

Syllabus for the Entrance Test for Master's/Integrated Master's-PhD Program-2018

(1) Entrance test in PHYSICS

Topics in Physics eg. Classical Mechanics, Quantum Mechanics, Electricity and Magnetism, Thermodynamics, Statistical Mechanics, Mathematical Methods, Electronics etc. taught at the bachelor's level in Indian Universities.

(2) Entrance test in CHEMISTRY

Inorganic Chemistry

1. **Atomic structure:** Fundamental particles. Bohr's theory of hydrogen atom; Wave-particle duality; Uncertainty principles; Schrodinger's wave equation; Quantum numbers, shapes of orbitals; Hund's rule and Pauli's exclusion principle.

Periodic Table: Periodic classification of elements, periodicity in properties.

2. **Chemical bonding:** Types of bonding. VSEPR theory and shapes of molecules. Hybridization, dipole moment. Ionic solids - lattice energy. Structure of diamond and graphite.

3. **Main group elements (s and p blocks):** Chemistry with emphasis on group relationship, properties and reactivity of the compounds of main group elements; structure of electron deficient compounds of main group elements and application of main group elements.

4. **Transition metals (d block):** Characteristics of d-block elements. Coordination compounds of first row transition elements, bonding in coordination compounds – VBT and CFT of tetrahedral and octahedral complexes. Application of CFT to spectral and magnetic properties. Electronic spectra of coordination compounds.

5. **Organometallic compounds:** Concept of hapticity, 18 electron rule. Carbonyl compounds of first row of transition metals.

6. **Acids and Bases:** Concepts of acid-base reactions, acid-base titrations and acid-base indicators, buffer solution. Lewis acid/base and HSAB concepts, chemistry of non-aqueous solvents.

7. **Redox Chemistry:** balancing redox reactions, redox potentials and spontaneity of redox reactions, pH-dependence of redox reactions, Latimer diagram, Frost diagram, redox titrations.

8. **Nuclear Chemistry:** Radioactivity, nuclear reactions, applications of isotopes.

9. Basics of electrochemical and spectral analysis, and analytical separation.

Organic Chemistry

1. Nomenclature of Organic compounds.

2. **Mechanism of Organic reactions:** Electronic effects in Organic molecules – Inductive effect, polarizability effect, resonance, hyperconjugation, structure, properties and general reactions of reactive intermediates –Carbocation, carbanion, carbon radical.

3. **Stereochemistry:** Types of isomerism. Projection formulae, chirality, assigning stereochemical descriptors to chiral centers and geometric isomers. Optical isomerism in compounds containing one and two asymmetric centers. Conformations of cyclohexanes.

4. **Aromaticity and Huckel's rule:** Mono and bicyclic carbocyclic aromatic hydrocarbons and their electrophilic substitution reactions.

5. **Synthetic chemistry:** Methods of preparation and reactions of alkanes, alkenes, alkynes (including their cyclic analogues), arenes and their simple functional derivatives (alkyl, halo, nitro, hydroxyl, alkoxy, formyl, carboxyl, amine etc). Functional group interconversions. Grignard reagents, acetoacetic and malonic ester chemistry. Synthesis of simple compounds. Structure determination and synthetic problems using chemical reactions.

6. **Mechanism (with stereochemistry):** Aliphatic nucleophilic substitution, elimination, enolate reactions, Claisen condensation, esterification and ester hydrolysis, Cannizzaro reaction, benzoin condensation, Perkin reaction, Claisen rearrangement, Beckmann rearrangement, Wagner-Meerwein rearrangement.

7. **Carbohydrates:** Classification, nomenclature. Open and cyclic formulae. Chemistry of glucose.

8. **Amino acids and peptides:** Structure, stereochemistry, and typical reactions of amino acids. Structure of peptides.

9. **Heterocyclic chemistry:** Monocyclic 5- and 6-membered aromatic compounds with one hetero atom (S,O,N), nomenclature, electronic structure, aromaticity, characteristic properties and general reactions.

Physical Chemistry

1. **Theory of gases:** Kinetic theory of gases. Real and ideal gases, critical phenomenon.

2. **Chemical thermodynamics:** Reversible and irreversible processes. First law and its application to ideal and nonideal gases. Thermochemistry. Second law. Entropy and free energy, Criteria for spontaneity.

3. **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.

4. **Electrochemistry:** Conductance and its applications; Transport number; Galvanic cells; EMF and Free energy. Liquid junction potential and concentration cells. Application of emf measurement for determination of K , ΔG , ΔH , ΔS . Stability of complexes.

5. **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.

6. **Quantum chemistry:** Elementary quantum chemistry, state function, operators, eigen values and eigen functions.

7. **Basic Spectroscopy:** UV-Vis, NMR, vibrational and rotational spectroscopy.

