTRACTION **Lectures: 13**

Introduction, Principle of solvent extraction, Distribution coefficient, distribution ratio, relation between Distribution coefficient and distribution ratio, factors affecting solvent extraction, percentage extracted, solvent extraction method, separation factor, batch extraction, counter current extraction, application of solvent extraction

Reference Books:

- Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. *Vogel's Textbook of Quantitative Chemical Analysis*, John Wiley & Sons, 1989.
- Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. *Instrumental Methods of Analysis*, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
- Christian, G.D; *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, D. C. *Exploring Chemical Analysis*, Ed. New York, W.H. Freeman, 2001.
- Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age, International Publisher, 2009.
- Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
- Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
- Ditts, R.V. *Analytical Chemistry; Methods of Separation*, van Nostrand, 1974.

DISCIPLINE SPECIFIC ELECTIVE I PRACTICAL: CHEMISTRY LAB DSE I ANALYTICAL METHODS IN CHEMISTRY

CREDIT: 02
LECTURE: 60

Course Objectives:

Conceptual understanding of Solvent extraction, Gravimetric and chromatographic analysis.

Course Learning Outcome:

Formation of complex ions, Various types of techniques of solvent extraction, Technique and application of chromatographic analysis.

SYLLABUS:

1. Safety practice in the chemical Laboratory.
2. Gravimetric determination
   Nickel (as dmg),
   Zinc (as Zinc ammonium phosphate)
   silver (as chloride)
3. Separation of mixtures by chromatography: measure the R_f value in each case. Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.
   Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.
4. Solvent Extraction:
   To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+} DMG complex in chloroform.

Reference Books:

- Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
- Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. *Vogel's Textbook of Quantitative Chemical Analysis*, John Wiley & Sons, 1989.

DISCIPLINE SPECIFIC ELECTIVE II: CHEMISTRY DSE II
INSTRUMENTAL METHIOD OF ANALYSIS

CREDIT: 4
LECTURE: 60

Course Objectives:

To get in depth knowledge about Principle, Theory, Instrumentation, and Applications of spectroscopic techniques such as UV, IR, NMR and Mass.

Course Learning Outcomes:

Classification of analytical methods and the types of instrumental methods. Separation of spectrum. Elemental analysis using Mass and Atomic spectroscopy.

SYLLABUS:

UNIT – I : INTRODUCTION TO SPECTROSCOPIC METHODS OF ANALYSIS **Lecture: 12**

Recap of the spectroscopic methods covered in detail in the core chemistry syllabus: Treatment of analytical data, including error analysis. Classification of analytical methods and the types of instrumental methods. Consideration of electromagnetic radiation.

UNIT – II : MOLECULAR SPECTROSCOPY **Lecture: 16**

INFRARED SPECTROSCOPY: Interactions with molecules: absorption and scattering. Means of excitation (light sources), separation of spectrum (wavelength dispersion, time resolution), detection of the signal (heat, differential detection), interpretation of spectrum (qualitative, mixtures, resolution), advantages of Fourier Transform (FTIR). Samples and results expected. Applications: Issues of quality assurance and quality control, Special problems for portable instrumentation and rapid detection.
UV-VISIBLE/ NEAR IR – emission, absorption, fluorescence and photoaccoustic. Excitation sources (lasers, time resolution), wavelength dispersion (gratings, prisms, interference filters, laser, placement of sample relative to dispersion, resolution), Detection of signal (photocells, photomultipliers, diode arrays, sensitivity and S/N), Single and Double Beam instruments, Interpretation (quantification, mixtures, absorption vs. fluorescence and the use of time, photoacoustic, fluorescent tags).

UNIT – III : SEPARATION TECHNIQUES **Lecture: 16**

CHROMATOGRAPHY: Gas chromatography, liquid chromatography, supercritical fluids, Importance of column technology (packing, capillaries), Separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, electrical field), Detection: simple vs. specific (gas and liquid), Detection as a means of further analysis (use of tags and coupling to IR and MS), Electrophoresis (plates and capillary) and use with DNA analysis.
MASS SPECTROMETRY: Making the gaseous molecule into an ion (electron impact,

chemical ionization), Making liquids and solids into ions (electrospray, electrical discharge, laser desorption, fast atom bombardment), Separation of ions on basis of mass to charge ratio, Magnetic, Time of flight, Electric quadrupole. Resolution, time and multiple separations, Detection and interpretation (how this is linked to excitation).

UNIT – IV : ATOMIC AND NMR SPECTROCOPY **Lecture: 16**

ATOMIC SPECTROSCOPY: Atomic absorption, Atomic emission, and Atomic fluorescence. Excitation and getting sample into gas phase (flames, electrical discharges, plasmas), Wavelength separation and resolution (dependence on technique), Detection of radiation (simultaneous/scanning, signal noise), Interpretation (errors due to molecular and ionic species, matrix effects, other interferences).
NMR SPECTROCOPY: Principle, Instrumentation, Factors affecting chemical shift, Spin-coupling, Applications

Reference Books:

- John R. Dyer: Applications of Absorption Spectroscopy of Organic Compounds,
- Prentice Hall. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
- Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
- P.W. Atkins: Physical Chemistry.
- G.W. Castellan: Physical Chemistry.
- C.N. Banwell: Fundamentals of Molecular Spectroscopy.
- Brian Smith: Infrared Spectral Interpretations: A Systematic Approach.
- W.J. Moore: Physical Chemistry.

