DEPARTMENT OF NANOTECHNOLOGY
UNIVERSITY OF KASHMIR, HAZRATBAL SRINAGAR

ENTRANCE TEST SYLLABUS FOR M.SC. NANOTECHNOLOGY

(Effective from the year 2021-onwards)*

Note: Entrance Test Syllabus in M.Sc. Nanotechnology comprises of three sections, namely, Physics, Chemistry and Biology. Candidates appearing in M.Sc. Nanotechnology Entrance Test shall opt to attempt questions from two out of three sections: Candidates can choose to opt for any one section from Physics and Biology, and Chemistry section shall be Compulsory for all.

PHYSICS

UNIT – I

Vectors: Vector algebra, Scalar and vector products, Frames of reference, Newton's Laws of motion, Momentum and energy conservation, Rotational Motion: Angular velocity and angular momentum, Torque. Conservation of angular momentum. Special Theory of Relativity: Galilean and Lorentz transformations. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities. Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field, Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions.

UNIT – II

Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Differential form of Gauss Law. Applications of Gauss theorem. Magnetostatics: Biot-Savart's law & its application: Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law. Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, transverse nature of EM waves, polarisation.

UNIT – III

Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes. Second law & Entropy. Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams. Law of equipartition of energy and its applications to specific heat of gases; mono-atomic and diatomic gases. Theory of Radiation: Blackbody radiation, Spectral distribution, Wien's distribution law, Rayleigh- Jeans Law, Stefan Boltzmann Law.

UNIT – IV

Superposition of Two Perpendicular Harmonic Oscillations, Lissajous Figures with equal an unequal frequency and their uses. Group velocity, Phase velocity. Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Diffraction: Fraunhofer diffraction: Single slit; Double Slit. Multiple slits & Diffraction grating. Sound: Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Viscosity: Viscosity - Rate flow of liquid in a capillary tube - Poiseuille's formula.

*Certified Copy of redrafted PG Entrance Test Syllabus for M.Sc. Nanotechnology Program

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UNIT – V

Photoelectric effect; Compton Effect. Pair Production. De-Broglie's matter wave; The concept of wave packets and group velocities. Heisenberg's uncertainty relation for p and x, Applications of uncertainty principle, Schrödinger's wave equation (Time independent form); linearity and superposition. Expectation values; operators; Particle in a box; Finite potential well; Potential Barrier, Tunnel effect.

UNIT – VI

Spin-orbit coupling, Normal and anomalous Zeeman Effect, Nuclear properties (size, spin, magnetic moment), Stable Nuclei (Nuclear decay, Binding energy), Meson theory of nuclear forces, Gamow Theory of Alpha decay (no derivation), Pauli theory of beta-decay, gamma decay, Leptons and hadrons, Elementary particle quantum numbers; Baryon, lepton and strangeness numbers; Quarks; colour, flavour, Quark confinement.

UNIT – VII

Bravais lattice and seven crystal systems, Specific heat; Einstein and Debye models, Electrical resistivity versus temperature, Electrical conductivity (effects of the Fermi surface); Thermal conductivity in metals. Kronig-Penney model; Concept of Brillouin zones, Metals, insulators and semiconductors, Electrical conductivity; Temperature dependence. FET and its characteristics, MOSFET; types and characteristics, applications of MOSFET, Transistor amplifiers, Two-stage RC coupled amplifier.

CHEMISTRY
(Mandatory Section for all candidates)

UNIT – I

Ionic Bond: Lattice energy and Born Haber Cycle. Factors affecting the structure of ionic solids; Radius ratio effect; Coordination number and limitations of radius ratio rule. Solvation energy and solubility of ionic solids. Covalent Bond: Formation of hydrogen molecule, Polarity in covalent bonds, Covalent-character of ionic bond, Fajan's rules, Percentage ionic character of a polar covalent bond. Dipole moment. Valence band theory, VSEPR theory and molecular orbital theory

Unit – II

Gaseous State: Deviation of gases from ideal behaviour, van der Waal's equation of state. Critical Phenomenon: PV isotherms of real gases, continuity of states, the isotherms of van der Waal's equation. Relationship between critical constants and van der Waal's constants, the law of corresponding states. Molecular velocities: Qualitative discussion of the Maxwell's distribution of molecular velocities, root mean square, average and most probable velocities; collision number, mean free path and collision diameter.

Liquid State: Vapour pressure, Viscosity and Surface tension of liquids. Solid State: Laws of crystallography: (i) Law of constancy of interfacial angles (ii) Law of rational indices and (iii) Law of symmetry. Symmetry elements in crystals, lattice planes and miller indices. Bragg's equation and derivation. Interplanar distances in terms of miller indices.

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UNIT – III

S-Block elements: Electronegativity and electron affinity and effective nuclear charge. Chemical reactivity of s-block elements. Chemical characteristics of alkali and alkaline earth metal compounds. P-Block elements: Boron family to Noble gases. Transition and Inner Transition Elements. Separation of lanthanoids. Werner's theory of coordination compounds and their stereochemistry. Bonding in coordination compounds: Valence bond and Crystal Field theories and spectrochemical series. Magnetic and electronic properties of transition metal complexes. Applications of coordination compounds.

UNIT–IV

Structure, generation and stability of carbocations, carbanions, free-radicals, carbenes, benzynes and nitrenes. Aromaticity: Molecular orbital description of benzene. Requirements of aromaticity. Huckel's rule and its significance. Chirality, Interconversion of Wedge formula, Newmann, Sawhorse and Fischer representations, Conformers, Conformations with respect to ethane, butane and cyclohexane. Cis-trans-nomenclature, E/Z nomenclature. Enantiomerism, Diastereomerism and Meso compounds. D and L system and R/ S nomenclature. Chemistry of saturated and unsaturated hydrocarbons: Alkanes, Alkenes and Alkynes.

