CHEMISTRY
PAPER-I

I. Atomic Structure and Quantum Chemistry:

- The Electromagnetic Spectrum
- Photoelectric effect
- Bohr's atomic model
- Wave and particle nature of light-matter
- De Broglie's equation
- Heisenberg's Uncertainty Principle
- Wave functions and Born interpretation of wave functions
- Probability density
- Eigenfunctions and Eigen values
- Hamiltonian operator
- Schrödinger Wave Equation and its solution for a particle in one and three-dimensional box.

II. Electrochemistry:

- Ions in solution
- Measurement of conductance and Kohlrausch's Law
- Mobility of ions and transport number
- Conductometric titrations
- Debye-Hückel theory
- Activity coefficient & determination of activities
- Redox reactions & Spontaneous reactions
- Electrochemical cells, standard electrode potentials, liquid junction potential, & electrochemical series
- Nernst's equation
- Measurement of pH
- Electrolytic cells, potentiometry, reference and indicator electrodes
- Fuel cells, corrosion and its prevention.

III. Thermodynamics:

- Equation of states
- Ideal and Real Gases
- The Van der Waals equation for Real Gases
- Critical phenomena and Critical constants
- Four laws of thermodynamics and their applications
- Thermochemistry & Calorimetry
- Heat capacities and their dependence on temperature, pressure and volume
- Reversible and non-reversible processes
- Spontaneous and non-spontaneous processes
- Hess's law

- The Born-Haber cycle
- Relations of entropy and Gibbs free energy with equilibrium constant
- Gibbs Helmholtz equation
- Fugacity and Activity

IV. Chemical Kinetics:

- The Rate and Molecularity of reactions
- Factors affecting the rate of a chemical reaction
- Zero, first, second and third-order reactions with same initial concentrations
- Half-lives of reactions
- Experimental techniques for determination of the order of reaction: integration, half-life, initial rate and graphical methods
- Collision theory & Transition state theory
- Arrhenius equation and rate equations of complex reactions.

V. Surface Chemistry and Catalysis:

- Properties of liquids
- Physical and chemical properties of surface
- Determination of the surface area
- **Adsorption and absorption:** physical adsorption and chemisorption, adsorption isotherms, Langmuir adsorption isotherm and Freundlich Adsorption isotherm.
- **Colloids:** properties, classification and preparation of colloidal systems.
- Surfactants
- Phase rule & Gibbs equation of phase rule
- One-component systems, two-component systems and their examples
- **Catalysis:** homogeneous and heterogeneous catalysis, acid-base and enzyme catalysis.

VI. Fundamentals of Chemometrics:

Sampling, significant figures, stoichiometric calculations, measurement errors, analysis of variance (ANOVA), arithmetic mean, median, mode, standard deviation/relative standard deviation, confidence limits, Gaussian distribution, least square method, Statistical tests.

VII. Separation Methods:

- Solvent extraction
- Theory of solvent extraction
- Solvent extraction of Metals
- Analytical separations
- Multiple batch extraction and counter-current distribution
- Chromatography; theory of chromatography, classification and overview of chromatographic techniques (paper, thin layer, column and ion-exchange chromatography)
- Principle of electrophoresis and its application as separation and characterization of proteins.

VIII. Basic Inorganic Chemistry:

- Types of chemical bonding
- Ionic and Covalent bonding
- Localized bond approach
- Theories of chemical bonding
- Valance Bond Theory (VBT)
- Hybridization and Resonance
- Prediction of molecular shapes using Valence-Shell Electron-Pair Repulsion (VSEPR) model
- Molecular Orbital Theory (MOT) applied to diatomic molecules
- Delocalized approach to bonding
- Bonding in electron-deficient compounds
- Hydrogen bonding
- Physical and chemical properties of p-block elements with emphasis on oxygen, carbon, chlorine, silicon, nitrogen, phosphorus and some of their representative compounds.

IX. Acids and Bases:

- Brief concepts of chemical equilibrium
- Acid-base theories including soft and hard acid and base (SHAB) concept
- The relative strength of acids and bases
- Significance of pH, pK_a, pK_b and buffer solutions
- Theory of indicators
- Solubility & solubility product, common ion effect and their industrial applications.