DISCIPLINE SPECIFIC ELECTIVE II PRACTICAL: CHEMISTRY LAB DSE II INSTRUMENTAL METHOD OF ANALYSIS

CREDIT: 02
LECTURE: 60

Course Objectives:

To determine the composition and analysis of a given mixture with the help of analytical methods

Course Learning Outcome:

Analysis and study of different mixtures with help of spectrometric methods.

SYLLABUS:

1. Safety Practices in the Chemistry Laboratory
2. Determination of the isoelectric pH of a protein.
3. Titration curve of an amino acid.
4. Determination of the void volume of a gel filtration column.
5. Determination of a Mixture of Cobalt and Nickel (UV/Vis spec.)
6. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water)
7. IR Absorption Spectra (Study of Aldehydes and Ketones)
8. Determination of Calcium, Iron, and Copper in Food by Atomic Absorption
9. Quantitative Analysis of Mixtures by Gas Chromatography (i.e., chloroform and carbon tetrachloride)
10. Separation of Carbohydrates by HPLC
11. Determination of Caffeine in Beverages by HPLC
12. Potentiometric Titration of a Chloride-Iodide Mixture
13. Cyclic Voltammetry of the Ferrocyanide/Ferricyanide Couple
14. Nuclear Magnetic Resonance
15. Use of fluorescence to do ―presumptive tests‖ to identify blood or other body fluids.
16. Use of ―presumptive tests‖ for anthrax or cocaine
17. Collection, preservation, and control of blood evidence being used for DNA testing
18. Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Y chromosome only or multiple chromosome)
19. Use of sequencing for the analysis of mitochondrial DNA
20. Laboratory analysis to confirm anthrax or cocaine
21. Detection in the field and confirmation in the laboratory of flammable accelerants or explosives
22. Detection of illegal drugs or steroids in athletes
23. Detection of pollutants or illegal dumping
24. Fibre analysis

(At least 10 experiments to be performed.)

Reference Books:

- John R. Dyer: Applications of Absorption Spectroscopy of Organic Compounds,

- Prentice Hall. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
- Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
- 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.

DISCIPLINE SPECIFIC ELECTIVE III: CHEMISTRY DSE III
POLYMER CHEMISTRY

CREDIT: 04
LECTURE: 60

Course Objectives:

To provide basic structural properties of polymers, mechanism and kinetics of polymerization. Role of polymers in vital life processes.

Course Learning Outcome:

To get depth knowledge about the structure, function, mechanism and kinetics of polymerization techniques. Analysis of molecular weight of polymers and its significance. To acquire knowledge of thermodynamics of polymer solution. Application of polymers in everyday life.

SYLLABUS:

UNIT – I : INTRODUCTION AND HISTORY OF POLYMERIC MATERIALS **Lectures: 10**

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of polymers.
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.

UNIT – II : KINETICS OF POLYMERIZATION **Lectures: 15**

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.
Determination of molecular weight of polymers (Mn, Mw, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.
Glass transition temperature (T_g) and determination of T_g, Free volume theory, WLF equation, Factors affecting glass transition temperature (T_g).

UNIT – III : CRYSTALLIZATION AND SOLUTION OF POLYMER **Lectures: 20**

Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. Nature and structure of polymers-Structure Property relationships.
Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures

UNIT – IV : PROPERTIES OF POLYMERS **Lectures: 15**

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly (vinyl chloride) and related polymers, poly

(vinyl acetate) and related polymers, acrylic 77 polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly (p-phenylene sulphide polypyrrole, polythiophene).

Reference Books:

- Seymour's 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.

DISCIPLINE SPECIFIC ELECTIVE III PRACTICAL : CHEMISTRY LAB DSE III
POLYMER CHEMISTRY

CREDIT: 02
LECTURE: 60

Course Objectives:

Synthesis of polymers and their characterization such as Molecular weight.

Course Learning Outcome:

Synthesis of different types of polymers. Analysis of polymer by instrumental techniques.

SYLLABUS:

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
2. Purification of monomer
3. Precipitation polymerization of acrylonitrile
4. Preparation of urea-formaldehyde resin
5. Determination of molecular weight by viscometry:
   i. Polyacrylamide-aq.$NaNO_2$ solution
   ii. (Poly vinyl proplylidine (PVP) in water
6. Testing of mechanical properties of polymers.
7. Determination of hydroxyl number of a polymer using colorimetric method.
8. Determination of molecular weight by end-group analysis: Polyethylene glycol (PEG) (OH group).
9. Instrumental Techniques.

Reference Books:

- M.P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed., Oxford University Press, 1999.
- H.R. Allcock, F.W. Lampe & J.E. Mark, Contemporary Polymer Chemistry, 3rd ed Prentice-Hall, 2003.
- F.W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience, 1984.
- J.R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall, 2003.
- P. Munk & T.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
- M.P. Stevens, Polymer Chemistry: An Introduction 3rd ed. Oxford University Press, 2005.

GENERIC ELECTIVES

GENERIC ELECTIVE I: CHEMISTRY GE I
ATOMIC STRUCTURE, BONDING, CHEMISTRY OF s- AND p-BLOCK ELEMENTS, GENERAL ORGANIC CHEMISTRY, ALIPHATIC & AROMATIC HYDROCARBONS

CREDIT: 04
LECTURE: 60

Course Objectives:

1. *INORGANIC CHEMISTRY:* Provide in-depth knowledge about different types of bonding in main group elements be acquainted with the concept of hybridization and geometry of covalent molecules, shapes of atomic and molecular orbitals. Recall the general trends in the periodic table of s and p block elements.
2. *ORGANIC CHEMISTRY:* Understand the core concepts of organic chemistry i.e. resonance, hyperconjugation, inductive effect etc. and their qualitative and quantitative treatment. Provide an in-depth knowledge about alkanes, alkenes & alkynes and their reactions. Provide an in-depth knowledge about the organic-chemical reactions with a focus on aromaticity & stereochemistry.

