

Syllabus of the Entrance Examination for Ph.D. (Chemistry) Programme

The syllabus is same as that of CSIR-UGC NET examination and reproduced here. It is also available on http://www.csirhrdg.res.in/Syllabi_NET.htm.

Physical Chemistry:

1. Basic principles and applications of quantum mechanics – hydrogen atom, angular momentum.
2. Variational and perturbational methods.
3. Basics of atomic structure, electronic configuration, shapes of orbitals, hydrogen atom spectra.
4. Theoretical treatment of atomic structures and chemical bonding.
5. Chemical applications of group theory.
6. Basic principles and application of spectroscopy – rotational, vibrational, electronic, Raman, ESR, NMR.
7. Chemical thermodynamics.
8. Phase equilibria.
9. Statistical thermodynamics.
10. Chemical equilibria.
11. Electrochemistry – Nernst equation, electrode kinetics, electrical double layer, Debye-Hückel theory.
12. Chemical kinetics – empirical rate laws, Arrhenius equation, theories of reaction rates, determination of reaction mechanisms, experimental techniques for fast reactions.
13. Concepts of catalysis.
14. Polymer chemistry. Molecular weights and their determinations. Kinetics of chain polymerization.
15. Solids - structural classification of binary and ternary compounds, diffraction techniques, bonding, thermal, electrical and magnetic properties
16. Collids and surface phenomena.
17. Data analysis.

Inorganic Chemistry

1. Chemical periodicity
2. Structure and bonding in homo- and heteronuclear molecules, including shapes of molecules.
3. Concepts of acids and bases.
4. Chemistry of the main group elements and their compounds. Allotropy, synthesis, bonding and structure.
5. Chemistry of transition elements and coordination compounds – bonding theories, spectral and magnetic properties, reaction mechanisms.
6. Inner transition elements – spectral and magnetic properties, analytical applications.
7. Organometallic compounds - synthesis, bonding and structure, and reactivity. Organometallics in homogenous catalysis.
8. Cages and metal clusters.
9. Analytical chemistry- separation techniques. Spectroscopic electro- and thermoanalytical methods.

10. Bioinorganic chemistry – photosystems, porphyrines, metalloenzymes, oxygen transport, electron- transfer reactions, nitrogen fixation.
11. Physical characterisation of inorganic compounds by IR, Raman, NMR, EPR, Mössbauer, UV-, NQR, MS, electron spectroscopy and microscopic techniques.
12. Nuclear chemistry – nuclear reactions, fission and fusion, radio-analytical techniques and activation analysis.

Organic Chemistry

1. IUPAC nomenclature of organic compounds.
2. Principles of stereochemistry, conformational analysis, isomerism and chirality.
3. Reactive intermediates and organic reaction mechanisms.
4. Concepts of aromaticity.
5. Pericyclic reactions.
6. Named reactions.
7. Transformations and rearrangements.
8. Principles and applications of organic photochemistry. Free radical reactions.
9. Reactions involving nucleophilic carbon intermediates.
10. Oxidation and reduction of functional groups.
11. Common reagents (organic, inorganic and organometallic) in organic synthesis.
12. Chemistry of natural products such as steroids, alkaloids, terpenes, peptides, carbohydrates, nucleic acids and lipids.
13. Selective organic transformations – chemoselectivity, regioselectivity, stereoselectivity, enantioselectivity. Protecting groups.
14. Chemistry of aromatic and aliphatic heterocyclic compounds.
15. Physical characterisation of organic compounds by IR, UV-, MS, and NMR.

Interdisciplinary topics

1. Chemistry in nanoscience and technology.
2. Catalysis and green chemistry.
3. Medicinal chemistry.
4. Supramolecular chemistry.
5. Environmental chemistry.

Note:

1. The question paper will consist of 70 marks objective type questions like multiple choice, fill in the blank, match the pairs etc.
2. Merit list will be prepared based on entrance test result only.
3. The questions paper have of 28 mark component based on entire syllabus along with general knowledge questions of about 10-15 marks.
4. The component of 42 marks will consist of specialization like organic, inorganic and physical chemistry and candidate will ask to opt for any one of the specialization based on his choice.
5. The interview of 30 marks will be conducted at several departments based on departmental requirements.

Institute of Chemical Technology, Matunga, Mumbai
Syllabus for PhD (Science) Biochemistry & Biotechnology Common Entrance Test

Written test of one hour duration with 70 marks

Section I: Basic Physics and Chemistry (XII standard level) and General scientific and mathematical aptitude

Section II: Biological Sciences

Organization of life. Importance of water, Cell structure and organelles. Structure and function of biomolecules: Amino acids, Carbohydrates, Lipids, Proteins and Nucleic acids. Biochemical separation techniques and characterization: ion exchange, size exclusion and affinity chromatography, electrophoresis, UV-visible, fluorescence and Mass spectrometry. Protein structure, folding and function: Myoglobin, Hemoglobin, Lysozyme, Ribonuclease A, Carboxypeptidase and Chymotrypsin. Enzyme kinetics including its regulation and inhibition, Vitamins and Coenzymes.

