Syllabi for screening tests and interviews

A. Biology

1. General Biology

- Characteristics of living organisms
- Viruses, prokaryotic & eukaryotic organisms
- Plant, animal, microbial taxonomy
- Physiology, metabolism, and cellular organization

2. Biochemistry, Biophysics, Cell and Molecular Biology

- Buffers, trace elements in biological systems
- Enzymes and proteins
- Structure of biomolecules and bio-molecular interactions
- Carbohydrate, lipid, and nucleic acid metabolism
- Thermodynamics and kinetics of biological systems
- Biochemical, biophysical, and molecular biology methods
- Mutations, DNA repair, replication, and recombination
- Transcription, translation, gene regulation
- Structural organization and function of intracellular organelles
- Cell membrane structure and function
- Cell division & cell cycle
- Recombinant DNA technology

3. Plant and Animal Physiology

- Photosynthesis
- Respiration
- Growth and development
- Digestive, locomotory, circulatory, excretory, and nervous systems
- Immune systems, antigens, and antibodies

4. Genetics and Genomics

- Mendelian genetics and heredity
- Chromosome structure and function
- Genetic interactions
- Microbial genetics
- Genome composition and organization

5. Organismal Biology

- Diversity of organisms
- Principles of ecology and evolution
- Population biology, conservation biology

6. Chemistry, Mathematics and Physics

- Topics at 10+2 level

B. Chemistry

Physical Chemistry

- **Basic Mathematical Concepts**: Functions; maxima and minima; integrals; ordinary differential equations; vectors and matrices; determinants; basics of statistics and probability theory.
- **Atomic and Molecular Structure**: Fundamental particles; Bohr's theory of hydrogen-like atom; wave-particle duality; uncertainty principle; Schrödinger's wave equation; quantum numbers; shapes of orbitals; Hund's rule and Pauli's exclusion principle; electronic configuration of simple homonuclear diatomic molecules.
- **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; Kp, Kc, Kx and Kn; 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; transition state theory; chain reactions – normal and branched; enzyme kinetics; 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.
- **Spectroscopy:** Beer-Lambert law; fundamental concepts of rotational, vibrational, electronic and magnetic resonance spectroscopy.

Organic Chemistry

- **Aliphatic and Aromatic Hydrocarbons:** Preparation, properties and their reactions. Reaction intermediates and stereo-electronic effects.
- **Mechanism of Organic Reactions**: Nucleophilic substitution reactions, electrophilic addition to carbon–carbon double bond, free radical addition to olefins, elimination reactions.
- **Aromatic Compounds and their reactions**: Aromaticity and antiaromaticity, aromatic electrophilic substitution, aromatic nucleophilic substitution: S_NAr 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, Oppeanauer 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.
- **Synthetic Reagents**: Active methylene group. Grignard reagent, Frankland reagent, Reformatsky reaction, and 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.
- Overview of amino acids, proteins, nucleic acids, dyes and pigments, polymer Chemistry
- **Structure Determination**: Structure determination of small organic molecules using IR, UV and NMR.

Inorganic Chemistry

- **Fundamental concepts**: Organization of elements in the periodic table, Periodic trends of the properties of the elements. Acids and bases, Redox reactions and reduction potentials.
- **Chemical Bonding and Shapes of Compounds**: Types of bonding; VSEPR theory and shapes of molecules; hybridization; dipole moment; ionic solids; structure of NaCl, CsCl, diamond and graphite; lattice energy.
- **Main Group Elements (s and p blocks)**: General concepts on group relationships and gradation in properties; structure of electron deficient compounds involving main group elements.
- **Transition Metals (d block)**: Characteristics of 3d elements; oxide, hydroxide and salts of first row metals; coordination complexes: structure, isomerism, reaction mechanism and electronic spectra; VB, MO and Crystal Field theoretical approaches for structure, color and magnetic properties of metal complexes; organometallic compounds having ligands with back bonding capabilities such as metal carbonyls.
- **Bioinorganic Chemistry**: Essentials and trace elements of life; basic reactions in the biological systems and the role of metal ions, especially Fe^{2+}, Fe^{3+}, Cu^{2+} and Zn^{2+}; structure and function of haemoglobin, myoglobin, and carbonic anhydrase.

C. Mathematics

- **Sequences and Series of Real Numbers:** Sequence of real numbers, convergence of sequences, bounded and monotone sequences, convergence criteria for sequences of real numbers, Cauchy sequences, subsequences, Bolzano-Weierstrass theorem. Series of real numbers, absolute convergence, tests of convergence for series of positive terms – comparison test, ratio test, root test; Leibniz test for convergence of alternating series.
- **Functions of One Real Variable:** Limit, continuity, intermediate value property, differentiation, Rolle's Theorem, mean value theorem, L'Hospital rule, Taylor's theorem, maxima and minima.
- **Functions of Two or Three Real Variables:** Limit, continuity, partial derivatives, differentiability, maxima and minima.
- **Integral Calculus:** Integration as the inverse process of differentiation, definite integrals and their properties, fundamental theorem of calculus. Double and triple integrals, change of order of integration, calculating surface areas and volumes using double integrals, calculating volumes using triple integrals.
- **Differential Equations:** Ordinary differential equations of the first order of the form $y'=f(x,y)$, Bernoulli's equation, exact differential equations, integrating factor, orthogonal trajectories, homogeneous differential equations, variable separable equations, linear differential equations of second order with constant coefficients, method of variation of parameters, Cauchy-Euler equation.
- **Vector Calculus:** Scalar and vector fields, gradient, divergence, curl, line integrals, surface integrals, Green, Stokes and Gauss theorems.
- **Group Theory:** Groups, subgroups, Abelian groups, non-Abelian groups, cyclic groups, permutation groups, normal subgroups, Lagrange's Theorem for finite groups, group homomorphisms and basic concepts of quotient groups.
- **Linear Algebra:** Finite dimensional vector spaces, linear independence of vectors, basis, dimension, linear transformations, matrix representation, range space, null space, rank-nullity theorem. Rank and inverse of a matrix, determinant, solutions of systems of linear equations, consistency conditions, eigenvalues and eigenvectors for matrices, Cayley-Hamilton theorem.
- **Real Analysis:** Interior points, limit points, open sets, closed sets, bounded sets, connected sets, compact sets, completeness of R. Power series (of real variable), Taylor's series, radius and interval of convergence, term-wise differentiation and integration of power series.

