

CHEMISTRY (CODE NO. 05)
PAPER - I

1. Symmetry

Symmetry elements and symmetry operations. Recognition of symmetry point group and symmetry elements in AB₂ and AB₃ molecules.

2. Atomic structure

Idea of de Broglie matter waves. Heisenberg's uncertainty principle, Schrodinger wave equation (time independent). Significance of ψ and ψ^2 , particle in one-dimensional box, quantum numbers, radial and angular wave functions, shapes of s, p, d and orbitals, Aufbau principle, Hund's multiplicity rule, Pauli exclusion principle. Effective nuclear charge.

3. Chemical bonding

Ionic bond, percent ionic character from dipole moment and electronegativity difference, characteristics of ionic compounds, factors affecting stability of ionic compounds, lattice energy, Born-Haber cycle; covalent bond and its general characteristics, polarities of bonds in molecules and their dipole moments. Valency bond theory, concept of resonance and resonance energy. Molecular orbital theory (LCAO method); bonding in homonuclear and heteronuclear molecules: H₂⁺, H₂ to Ne₂, NO, CO. The concept of hybridization, character of bonds, bond angles and bond length. Hydrogen bonding and van der Waals forces. Metallic bonding.

4. Solid State

Forms of solids, law of constancy of interfacial angles, crystal systems and crystal classes (crystallographic groups). Designation of crystal faces, lattice structures and unit cell. Laws of rational indices. Bragg's law. X-ray diffraction by crystals. Close packing, radius ratio rules, calculation of some limiting radius ratio values. Structures of NaCl, CsCl, and KCl. crystal Imperfections in crystals. Elementary study of liquid crystals.

5. Thermodynamics

Thermodynamic systems, states and processes, work, heat and internal energy; first law of thermodynamics, work done on the systems and heat absorbed in different types of processes;

calorimetry, energy and enthalpy changes in various processes and their temperature dependence.

Second law of thermodynamics; entropy as a state function, entropy changes in various process, entropy–reversibility and irreversibility, Free energy functions; criteria for equilibrium, relation between equilibrium constant and thermodynamic quantities; Nernst heat theorem and third law of thermodynamics.

Thermodynamics derivations of -

Gibbs-Helmholtz equation,
law of mass action and
Clapeyron-Clausius equations.

6. Electrochemistry

Conductivity and its applications to determine -

Dissociation constant of weak electrolyte
Solubility product of sparingly soluble salts
Conductometric titration.

Debye-Huckel theory of strong electrolytes.

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

Processes at electrodes; double layer at the interface of metal and solvent; rate of charge transfer, current density; overpotential.

7. Chemical kinetics

Concentration dependence of rate of reaction; differential and integral rate equations for zeroth, first, and second order of reactions. Effect of temperature and pressure on rate constant. Collisions and transition state theories.

8. Photochemistry

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

9. Surface phenomena and catalysis

Absorption from gases and solutions on solid adsorbents, Freundlich and Langmuir adsorption isotherm; determination of surface area, characteristics and mechanism of reaction on heterogeneous catalysts.

10. Bio-inorganic chemistry

Essential and trace elements in biological processes, metalloporphyrins with special reference to haemoglobin and myoglobin. nitrogen fixation, oxygen-uptake proteins, cytochromes and ferredoxins. Biological role of alkali and alkaline earth metal ions.

11. Coordination chemistry

- (1) Introduction to bonding theories in transition metal complexes: Valency bond theory, crystal field theory, Ligand field theory and molecular orbital theory.
- (2) Magnetic properties of transition metal complexes: Magnetic moment (spin only and with L-S coupling), orbital contribution to magnetic moment.
- (3) Electronic spectra of transition metal complexes: Spectroscopic ground and excited states, types of electronic transitions, selection rules for d-d transitions. Spectrochemical series. Orgel-energy level diagram for d^1 to d^9 states.
- (4) Isomerism in coordination compounds. IUPAC nomenclature of coordination compounds; stereochemistry of complexes with 4, 5 and 6 coordination numbers; chelate effect and polynuclear complexes; trans effect and its theories; thermodynamic and kinetic stability of complexes.
- (5) Organometallic chemistry: Synthesis, structure and bonding in metal carbonyl complexes, metal olefin complexes and metal alkyne complexes. Oxidative addition reactions.

12. General chemistry of inner transition elements

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

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PAPER - II

1. Reaction mechanisms

General methods (both kinetic and non-kinetic) of study of mechanism of organic reactions illustrated by examples—use of isotopes, intermediate trapping, stereochemistry; energy diagrams of simple organic reactions—transition states and intermediates; energy of activation; thermodynamic control and kinetic control of reactions.

2. Reactive intermediates

Generation, geometry, stability and reactions of carbonium ions, carbanions, free radicals, carbenes and benzyne.

3. Name reactions

Aldol condensation, Claisen condensation, Perkin reaction, Knoevenagel reaction, Wittig reaction, Wolff-Kishner reduction, Cannizzaro reaction and von Richter reaction; benzoin condensation; Fischer indole synthesis, Skraup synthesis, Sandmeyer reaction, Reimer-Tiemann reaction and Reformatsky reaction.

4. Synthetic polymers

Addition or chain growth polymerization free radical vinyl polymerization, ionic vinyl polymerization, Ziegler-Natta polymerization, vinyl polymerization Condensation or step growth polymerization. Polyesters, polyamides, phenol-formaldehyde resins, urea-formaldehyde resins, epoxy resins.

5. Photochemistry

Photochemical reactions of simple organic compounds, excited and ground states, singlet and triplet states, Jablonski diagram. Fluorescence and phosphorescence. Quantum yield and energy transfer process.

6. Organic spectroscopy

Problems pertaining to the structure elucidation of simple organic compounds using UV-visible, IR and NMR spectroscopy.

7. Heterocyclic compounds

Molecular orbital picture and aromatic characteristic of pyrrole, furane, thiophene and pyridene. Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution. Comparison of basicity of pyridene, piperidine and pyrrole. Preparation and reactions of indole, quinoline and isoquinoline.

8. Stereochemistry of carbon compounds

Elements of symmetry, chiral and achiral compounds. Fischer projection formulae; optical isomerism of lactic and tartaric acids, enantiomerism and diastereoisomerism; configuration (relative and absolute); conformations of ethane and n-butane, and cyclohexane. D, L-and R, S-notations of compounds containing chiral centres; projection formulae-Fischer, Newman and Sawhorse of compounds containing two adjacent chiral centres; meso and dl-isomers, erythro and threo isomers; racemization and resolution; geometrical isomers; E and Z notations.

9. Organometallic compounds

Preparation and synthetic uses of Grignard reagents, alkyl lithium compounds.

10. Active methylene compounds

Diethyl malonate and ethyl acetoacetate-applications in organic synthesis; tautomerism (keto-enol).

11. Analytical chemistry

Errors in quantitative analysis, classification of errors, minimization of errors, precision and accuracy, significance of figures, co-precipitation and post-precipitation, optimum conditions for precipitation, choice of indicators in the acid-base titration, theories of indicators, principle of EDTA titration. Numerical questions on Quantitative estimation of pyrolusite, iodometry, silver coin, acid-base titration, redox titration.