IIT Suggested Syllabus: Chemistry

Chemistry

- Chemistry Physical chemistry General topics: The theory of atoms and molecules; Dalton's atomic theory; Mole concept; Chemical formulae; Balanced chemical equations; Calculations based on the mole concept comprising common oxidation-reduction, neutralisation, and displacement reactions; Concentration in terms of mole fraction, molarity, molality and normality.

- Gaseous and liquid states: Absolute scale of temperature, ideal gas equation; Deviation from ideality, van der Waals equation; Kinetic theory of gases, average, root mean square and most probable velocities and their relation with temperature; Law of partial pressures; Vapour pressure; Diffusion of gases.

- Atomic structure and chemical bonding: Bohr model, spectrum of hydrogen atom, quantum numbers; Wave-particle duality, de Broglie hypothesis; Uncertainty principle; Quantum mechanical picture of hydrogen atom (qualitative treatment), shapes of s, p and d orbitals; Electronic configurations of elements (up to atomic number 36); Aufbau principle; Pauli's exclusion principle and Hund's rule; Orbital overlap and covalent bond; Hybridisation involving s, p and d orbitals only; Orbital energy diagrams for homonuclear diatomic species; Hydrogen bond; Polarity in molecules, dipole moment (qualitative aspects only); VSEPR model and shapes of molecules (linear, angular, triangular, square planar, pyramidal, square pyramidal, trigonal bipyramidal, tetrahedral and octahedral).

- Energetics: First law of thermodynamics; Internal energy, work and heat, pressure-volume work; Enthalpy, Hess's law; Heat of reaction, fusion and vaporization; Second law of thermodynamics; Entropy; Free energy; Criterion of spontaneity.

- Chemical equilibrium: Law of mass action; Equilibrium constant, Le Chatelier's principle (effect of concentration, temperature and pressure); Significance of? G and? Go in chemical equilibrium; Solubility product, common ion effect, pH and buffer solutions; Acids and bases (Bronsted and Lewis concepts); Hydrolysis of salts.

- Electrochemistry: Electrochemical cells and cell reactions; Electrode potentials; Nernst equation and its relation to? G; Electrochemical series, emf of galvanic cells; Faraday's laws of electrolysis; Electrolytic conductance, specific, equivalent and molar conductance, Kohlrausch's law; Concentration cells.

- Chemical kinetics: Rates of chemical reactions; Order of reactions; Rate constant; First order reactions; Temperature dependence of rate constant (Arrhenius equation).

- Solid state: Classification of solids, crystalline state, seven crystal systems (cell parameters a, b, c, a), close packed structure of solids (cubic), packing in fcc, bcc and hcp lattices; Nearest neighbours, ionic radii, simple ionic compounds, point defects.
- Solutions: Raoult's law; Molecular weight determination from lowering of vapor pressure, elevation of boiling point and depression of freezing point.
- Surface chemistry: Elementary concepts of adsorption (excluding adsorption isotherms); Colloids: Types, methods of preparation and general properties; Elementary ideas of emulsions, surfactants and micelles (only definitions and examples).
- Nuclear chemistry: Radioactivity: Isotopes and isobars; Properties of alpha, beta and X rays; Kinetics of radioactive decay (decay series excluded), Carbon dating; Stability of nuclei with respect to proton-neutron ratio; Brief discussion on fission and fusion reactions.
- Inorganic ChemistryIsolation/preparation and properties of the following non-metals: Boron, silicon, nitrogen, phosphorus, oxygen, sulphur and halogens; Properties of allotropes of carbon (only diamond and graphite), phosphorus and sulphur.
- Preparation and properties of the following compounds: Oxides, peroxides, hydroxides, carbonates, bicarbonates, chlorides and sulphates of sodium, potassium, magnesium and calcium; Boron: Diborane, boric acid and borax; Aluminium: Alumina, aluminium chloride and alums; Carbon: Oxides and oxyacid (carbonic acid); Silicon: Silicones, silicates and silicon carbide; Nitrogen: Oxides, oxyacids and ammonia; Phosphorus: Oxides, oxyacids (phosphorus acid, phosphoric acid) and phosphine; Oxygen: Ozone and hydrogen peroxide; Sulphur: Hydrogen sulphide, oxides, sulphurous acid, sulphuric acid and sodium thiosulphate; Halogens: Hydrohalic acids, oxides and oxyacids of chlorine, bleaching powder; Xenon fluorides; Fertilizers: Commercially available (common) NPK type.
- Transition elements (3d series): Definition, general characteristics, oxidation states and their stabilities, colour (excluding the details of electronic transitions) and calculation of spin-only magnetic moment; Coordination compounds: Nomenclature of mononuclear coordination compounds, cis-trans and ionization isomerisms, hybridization and geometries of mononuclear coordination compounds (linear, tetrahedral, square planar and octahedral).
- Preparation and properties of the following compounds: Oxides and chlorides of tin and lead; Oxides, chlorides and sulphates of Fe^{2+}, Cu^{2+} and Zn^{2+}; Potassium permanganate, potassium dichromate, silver oxide, silver nitrate, silver thiosulphate.
- Ores and minerals: Common ores and minerals of iron, copper, tin, lead, magnesium, aluminium, zinc and silver.
- Extractive metallurgy: Chemical principles and reactions only (industrial details excluded); Carbon reduction method (iron and tin); Self reduction method (copper and lead); Electrolytic reduction method (magnesium and aluminium); Cyanide process (silver and gold).

