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SYLLABUS 2026–27

CHEMISTRY

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PHYSICAL CHEMISTRY – UNITS 1 TO 8

UNIT 01 SOME BASIC CONCEPTS IN CHEMISTRY

- Matter and its nature, Dalton's atomic theory: concept of atom, molecule, element and compound; laws of chemical combination; atomic and molecular masses, mole concept, molar mass, percentage composition, empirical and molecular formulae; chemical equations and stoichiometry.

UNIT 02 ATOMIC STRUCTURE

- Nature of electromagnetic radiation, photoelectric effect; spectrum of the hydrogen atom. Bohr model of a hydrogen atom – its postulates, derivation of the relations for the energy of the electron and radii of the different orbits, limitations of Bohr's model; dual nature of matter, de Broglie's relationship. Heisenberg uncertainty principle.
- Elementary ideas of quantum mechanics, the quantum mechanical model of the atom, its important features. Concept of atomic orbitals as one-electron wave functions; variation of ψ and ψ^2 with r for 1s and 2s orbitals.
- Various quantum numbers (principal, angular momentum and magnetic quantum numbers) and their significance; shapes of s, p and d orbitals, electron spin and spin quantum number; rules for filling electrons in orbitals – Aufbau principle, Pauli's exclusion principle and Hund's rule, electronic configuration of elements, extra stability of half-filled and completely filled orbitals.

UNIT 03 CHEMICAL BONDING AND MOLECULAR STRUCTURE

- Kossel–Lewis approach to chemical bond formation, the concept of ionic and covalent bonds.
- **Ionic bonding:** Formation of ionic bonds, factors affecting the formation of ionic bonds; calculation of lattice enthalpy.
- **Covalent bonding:** Concept of electronegativity. Fajan's rule, dipole moment; Valence Shell Electron Pair Repulsion (VSEPR) theory and shapes of simple molecules.
- Quantum mechanical approach to covalent bonding: Valence bond theory – its important features, the concept of hybridization involving s, p and d orbitals; resonance.
- **Molecular orbital theory:** Its important features. LCAOs, types of molecular orbitals (bonding, antibonding), sigma and pi bonds, molecular orbital electronic configurations of homonuclear diatomic molecules, the concept of bond order, bond length and bond energy.
- Elementary idea of metallic bonding. Hydrogen bonding and its applications.

UNIT 04 CHEMICAL THERMODYNAMICS

- **Fundamentals of thermodynamics:** System and surroundings, extensive and intensive properties, state functions, types of processes.
- **The first law of thermodynamics:** Concept of work, heat, internal energy and enthalpy, heat capacity, molar heat capacity; Hess's law of constant heat summation; enthalpies of bond dissociation, combustion, formation, atomization, sublimation, phase transition, hydration, ionization and solution.

- **The second law of thermodynamics:** Spontaneity of processes; ΔS of the universe and ΔG of the system as criteria for spontaneity. ΔG° (standard Gibbs energy change) and equilibrium constant.

UNIT 05 SOLUTIONS

- Different methods for expressing the concentration of a solution – molality, molarity, mole fraction, percentage (by volume and mass both).
- The vapour pressure of solutions and Raoult's law – ideal and non-ideal solutions, vapour pressure–composition plots for ideal and non-ideal solutions.
- Colligative properties of dilute solutions – relative lowering of vapour pressure, depression of freezing point, elevation of boiling point and osmotic pressure; determination of molecular mass using colligative properties; abnormal value of molar mass, van't Hoff factor and its significance.

UNIT 06 EQUILIBRIUM

- Meaning of equilibrium, the concept of dynamic equilibrium.
- **Equilibria involving physical processes:** Solid–liquid, liquid–gas and solid–gas equilibria, Henry's law. General characteristics of equilibrium involving physical processes.
- **Equilibrium involving chemical processes:** Law of chemical equilibrium, equilibrium constants (K_p and K_c) and their significance, the significance of ΔG and ΔG° in chemical equilibrium, factors affecting equilibrium – concentration, pressure, temperature, the effect of catalyst; Le Chatelier's principle.
- **Ionic equilibrium:** Weak and strong electrolytes, ionization of electrolytes, various concepts of acids and bases (Arrhenius, Brønsted–Lowry and Lewis) and their ionization, acid–base equilibria (including multistage ionization) and ionization constants, ionization of water. pH scale, common ion effect, hydrolysis of salts and pH of their solutions, the solubility of sparingly soluble salts and solubility products, buffer solutions.

