

CHEMISTRY

PAPER - I

1. **Atomic Structure:**

Heisenberg's uncertainty principle, Schrodinger wave equation (time independent); Interpretation of wave function, particle in one-dimensional box, quantum numbers, hydrogen atom wave functions; Shapes of s, p and d orbitals.

2. **Chemical Bonding:**

Ionic bond, characteristics of ionic compounds, lattice energy, Born-Haber cycle; covalent bond and its general characteristics, polarities of bonds in molecules and their dipole moments; Valence bond theory, concept of resonance and resonance energy; Molecular orbital theory (LCAO method); bonding in H_2^+ , H_2 , He_2^+ to Ne_2 , NO, CO, HF, and

CN⁻; Comparison of valence bond and molecular orbital theories, bond order, bond strength and bond length.

3. **Solid State:**

Crystal systems; Designation of crystal faces, lattice structures and unit cell; Bragg's law; X-ray diffraction by crystals; Close packing, radius ratio rules, calculation of some limiting radius ratio values; Structures of NaCl, ZnS, CsCl and CaF_2 ; Stoichiometric and nonstoichiometric defects, impurity defects, semi-conductors.

4. **The Gaseous State and Transport Phenomenon:**

Equation of state for real gases, inter-molecular interactions and critical phenomena and liquefaction of gases, Maxwell's distribution of speeds, intermolecular collisions, collisions on the wall and effusion; Thermal conductivity and viscosity of ideal gases.

5. **Liquid State:**

Kelvin equation; Surface tension and surface energy, wetting and contact angle, interfacial tension and capillary action.

6. **Thermodynamics:**

Work, heat and internal energy; first law of thermodynamics.

Second law of thermodynamics; entropy as a state function, entropy changes in various processes, entropy-reversibility and irreversibility, Free energy functions; Thermodynamic equation of state; Maxwell relations; Temperature, volume and pressure dependence of U, H, A, G, C_p and C_v , α and β J-T effect and inversion temperature; criteria for equilibrium, relation between equilibrium constant and thermodynamic quantities; Nernst heat theorem, introductory idea of third law of thermodynamics.

7. **Phase Equilibria and Solutions:**

Clausius-Clapeyron equation; phase diagram for a pure substance; phase equilibria in binary systems, partially miscible liquids-upper and lower critical solution temperatures; partial molar quantities, their significance and determination; excess thermodynamic functions and their determination.

8. **Electrochemistry:**

Debye-Huckel theory of strong electrolytes and Debye-Huckel limiting Law for various equilibrium and transport properties.

Galvanic cells, concentration cells; electrochemical series, measurement of e.m.f. of cells and its applications fuel cells and batteries.

Processes at electrodes; double layer at the interface; rate of charge transfer, current density; overpotential; electroanalytical techniques: Polarography, amperometry, ion selective electrodes and their uses.

9. **Chemical Kinetics:**

Differential and integral rate equations for zeroth, first, second and fractional order reactions; Rate equations involving reverse, parallel, consecutive and chain reactions; branching chain and explosions; effect of temperature and pressure on rate constant; Study of fast reactions by stop-flow and relaxation methods; Collisions and transition state theories.

10. **Photochemistry:**

Absorption of light; decay of excited state by different routes; photochemical reactions between hydrogen and halogens and their quantum yields.

11. **Surface Phenomena and Catalysis:**

Absorption from gases and solutions on solid adsorbents, Langmuir and B.E.T. adsorption isotherms; determination of surface area, characteristics and mechanism of reaction on heterogeneous catalysts.

12. **Bio-inorganic Chemistry:**

Metal ions in biological systems and their role in ion transport across the membranes (molecular mechanism), oxygen-uptake proteins, cytochromes and ferredoxins.

13. **Coordination Compounds:**

(i) Bonding theories of metal complexes; Valence bond theory, crystal field theory and its modifications; applications of theories in the explanation of magnetism and electronic spectra of metal complexes.

(ii) Isomerism in coordination compounds; IUPAC nomenclature of coordination compounds; stereochemistry of complexes with 4 and 6 coordination numbers; chelate effect and polynuclear complexes; trans effect and its theories; kinetics of substitution reactions in square-planar complexes; thermodynamic and kinetic stability of complexes.

(iii) EAN rule, Synthesis structure and reactivity of metal carbonyls; carboxylate anions, carbonyl hydrides and metal nitrosyl compounds.

