

**SYLLABUS FOR PRELIMINARY EXAMINATION FOR RECRUITMENT TO THE POSTS OF  
ASSISTANT MASTER/MISTRESS IN CHEMISTRY**

**Full Marks : 100**

**Time : 1 Hour 30 Minutes**

**Group - A  
Organic Chemistry**

**1. Bonding in organic molecules :**

$\sigma$  and  $\pi$  bonds, bond distance, bond angle, and bond energy. Dipole moment of organic molecules. Inductive, resonance and hyperconjugative effect. Hydrogen bond. Tautomerism, Aromaticity, Huckel's rule, aromatic, non aromatic and anti aromatic compounds. Effects of structure, substituents and solvent on acid and base strength.

**2. Stereo Chemistry of carbon compounds :**

Elements of symmetry. Chirality, Eanantiomerism and diastereo isomerism. Optical purity, racemization, resolution. Projection structure of stereoisomers – Fischer, Sawhorse, Newman, Flying – wedge DL, RS and EZ notations. Examples of enantiotopic and diastereotopic ligands and faces. Conformations of alkanes (upto 4 carbon), Cyclohexane, dimethylcyclohexanes and 1, 2 – glycols. Stereoisomerism in allenes and biphenyls (excluding RS notation).

**3. Reaction mechanism :**

General methods of study of mechanism of organic reactions illustrated by examples – use of isotopes, cross-over experiment, intermediate trapping, kinetic studies, stereochemistry. Energy profile diagrams of simple organic reactions, thermodynamic and kinetic control of reactions.

**4. Reactive intermediates :**

Generation, geometry, stability and reactions of carbocations, carbanions, free radicals, carbenes and benzyenes.

- 5.**
- a) **Substitution reaction** –  $S_N1$ ,  $S_N2$ ,  $S_Ni$  and NGP. Electrophilic and nucleophilic substitution of aromatic compounds.
  - b) **Elimination reaction** –  $E_1$ ,  $E_2$ ,  $E_1CB$  and Syn - elimination.
  - c) **Addition reaction** – electrophilic addition to  $C=C$  and  $C\equiv C$ , nucleophilic addition to  $C=O$ , conjugated olefins and carbonyls.
  - d) **Rearrangement reaction** :  
Pinacol-pinacolone, Hofmann, Beckmann, Claisen, Baeyer-Villiger, Favorskii.

**6. Chemistry and mechanism of :**

Aldol condensation, Claisen condensation, Perkin reaction, Knoevenagel reaction, Wittig reaction, Michael reaction Arndt Eistert reaction, Acyloin condensation, Friedel-Craft reaction and Von Richter reaction.

**7. Synthetic uses of reagents :**

$OsO_4$ ,  $HIO_4$ ,  $Pb(OAc)_4$ ,  $SeO_2$ ,  $LiAlH_4$ ,  $NaBH_4$ ,  $B_2H_6$ , NBS, PCC, Na or Li in liq- $NH_3$ , Alkyl lithium, Lithium dialkylcuprate, Lithium diisopropylamide, Aluminium isopropoxide.

- 8.** IUPAC nomenclature. Synthesis and reactions of alkanes, alkenes, alkynes, alkyl halides, ethers, alkanols, alkanals, alkanones, alkanolic acids, esters, amides, nitriles and amines.

**9. Pericyclic reaction :**

Definition and classification. FMO approach of electrocyclic, cycloaddition reactions and sigmatropic H-shifts.

- 10.** Basic principles and applications of UV, IR, and NMR spectroscopy of simple organic molecules. Road-map problems related to spectroscopy and organic reactions.