Course Learning Outcome:

INORGANIC CHEMISTRY: Comparison b/w classical and quantum mechanics. Solve Schrodinger's wave equation of electron for calculating the energy of atom and discuss the concepts of quantum numbers. Concept of Born-Haber cycle and predict the lattice energy, ionization energy and stability of the ionic compounds. Describe the various types of hybridization and geometry of molecules. Molecular orbital diagrams of homo and hetero nuclear diatomic molecules and determine the bond order with the help of M.O. diagram. Describe the periodicity in properties, structures, applications and chemical reactivity of the s-block elements.Describe properties, structures, applications and chemical reactivity of the s-block and p-block elements.

ORGANIC CHEMISTRY: Identify different electronic effects, their role and impact on molecules. Explain the behavior of different aliphatic hydrocarbons. Identify various organic reaction mechanisms including free radical substitution, electrophilic and nucleophilic addition reactions. **T**o solve problems based on the concept of electronic effect. Apply the fundamental concepts of stereochemistry on simple molecules. **I**llustrate the mechanism of organic reactions on hydrocarbons depending upon the reactants involved. Identify the different aromatic, non-aromatic, homoaromatic & antiaromatic compounds and interpret their properties. **L**earn and identify many organic reaction mechanisms including electrophillic aromatic substitution. **P**redict and describe various types of reactive intermediates, reactivity and factors affecting the reactivity and stability of aromatic substrates

SYLLABUS:

SECTION A: INORGANIC CHEMISTRY - I ***Lecture: 30***

UNIT – I **Lecture : 18**

ATOMIC STRUCTURE: Bohr's theory and its limitations, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Introduction of Quantum mechanics, Schrodinger equation, Significance of ψ and ψ^2, Quantum numbers (n, l, m and s), Shapes of s, p and d atomic orbitals, nodal planes. Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, Anomalous electronic configurations. Effective nuclear charge

CHEMICAL BONDING: IONIC BONDING: General characteristics of ionic bonding, energy (lattice energy and solvation energy and their importance in the context of stability and solubility. Born-Landé equation, Born-Haber cycle and its applications, polarizing power and polarizability, Fajan's rules and its applications. COVALENT BONDING: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with examples. MO THEORY: 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 of Homonuclear and Heteronuclear diatomic molecules. Comparison of VB and MO approaches.

UNIT – II : **Lecture : 12**

PERIODIC PROPERTIES: Periodicity with respect to Electronic Configuration, Atomic and Ionic Size, Ionization enthalpy, Electron affinity and Electronegativity

s-block ELEMENTS: Comparative study, diagonal relationship, salient features of hydrides, solvation and complexation tendencies including their function in bio system, an introduction to alkyls and aryls.

p-BLOCK ELEMENTS: Synthesis, structure and properties of diborane, ammonia, silane, phosphine and hydrogen sulphide. Synthesis and properties of Borazine.

SECTION B: ORGANIC CHEMISTRY - I ***Lecture: 30***

UNIT – III : **Lecture : 14**

GENERAL ORGANIC CHEMISTRY: Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions, free radicals, carbenes, benzyne and nitrenes, types of organic reaction, Method of determination of reaction mechanism (product analysis, intermediates, isotope effects, kinetics and stereo chemical studies), formal charges.

STEREOCHEMISTRY: Concept of isomerism, types of isomerism, Difference between configuration and conformation. OPTICAL ISOMERISM: Representation and interconversion of wedge-dash, Newmann-sawhorse and fischer projection formula, concept of chilarity (elements of symmetry, molecular chirality, sterogenic centres), Enantiomerism, Diastereomerism and Meso compounds. Threo and erythro; Relative and absolute configuration, sequence rules, D and L and R/S nomenclature. Resolution of enantiomers, concept of inversion, retention and racemization GEOMETRICAL ISOMERISM: Determination of configuration of geometrical isomers, syn-anti, E-Z, cis-trans, Geometrical isomerism in oximes and alicyclic compounds. CONFORMATIONAL ISOMERISM: Conformations with respect to acyclic system (ethane, butane) and cyclic system (cyclohexane and mono & disubstituted cyclohexane)

UNIT – IV : **Lecture : 16**

(Functional group approach for the following reactions (Nomenclature, classification, preparations physical property & chemical reactions) to be studied with mechanism in context to their structure.)

ALIPHATIC HYDROCARBONS: ALKANES: Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent, Corey house reaction. Reactions: Free radical Substitution: Halogenation. ALKENE: Preparation: Elimination reactions: Dehydration of alcohols and dehydrohalogenation of alkyl halides, Regioselectivity (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 (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation. DIENE: Structure of allenes, and butadiene, method of formation, Reaction: 1,2 and 1,4- addition, Diels-alder reaction and polymerization. ALKYNES: Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydro-halogenation of vicinal-dihalides. Reactions: Acidity of alkynes, Mechanism of electrophilic and nucleophilic addition reaction. Formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline $KMnO_4$.