(iv) Complexes with aromatic systems, synthesis, structure and bonding in metal olefin complexes, alkyne complexes and cyclopentadienyl complexes; coordinative unsaturation, oxidative addition reactions, insertion reactions, fluxional molecules and their characterization; Compounds with metal-metal bonds and metal atom clusters.

14. **Main Group Chemistry:**

Boranes, borazines, phosphazenes and cyclic phosphazene, silicates and silicones, Interhalogen compounds; Sulphur – nitrogen compounds, noble gas compounds.

15. **General Chemistry of 'f' Block Elements:**

Lanthanides and actinides; separation, oxidation states, magnetic and spectral properties; lanthanide contraction.

PAPER - II

1. **Delocalised Covalent Bonding:**

Aromaticity, anti-aromaticity; annulenes, azulenes, tropolones, fulvenes, sydnones.

2. (i) **Reaction Mechanisms.**—General methods (both kinetic and non-kinetic) of study of mechanism of organic reactions: isotopic method, cross-over experiment, intermediate trapping, stereochemistry; energy of activation; thermodynamic control and kinetic control of reactions.

(ii) **Reactive Intermediates.**—Generation, geometry, stability and reactions of carbonium ions and carbanions, free radicals, carbenes, benzyne and nitrenes.

(iii) **Substitution Reactions.**— S_N1 , S_N2 and S_Ni mechanisms; neighbouring group participation; electrophilic and nucleophilic reactions of aromatic compounds including heterocyclic compounds—pyrrole, furan, thiophene and indole.

(iv) **Elimination Reactions:** $E1$, $E2$ and $Elcb$ mechanisms; orientation in $E2$ reactions—Saytzeff and Hoffmann; pyrolytic syn elimination – Chugaev and Cope eliminations.

(v) **Addition Reactions.**—Electrophilic addition to $C=C$ and $C\equiv C$; nucleophilic addition to $C=O$, $C=N$, conjugated olefins and carbonyls.

(vi) **Reactions and Rearrangements.**—(a) Pinacol-pinacolone, Hoffmann, Beckmann, Baeyer–Villiger, Favorskii, Fries, Claisen, Cope, Stevens and Wagner–Meerwein rearrangements.

(b) Aldol condensation, Claisen condensation, Dieckmann, Perkin, Knoevenagel, Witting, Clemmensen, Wolff–Kishner, Cannizzaro and von Richter reactions; Stobbe, benzoin and acyloin condensations; Fischer indole synthesis, Skraup synthesis, Bischler–Napieralski, Sandmeyer, Reimer–Tiemann and Reformatsky reactions.

3. **Pericyclic Reactions:**

Classification and examples; Woodward–Hoffmann rules—electrocyclic reactions, cycloaddition reactions [2+2 and 4+2] and sigmatropic shifts [1, 3; 3, 3 and 1, 5] FMO approach.

4. (i) **Preparation and Properties of Polymers.**—Organic polymers—polyethylene, polystyrene, polyvinyl chloride, teflon, nylon, terylene, synthetic and natural rubber.

(ii) **Biopolymers.**—Structure of proteins, DNA and RNA.

5. **Synthetic Uses of Reagents:**

OsO_4 , HIO_4 , CrO_3 , $Pb(OAc)_4$, SeO_2 , NBS, B_2H_6 , Na-Liquid NH_3 , $LiAlH_4$, $NaBH_4$, n-BuLi and MCPBA.

6. **Photochemistry:**

Photochemical reactions of simple organic compounds, excited and ground states, singlet and triplet states, Norrish-Type I and Type II reactions.

7. **Spectroscopy:**

Principle and applications in structure elucidation:

- (i) **Rotational.**—Diatomic molecules; isotopic substitution and rotational constants.
- (ii) **Vibrational.**—Diatomic molecules, linear triatomic molecules, specific frequencies of functional groups in polyatomic molecules.
- (iii) **Electronic.**—Singlet and triplet states; $n \rightarrow \pi^*$ and $\pi \pi^* \rightarrow$ transitions; application to conjugated double bonds and conjugated carbonyls—Woodward-Fieser rules; Charge transfer spectra.
- (iv) **Nuclear Magnetic Resonance (^1H NMR).**—Basic principle; chemical shift and spin-spin interaction and coupling constants.
- (v) **Mass Spectrometry.**—Parent peak, base peak, metastable peak, McLafferty rearrangement.