Syllabus for the MSc. Chemistry Entrance Examination

Physical Chemistry:

1. Basic principles and applications of quantum mechanics: particle in one dimensional box, hydrogen atom, angular momentum.
2. Chemical kinetics: order, molecularity, methods to determine order of reaction using integrated rate equation, zero, first, second and half integral order reactions, determining the order- graphical method, half-life method, differential method, effect of temperature on reaction rate, Arrhenius equation, related numericals.
3. Basics of atomic structure: electronic configuration, shapes of orbitals, hydrogen atom spectra.
4. Electrolytic conductance: Electrolytic conductance, specific and equivalent conductance, variation of equivalent conductance with concentration, Kohlrausch's law and its applications.
5. Thermodynamics: Zero, first, second and third law of thermodynamics- enthalpy, entropy, free energy and their dependence on pressure and temperature.
6. Surface Chemistry: adsorption, physisorption and chemisorption, Freundlich and Langmuir adsorption isotherms, surface area determination.
7. Phase rule: Definitions, Gibb's phase rule, one component system (moderate pressure only) for sulphur and water system, two component system for silver-lead and zinc-cadmium.
8. Nuclear chemistry: The atom, nucleus and outer sphere, classification of nuclides, nuclear stability and binding energy, discovery of radioactivity, types of radioactivity, general characteristics of radioactive decay and decay kinetics, measurements radioactivity, gaseous ion collection method, proportional and G.M. counter, applications of radioactivity, radiochemical principles in the use of tracers, typical applications of radioisotopes as a tracer.
9. Crystal structure: Crystallization and fusion process, crystallography, crystal systems, properties of crystals, crystal lattice and unit cell, crystal structure analysis by X ray, The Laue's method and Bragg's method, X-ray analysis of NaCl crystal system, calculation of d and λ for a crystal system.
10. Electrochemical cells: Reversible and irreversible cells, EMF and its measurements, standard cells, cell reaction and EMF, single electrode potential and its calculation, calculation of cell EMF, thermodynamics of cell EMF, types of electrodes, classification of electrochemical cells with and without transference, applications of EMF measurement i) Solubility product of sparingly soluble salt, ii) Determination of pH, iii) Potentiometric titration.
11. Photochemistry: Introduction, thermal reactions and photochemical reactions, laws of photochemistry, quantum yield, measurement of quantum yield, types of photochemical reactions, photosynthesis, photolysis, photocatalysis, photosensitization, photophysical

process, fluorescence, phosphorescence, quenching, chemiluminescence.

Inorganic Chemistry:

1. Molecular Orbital Theory: Limitations of Valence Bond theory (VBT), need of Molecular Orbital Theory (MOT), features of MOT, formation of molecular orbitals (MO's) by LCAO principle, rules of LCAO combination, different types of combination of Atomic orbital (AO's): σ, π and δ MOs, Non-bonding combination of orbitals (formation of NBMO), M.O. energy level diagram for homonuclear diatomic molecules, bond order and existence of molecule from bond order.
2. Co-ordination chemistry: Coordinate bond, central metal atom or ions, ligand, double salt, complex compound, coordination number, charge on the complex ion, oxidation number of metal ion, first and second coordination sphere, ligands: definition, classification, chelates and chelating agents, formation constant, inert and labile complexes, IUPAC nomenclature of coordination compounds, different geometries of coordination compounds with C.N.= 4 to C.N.=10 and examples of each geometry.
3. Chemistry of the main group elements and their compounds: Allotropy, synthesis, bonding and structure.
4. Chemistry of transition elements and coordination compounds: Bonding theories, spectral and magnetic properties, reaction mechanisms.
5. Metals, semiconductors and Super conductors: Metallic bonding, band theory in metals with respect to Na along with n (E) and N(E) diagrams, Electrical conductivity of metals (Na, Mg, Al), valence electrons and conductivity.
6. Ionic Solids: Crystalline and amorphous solids, crystal structures, simple cubic, body centered cubic and face centered cubic, properties of ionic solids, packing arrangements of anions in an ionic solids, voids in crystal structure, tetrahedral and octahedral, ionic radius, Pauling's univalent and crystal radii, conversion of univalent radii to crystal radii, problems based on conversion of radii, radius ratio effect, Lattice energy, Born-Lande equation, Born Haber cycle and its applications, Schottky and Frenkel defect.
7. Heterogenous and homogenous catalysis.
8. Analytical chemistry: Separation techniques, spectroscopic electro- and thermoanalytical methods.
9. Bioinorganic chemistry: Photosystems, porphyrines, metalloenzymes, oxygen transport, electron-transfer reactions, nitrogen fixation.

Organic Chemistry:

1. IUPAC nomenclature of organic compounds.

2. Strength of organic acids and bases: pK_a, origin of acidity, influence of solvent, simple aliphatic saturated and unsaturated acids, substituted aliphatic acid, phenols, aromatic carboxylic acids, pK_a and temperature, pK_b, aliphatic and aromatic bases, heterocyclic bases, acid base catalysis.