D. Physics

- **Mathematical Methods**: Calculus of single and multiple variables, partial derivatives, Jacobian, imperfect and perfect differentials, Taylor expansion, Fourier series. Vector algebra, Vector Calculus, Multiple integrals, Divergence theorem, Green's theorem, Stokes' theorem. First order equations and linear second order differential equations with constant coefficients. Matrices and determinants, Algebra of complex numbers.
- **Mechanics and General Properties of Matter**: Newton's laws of motion and applications, Velocity and acceleration in Cartesian, polar and cylindrical coordinate systems, uniformly rotating frame, centrifugal and Coriolis forces, Motion under a central force, Kepler's laws, Gravitational Law and field, Conservative and non-conservative forces. System of particles, Center of mass, equation of motion of the CM, conservation of linear and angular momentum, conservation of energy, variable mass systems. Elastic and inelastic collisions. Rigid body motion, fixed axis rotations, rotation and translation, moments of Inertia and products of Inertia, parallel and perpendicular axes theorem. Principal moments and axes.
- **Oscillations, Waves and Optics**: Differential equation for simple harmonic oscillator and its general solution. Superposition of two or more simple harmonic oscillators. Lissajous figures. Damped and forced oscillators, resonance. Wave equation, traveling and standing waves in one-dimension. Energy density and energy transmission in waves. Group velocity and phase velocity. Sound waves in media. Doppler Effect. Fermat's Principle. General theory of image formation. Thick lens, thin lens and lens combinations. Interference of light, optical path retardation. Fraunhofer diffraction. Rayleigh criterion and resolving power. Diffraction gratings. Polarization: linear, circular and elliptic polarization. .
- **Electricity and Magnetism**: Coulomb's law, Gauss's law. Electric field and potential. Electrostatic boundary conditions, Solution of Laplace's equation for simple cases. Conductors, capacitors, dielectrics, dielectric polarization, volume and surface charges, electrostatic energy. Biot-Savart law, Ampere's law, Faraday's law of electromagnetic induction, Self and mutual inductance. Alternating currents. Simple DC and AC circuits with R, L and C components. Displacement current, Maxwell's equations and plane electromagnetic waves, Poynting's theorem, reflection and refraction at a dielectric interface, transmission and reflection coefficients (normal incidence only). Lorentz Force and motion of charged particles in electric and magnetic fields.
- **Kinetic Theory, Thermodynamics**: Elements of Kinetic theory of gases. Velocity distribution and Equipartition of energy. Specific heat of Mono-, di- and tri-atomic gases. Ideal gas, van-der-Waals gas and equation of state. Mean free path. Laws of thermodynamics. Zeroth law and concept of thermal equilibrium. First law and its consequences. Isothermal and adiabatic processes. Reversible, irreversible and quasi-static processes. Second law and entropy. Carnot cycle. Maxwell's

thermodynamic relations and simple applications. Thermodynamic potentials and their applications. Phase transitions and Clausius-Clapeyron equation.

- **Modern Physics**: Inertial frames and Galilean invariance. Postulates of special relativity. Lorentz transformations. Length contraction, time dilation. Relativistic velocity addition theorem, mass energy equivalence. Blackbody radiation, photoelectric effect, Compton effect, Bohr's atomic model, X-rays. Wave-particle duality, Uncertainty principle, the superposition principle, calculation of expectation values, Schrödinger equation and its solution for one, two, and three-dimensional boxes. Solution of Schrödinger equation for the one-dimensional harmonic oscillator. Reflection and transmission at a step potential, Pauli exclusion principle. Radioactivity and its applications. Laws of radioactive decay.
- **Solid State Physics, Devices and Electronics**: Crystal structure, Bravais lattices and basis. Miller indices. X-ray diffraction and Bragg's law; Intrinsic and extrinsic semiconductors, variation of resistivity with temperature. Fermi level. p-n junction diode, I-V characteristics, Zener diode and its applications, BJT: characteristics in CB, CE, CC modes. Single stage amplifier, two stage R-C coupled amplifiers. Simple Oscillators: sinusoidal oscillators. OPAMP and applications: Inverting and non-inverting amplifier. Boolean algebra: Binary number systems; conversion from one system to another system; binary addition and subtraction. Logic Gates AND, OR, NOT, NAND, NOR exclusive OR; Truth tables; combination of gates