AROMATIC HYDROCARBONS: Aromaticity, Benzenoids and Huckel rule. Structure, Stability and C-C bond length of Bnezene, resonance structure and MO diagram. Nomenclature: Benzene derivatives, aryl group, aromatic nucleus and side chain. Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions: Electrophilic substitution reaction: Mechanism of nitration, halogenation, Sulphonation and Friedel-Craft's reaction. Side chain oxidation of alkyl benzene, Birch reduction. Activating and Deactivating substituents, Directive effect of the groups - orientation and ortho/para ratio, ipso effect.

Reference Books:

- Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
- Cotton, F.A., Wilkinson, G. & Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
- Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.
- Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India, 2006.
- Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry*, John Wiley & Sons, 2014.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi, 1988.
- Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education, 2000.
- Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
- Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.

GENERIC ELECTIVE I PRACTICAL : CHEMISTRY LAB GE I
ATOMIC STRUCTURE, BONDING, CHEMISTRY OF s- AND p-BLOCK ELEMENTS, GENERAL ORGANIC CHEMISTRY, ALIPHATIC & AROMATIC HYDROCARBONS

CREDIT: 02
LECTURE: 60

Course Objectives:

1. *INORGANIC CHEMISTRY:* Acquire knowledge of conductometric titrations and their calculations. Make the students to get an insight on the use of apparatus used in volumetric analysis and correct titrimetric procedure along with standard and nonstandard solutions. Perform all sorts of volumetric calculations.
2. *ORGANIC CHEMISTRY:* Acquaint students with the identification of different functional groups and draw formulas and structures of these groups. Provide an in-depth knowledge about the organic stereochemistry

Course Learning Outcome:

INORGANIC CHEMISTRY: Develop the analytical skills to carry out different types of volumetric analysis.
ORGANIC CHEMISTRY: Predict the different types of functional groups in organic compounds and determine melting and boiling points. Apply the fundamental concepts of stereochemistry on simple molecules.

SYLLABUS:

Section A: Inorganic Chemistry
Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Section B: Organic Chemistry

6. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
7. Criteria of Purity: Determination of melting and boiling points.
8. Systematic Qualitative Organic Analysis: Elemental analysis (N, S and halogens),
9. Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (carboxylic, phenolic, aldehydic, ketonic, amide, nitro, amines, esters, carbohydrates) and preparation of one derivative in simple organic solids and liquids.
10. Stereochemical study of organic compounds via models:
    a) R and Z configuration of optical isomers
    b) E, Z configuration of geometrical isomers
    c) Conformational analysis of cyclohexanes and substituted cyclohexanes.

Reference Books:

- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
- Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.

- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G. *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.

GENERIC ELECTIVE II : CHEMISTRY-GE II
CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY – I

CREDIT: 04
LECTURE:60

Course Objectives:

1. *PHYSICAL CHEMISTRY:* Learn various laws of thermodynamics and their applications. Be acquainted with the laws of thermodynamics in understanding homogenous and heterogenous equilibria.
2. *ORGANIC CHEMISTRY:* Learn about the reaction and reactivity of some specific functional groups.

Course Learning Outcome:

PHYSICAL CHEMISTRY: Describe the basic concepts of laws of thermodynamics and apply them to calculate thermodynamic properties. Calculate reaction enthalpy for different chemical processes. Explain the concepts of entropy, enthalpy, reversibility and irreversibility. Describe concept of Gibbs function, Helmholtz function and discuss their variation with pressure, volume and temperature. Deduce the thermodynamic relations of equilibrium constant with other thermodynamic properties Explain heterogeneous equilibrium having one component and two component systems.

ORGANIC CHEMISTRY: Predict the products and stereochemistry of nucleophilic substitution reactions (S_N1 & S_N2) and elimination reactions (E_1,E_2,E_{1CB}) of alkyl halides. Predict and explain the effect of alkyl, vinyl, aryl and allyl substrates nucleophilic substitution. Identify the effect of nucleophile, leaving group, substrate and solvent on both substitution and elimination reactions and predict the predominant product. Illustrate the methods of formation and reactivities of various type of aliphatic alcohols (monohydric, dihydric and trihydric) and phenols. Compare the difference in acidity of aliphatic alcohols and phenols Predict the reactivity of different carbonyl compounds (saturated and unsaturated aldehydes and ketones) and their methods of formation. Outline the nucleophilic addition reaction mechanism for carbonyl compounds. Interpret the mechanism and products in the prescribed name reactions following nucleophilic addition mechanism. Explain the acidity and reactivity of active methylene groups. Describe the synthesis of carboxylic acids and its derivatives from different substrates. Justify the factors of the relative acidities of aliphatic and aromatic carboxylic acids by considering the inductive, resonance and steric effects on the neutral (conjugate acid) form and the anionic (conjugate base) form and compare with alcohols and phenols.

SYLLABUS:

SECTION A: PHYSICAL CHEMISTRY - I ***Lecture : 30***

UNIT – I	**Lecture: 14**

THERMODYNAMICS – I: Definition of thermodynamic terms: system, surrounding etc. Types of systems, intensive and extensive properties, State and path functions and their differentials. Thermodynamic process. Concept of heat and work. First Law of Thermodynamics: statement, definition of internal energy and enthalpy. Heat capacity, heat capacities at constant volume and pressure and their relationship. Joule law, joule Thomson coefficient and inversion temperature.

THERMOCHEMISTRY: Standard state, standard enthalpy of formation, Hess's law of heat, summation and its application. Enthalpy of neutralization. Bond dissociation energy and its calculation from thermochemical data, temperature dependence of enthalpy, Kirchhoff's equation.

