Mains Syllabus of 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 in H2+, H2, He2+ to Ne2, 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 CaF2; Stoichiometric and nonstoichiometric defects, impurity defects, semi-conductors.


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, Cp and Cv α and β; J-T effect and inversion temperature; criteria for equilibrium, relation between equilibrium constant and thermodynamic quantities; Nernst's 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; electro-analytical 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-planer 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 ʻfʼ Block Elements**: 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, sydnone.

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, benzenes and nitrenes. (iii) Substitution Reactions: SN1, SN2 and SNi mechanisms; neighbouring group participation; electrophilic and nucleophilic reactions of aromatic compounds including heterocyclic compounds-pyrole, furan, thiophene and indole. (iv) Elimination Reactions: E1, E2 and E1cb 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=N; nucleophilic addition to C=0, C=N, conjugated olefins and carbonyls. (vi) Rearrangements: Pinacol-pinacolone, Hoffmann, Beckmann, Baeyer-Villiger, Favoritski, Fries, Claisen, Cope, Stevens and Wagner-Meerwein rearrangements. (b) Aldol condensation, Claisen condensation, Dieckmann, Perkin, Knoevenagel, Witting, Clemmensen, Wolff-Kishner, Cannizzaro and von Richler 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 - electro cyclic reactions, cycloaddition reactions [2+2 and 4+2] and sigma tropic 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**: OsO₄, HIO₄, CrO₃, Pb(OAc)₄, SeO₂, NBS, B₂H₆, Na-Liquid NH₃, LiAlH₄, NaBH₄, 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→π* and ππ*→ transitions; application to conjugated double bonds and conjugated carbonyl-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.