

**ENGINEERING/MEDICAL ENTRANCE EXAMINATIONS - 2005**  
**SYLLABUS - CHEMISTRY**

**UNIT 1: BASIC CONCEPTS AND ATOMIC STRUCTURE**

**Laws of chemical combination:** Law of conservation of mass. Law of definite proportion, Law of multiple proportions. Gay-Lussac's law of combining volumes. Dalton's atomic theory. Mole concept. Atomic, molecular and molar masses. Chemical equations. Balancing and calculation based on chemical equations.

**Atomic structure:** Fundamental particles. Rutherford model of atom. Nature of electromagnetic radiation. Emission spectrum of hydrogen atom. Bohr model of hydrogen atom. Drawbacks of Bohr model. Dual nature of matter and radiation. de Broglie relation. Uncertainty principle. Wave function (mention only). Atomic orbitals and their shapes (s, p and d orbitals only). Quantum numbers. Electronic configurations of elements. Pauli's exclusion principle. Hund's rule. Aufbau principle.

**UNIT 2: BONDING AND MOLECULAR STRUCTURE**

Kossel and Lewis approach of bonding. Ionic bond. Lattice energy. Born-Haber cycle. Covalent bond. Lewis structure of covalent bond. Concept of orbital overlap. VSEPR theory and geometry of molecules. Polarity of covalent bond. Valence bond theory and hybridization ( $sp$ ,  $sp^2$ ,  $sp^3$ ,  $dsp^2$ ,  $d^2sp^3$  and  $sp^3d^2$ ). Resonance. Molecular orbital method. Bond order. Molecular orbital diagrams of homodiatomic molecules. Bond strength and magnetic behaviour. Hydrogen bond. Coordinate bond. Metallic bond.

**UNIT 3: STATES OF MATTER**

**Gaseous state:** Boyle's law. Charles' law. Avogadro's hypothesis. Graham's law of diffusion. Absolute scale of temperature. Ideal gas equation. Gas constant and its values. Dalton's law of partial pressure. Aqueous tension. Kinetic theory of gases. Deviation of real gases from ideal behaviour. van der Waals equation. Liquefaction of gases. Joule-Thomson effect. Critical temperature.

**Liquid state:** Properties of liquids. Vapour pressure and boiling point. Surface tension. Viscosity.

**Solid state:** Types of solids (ionic, covalent and molecular). Space lattice and unit cells. Cubic crystal systems. X-ray studies of crystals. The Bragg equation. Close packing. Different voids (tetrahedral and octahedral only). Structures of simple ionic compounds of  $AB$  and  $AB_2$  types. Density calculations. Point defects (Frenkel and Schottky). Electrical properties of solids. Conductors, semiconductors and insulators. Piezoelectric and pyroelectric crystals. Magnetic properties of solids. Diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic and ferrimagnetic substances.

**UNIT 4: PERIODIC PROPERTIES OF ELEMENTS AND HYDROGEN**

**Classification of elements:** Mendeleev's periodic table. Atomic number and modern periodic law. Long form of periodic table. Electronic configurations of elements and their position in the periodic table. Classification into s-, p-, d- and f-block elements. **Periodic properties:** Ionization energy, electron affinity, atomic radii, valence and electronegativity.

**Hydrogen:** Position in the periodic table, occurrence, isolation, preparation (including commercial), properties, reactions and uses. Isotopes of hydrogen. **Hydrides:** Molecular, saline and interstitial hydrides. **Water:** Structure of water molecule and its aggregates. Physical and chemical properties of water. Hard and soft water. Removal of hardness. Preparation and uses of heavy water: Liquid hydrogen as fuel.

**UNIT 5: S-BLOCK ELEMENTS AND PRINCIPLES OF METALLURGY**

**Alkali metals:** Occurrence, electronic configuration, trends in atomic and physical properties (ionization energy, atomic radii and ionic radii), electrode potential, and reactions with oxygen, hydrogen, halogens and liquid ammonia. Oxides, hydroxides and halides.

**Alkaline earth metals:** Occurrence, electronic configuration, trends in atomic and physical properties, electrode potential, and reactions with oxygen, hydrogen and halogens. Oxides, hydroxides, halides and sulphides.