THERMODYNAMICS – II: SECOND LAW OF THERMODYNAMICS: Carnot cycle and its efficiency. Concept of the entropy: entropy as a state function, Clausius inequality, entropy as criteria of spontaneity and equilibrium. Entropy change in ideal gases and mixing of gases. Third Law of Thermodynamics: Nernst heat theorem, statement and concept of residual entropy, evaluation of absolute entropy from heat capacity data, Gibbs and Helmholtz function.

UNIT – II **Lecture: 16**

CHEMICAL EQUILIBRIUM: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^o, Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases.

IONIC EQUILIBRIUM: Strong, 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, strong and weak electrolytes, degree of ionization, factors affecting degree of ionization.

PHASE EQUILIBRIUM: Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Phase diagrams of one-component systems and two component systems involving eutectics, congruent and incongruent melting points.

SECTION B: ORGANIC CHEMISTRY - II ***Lecture: 30***

(Functional group approach for the following reactions (Nomenclature, classification, preparations, physical property & chemical reactions) to be studied with mechanism in context to their structure.)

UNIT – III : **Lecture: 17**

ALKYL AND ARYL HALIDES: ALKYL HALIDES: Method of preparation: from alkenes and alcohols, Reactions: Types of Nucleophilic Substitution (S_N1, S_N2 and S_Ni) reactions, hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination v/s substitution. ARYL HALIDES: Preparation: from phenol, Sandmeyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution, Benzyne Mechanism. Reactivity and Relative strength of C-X bond in alkyl, allyl, benzyl, vinyl and aryl halides.

ALCOHOLS, PHENOLS AND ETHERS: ALCOHOLS: Preparation of 1^o, 2^o and 3^o alcohols (Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters). Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alkaline $KMnO_4$, acidic dichromate, conc. HNO_3). Dihydric Alcohols: Reaction- oxidation of diols, Pinacol-Pinacolon Reaction. Trihydric alcohols. PHENOLS: Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten Baumann Reaction. ETHERS: Cleavage of ethers with HI.

UNIT – IV : **Lecture: 13**

ALDEHYDES AND KETONES: Reactions – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Perkin condensation. Meerwein-Pondorff Verley reduction, Knoevenagel condensation, Mannich reaction, Bayer-villiger oxidation, $LiAlH_4$ and $NaBH_4$ reduction.

CARBOXYLIC ACIDS AND THEIR DERIVATIVE: CARBOXYLIC ACID: Reactions: Hell – Vohlard - Zelinsky Reaction, Reformatsky Reaction, decarboxylation. CARBOXYLIC ACID DERIVATIVES: Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their inter-conversion. Reactions: Comparative study of nucleophilicity of acyl derivatives.

Reference Books:

- Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. Organic Chemistry, John Wiley & Sons, 2014.
- McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
- Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi, 1988.
- Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
- Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
- Barrow, G.M. Physical Chemistry Tata McGraw-Hill, 2007.
- Castellan, G.W. Physical Chemistry 4th Ed. Narosa, 2004.
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi, 2009.
- Mahan, B.H. University Chemistry 3rd Ed. Narosa, 1998.
- Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York, 1985.

GENERIC ELECTIVE II PRACTICAL : CHEMISTRY LAB GE II CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY – I

CREDIT: 02
LECTURE: 60

Course Objectives:

1. *PHYSICAL CHEMISTRY:* Develop experimental skills of thermochemistry, Ionic equilibria and phase equilibria.
2. *ORGANIC CHEMISTRY:* Understand the core concepts of green synthesis.

Course Learning Outcome:

Physical Chemistry: Measure enthalpy of neutralization and ionization for different acid base combinations. Determine critical solution temperature of partially miscible liquids.

Organic Chemistry: Learn the principles and processes in laboratory reactions to synthesize organic compound.

SYLLABUS:

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 (KNO_3, NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of ΔH.

Ionic equilibria

pH measurements

7. 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.
8. 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.

Phase equilibria

9. Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
10. Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
11. Study of the variation of mutual solubility temperature with concentration for the

phenol water system and determination of the critical solubility temperature.

Section B: Organic Chemistry

Preparations: Mechanism of various reactions involved to be discussed. Recrystallization, determination of melting point and calculation of quantitative yields to be done.

12. Bromination of Phenol/Aniline
13. Benzoylation of amines/phenols
14. Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone

Reference Books

- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi, 2011.

GENERIC ELECTIVE III : CHEMISTRY GE III

SOLUTIONS, CONDUCTANCE, ELECTROCHEMISTRY, NUCLEAR-RADIOCHEMISTRY, FUNCTIONAL GROUP ORGANIC CHEMISTRY-II & SPECTROSCOPY

CREDIT: 04
LECTURE: 60

Course Objectives:

1. *PHYSICAL CHEMISTRY:* Understand the concept of ideal, non-ideal and partially miscible liquids. Understand the concept of colligative properties of dilute solutions. Be acquainted with the concept of electrochemistry. Knowledge gain about the application of nuclear chemistry and radioactivity.
2. *ORGANIC CHEMISTRY:* Learn about reaction and reactivity of Nitro containing compounds. To gain in depth knowledge of Amino acids, proteins and carbohydrates. Be aware about the principles and applications of UV, IR and NMR spectroscopy techniques.

