

Syllabus of the Integrated Ph.D. Chemical Sciences written test

Physical chemistry

Mathematical Concepts: Probability, Differential equations, vectors and matrices.
Atomic Structure: Electromagnetic radiations, Bohr's theory of hydrogen atom; Wave-particle duality; Uncertainty principles; Schrödinger's wave equation; Quantum numbers, shapes of orbitals; Hund's rule and Pauli's exclusion principle.

Theory of Gases: Kinetic theory of gases. Maxwell-Boltzmann distribution law; Equipartition of energy. Chemical Thermodynamics: Reversible and irreversible processes; First law and its application to ideal and non-ideal gases; Thermochemistry; Second law; Entropy and free energy, Criteria for spontaneity. Chemical and Phase Equilibria: Law of mass action; K_p , K_c , K_x and K_n ; Effect of temperature on K ; Ionic equilibria in solutions; pH and buffer solutions; Hydrolysis; Solubility product; Phase equilibria-Phase rule and its application to one-component and two-component systems; Colligative properties.

Electrochemistry: Conductance and its applications; Transport number; Galvanic cells; EMF and Free energy; Concentration cells with and without transport; Polarography.

Chemical Kinetics: Reactions of various order, Arrhenius equation, Collision theory; Theory of absolute reaction rate; Chain reactions- Normal and branched chain reactions; Enzyme kinetics; Photophysical and photochemical processes; Catalysis.

Colloids and Surfaces: Colloidal state of matter. Properties of lyophilic and lyophobic colloidal solutions. Thermodynamics of colloidal solutions. Determination of molecular weight of macromolecules. Surface energetics and adsorption.

Organic Chemistry

Aliphatic and Aromatic Hydrocarbons: Preparation, properties and their reactions. Reaction Intermediates and Stereoelectronic Effects

Mechanism of Organic Reactions: Nucleophilic substitution— SN^1 and SN^2 . Electrophilic addition to Carbon–Carbon double bond. Free radical addition to Olefins. Elimination reactions-E1 and E2.

Aromaticity and Antiaromaticity, Aromatic Electrophilic Substitution, Aromatic Nucleophilic Substitution: SN^{Ar} and Benzyne Mechanism.

Alkyl Halides: Preparation, properties and important reactions of alkyl halides.

Stereochemistry: Classification of Stereo isomers—Geometrical isomers—conformational analyses. Configuration—Wedge formula and Fischer projection formula—Newmann projection formula. Optical isomerism and chirality.

Alcohols and Phenols-Synthesis, 1°, 2° and 3° alcohols. Glycerol-preparation, properties and uses. Phenols and derivatives– preparation and properties. Pinacol-Pinacolone, Fries and Claisen rearrangements.

Carbonyl Compounds: Preparation of aldehydes and ketones-Rosenmund's reduction, Etard's reaction, Oppenauer oxidation, Houben-Hoesh synthesis. Oxidation, reduction, condensation and rearrangement reactions of aldehydes and ketones. Reactions of α,β -unsaturated carbonyl compounds.

Carboxylic acids and Derivatives – Hydroxy acids and their properties. Dicarboxylic acids- Aromatic acids- Aromatic sulphonic acids- Saccharin and chloramine-T, sulphanilic acid, sulphanilamide, and Sulpha drugs. Amino acids, Proteins and Nucleic acids.

Synthetic Reagents: Active methylene group. Grignard reagent, Frankland reagent, Reformatsky reaction, Claisen Condensation.

Nitrogen Compounds: Cyanides and Isocyanides –Aromatic nitro compounds- Benzidine rearrangement. Separation of 1°, 2° and 3° amines. Quaternary ammonium salts. Aromatic amines, diazonium salts-diazomethane, diazoacetic ester-Ardnt-Eistert synthesis, Wolf rearrangement.

Heterocyclic Compounds, Hoffmann's exhaustive methylation.

Carbohydrates: Anomers, mutarotation. Reactions of aldoses and ketoses. Epimer and Epimerisation. Disaccharides.

Dyes and Pigments: Polymer Chemistry:

Structure Determination: Structure determination of small organic molecules using IR, UV and NMR.

Inorganic Chemistry

Fundamental Concepts

Atomic structure, *Aufbau* principle, electron configuration, atomic orbitals, mole concept, ionization energy, electron affinity, electronegativity, polarization, shielding, oxidation and reduction, acids and bases, reduction potential, organization of elements in the periodic table

Chemistry of elements

Hydrogen compounds, alkali and alkaline earth metals, transition metals, main group elements, noble gases, lanthanides and actinides

Chemical Bonding

Octet rule, resonance structures, ionic and covalent compounds, Born-Haber cycle, valence bond theory, VSEPR model, molecular orbital theory for diatomic molecules, structures of simple solids

Coordination Chemistry and Organometallics

Coordination compounds, geometry, hapticity, chelation, isomerism, bonding models – valence bond theory and crystal field theory, transition metal carbonyls, 18 electron rule.