Anomalous properties of lithium and beryllium. **Compounds of s-block elements:** Large scale preparation of NaOH and  $Na_2CO_3$ , their properties and uses. Preparation and properties of CaO,  $Ca(OH)_2$ , Plaster of Paris and  $MgSO_4$ . Industrial uses of lime, limestone and cement.

**Principles of metallurgy:** Occurrence of metals. Concentration of ores. General principles of extraction of metals from ore. Refining of metals. Extraction of sodium, aluminium, iron and copper. Manufacture of steel. Different types of steel. Heat treatment and uses of steel.

#### UNIT 6: p-BLOCK ELEMENTS

**General characteristics of p-block elements:** atomic and physical properties. Oxidation states. Trends in chemical reactivity of Groups 13, 14, 15, 16 and 17 elements.

**Boron:** Occurrence, isolation, physical and chemical properties. Borax and boric acid. Boron hydrides. Structure of diborane. Uses of boron and its compounds. **Carbon:** Allotropes, properties, carbides, halides and sulphide. **Nitrogen:** Terrestrial abundance and distribution, isolation, properties and chemical reactivity. Fixation of nitrogen. **Ammonia:** Haber process of manufacture, properties and uses. **Nitric acid:** Ostwald process of manufacture and important uses. **Oxides of nitrogen:** Preparation and structures (skeletal only). **Oxygen:** Terrestrial abundance, isolation, properties and chemical reactivity. **Oxides:** Acidic, basic and amphoteric oxides. Preparation, structure, properties and uses of ozone and hydrogen peroxide.

**Silica:** Different forms and uses. Structures of silicates. **Phosphorus:** Production, allotropes and phosphine. Preparation and structures of  $\text{PCl}_3$ ,  $\text{PCl}_5$ ,  $\text{P}_4\text{O}_6$ ,  $\text{P}_4\text{O}_{10}$ , oxyacids of phosphorus. Comparison of halides, hydrides and oxides of Group 15 elements. **Sulphur:** Production, allotropes, oxides and halides. **Hydrogen sulphide:** Preparation, properties and uses in qualitative analysis. **Sulphuric acid:** Manufacture, properties and uses. Preparation and properties of  $\text{Na}_2\text{S}_2\text{O}_3$ . Comparison of oxides, halides and hydrides of Group 17 elements. Hydrides, oxides and oxyacids of chlorine. Preparation and properties of bleaching powder. Interhalogen compounds.

**Group 18 elements:** Occurrence, isolation, atomic and physical properties, uses. **Compounds of xenon:** Preparation of fluorides and oxides, and their reactions with water.

#### UNIT 7: d-BLOCK AND f-BLOCK ELEMENTS

**d-Block elements:** Electronic configuration and general characteristics. Metallic properties, ionization energy, electrode potential, oxidation states, ionic radii, catalytic properties, coloured ions, complex formation, magnetic properties, interstitial compounds and alloys. Preparation and properties of  $\text{KMnO}_4$ ,  $\text{K}_2\text{Cr}_2\text{O}_7$ ,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ,  $\text{AgNO}_3$ , and halides of silver and mercury. Photography.

**f-Block elements:** **Lanthanides:** Occurrence, electronic configuration and oxidation states. Lanthanide contraction. Uses. **Actinides:** Occurrence, electronic configuration and comparison with lanthanides.

#### UNIT 8: NUCLEAR CHEMISTRY

**Natural radioactivity:** Properties of alpha, beta and gamma radiations. Group displacement law. Nuclear stability and binding energy. Nuclear reactions. Radioactive disintegration series. Rate of radioactive disintegration and half life. **Artificial radioactivity:** Transmutation of elements. Nuclear energy. Nuclear fission and nuclear fusion. Nuclear reactors. Radio isotopes and their uses. Radiochemical dating. Synthetic elements.

#### UNIT 9: THERMODYNAMICS

**System and surrounding:** Types of systems. Types of processes. Intensive and extensive properties. State functions and path functions. Reversible and irreversible processes. Zeroth law. **First law of thermodynamics:** Internal energy and enthalpy. Application of first law of thermodynamics. Enthalpy changes during phase transition. Enthalpy changes in chemical reactions. Standard enthalpy of formation. Hess's law of constant heat summation and numerical problems. **Second law of thermodynamics:** Entropy and Gibbs free energy. Free energy change and chemical equilibrium. Criteria for spontaneity.