UNIT 07 REDOX REACTIONS AND ELECTROCHEMISTRY

- Electronic concepts of oxidation and reduction, redox reactions, oxidation number, rules for assigning oxidation number, balancing of redox reactions.
- Electrolytic and metallic conduction, conductance in electrolytic solutions, molar conductivities and their variation with concentration; Kohlrausch's law and its applications.
- Electrochemical cells – electrolytic and galvanic cells, different types of electrodes, electrode potentials including standard electrode potential, half-cell and cell reactions, emf of a galvanic cell and its measurement; Nernst equation and its applications; relationship between cell potential and Gibbs energy change; dry cell and lead accumulator; fuel cells.

UNIT 08 CHEMICAL KINETICS

- Rate of a chemical reaction, factors affecting the rate of reactions: concentration, temperature, pressure and catalyst; elementary and complex reactions, order and molecularity of reactions, rate law, rate constant and its units, differential and integral forms of zero and first-order reactions, their characteristics and half-lives, the effect of temperature on the rate of reactions, Arrhenius theory, activation energy and its calculation, collision theory of bimolecular gaseous reactions (no derivation).

INORGANIC CHEMISTRY – UNITS 9 TO 12

UNIT 09 CLASSIFICATION OF ELEMENTS AND PERIODICITY IN PROPERTIES

- Modern periodic law and present form of the periodic table, s, p, d and f block elements, periodic trends in properties of elements – atomic and ionic radii, ionization enthalpy, electron gain enthalpy, valence, oxidation states and chemical reactivity.

UNIT 10 P-BLOCK ELEMENTS

- **Group 13 to Group 18 elements.** General introduction: electronic configuration and general trends in physical and chemical properties of elements across the periods and down the groups; unique behaviour of the first element in each group.

UNIT 11 D- AND F-BLOCK ELEMENTS

- **Transition elements:** General introduction, electronic configuration, occurrence and characteristics, general trends in properties of the first-row transition elements – physical properties, ionization enthalpy, oxidation states, atomic radii, colour, catalytic behaviour, magnetic properties, complex formation, interstitial compounds, alloy formation; preparation, properties and uses of $K_2Cr_2O_7$ and $KMnO_4$.
- **Inner transition elements:** Lanthanoids – electronic configuration, oxidation states and lanthanoid contraction. Actinoids – electronic configuration and oxidation states.

UNIT 12 COORDINATION COMPOUNDS

- Introduction to coordination compounds. Werner's theory; ligands, coordination number, denticity, chelation; IUPAC nomenclature of mononuclear coordination compounds, isomerism; bonding – valence bond approach and basic ideas of crystal field theory, colour and magnetic properties; importance of coordination compounds (in qualitative analysis, extraction of metals and in biological systems).

ORGANIC CHEMISTRY – UNITS 13 TO 20

UNIT 13 PURIFICATION AND CHARACTERISATION OF ORGANIC COMPOUNDS

- **Purification:** Crystallization, sublimation, distillation, differential extraction and chromatography – principles and their applications.
- **Qualitative analysis:** Detection of nitrogen, sulphur, phosphorus and halogens.
- **Quantitative analysis** (basic principles only): Estimation of carbon, hydrogen, nitrogen, halogens, sulphur, phosphorus.
- Calculations of empirical formulae and molecular formulae; numerical problems in organic quantitative analysis.

UNIT 14 SOME BASIC PRINCIPLES OF ORGANIC CHEMISTRY

- Tetravalency of carbon; shapes of simple molecules – hybridization (s and p); classification of organic compounds based on functional groups: those containing halogens, oxygen, nitrogen and sulphur; homologous series; isomerism – structural and stereoisomerism.
- Nomenclature (trivial and IUPAC).

- Covalent bond fission – homolytic and heterolytic: free radicals, carbocations and carbanions; stability of carbocations and free radicals, electrophiles and nucleophiles.
- Electronic displacement in a covalent bond – inductive effect, electromeric effect, resonance and hyperconjugation.
- Common types of organic reactions – substitution, addition, elimination and rearrangement.