8. Basic properties of solids, interfaces (surface tension, viscosity) and dielectrics

9. Basic mathematics related to the above Physical Chemistry Syllabus.

3. Entrance test in BIOLOGY

General Biology: Taxonomy and physiology, pro- and eukaryotic organisms; cell organelles and their function; multicellular organization; energy transformations; internal transport systems of plants; respiration; regulation of body fluids and excretory mechanisms; cellular reproduction; Mendelian genetics and heredity; biology and populations and communities; evolution; genesis and diversity of organisms; nervous system; animal behaviour, plant and animal diseases.

Basics of Biochemistry, Biophysics, Molecular Biology: Buffers; trace elements in biological systems; enzymes and proteins; vitamins; biological oxidations, carbohydrates and lipids and their metabolisms; digestion and absorption; detoxifying mechanisms; plant and animal hormones and their action, nervous system, nucleic acids, nature of gene and its function, genetic code, synthesis of nucleic acids and proteins. Enzyme mechanisms and kinetics, nucleic acid metabolism, photo synthesis. Structure of biomolecules; protein conformation and folding; intra and intermolecular forces; thermodynamics and kinetics of biological systems, principles of X-ray diffraction, NMR spectroscopy, IR and UV spectroscopy and hydrodynamic techniques.

Microbiology, Cell Biology and Immunology: Classes of microorganisms and their characterization, nutrient requirement for growth; laboratory techniques in microbiology, pathogenic microorganisms and disease; applied microbiology; viruses, microbial genetics. Innate and adaptive immunity, antigen and antibodies. Cell theory, cell architecture; methods of cell fractionation; cell division; types of chromosome structure; biochemical genetics- inborn errors of metabolisms, viruses and fungi; principles of processes of development.

Chemistry:

Atomic Structure and Periodicity: Planck's quantum theory, wave particle duality, uncertainty principle, quantum mechanical model of hydrogen atom, electronic configuration of atoms and ions. Periodic table and periodic properties.

Structure and Bonding: Ionic and covalent bonding, MO and VB approaches for diatomic molecules, VSEPR theory and shape of molecules, hybridization, resonance.

d Block Elements: General characteristics of 3d elements. Coordination complexes: valence bond and crystal field theory, color, geometry, magnetic properties and isomerism.

Chemical Equilibria: Colligative properties of solutions, ionic equilibria in solution, solubility product, common ion effect, hydrolysis of salts, pH, buffer.

Electrochemistry: Conductance, Kohlrausch law, cell potentials, emf, Nernst equation.

Reaction Kinetics: Rate constant, order of reaction, molecularity, activation energy, zero, first and second order kinetics, catalysis and elementary enzyme reactions.

Thermodynamics: First law, reversible and irreversible processes, internal energy, enthalpy, entropy and free energy.

Structure-reactivity of organic molecules: organic acids and bases, electronic and steric effects, optical and geometrical isomerism, tautomerism, conformers and concept of aromaticity. Elementary treatment of SN1, SN2, E1 and E2 reactions, Hoffmann and Saytzeff rules, addition reactions, Markownikoff rule and Kharash effect. Aromatic electrophilic substitutions, orientation effect as exemplified by various functional groups. Diels-Alder, Wittig and hydroboration reactions.

Chemistry and biology of medicines: Molecular basis of therapeutics; mechanism of action of drugs like common antibiotics, anticancer and anti-inflammatory agents.

Mathematics: Mathematical functions (algebraic, exponential, trigonometric), their derivatives (derivatives and integrals of simple functions), permutations and combinations.

(4) Entrance test in MATHEMATICS & COMPUTATION

(Covers bachelor degree courses (pass or honours) in Computer Science, Mathematics, Statistics and class 12+ to bachelor degree courses in Physics, Chemistry & Biology)

Data science/computer science (Weight: 40%)

Digital Logic: Boolean algebra, logic gates, and switching functions, truth tables and switching expressions, minimization of switching functions

Basics of Programming: Conditional constructs, iteration (loops), function, recursion, arrays

Concepts of programming, ability to write programs in any one of the following languages: C, C++, Fortran or Java.

Basics of searching and sorting, root finding, first order differential equation, numerical integration, interpolation.

Mathematics (Weight: 20%):

Basic set theory: Venn diagram, set operations

Algebra and linear algebra: Theory of equations, complex numbers, matrices and determinants

Basics of real and complex analysis : Basics of limit, continuity, differentiation, integration, elementary differential equations, series and sequences and their convergence, Analytic functions, Cauchy-Riemann equations, complex integration

Combinatorics: permutation, combination

Probability and statistics : Mean, median, mode, basic notion of probability, expectation, variance and standard deviation

Physics, Chemistry, Biology (Weight: 20%):

Basic knowledge in physics, chemistry, biology (Class 12+ to Bachelor's degree syllabus).

General aptitude (Weight: 20%)