#### UNIT 10: CHEMICAL EQUILIBRIUM

**Physical and chemical equilibria:** Dynamic nature of equilibrium. Equilibria involving physical changes (solid-liquid, liquid-gas, dissolution of solids in liquids and dissolution of gases in liquids). General characteristics of equilibria involving physical processes. **Equilibria involving chemical systems:** Law of chemical equilibrium. Magnitude of equilibrium constant. Numerical problems. Effect of changing

conditions of systems at equilibrium (changes of concentration, temperature and pressure). Effect of catalyst. The Le Chatelier principle and its applications. Relationship between  $K_p$  and  $K_c$ . Ionic equilibrium. Ionization of weak and strong electrolytes. **Concepts of acids and bases:** Those of Arrhenius, Bronsted-Lowry and Lewis. Acid-base equilibrium. Ionization of water. pH scale. Salt hydrolysis. Theory of acid-base indicators. Solubility product. Common ion effect. Buffer action and buffer solutions.

#### UNIT 11: SOLUTIONS

**Types of solutions:** Different concentration terms (normality, molarity, molality, mole fraction and mass percentage). Solubility of gases and solids. Vapour pressure of solutions and Raoult's law. Deviation from Raoult's law. **Colligative properties:** Lowering of vapour pressure, elevation in boiling point, depression in freezing point and osmotic pressure. Ideal and non-ideal solutions. Determination of molecular mass. Abnormal molecular mass. The van't Hoff factor and related numerical problems

#### UNIT 12: REDOX REACTIONS AND ELECTROCHEMISTRY

**Oxidation and reduction:** Electron transfer concept. Oxidation number. Balancing equations of redox reactions: Oxidation number method and ion electron method (half reaction method).

**Faraday's laws of electrolysis:** Quantitative aspects. Electrolytic conduction. Conductance. Molar conductance. Kohlrausch's law and its applications. Electrode potential and electromotive force (e.m.f.). Reference electrode (SHE only). Electrolytic and Galvanic cells. Daniel cell. The Nernst equation. Free energy and e.m.f. Primary and secondary cells. Fuel cell ( $H_2-O_2$  only). **Corrosion and its prevention:** Electrochemical theory of rusting of iron. Methods of prevention of corrosion. Galvanization and cathodic protection.

#### UNIT 13: CHEMICAL KINETICS

Rate of reaction. Average and instantaneous rates. Rate expressions. Rate constant. Rate law. Order and molecularity. Integrated rate law expressions for zero and first order reactions and their derivations. Units of rate constant. Half life period. Temperature dependence of rate constant. Arrhenius equation. Activation energy and related numerical problems. Elementary and complex reactions with examples.

#### UNIT 14: SURFACE CHEMISTRY

**Adsorption:** Physical and chemical adsorption. Factors affecting adsorption. Effect of pressure. Freundlich adsorption isotherm. Langmuir adsorption isotherm. Catalysis. Enzymes. Zeolites. **Colloids:** Colloids and suspensions. Dispersion medium and dispersed phase. Types of colloids: Lyophobic, lyophilic, multimolecular, macromolecular and associated colloids. Preparation, properties and protection of colloids. Gold number. Hardy Schulze rule. Emulsions.

#### UNIT 15: COORDINATION COMPOUNDS AND ORGANOMETALLICS

Ligand. Coordination number. IUPAC nomenclature of coordination compounds. Isomerism in coordination compounds. Geometrical, optical and structural isomerism. Bonding in coordination compounds. Werner's coordination theory. Valence bond approach. Hybridization and geometry. Magnetic properties of octahedral, tetrahedral and square planar complexes. Introduction to crystal field theory. Splitting of d orbitals in octahedral and tetrahedral fields (qualitative only). Importance of coordination compounds in qualitative analysis and biological systems such as chlorophyll, hemoglobin and vitamin  $B_{12}$  (structures not included).

