CHEMISTRY

PAPER-I

1. Atomic Structure:

Heisenberg's uncertainty principle Schrödinger 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 H_2^+, H_2, He_2^+ to Ne_2, NO, CO, HF, 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 X-ray diffraction by crystals; Close packing, radius ratio rules, calculation of some limiting radius ratio values; Structures of NaCl, ZnS, CsCl, CaF_2; Stoichiometric and nonstoichiometric defects, impurity defects, semi-conductors.

4. The Gaseous State and Transport Phenomenon:

Equation of state for real gases, intermolecular 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, Cp and Cv, and βJ-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-Hückel theory of strong electrolytes and Debye-Hückel 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; electrocatalysis techniques: amperometry, ion and Poison; corrosion and their use.

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 the 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:

Adsorption 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 ferrodoxins.

13. Coordination Chemistry:
(i) Bonding in transition 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 Element:

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

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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 mechanisms or organic reactions: isotopies, method crossover experiment, intermediate trapping, stereochemistry; energy of activation; thermodynamic control and kinetic control of reactions.

(ii) Reactive Intermediates:

Generation, geometry, stability, and reactions of carboniumions and carbanions, free radicals, carbenes, benzynes, and nitrenes.

(iii) Substitution Reactions:

SN1, SN2, and SNi 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 E1CB mechanisms; orientation in E2 reactions—Saytzeff and Hoffmann; pyrolytic syn elimination—acetate pyrolysis, Chugaev and Cope eliminations.

(v) Addition Reactions:

Electrophilic addition to C=C and C≡C; nucleophilic addition to C=O, C=N, conjugated olefins and carbonyls.

(vi) Reactions and Rearrangements:

(a) Pinacol-pinacolone, Hofmann, Beckmann, Bayer-Villiger, Favorskii, Fries, Claisen, Cope, Stevens, and Wagner—Meerwein rearrangements.

(b) Aldol condensation, Claisen condensation, Dieckmann, Perkin, Knoevenagel, Wittig, 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, 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 $\pi \rightarrow \pi^*$ transitions; application to conjugated double bonds and conjugated carbonyls Woodward-Fieser rules; Charge transfer spectra.

(iv) Nuclear Magnetic Resonance (NMR):

Basic principle; chemical shift and spin-spin interaction and coupling constants.

(v) Mass Spectrometry:

Parent peak, base peak, metastable peak, McLafferty rearrangement.