Course Learning Outcome:

PHYSICAL CHEMISTRY: Compile the properties of solutions of solids and gases in liquids, miscible liquids, partially miscible liquids, and immiscible liquids, appraise the concept of colligative properties and apply for molecular weight determination. Discuss the classification of nuclides, nuclear stability, and general characteristics of radioactive decay. Applications of radioactivity. Explain the basic concepts of electrochemistry and use this knowledge to calculate degree of dissociation, hydrolysis constant, solubility product etc. for strong and weak electrolytes. Describe types of reversible electrodes and pH determination using it. Knowledge gain about liquid junction potential and potentiometric titration.
ORGANIC CHEMISTRY: Differentiate between 1°/ 2°/ 3° amines and discuss their role in acting as a base, phase transfer catalysts and as a precursor to diazotization. Discuss the structure elucidation of amino acids, peptides and proteins. Discuss the classification and general properties of glucose and fructose and their conversion to some other aldoses. Discuss qualitative and quantitative knowledge of the fundamental concepts of spectroscopy, apply spectroscopic data for molecular characterization, and describe principles, selection rules and applications of UV, IR and NMR spectroscopy.

SYLLABUS:

SECTION A: PHYSICAL CHEMISTRY-2 ***Lecture: 30***

UNIT – I	**Lecture: 14**
SOLUTIONS AND COLLIGATIVE PROPERTIES: Types of solution, Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions, methods of expressing concentration of solutions, activity and activity coefficient, Dilute solution, Azeotropes. Colligative properties, relative lowering of vapour pressure, Osmosis, law of osmotic pressure and its measurement, determination of molecular mass from osmotic pressure, Elevation of boiling point	

and depression in freezing point, Experimental methods for determining various colligative properties, Abnormal molar mass, degree of dissociation and association of solutes.

NUCLEAR AND RADIO CHEMISTRY: Introduction, fundamental particles of nucleus, concept of nuclides and its representation, types of nuclides- isotopes, isobars, isotones and nuclear isomers, force operating between nucleus, stability of nucleus (n/p ratio). Natural and Artificial radioactivity, Radioactive Disintegration, disintegration series, Radioactive Displacement Law, rate of radioactive decay, Half-life and Average life, applications of radioactivity, binding energy and its calculation, mass defect and its calculation, types of nuclear reactions (nuclear fission, Spallation and nuclear fusion),

UNIT – II : **Lecture: 16**

ELECTROCHEMISTRY I: Electrical transport-conduction in metals and in electrolyte solutions, specific, molar and equivalent conductance, variation of equivalent and specific conductance with dilution, Migration of ions and Kohlrausch law, Arrhenius theory of electrolyte dissociation and its limitations, weak and strong electrolytes, Ostwald's dilution law and its limitations, Debye-Huckel-Onsager's equation for strong electrolytes (elementary treatment only), Transport number-definition and determination by Hittorf method and moving boundary method, Applications of conductivity measurements: determination of degree of dissociation, determination of Ka of acids, determination of solubility product of a sparingly soluble salt, ionic product of water, hydrolysis constant of a salt, Conductometric titrations (only acid and base).

ELECTROCHEMISTRY II: Electrolytic and Galvanic cells-reversible and irreversible cells, Notations and sign conventions, Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Types of reversible electrodes: gas-metal ion, metal-metal ion, metal insoluble salt anion and redox electrodes, Electrode reactions, pH determination using hydrogen electrode and quinhydrone electrode, Concentration cell with and without transport, liquid junction potential, potentiometric titration,

SECTION B: ORGANIC CHEMISTRY-III ***Lecture: 30***

UNIT – III : **Lecture: 21**

ORGANIC CHEMISTRY OF NITROGEN: NITRO COMPOUND; Preparation of nitroalkanes and nitroarenes, chemical reaction of nitroalkanes, mechanism of nucleophilic substitution in nitroarenes and their reductions in acidic, neutral and alkaline media, picric acid, Gabriel's Phthalimide synthesis, and Hofmann Bromamide reaction. AMINES; Structure and nomenclature of amines, physical properties, stereochemistry of amines, Structural features affecting basicity of amines. Amine salts as phase transfer catalyst. Preparation: Carbylamine test, Hinsberg test, with HNO_2, Schotten Baumann Reaction. Electrophilic substitution reaction. DIAZONIUM SALTS: Reactions; conversion to benzene, phenol, dyes. Preparation: from aromatic amines. Diazo coupling.

BIOMOLECULES: AMINO ACIDS; Classification, structure and stereochemistry of amino acids, Acid base behaviour, isoelectric point and electrophoresis, Preparation and reactions of α-amino acids. PEPTIDE AND PROTEINS; Structure and nomenclature of peptides and proteins, Classification of proteins, Peptide structure determination, end group analysis, selective hydrolysis of peptides, Classical peptide synthesis, solid-phase peptide synthesis, Structures of peptides

andprimary, secondary, tertiary and quaternary structures (definition only) of proteins, Proteins denaturation/ renaturation. NUCLEIC ACIDS: Introduction, Constitution of nucleic acids, Ribnonucleosides and ribonucleotides, The double helical structure of DNA. CARBOHYDRATES; Classification and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of ring size of monosaccharides, Interconversion of glucose and fructose, Ertyhro and Threo diastereomers, Conversion of glucose into mannose, Epimers, anomers and Mutarotation. Ascending and descending in monosaccharides, Structure of disaccharides (sucrose, cellobiose, maltose, lactose) and Polysaccharides (starch and cellulose) excluding their structure elucidation.

UNIT – IV **Lecture: 9**

ORGANIC SPECTROSCOPY: UV SPECTROSCOPY; absorption laws (Beer-lambert law), molar absorptivity, presentation and analysis of UV spectra, types of electronic transition, effects of conjugation, concept of chromophore and auxochrome, bathochromic, hypsochromic, hyperchromic and hypochromic shift, Woodward-Fieser rule.