#### UNIT 16: BASIC PRINCIPLES, PURIFICATION AND CHARACTERIZATION OF ORGANIC COMPOUNDS

Distinction between organic and inorganic compounds. Tetra valence of carbon. Catenation. Hybridization ( $sp$ ,  $sp^2$  and  $sp^3$ ). Shapes of simple molecules. General introduction to naming of organic compounds. Trivial names and IUPAC nomenclature. Illustrations with examples. Structural isomerism. Examples of functional groups containing oxygen, hydrogen, sulphur and halogens. **Purification of carbon compounds:** Filtration, crystallization, sublimation, distillation, differential extraction and chromatography (column and paper only). **Qualitative analysis:** Detection of carbon, hydrogen, nitrogen and halogens. **Quantitative analysis:** Estimation of carbon, hydrogen, nitrogen, sulphur, phosphorus and halogens (principles only), and related numerical problems. **Determination of**

**molecular mass:** Silver salt method and chloroplatinate salt method. Calculation of empirical and molecular formulae.

### UNIT 17: HYDROCARBONS

Classification of hydrocarbons. **Alkanes and cycloalkanes:** Nomenclature and conformation of ethane, propane, butane and cyclohexane. 3D structures and 2D projections (Sawhorse and Newman).

**Alkenes and alkynes:** Nomenclature. Geometrical isomerism in alkenes. Stability of alkenes. General methods of preparation. Physical and chemical properties. Markownikoff's rule. Peroxide effect. Acidic character of alkynes. Polymerization reactions of dienes.

**Aromatic hydrocarbons:** Nomenclature. Isomerism. Source of aromatic hydrocarbons. Coal and petroleum. Benzene and its homologues. Structure of Benzene. Resonance. Delocalisation in benzene. Concept of aromaticity (an elementary idea). Chemical reactions of benzene. Polynuclear hydrocarbons and their toxicity.

**Petroleum and petrochemicals:** Composition of crude oil. Fractionation. Uses of different fractions. Quality of gasoline. LPG and CNG. Cracking and reforming of petrochemicals

### UNIT 18: ORGANIC REACTION MECHANISM

**Electronic displacement in a covalent bond:** Inductive, electromeric, resonance and hyperconjugation effects. Fission of a covalent bond. Free radicals, electrophiles, nucleophiles, carbocations and carbanions.

**Common types of organic reactions:** Substitution, addition, elimination and rearrangement reactions. Illustrations with examples. Mechanism of electrophilic addition reactions in alkenes. Concept of delocalisation of electrons. Addition reactions in dienes (1,2- and 1,4- additions). Mechanism of electrophilic substitution reactions. Directive influence of substituents and their effect on reactivity (in benzene ring only).

### UNIT 19: STEREOCHEMISTRY

**Stereoisomerism:** Geometrical isomerism and optical isomerism. Specific rotation. Chirality and chiral objects. Chiral molecules. Configuration and Fischer projections. Asymmetric carbon. Elements of symmetry. Compounds containing one chiral center. Enantiomers. Racemic form. Racemization. Compounds containing two chiral centers. Diastereo isomers. Meso form. Resolution. Importance of stereochemistry.

### UNIT 20: ORGANIC COMPOUNDS WITH FUNCTIONAL GROUPS CONTAINING HALOGENS

**Haloalkanes and haloarenes:** Nomenclature and general methods of preparation. Physical properties. Nature of C-X bond in haloalkanes and haloarenes. Chemical properties and uses of chloromethane and chlorobenzene. **Polyhalogen compounds:** Preparation and properties of chloroform and iodoform. Uses of some commercially important compounds (chloroform, iodoform, DDT, BHC and freon).

### UNIT 21: ORGANIC COMPOUNDS WITH FUNCTIONAL GROUPS CONTAINING OXYGEN

**Alcohols:** Nomenclature. Important methods of preparation (from aldehydes, ketones, alkyl halides and hydration of alkenes). Manufacture of ethanol from molasses and starch. Physical and chemical properties. Reactions with alkali metals and acids. Formation of alkenes, ethers and esters. Reactions with  $PX_3$ ,  $PX_5$ ,  $SOCl_2$ . Oxidation of alcohols. Dehydrogenation.

