

Syllabus for Nanoscience (SCPH20)

Note:

- i. There will be one Question Paper which will have 100 questions.
- ii. All questions will be compulsory.
- iii. The Question Paper will have two Parts i.e. Part A and Part B
- iv. Part A will have 50 questions based on Research Methodology
- v. From Part B candidate will have to choose one Subject having 50 questions based on Domain Specific Knowledge.

Part-A: Research Methodology (Common for all)

1. General Science: General appreciation and understanding of science including matters of everyday observation and experience.
2. Environmental awareness: Pollution and its impacts, climate change, sustainable development.
3. Current events: Knowledge of significant national and international events.
4. General mental ability and reasoning: Reasoning and analytical abilities.
5. Elementary Computer Science: Basic computer awareness and its uses.
6. Interactive English: Grammar, vocabulary, sentence completion, usage, synonyms, antonyms, one word substitute, idioms/phrases, error detection and comprehension.
7. Information and Communication Technology (ICT): Terminology and abbreviations used in ICT, applications of ICT in academics and research.
8. Research aptitude: Basic Concepts- 1. Meaning, nature, significance and types of research. 2. End to end process of research, Formulation of research problem, Design strategies in Research- Descriptive Studies, Analytic Studies, Experimental studies, Intervention trials etc., research proposal, Synopsis, Hypothesis, Data collection, Literature survey, Sampling, Interviewing, questionnaire, Data processing, Interpretation, Report writing, Bibliography, Data presentation and summarization, Graphical presentation of data, Research Ethics. 3. Thesis/ Dissertation writing. 4. Article, research paper, seminar, conference, symposium, workshop etc. 5. Role of governing bodies/research organizations like UGC, CSIR, ICAR, ICSSR, ICPR, ISRO, DRDO etc. in research and development. 6. Role and use of computers in research.

9. Basic concepts of Statistical methods for research (Probability, Test of significance, Standard deviation, Measures of central tendency, Measures of variability, Measures of Relationship – Correlation, Hypothesis Testing – parametric and non-parametric tests, Proportions, Relative risk, Odds ratio, Student t test, Anova, Error bars)

Part-B: Subject Specific

In Part-B, Subject Streams: (Physical Sciences) or (Biological Sciences) or (Chemical Sciences) or (Engineering Sciences) (Candidate to appear in the subject only)

Physical Sciences

Interference. Diffraction. Polarization. Basic principles of quantum mechanics: Postulates; Wave-particle duality. Commutators and Heisenberg uncertainty principle. Schrödinger equation (time-dependent and time-independent). Exactly- solvable systems: particle-in-a-box, harmonic oscillator and the hydrogen atom. Tunnelling through a barrier. Electrostatics: Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Scalar and Vector potentials, Maxwell equations. The first and second laws of thermodynamics, Thermodynamic functions, Heat capacity, enthalpy, entropy. Bonding in solids, Crystal structures. Bravais lattices. Miller indices. Reciprocal lattice. Bragg's law and applications; Diffraction and the structure factor. Defects in Solids, Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Drude model of electrical and thermal conductivity. Hall Effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Dielectrics. Ferroelectrics. Magnetic materials. Superconductivity: type-I and type-II superconductors.

Biological Sciences

Biomolecules and their relevant interactions: Biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.). Biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties). Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers. Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation and isozymes.

Cell Biology: Membrane structure and function. Cellular organization and function of organelles. Cell division and cell cycle. Cell communication and cell signalling. Microbes and infectious disease biology. Cancer.

Fundamental Processes: DNA replication, repair and recombination. RNA synthesis and processing. Protein synthesis.

Immunology: Innate and adaptive immunity, antigens, antibody, antigen-antibody interactions, immune responses, immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immunodeficiencies, vaccines. Genetics: Gene, Allele, mutation types, cause and inheritance biology.

Human Physiology: Blood, coagulation, blood groups, haemoglobin. Endocrine glands, hormones and diseases, neuroendocrine regulation.