UNIT–V

Aliphatic Substitution and Elimination reactions: Mechanistic details of SN1 and SN2, E1 and E2 reactions. Effects of structure of alkyl halides, nature of nucleophiles, leaving groups, solvent and stereochemical implications of SN reactions. Aromatic electrophilic substitution reactions. General mechanism of aromatic electrophilic substitution reactions. The second substitution- Effect of substituents on reactivity and orientation. Pinacole-Pinacolone, Fries and Claisen rearrangements. Gatterman, Huben-Hoesch, Kolbe-Schmidt reaction, Reimer Tieman, Benzoin, Aldol, Perkin, Knoevenagal, Mannich and Cannizzaro's reactions. Meerwein-pondroff Verley, Bouvaelt-Blanc, Clemmenson and Wolf-Kishner reductions. Oppenaner and Baeyer-villiger oxidation. HVZ reaction.

Unit–VI

Chemical Thermodynamics: State and path functions. Heat capacity, Joule-Thomson effect, Calculation of w, q, ΔU & ΔH. Kirchhoff's equation. Second law of thermodynamics: Carnot cycle and its efficiency, Carnot theorem. Concept of entropy; entropy as criteria for spontaneity and equilibrium. Entropy changes in physical processes, ideal gas expansion and entropy of mixing of ideal gases. Third law of thermodynamics: Gibbs function (G) and Helmholtz function (A) and spontaneity, Gibbs-Helmholtz equation. Nernst heat theorem, third law of thermodynamics.

Chemical and Phase Equilibria: Relationship between equilibrium constant and free energy change. Thermodynamic derivation of law of mass action. Clausius-Clapeyron equation, applications. Phase, component and degree of freedom, Phase rule. Phase diagrams of one component system (water) two component system (simple eutectic system Pb-Ag, desilverisation of lead). Partially miscible liquid (phenol-water system). Nernst distribution law and its applications.

Unit–VII

Arrhenius theory, Kohlrausch's law and Debye-Huckel Onsager's equation. Transport number and its determination. Degree of dissociation and dissociation constants of acids, solubility product of a sparingly soluble salt, conductometric titrations. Electrochemical reaction and electrode potential. Nernst equation and equilibrium electrode potential. Reversible electrodes (half-cells), Glass electrode, Standard hydrogen electrode, Secondary reference electrodes. Electrochemical series and its significance. Application of EMF measurements. Order of reaction, derivation of integrated rate equations for second (two reactants) and third order reactions. Determination of order of reaction by differential rate, integration, half-life period and isolation methods. Temperature dependence of reaction rates: Arrhenius equation, concept of activation energy. Theories of chemical kinetics. Kinetics of thermal and photochemical reactions (HI and HBr)

UNIT–VIII

Qualitative, Quantitative and Volumetric analysis. Paper Chromatography. Preparation of Coordination complexes. Surface tension and Viscosity measurement. Chemical Kinetics, Polarimetry and Calorimetry. Construction of Phase diagrams. Detection of N, S and halogens. Functional group Identification. Synthesis and purification of organic compounds. Separation and Identification of binary mixtures of Organic Compounds.

BIOLOGY
(Biochemistry & Biotechnology)

UNIT – I

Biomolecules: Carbohydrates, Lipids, Proteins, Nucleic acids, and Vitamins. Types, Structure, and biological functions; Enzymes and their function. Cofactors and multimeric enzyme complexes. Enzyme inhibition.

UNIT – II

Cell biology: Prokaryotic and Eukaryotic cells, Cell membranes and its composition, Cell Organelles Nucleus, ER, Golgi complex, Lysosomes, Mitochondria, Peroxisomes. Extracellular matrix-basis for cell adhesion and communication; Phases of cell cycle with their function; General organization of bacterial cells. Gram +ve and –ve bacteria, bacterial cell culture, sterilization techniques; Structure of viruses.

UNIT – III

Molecular Biology: Prokaryotic and Eukaryotic replication, transcription and translation; Mechanisms and cellular machinery involved; Regulation of gene expression; Operons concept (Lac. and Trp.); Genetic disorders.

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UNIT – IV

Recombinant DNA technology: Cloning vectors, Restriction Endonucleases (types and specificity). Plasmids, Bacteriophages, Cosmids and phagemids. Basic concepts of PCR (polymerase chain reaction) and applications in modern biology. DNA modifying enzymes, Phosphatases, Ligases etc. DNA cloning (basic idea and steps).

UNIT – V

Bio-techniques: Centrifugation, Electrophoresis (Agarose gel, Polyacrylamide and Starch), Blotting Techniques, ELISA, RIA, Cell visualization and imaging techniques.

UNIT – VI

Bioenergetics and Metabolism: Energy transformation by biological systems, Laws of thermodynamics and concepts of free energy. Basic concepts in Metabolism: ATP as energy currency, glycolysis, TCA cycle, pentose phosopahate pathway, gluconeogenesis, oxidation and synthesis of fatty acids, general reactions of amino acid metabolism. Metabolic disorders.

UNIT – VII

Immunology: Immunity, Cells of immune system. Cell mediated and Humoral Immunity, Antigen recognition and antibody formation. Antibody types and function, Mechanisms of distinguishing self from non self, Cellular receptors. Hypersensitivity and allergies.