- Principles of qualitative analysis: Groups I to V (only Ag +, Hg2 +, Cu2 +, Pb2 +, Bi3 +, Fe3 +, Cr3 +, Al3 +, Ca2 +, Ba2 +, Zn2 +, Mn2 + and Mg2 +); Nitrate, halides (excluding fluoride), sulphate, sulphide and sulphite.

- Organic Chemistry Concepts: Hybridization of carbon; Sigma and pi-bonds; Shapes of molecules; Structural and geometrical isomerism; Optical isomerism of compounds containing up to two asymmetric centers (R, S and E, Z nomenclature excluded), IUPAC nomenclature of simple organic compounds (only hydrocarbons, mono-functional and bi-functional compounds); Conformations of ethane and butane (Newman projections); Resonance and hyperconjugation; Keto-enol tautomerism; Determination of empirical and molecular formula of simple compounds (only combustion method); Hydrogen bonds: Definition and their effects on physical properties of alcohols and carboxylic acids; Inductive and resonance effects on acidity and basicity of organic acids and bases; Polarity and inductive effects in alkyl halides; Reactive intermediates produced during homolytic and heterolytic bond cleavage; Formation, structure and stability of carbocations, carbanions and free radicals.

- Preparation, properties and reactions of Alkanes: Homologous series, physical properties of alkanes (melting points, boiling points and density); Combustion and halogenation of alkanes; Preparation of alkanes by Wurtz reaction and decarboxylation reactions.

- Preparation, properties and reactions of alkenes and alkynes: Physical properties of alkenes and alkynes (boiling points, density and dipole moments); Acidity of alkynes; Acid catalysed hydration of alkenes and alkynes (excluding the stereochemistry of addition and elimination); Reactions of alkenes with KMnO4 and ozone; Reduction of alkenes and alkynes; Preparation of alkenes and alkynes by elimination reactions; Electrophilic addition reactions of alkenes with X2, HX, HOX and H2O (X = halogen); Addition reactions of alkynes; Metal acetylides.

- Reactions of benzene: Structure and aromaticity; Electrophilic substitution reactions: Halogenation, nitration, sulphonation, Friedel-Crafts alkylation and acylation; Effect of o-, m-and p-directing groups in monosubstituted benzenes.

- Phenols: Acidity, electrophilic substitution reactions (halogenation, nitration and sulphonation); Reimer-Tieman reaction, Kolbe reaction.

- Characteristic reactions of the following (including those mentioned above): Alkyl halides: Rearrangement reactions of alkyl carbocation, Grignard reactions, nucleophilic substitution reactions; Alcohols: Esterification, dehydration and oxidation, reaction with sodium, phosphorus halides, ZnCl2/conc. HCl, conversion of alcohols into aldehydes and ketones; Aldehydes and Ketones: Oxidation, reduction, oxime and hydrazone formation; aldol condensation, Perkin reaction; Cannizzaro reaction; haloform reaction and nucleophilic addition reactions (Grignard addition); Carboxylic acids: Formation of esters, acid chlorides and amides, ester hydrolysis; Amines: Basicity of substituted anilines and aliphatic amines, preparation from nitro compounds, reaction with nitrous acid, azo coupling reaction of

diazonium salts of aromatic amines, Sandmeyer and related reactions of diazonium salts; carbylamine reaction; Haloarenes: Nucleophilic aromatic substitution in haloarenes and substituted haloarenes (excluding Benzyne mechanism and Cine substitution).

- Carbohydrates: Classification; mono and di-saccharides (glucose and sucrose); Oxidation, reduction, glycoside formation and hydrolysis of sucrose.
- Amino acids and peptides: General structure (only primary structure for peptides) and physical properties.
- Properties and uses of some important polymers: Natural rubber, cellulose, nylon, teflon and PVC.
- Practical organic chemistry: Detection of elements (N, S, halogens); Detection and identification of the following functional groups: Hydroxyl (alcoholic and phenolic), carbonyl (aldehyde and ketone), carboxyl, amino and nitro; Chemical methods of separation of mono-functional organic compounds from binary mixtures.