UNIT 15 HYDROCARBONS

- Classification, isomerism, IUPAC nomenclature, general methods of preparation, properties and reactions.
- **Alkanes** – Conformations: Sawhorse and Newman projections (of ethane); mechanism of halogenation of alkanes.
- **Alkenes** – Geometrical isomerism; mechanism of electrophilic addition: addition of hydrogen, halogens, water, hydrogen halides (Markownikoff's and peroxide effect); ozonolysis and polymerization.
- **Alkynes** – Acidic character; addition of hydrogen, halogens, water and hydrogen halides; polymerization.
- **Aromatic hydrocarbons** – Nomenclature, benzene – structure and aromaticity; mechanism of electrophilic substitution: halogenation, nitration, Friedel–Crafts alkylation and acylation, directive influence of the functional group in monosubstituted benzene.

UNIT 16 ORGANIC COMPOUNDS CONTAINING HALOGENS

- General methods of preparation, properties and reactions; nature of C–X bond; mechanisms of substitution reactions.
- Uses; environmental effects of chloroform, iodoform, freons and DDT.

UNIT 17 ORGANIC COMPOUNDS CONTAINING OXYGEN

- General methods of preparation, properties, reactions and uses.
- **Alcohols:** Identification of primary, secondary and tertiary alcohols; mechanism of dehydration.
- **Phenols:** Acidic nature, electrophilic substitution reactions: halogenation, nitration and sulphonation. Reimer–Tiemann reaction.
- **Ethers:** Structure.
- **Aldehydes and ketones:** Nature of carbonyl group; nucleophilic addition to >C=O group, relative reactivities of aldehydes and ketones; important reactions such as – nucleophilic addition reactions (addition of HCN, NH_3 and its derivatives), Grignard reagent; oxidation; reduction (Wolff–Kishner and Clemmensen); the acidity of α-hydrogen, aldol condensation, Cannizzaro reaction, haloform reaction, chemical tests to distinguish between aldehydes and ketones.
- **Carboxylic acids:** Acidic strength and factors affecting it.

UNIT 18 ORGANIC COMPOUNDS CONTAINING NITROGEN

- General methods of preparation, properties, reactions and uses.
- **Amines:** Nomenclature, classification, structure, basic character and identification of primary, secondary and tertiary amines and their basic character.
- **Diazonium salts:** Importance in synthetic organic chemistry.

UNIT 19 BIOMOLECULES

- General introduction and importance of biomolecules.
- **Carbohydrates** – Classification; aldoses and ketoses; monosaccharides (glucose and fructose) and constituent monosaccharides of oligosaccharides (sucrose, lactose and maltose).
- **Proteins** – Elementary idea of α-amino acids, peptide bond, polypeptides. Proteins: primary, secondary, tertiary and quaternary structure (qualitative idea only), denaturation of proteins, enzymes.
- **Vitamins** – Classification and functions.
- **Nucleic acids** – Chemical constitution of DNA and RNA. Biological functions of nucleic acids.
- **Hormones** (general introduction).

UNIT 20 PRINCIPLES RELATED TO PRACTICAL CHEMISTRY

- Detection of extra elements (nitrogen, sulphur, halogens) in organic compounds; detection of the following functional groups: hydroxyl (alcoholic and phenolic), carbonyl (aldehyde and ketones), carboxyl and amino groups in organic compounds.
- The chemistry involved in the preparation of the following: **Inorganic compounds:** Mohr's salt, potash alum. **Organic compounds:** Acetanilide, p-nitroacetanilide, aniline yellow, iodoform.
- The chemistry involved in the titrimetric exercises – acids, bases and the use of indicators, oxalic acid vs $KMnO_4$, Mohr's salt vs $KMnO_4$.
- Chemical principles involved in the qualitative salt analysis: **Cations** – Pb^{2+}, Cu^{2+}, Al^{3+}, Fe^{3+}, Zn^{2+}, Ni^{2+}, Ca^{2+}, Ba^{2+}, Mg^{2+}, NH_4^+. **Anions** – CO_3^{2-}, S^{2-}, SO_4^{2-}, NO_3^-, NO_2^-, Cl^-, Br^-, I^- (insoluble salts excluded).
- Chemical principles involved in the following experiments:
  1. Enthalpy of solution of $CuSO_4$.
  2. Enthalpy of neutralization of strong acid and strong base.
  3. Preparation of lyophilic and lyophobic sols.
  4. Kinetic study of the reaction of iodide ions with hydrogen peroxide at room temperature.