INFRARED ABSORPTION SPECTROSCOPY (IR); molecular vibrations, Hooke's law, selection rules, intensity and position of IR bands, measurement of IR spectrum, fingerprint regions, characteristic absorption of various functional groups and interpretation of IR spectra of simple organic compounds.

NUCLEAR MAGNETIC RESONANCE (NMR); Proton resonance spectroscopy (PMR), nuclear shielding and deshielding, intensity of peaks, number of signals, chemical shift, spin splitting and coupling constants, Application of ^{1}H NMR to simple organic molecules such as ethyl bromide, ethanol, acetaldehyde, 1,1,2-tribromoethane, toluene and acetophenone.

Reference Books:

- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill, 2007
- Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa, 2004
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry*, Cengage Learning India Pvt. Ltd.: New Delhi, 2009
- Mahan, B.H. *University Chemistry*, 3rd Ed. Narosa, 1998
- Petrucci, R.H. *General Chemistry*, 5th Ed., Macmillan Publishing Co.: New York, 1985
- 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)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Bioch*emistry *7th Ed.*, W. H. Freeman.
- Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002

GENERIC ELECTIVE III PRACTICAL : CHEMISTRY LAB GE III

SOLUTIONS, CONDUCTANCE, ELECTROCHEMISTRY, NUCLEAR-RADIOCHEMISTRY, FUNCTIONAL GROUP ORGANIC CHEMISTRY-II & SPECTROSCOPY

CREDIT: 02
LECTURE: 60

Course Objectives:

1. *PHYSICAL CHEMISTRY: D*evelop experimental skills of conductometry and potentiometry. Acquire knowledge of conductometric and potentiometric titrations and their calculations. Make the students to get an insight on the use of apparatus used in volumetric analysis and correct titrimetric procedure along with standard and nonstandard solutions.
2. *ORGANIC CHEMISTRY:* learn the concept of chromatographic techniques. Know various spectral techniques. Develop quantitative skills for different analytical purposes.

Course Learning Outcome:

PHYSICAL CHEMISTRY: Operate conductivity meter & potentiometer to determine the strength of given unknown acid/base solutions by using it.
ORGANIC CHEMISTRY: Apply chromatographic technique to separate and identify different components of mixture. Assign structures to simple molecules on the basis of infra-red and nuclear magnetic resonance spectroscopy.

SYLLABUS:

Section A: Physical Chemistry

Conductance

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:
   a. Strong acid vs. strong base
   b. Weak acid vs. strong base

Potentiometry

Perform the following potentiometric titrations:

1. Strong acid vs. strong base
2. Weak acid vs. strong base
3. Potassium dichromate vs. Mohr's salt

Section B: Organic Chemistry

1. Separation of amino acids by paper chromatography
2. Determination of the concentration of glycine solution by formylation method.
3. Titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. Differentiation between a reducing and a non-reducing sugar.
7. Spectroscopy: Interpretation of IR and NMR spectra of simple organic compounds (ethanol, 1-propanol, 2-propanol, methyl ethanoate, ethyl acetate, stilbene, ethyl acetate, propanone etc).

Reference Books:

- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi, 2011
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry*, Universities Press.

GENERIC ELECTIVE IV: CHEMISTRY GE IV
CHEMISTRY OF d- AND f-BLOCK ELEMENTS, COORDINATION CHEMISTRY, ACID-BASE AND HSAB, STATES OF MATTER & CHEMICAL KINETICS

CREDIT: 04
LECTURE: 60

Course Objectives:

1. *INORGANIC CHEMISTRY:* Explain the trends in physical and chemical properties and reactivity of d-block elements. Be acquainted with the basic concepts of coordination chemistry and electronic configuration of the lanthanides and actinides including trends observed across the periodic table. Understand the basic concepts of acid and bases.
2. *PHYSICAL CHEMISTRY:* Enhance the knowledge on principles and bulk properties of matter. Provide an in-depth knowledge of experimental methods and theories of chemical kinetics.

Course Learning Outcome:

INORGANIC CHEMISTRY: Explain the trends in physical and chemical properties and reactivity of d-block and f-block elements. Understand the basic concepts of acid and bases. Describe the important postulates of CFT, construct splitting diagrams of d-orbitals for different geometries and calculate CFSE of different complexes, apply John-Teller theorem to explain the crystal field splitting in square planar complexes, differentiate between high spin and low spin complexes and explain the colour of complexes. Differentiate between different types of magnetic behavior and interpret magnetic moments for different complexes. Describe L-S coupling and compute ground state terms, employ selection rules, sketch Orgel diagrams.

PHYSICAL CHEMISTRY: Explain kinetic theory of gases and Maxwell distribution of Molecular velocities to describe the behavior of gases. Discuss structure and application of liquid crystal. Describe laws of crystallography and apply these laws. Appraise the rules of kinetics to evaluate the order of reaction and rate constant, compare and conclude theories of chemical kinetics and evaluate the kinetics of a reaction using experimental methods.

SYLLABUS:

SECTION A: INORGANIC CHEMISTRY – 2 ***Lecture: 30***

UNIT – I :	**Lecture: 16**
d-BLOCK AND f-BLOCK ELEMENTS: d-BLOCK: General characteristics of elements of First, second and third transition series: electronic configuration, oxidation state, magnetic behavior, Comparative treatment 3d-analogs in respect of ionic radii, spectral properties and stereochemistry, Coordination number and geometry. f-BLOCK: Lanthanides and actinides: Electronic configurations, oxidation states, color, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only)	

ACID-BASE AND HSAB PRINCIPLE; Arrhenius, Bronsted-Lowry, the Lux-Flood, solvent system and Lewis concepts of acid and bases Pearson's HSAB principle.