## Group - B

### Inorganic Chemistry

1. **Chemical bonding** :
  - a) **Ionic bonding** ;  
polarizing power and polarizability, ionic potential, Fajan's rules.
  - b) **Covalent bonding** :  
Lewis structures, VSEPR theory, Valence Bond theory (Heitler-London approach), Directional character of covalent bonds, hybridization, Bent's rule, concept of resonance. Molecular orbital theory (MO) elementary approach – sigma and pi bonds, multiple bonding, MO diagrams of simple homonuclear and heteronuclear diatomic molecule, simple triatomic molecules like BeH<sub>2</sub>, CO<sub>2</sub>, BF<sub>3</sub>, bond order, bond energy.  
Shapes of the molecules and ions containing lone pairs and bond pair.
  - c) **Weak Chemical forces** :  
Vander Waals forces; Hydrogen bonding, Effects of chemical forces on physical properties.
  - d) **Metallic bonding** :  
Qualitative ideas of band theory, Conducting, Semiconducting and insulating properties.
  
2. **Chemical periodicity** :
  - a) **Periodic Table** :  
Classification of elements on the basis of electronic configuration, Modern periodic Table (current IUPAC version).
  - b) **Atomic and ionic properties** :  
Effective nuclear charge, screening effect, Slater rules, atomic radii, ionic radii, covalent radii, ionization energies, electron affinity, electro-negativity, inert pair effect.
  
3. **Acid-Base Concepts** :  
Bronsted and Lowry's concept, Lewis concept, HSAB principle.
  
4. **Non-aqueous solvents** :  
Liquid ammonia and liquid sulphur dioxide.
  
5. **Coordination Compounds** :  
Double and complex salts, Werner's theory, Chelate complexes, nomenclature of complex compound, stereo chemistry and coordination number, isomerism of coordination compounds – geometrical and optical isomers in respect of coordination numbers 4 and 6.  
  
Bonding in coordination compounds : valence bond descriptions and its limitations, crystal field theory (elementary). Crystal field stabilization energies in weak and strong field cases mainly of octahedral and tetrahedral complexes.
  
6. **Magnetism and Colour** :  
Origin of magnetic moments, paramagnetism, diamagnetism, ferro and antiferromagnetism, orbital and spin contributions, spin only moments of 3d<sup>n</sup> ions.  
  
Theoretical aspects of d-d spectra (elementary idea) selection rules for spectral transitions.
  
7. **Organo metallic compounds** :  
Definition and classification, Metal-Carbon bonded complexes of transition metals – their preparation, properties and stability. Application of 18 electron rule to carbonyl, nitrosyl and cyanides of transition metals.
  
8. **The Chemical elements and its compounds** :
  - (a) (i) Group trends and periodic trends of effective nuclear charge, atomic and ionic radii, ionisation energies, electron affinity and electronegativity with respect to s-, p-, d- block elements.  
  
(ii) General trends of variation of electronic structures, elemental forms, oxidation states, catenation and properties of important class of compounds such as oxides, oxyacids, halides and formation of complex compounds with respect to the following groups of (i) Li, Na, K (ii) Be, Mg, Ca, Sr and Ba (iii) B, Al, Ga, In, Tl (iv) C, Si, Ge, Sn, Pb (v) N, P, As, Sb, Bi (vi) O, S, Se, Te (vii) F, Cl, Br, I. and (viii) Chemistry of noble gases.
  
9. **Extraction/Preparation/Isolation of the following elements** :
  - (i) Extraction and purification of Li, Mg, Sn, Pb.
  - (ii) Extraction and purification of Ti, V, Cr, Mn, Pt, Ag, Au, U.
  - (iii) Manufacture of Steel, Alloy Steels.
  
10. **Radioactivity and Atomic structure** :
  - (a) **Radioactivity** : Radioactive decay, half-life, Average life of radio elements, radioactive equilibrium Group displacement law, isotopes (uses of isotopes), isobars and isotones.
  - (b) **Atomic nucleus** : Fundamental particles of atomic nucleus, nuclear stability, neutron-proton ratio, nuclear binding energy. Nuclear forces.  
  
Transmutation of elements, fission, fusion reactions.
  - (c) **Extra nuclear structure** : Bohr's theory and its limitations, Sommerfield's modification, spectrum of H-atom.