Chemical Sciences

Stereochemistry: IUPAC nomenclature, Configuration, Chirality, Isomerism. Conformational analysis and its effect on reactivity. Organic Reaction mechanisms, Free radicals, mechanism of nucleophilic substitution (SN1 and SN2) and elimination (E1 and E2). Addition to carbon-carbon multiple bonds, addition to alkenes and alkynes, transition metal organometallics. Addition to carbon-hetero multiple bonds. Oxidation and Reduction. Spectroscopy: Structure elucidation using UV-Vis, IR, ^1H and ^{13}C NMR. Photochemistry and pericyclic reactions: Features, classification. Natural Products and drugs of natural origin. Solutions: Ideal and non-ideal, methods of expressing concentrations of solutions, activity and activity coefficient, Raoult's law, relative lowering of vapour pressure, molecular weight determination, Osmotic pressure, Elevation of boiling point and depression of freezing point.

Theory of Gases: Kinetic theory of gases, Maxwell-Boltzmann distribution law. Chemical Thermodynamics: Reversible and irreversible processes, First, second and third laws of thermodynamics, Ideal and non-ideal gases, Gibbs and Helmholtz energy, Free energy change and spontaneity. Chemical and Phase Equilibria: Law of mass action, Effect of temperature on K , Ionic equilibria in solutions, pH and buffer solutions, Hydrolysis, Solubility product; Phase equilibria–Phase rule. Electrochemistry: Conductance, Transport number, Galvanic cells, EMF and Free energy. Chemical Kinetics: Reactions of various order, Arrhenius equation, Collision theory, Theory of absolute reaction rate, Chain reactions, Enzyme kinetics, Catalysis. Periodic Table: Periodic classification of elements and periodicity in properties. Chemical bonding and shapes of compounds: Types of bonding; VSEPR theory and shapes of molecules, hybridization, dipole moment, lattice energy. Main group elements (s and p blocks): Group relationship and gradation in properties. Transition metals and inner transition metals (d and f block): Characteristics of 3d elements, oxide, hydroxide and salts of first row metals, coordination complexes, metal complexes. Analytical Chemistry: Principles of qualitative and quantitative analysis, acid-base, oxidation reduction and precipitation reactions, use of indicators and organic reagents in inorganic analysis, radioactivity, nuclear reactions, applications of isotopes.

Engineering Sciences

Unit-I: Electronic Transport in semiconductor, PN Junction, Diode equation and diode equivalent circuit. Breakdown in diodes, Zener diodes, Tunnel diode, Semiconductor diodes, characteristics and equivalent circuits of BJT, JFET, MOSFET, IC fabrication-crystal growth, epitaxy, oxidation, lithography, doping, etching, isolation methods, metallization, bonding, Thin film active and passive devices.

Unit-II: Superposition, Thevenin, Norton and Maximum Power Transfer Theorems, Network elements, Network graphs, Nodal and Mesh analysis, Zero and Poles, Bode Plots, Laplace, Fourier and Z-transforms. Time and frequency domain responses. Image impedance and passive filters. Two port Network Parameters. Transfer functions, Signal representation. State variable method of circuit analysis, AC circuit analysis, Transient analysis.

Unit-III: Rectifiers, Voltage regulated ICs and regulated power supply, Biasing of Bipolar junction transistors and JFET. Single stage amplifiers, Multistage amplifiers, Feedback in amplifiers, oscillators, function generators, multivibrators, Operational Amplifiers (OP AMP) - characteristics and Applications, Computational Applications, Integrator, Differentiator, Wave shaping circuits, F to V and V to F converters. Active filters, Schmitt trigger, Phase locked loop.

Unit-IV: Logic families, flip-flops, Gates, Boolean algebra and minimization techniques, Multivibrators and clock circuits, Counters-Ring, Ripple. Synchronous, Asynchronous, Up and down shift registers, multiplexers and DE multiplexers, Arithmetic circuits, Memories, A/D and D/A converters.

Unit-V: Modulation index, frequency spectrum, generation of AM (balanced modulator, collector modulator), Amplitude Demodulation (diode detector Other forms of AM: Double sideband suppressed carrier, DSBSC generation (balanced modulator), Single side band suppressed carrier, SSBSC generation (filter method, phase cancellation method, third method), SSB detection, Frequency and Phase modulation, modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM (direct and indirect methods), FM detector (slope detector)