**Phenols:** Nomenclature. Preparation of phenol (from sodium benzenesulphonate, benzene diazoniumchloride and chlorobenzene). Physical and chemical properties of phenol. Acidity of phenol. Action of phenol with  $FeCl_3$ . Bromination, sulphonation and nitration of phenol.

**Ethers:** Nomenclature. Methods of preparation (from alcohols and alkyl halides). Williamson's synthesis. Physical and chemical properties. Formation of peroxides. Actions with HI, HF and  $H_2SO_4$ .

**Some commercially important compounds:** Methanol, ethanol (fermentation), glycol and glycerol. Ascending and descending in alcohol series.

**Aldehydes and ketones:** Nomenclature. Electronic structure of carbonyl group. Methods of preparation (from alcohols, acid chlorides, ozonolysis of alkenes and hydration of alkynes). Friedel-Crafts acylation for acetophenone. General properties (physical and chemical) of aldehydes and ketones. Formation of paraldehyde and metaldehyde. Addition of  $NaHSO_3$ ,  $NH_3$  and its derivatives,

Grignard reagent, HCN and alcohols. Oxidation reactions with Tollen's reagent and Fehling's solution. Oxidation of ketones. Reduction with  $\text{LiAlH}_4$ . Clemmensen reduction. Wolff-Kishner reduction. Aldol condensation. Cannizzaro reaction.

**Carboxylic acid:** Nomenclature. Electronic structure of  $-\text{COOH}$ . Methods of Preparation (from alcohols, aldehydes, ketones, alkyl benzenes and hydrolysis of cyanide). Physical properties. Effects of substituents on acid strength. Chemical reactions.

**Derivatives of carboxylic acids:** Nomenclature. Esters, acid chlorides, amides and anhydrides. Important methods of preparation.

## UNIT 22: ORGANIC COMPOUNDS WITH FUNCTIONAL GROUPS CONTAINING NITROGEN

**Nitrocompounds:** Nomenclature. Electronic structure of nitro group. Preparation and properties.

**Amines:** Nomenclature. Primary, secondary and tertiary amines. Methods of preparation. Physical properties. Basic nature. Chemical reaction. Separation of primary, secondary and tertiary amines. Cyanides and isocyanides. Diazonium salts. Preparation and chemical reactions of benzene diazoniumchloride in synthetic organic chemistry.

## UNIT 23: POLYMERS AND BIOMOLCULES

**Polymers:** Classification. Addition and condensation polymerization. Copolymerization. Natural rubber and vulcanization. Synthetic rubbers. Condensation polymers. Biopolymers. Biodegradable polymers. Some commercially important polymers: Polyethylene, polystyrene, PVC, Teflon, PAN, BUNA-N, BUNA-S, neoprene, Terylene, glyptal, nylon-6, nylon-66 and Bakelite.

**Biomolecules:** The cell energy cycle. Classification of carbohydrates. Structure and properties of glucose. **Reducing and non-reducing sugars:** Properties of sucrose, maltose and lactose (structures not included). **Polysaccharides:** Properties of starch and cellulose. **Proteins:** Amino acids. Zwitterions. Peptide bond. Polypeptides. Primary, secondary and tertiary structures of protein. Denaturation of proteins. Enzymes. Nucleic acids. Types of nucleic acids. DNA and RNA, and their chemical composition. Primary structure of DNA. Double helix. Replication, translation and transcription. Protein synthesis. Genetic code. **Lipids:** Classification, structural features and functions in biosynthesis. **Hormones:** Classification, structural features and functions in biosystems. **Vitamins:** Classification and functions in biosystems.

## UNIT 24: ENVIRONMENTAL CHEMISTRY AND CHEMISTRY IN EVERY DAY LIFE

Soil, water and air pollutions. Ozone layer. Smog. Acid rain. Green house effect and global warming. Industrial air pollution. Importance of green chemistry.

Chemicals in medicine and health care. Analgesics, tranquillizers, antiseptics, antacids and dyes. Classification of dyes with examples. Indigo, methyl orange and alizarin. Chemicals in cosmetics: Creams, perfumes, talc powder and deodorants. Advanced materials: Carbon fibers, ceramics, chemicals in food, preservatives, artificial sweetening agents, antioxidants and edible colours. Insect repellents. Pheromones. Sex attractants. Rocket propellants: Characteristics and chemicals used.

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