3. Stereochemistry of disubstituted cyclohexane: 1,1-alkyl disubstituted cyclohexane; Dimethyl cyclohexane 1,2; 1,3 and 1,4; geometrical isomerism, optical isomerism, stability of conformation, energy calculations.

4. Nucleophilic substitution at aliphatic carbon: The SN^1 reaction: kinetics, mechanism and stereochemistry (Racemization), stability of carbocation. The SN^2 reaction: Kinetics, mechanism & stereochemistry (inversion), SNi reaction and mechanism.

5. Reactions of unsaturated hydrocarbons and carbon oxygen double bond: Mechanism of electrophilic addition to C=C bond, orientation & reactivity, rearrangements, (support for formation of carbocation), addition of hydrohalogen, Anti Markownikoff's addition (peroxide effect) with mechanism, addition of halogens (dl pairs and meso isomers), hypohalous acids (HOX), hydroxylation (mechanism of cis and trans 1,2-diols), hydroboration- oxidation (formation of alcohol), hydrogenation (formation of alkane), ozonolysis (formation of aldehydes & ketones).

6. Elimination reactions: 1,1; 1,2 elimination, E1, E2 and E1cB mechanism with evidences, Hoffmann and Saytzeff's elimination, reactivity effect of structure, attacking and leaving groups.

7. Aromatic Electrophilic and Nucleophilic Substitution reactions: Arenium ion mechanism, effect of substituent group (orientation, o/p directing and meta directing groups). classification of substituent groups (activating and deactivating groups), mechanism of – nitration, sulfonation, haloganation, Fridel-Crafts reactions, Diazo Coupling reactions, Ipso-substitution, Addition-elimination (SNAr), SN^1, Elimination-addition (Benzyne) SNR1 reactions, reactivity.

8. Carbanions and their reactions: Reactions involving carbanions and their mechanisms: Aldol, Claisen, Dieckmann and Perkin condensations. Synthesis and Synthetic applications of Malonic ester, Acetoacetic ester and Wittig reagent.

9. Retrosynthetic analysis and applications: Retrosynthesis and synthesis of target molecules: Acetophenone, Crotonaldehyde, Cyclohexene, Benzylbenzoate, and Benzyl diethyl malonate.

10. Rearrangement reactions: Mechanism of rearrangement reaction involving carbocation, nitriene and oxonium ion intermediate.Beckmann, Bayer-Villiger, Pinacol-pincolone, Curtis, Favorski, Claisen rearrangement.

11. Spectroscopic methods in structure determination of organic compounds: Different units of measurement of wavelength frequency, different regions of electromagnetic radiations. Interaction of radiation with matter, excitation of molecules with different energy levels, such as rotational, vibrational and electronic level, types of spectroscopy and advantages of spectroscopic methods.

12. Natural Products: Terpenoids and alkaloids

Biochemistry

1. Amino acids and proteins: Introduction, biological functions, classification-based on structure, function and composition. Structural organization of proteins- primary, secondary, tertiary and quarternary structures (general overview). Factors that stabilize protein structure. Denaturation of Proteins.
2. Carbohydrates: Introduction of carbohydrates, Introduction and biological significance of proteoglycans, Glycoproteins, Glycolipids, Analysis of carbohydrates.
3. Lipids: Introduction, Biological significance, Classification-Simple, compound, steroids and derived lipids. Structure of saturated and unsaturated fatty acids, structure of phospholipids (Phosphatidic acid, Lecithin, Cephalin, Lipositol), structure of Sphingomyelin and Cholesterol. Amphipathic lipids and their behavior in water. Saponification number, Acid number, Iodine number and their significance. Rancidity of lipids. Structural Lipids in membrane glycerophospholipids, Sulphalipids, Galactolipids, glycosphingolipids
4. Hormones: Definition, classification based on biochemical nature, location and mechanism of action.
5. Enzymes: Classification- Six major classes of enzymes, Conjugated enzymes- Apoenzyme, Holo-enzyme, prosthetic group (coenzymes and cofactors). Features of active site. Enzyme specificity, Factors affecting enzyme activity- substrate concentration, pH, temperature, and enzyme concentration, product concentration. MM equation, LB equation and significance of Km. Enzyme inhibition-competitive, non-competitive and uncompetitive with suitable examples. Allosteric enzymes and clinical significance of Isoenzymes.
6. Vitamins and Coenzymes: Classification- Fat soluble and water soluble vitamins (source, biological functions and deficiency disorders), coenzyme forms of vitamin B complex.
7. Cell Biochemistry: Introduction to Cell, Unicellular and Multicellular organisms, Distinguishing features of Prokaryotic and Eukaryotic cell. Structure and function of Cell membrane, Mitochondria, Endoplasmic reticulum, Golgi complex, Lysosomes, Peroxisomes, Plant cell wall and Chloroplast. Concepts of Biomolecules and types of bonds in biomolecules.
8. Biochemical techniques: Principle, working and applications of dialysis, Paper chromatography, TLC, Column chromatography- Gel filtration, Ion exchange, Affinity Chromatography. Electrophoresis- Paper and Gel (Agarose, Native and SDS- PAGE).