## Group - C

### Physical Chemistry

1. **Quantum Theory** :

Black-body radiation and Planck's Law, photo-electric effect and photon concept of light, wave particle duality, de Broglie hypothesis, Heisenberg uncertainty principle, Schrodinger's wave equation (time independent), Interpretation of wave function particle in one-dimensional box, quantum numbers, hydrogen atom wave functions separation of radial and angular part, shapes of s, p and d orbitals.

2. **The Gaseous State** :

Kinetic theory of gases, equation of state of real gases, intermolecular interactions, liquefaction of gases and critical phenomena, Maxwell's distribution of speeds, features of kinetic energy distribution, mean speed, root mean square speed, most probable speed, principle of equipartition of energy, specific heats of gases, intermolecular collisions, collision number and mean free-path, viscosity of gases and mean free-path.

3. **The Liquid State** :

Nature of liquid state, surface tension, capillary rise, spreading of liquid over other surface, temperature dependence of surface tension. Measurement of surface tension, viscosity of liquids, origin of viscosity of gases and liquids, determination of viscosity coefficient, Poiseuille's equation, temperature dependence of viscosity coefficients of gases and liquids.

4. **Solid State** :

Forms of solids, laws of crystallography, crystal lattices, crystal systems and crystal classes, Bragg's Law, X-ray diffraction by crystals, crystal structure of NaCl, KCl, structure of diamond and graphite, Lattice energy, Born-Haber Cycle, Einstein's equation for heat capacity of solids, Debye equation (elementary concept).

5. **Thermodynamics** :

- a) Thermodynamic systems, states, processes, work, heat and internal energy, first law of thermodynamics, work done and heat absorbed in different types of processes. Reversible and irreversible process, energy and enthalpy changes in various processes and their temperature dependence.
- b) Second law of thermodynamics, Carnot's cycle and Carnot's theorem, absolute scale of temperature, entropy as a state function, entropy change in various processes, entropy – reversibility and irreversibility, Free-energy functions, criteria for spontaneity and equilibrium, physical concept of entropy, entropy and probability.
- c) Application thermochemistry, laws and their applications, Kirchoff's relation, Maxwell relation,  $C_p - C_v$  relation Joule-Thomson expansion, thermodynamic equation of state, Gibbs-Helmholtz equation, Clausius-Clapeyron relation and phase transition, colligative properties of dilute solutions.

6. **Reaction equilibrium** :

- a) Homogeneous equilibrium, relationship  $K_p, K_c, K_x$ . Van't Hoff's reaction isotherm (deduction using chemical potential). Temperature dependence of equilibrium constant, Le-Chatelier's principle, response of equilibria to different conditions.
- b) Ionic equilibrium, solubility product, dissociation constant of weak acids, ionic product of water, pH, buffer, indicators, hydrolysis of salt solutions.

7. **Electrochemistry** :

- a) Electrical conductance, weak and strong electrolytes, variation of equivalent conductance with dilution, Kohlrausch's law, transport number, determination of transport number by moving boundary method, theory of strong electrolytes, applications of conductance measurements.
- b) Galvanic cells, thermodynamic derivation of E.M.F. of chemical cells with examples, Transference cell, liquid junction potential and salt bridge, measurement of e.m.f. of cells and its applications, fuel cells and batteries.

8. **Chemical Kinetics** :

Concentration dependence of rate of reaction, differential and integral rate equations for zeroth, first, second order reactions, rate equations involving reverse, parallel, consecutive and chain reactions, effect of temperature and pressure on rate constant, collision and transition state theories of reaction rates.

9. **Photo Chemistry** :

Absorption of light, Lambert-Beer's law, laws of photochemistry, quantum yield, some typical photochemical reactions, HI-decomposition,  $\text{CH}_3\text{CHO}$ -decomposition,  $\text{H}_2 - \text{Br}_2$  reaction, photosensitized reaction, Fluorescence and phosphorescence.

10. **Surface phenomenon and Catalysis** :

Adsorption from gases and solutions on solid adsorbents, adsorption isotherms – Langmuir and B.E.T. isotherms, determination of surface area. Gibbs adsorption isotherms, surfactants, micelle formation. Characteristics and mechanism of homogeneous and heterogeneous catalytic reactions Enzyme catalysis.

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