UNIT – II : **Lecture: 14**

COORDINATION CHEMISTRY: IUPAC system of nomenclature, Werner's coordination theory, effective atomic number, Structural and stereoisomerism in complexes with coordination numbers 4 and 6. VALENCE BOND THEORY (VBT): Inner and outer orbital complexes (coordination numbers 4 and 6). Drawbacks of VBT. CFT: Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of Δ_{oh}. Spectrochemical series. Comparison of CFSE for Oh and Td complexes, Tetragonal distortion of octahedral geometry. John-Teller distortion, Square planar coordination Chelate effect, Trans-effect, Thermodynamic and Kinetic stability of complexes.

MAGNETIC PROPERTIES OF TRANSITION METAL COMPLEXES: Type of magnetic behavior, spin-only value, L-S coupling. ELECTRONIC SPECTRA OF TRANSITION METAL COMPLEXES: Types of electronic transition, selections rule for d-d transition, Applications (Ligand field strength, colour of complexes)

SECTION B: PHYSICAL CHEMISTRY – 3 ***Lecture: 30***

UNIT – III : **Lecture:22**

STATES OR MATTER

GASES: Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behavior, compressibility factor, causes of deviation. Van der Waals equation of state for real gases. Boyle temperature. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews's isotherms of CO_2. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity.

LIQUIDS: Intermolecular forces, structure of liquids, Surface tension Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid.

SOLIDS: Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X–Ray diffraction by crystals, Bragg's law. Ionic solids: (Ionic structure, radius ratio rule, coordination number), Structures of NaCl, KCl and CsCl. Defects in crystals. Band theory of solids.

UNIT – IV : **Lecture: 8**

CHEMICAL KINETICS: The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories. Concept of activation energy and its calculation from Arrhenius equation. Catalysis, characteristics of catalyzed reactions, Michaelis-Menten mechanism, classification of catalysis.

Reference Books:

- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill, 2007.
- Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa, 2004.
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi, 2009.
- Mahan, B.H. *University Chemistry* 3rd Ed. Narosa, 1998.
- Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York, 1985).
- Cotton, F.A. & Wilkinson, G. *Basic Inorganic Chemistry*, Wiley.
- Shriver, D.F. & Atkins, P.W. *Inorganic Chemistry*, Oxford University Press.
- Wulfsberg, G. *Inorganic Chemistry*, Viva Books Pvt. Ltd.
- Rodgers, G.E. *Inorganic & Solid State Chemistry*, Cengage Learning India Ltd., 2008.

GENERIC ELECTIVE IV PRACTICAL: CHEMISTRY LAB GE IV CHEMISTRY OF d- AND f-BLOCK ELEMENTS, COORDINATION CHEMISTRY, ACID-BASE AND HSAB, STATES OF MATTER & CHEMICAL KINETICS

CREDIT: 02
LECTURE: 60

Course Objectives:

1. *INORGANIC CHEMISTRY:* Be acquainted with various safety measures including handling of chemicals, safe disposal of chemical wastes etc. Understand the concept of separation of mixtures containing metal ions. Provide sample training in the synthesis of different inorganic complexes and identification of given organic compound.
2. *PHYSICAL CHEMISTRY:* Learn about the determination of percent composition of binary solutions by using viscometer and stalagmometer. Acquire knowledge of kinetics and their calculations.

Course Learning Outcome:

INORGANIC CHEMISTRY: Analyze and detect various cations and anions in the presence of each other in a given mixture qualitatively. Prepare inorganic complexes.

PHYSICAL CHEMISTRY: Determine the percentage composition of non-interacting systems by viscosity and surface tension method. Calculate rate constant of different reactions.

SYLLABUS:

Section A: Inorganic Chemistry

a. Semi-micro qualitative analysis using H_2S of mixtures - not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:
   Cations : NH^{4+}, Pb^{2+}, Ag^{+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^{+}
   Anions : CO_3^{2-} , S^{2-}, SO_2^{-}, $S_2O_3^{2-}$, NO_3^{-}, CH_3COO^{-}, Cl^{-}, Br^{-}, I^{-}, NO_3^{-},SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$, F^{-} (Spot tests should be carried out wherever feasible)
b. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximato)nickel(II) or aluminium as oximate in a given solution gravimetrically.
c. Draw calibration curve (absorbance at λ_{max} vs. concentration) for various concentrations of a given coloured compound ($KMnO_4$/ $CuSO_4$) and estimate the concentration of the same in a given solution.
d. Determine the composition of the Fe^{3+}-salicylic acid complex solution by Job's method.
e. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.
f. Estimation of total hardness of a given sample of water by complexometric titration.
g. Determination of concentration of Na^{+} and K^{+} using Flame Photometry.

Section B: Physical Chemistry

Surface tension measurement (use of organic solvents excluded).

1. Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

2. Study of the variation of surface tension of a detergent solution with concentration.

Viscosity measurement (use of organic solvents excluded).

1. Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.
2. Study of the variation of viscosity of an aqueous solution with concentration of solute.

Chemical Kinetics (Study the kinetics of the following reactions.)

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
   a. Acid hydrolysis of methyl acetate with hydrochloric acid.
   b. Saponification of ethyl acetate.
   c. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate

Reference Books:

- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
- Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi, 2011.