X. Chemistry of d and f-block elements:

- General characteristics of d-block elements
- Historical background of Coordination Chemistry
- Nomenclature and structure of coordination complexes with coordination number 2-10
- Chelates and chelate effect
- **Theories of coordination complexes:** Werner's theory, Valence bond theory (VBT), Crystal field theory (CFT) and Molecular orbital theory (MOT).
- Jahn-Teller theorem
- Magnetic properties & Spectral properties
- Isomerism, Stereochemistry and stability constants of coordination complexes
- **Lanthanides:** General characteristics, occurrence, extraction and general principles of separation, electronic structure and position in the periodic table, lanthanide contraction, oxidation states, spectral and magnetic properties and uses.
- **Actinides:** General characteristics, electronic structure, oxidation state and position in the periodic table, half-life and decay law.

CHEMISTRY
PAPER-II

I. Basic Concepts of Organic Chemistry:

- Bonding and orbital hybridization
- Localized and delocalized bonding
- Inductive effect
- Dipole moment, Resonance
- Hyperconjugation.

II. Saturated and Unsaturated Hydrocarbon:

- Nomenclature
- Physical properties
- Preparation and reactions of alkanes, alkenes and alkynes

III. Chemistry of Aromatic Compounds:

- Benzene structure
- Aromaticity
- Mechanism of electrophilic substitution reaction
- Activating and deactivating substituents
- Effect of substituents on orientation and reactivity

IV. Chemistry of Functional Groups:

- Preparation and properties of alcohols, phenols, ethers, and amines with focus on reaction mechanism and applications
- Preparation and reactions of alkyl halides
- Synthetic applications of Grignard reagent
- Carbonyl compounds
- Preparations and reaction mechanism of aldehydes and ketones and their applications
- Carboxylic acids and their derivatives
- Acidity of carboxylic acids and effect of substituents on their acidity
- preparation and reactions of carboxylic acids and their derivatives including acid halides, acid anhydrides, esters and amides.

V. Aliphatic nucleophilic substitution and elimination reactions:

- Mechanism of nucleophilic substitution reactions
- Elimination reactions
- Zaitsev rule and Hofmann rule
- Competition between Substitution and elimination reactions

VI. Stereochemistry:

- Molecular chirality
- Types of stereoisomers.
- R,S configuration and E,Z designation
- Optical activity
- Stereoselectivity and stereospecificity
- Resolution of racemic mixtures

VII. Organic Spectroscopy:

- Theory, Principle, instrumentation and applications of UV/Visible, 1H NMR, IR spectroscopy and Mass spectroscopic techniques.

VIII. Biomolecules:

- **Carbohydrates:** Monosaccharides, oligosaccharides and polysaccharides, biological functions of starch, glycogen, cellulose, and cell wall polysaccharides.
- **Lipids:** Classification and biological importance of lipids. Significance of lipids in biological membranes and transport mechanism.

1. **Amino Acids:** Classification of amino acids. Physical and chemical properties of amino acids. Biological significance. Proteins; Classification. Properties and biological significance. Primary, secondary tertiary and quaternary structures.

- **Nucleic Acids:** Chemical composition of nucleic acids. Structure and biological significance of nucleic acids.
- **Enzymes:** Enzyme-substrate interactions and nature of active site, mechanism of enzyme action, the kinetics of single substrate reactions, enzyme inhibition, regulatory enzymes and allosteric enzymes.

IX. Metabolism:

- Digestion; absorption and transport of proteins, carbohydrates, lipids and nucleic acids.
- Glycolysis; citric acid cycle, gluconeogenesis, glycogenesis, glycogenolysis and photosynthesis.
- Biosynthesis of triglycerides, phosphides, steroids and bile acids and ketone bodies.
- Biochemical reaction of amino acids: decarboxylation, deamination, transamination and transmethylation, etc., urea cycle, creatine and uric acid synthesis.
- Catabolism of nucleosides, DNA polymerases and other enzymes involves in metabolism.

X. Chemical Industries:

- Manufacturing and processing of sugar, cement, glass, paper, fertilizers, soap and detergents.