Metabolism and bioenergetics. Generation and utilization of ATP. Metabolic pathways and their regulation: glycolysis, TCA cycle, pentose phosphate pathway, oxidative phosphorylation, gluconeogenesis, glycogen and fatty acid metabolism. Metabolism of Nitrogen containing compounds: nitrogen fixation, amino acids and nucleotides. Photosynthesis: the Calvin cycle.

Biological membranes. Transport across membranes. Signal transduction; hormones and neurotransmitters.

DNA replication, transcription and translation. Biochemical regulation of gene expression. Recombinant DNA technology and applications: PCR, site directed mutagenesis and DNA-microarray.

Immune system. Active and passive immunity. Complement system. Antibody structure, function and diversity. Cells of the immune system: T, B and macrophages. T and B cell activation. Major histocompatibility complex. T cell receptor. Immunological techniques: Immunodiffusion, immunoelectrophoresis, RIA and ELISA.

Advanced techniques in gene expression and analysis: PCR and RT-PCR, microarray technology, DNA fingerprinting and recombinant DNA technology; prokaryotic and eukaryotic expression systems; Vectors: plasmids, phages, cosmids and BAC.

Architecture of plant genome; plant tissue culture techniques; methods of gene transfer into plant cells and development of transgenic plants; manipulation of phenotypic traits in plants; plant cell fermentations and production of secondary metabolites using suspension/immobilized cell culture; expression of animal protein in plants; genetically modified crops.

Animal cell metabolism & regulation; cell cycle; primary cell culture; nutritional requirements for animal cell culture; techniques for mass culture of animal cell lines; application of animal cell culture for production of vaccines, growth hormones; interferons, cytokines & therapeutic proteins; hybridoma technology and gene knockout; stem cells, its application in organ synthesis; gene therapy; transgenic animals & molecular pharming.

Industrial bioprocesses: microbial production of organic acids, amino acids, proteins, polysaccharides, lipids, polyhydroxyalkanoates, antibiotics and pharmaceuticals; methods and applications of immobilization of cells and enzymes; kinetics of soluble and immobilized enzymes; biosensors; biofuels; biopesticides; environmental bioremediation.

Microbial growth kinetics; batch, fed-batch and continuous culture of microbial cells; media for industrial fermentations; sterilization of air and media, design and operation of stirred tank, airlift, plug flow, packed bed, fluidized bed, membrane and hollow fibre reactors; aeration and agitation in aerobic fermentations; bioprocess calculations based on material and energy balance; Downstream processing in industrial biotechnology: filtration, precipitation, centrifugation, cell disintegration, solvent extraction, and chromatographic separations, membrane filtration, aqueous two phase separation.

Historical Perspective: Discovery of microbial world; Landmark discoveries relevant to the field of microbiology; Controversy over spontaneous generation; Role of microorganisms in transformation of organic matter and in the causation of diseases, Methods in Microbiology: Pure culture techniques; Theory and practice of sterilization; Principles of microbial nutrition; Enrichment culture techniques for isolation of microorganisms; Light-, phase contrast- and electron-microscopy.

Microbiology: Bacteria, Archea and their broad classification; Eukaryotic microbes: Yeasts, molds and protozoa; Viruses and their classification; Molecular approaches to microbial taxonomy. Prokaryotic and Eukaryotic Cells: Structure and Function: Prokaryotic Cells: cell walls, cell membranes, mechanisms of solute transport across membranes, Flagella and Pili, DNA replication, repair and recombination: Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms. RNA synthesis and processing: Protein synthesis and processing Control of gene expression at transcription and translation level. PCR and RT-PCR, microarray technology, DNA fingerprinting and recombinant DNA technology; prokaryotic and eukaryotic expression systems; Vectors: plasmids, phages and cosmids. Gene mutation: Types of mutation; UV and chemical mutagens; Selection of mutants; Ames test for mutagenesis; Bacterial genetic system: transformation, conjugation, transduction, recombination, transposons; DNA repair and chromosomal aberrations

Bioinformatics: genomics; proteomics and computational biology

Note:

1. The paper will be divided into two sections with a total of 140 questions (70 in each section) Candidates have to attempt 35 questions from each section.
2. Time for test is one hour.
3. The question paper will consist of objective type questions like multiple choice, fill in the blank, match the pairs etc.

Syllabus for Entrance Test for Ph.D. (Science) in Food Science

- 1. Chemistry of food constituents:** General composition of foods, proximate analysis of foods, chemistry of carbohydrates, proteins, lipids, vitamins and other minor constituents, water activity, texture, flavor, colour of foods, various minor phyto-constituents, Natural fragrances and flavor constituents, Anti-nutritional factors in plant foods.
- 2. Human nutrition:** Energy value of foods, calculation of energy value based on proximate composition of foods, daily energy need of body for basal metabolism, physical activity and diet induced thermogenesis, energy balance, B. M. I.; role of carbohydrates in nutrition including dental caries, lactose intolerance, galactosemia, dietary fiber, resistant starch, glycemic index of foods, prebiotics including oligosaccharides; role of proteins in nutrition including essential amino acids, protein quality, complete proteins, animal and plant sources of proteins, protein calorie malnutrition, protein quality estimation methods including in vivo and in vitro; role of lipids in nutrition including fat digestion, absorption, saturated fats, medium chain triglycerides, PUFAs as essential fatty acids, omega 6 and omega 3 fats, cholesterol, plant sterols; role of micronutrients in nutrition including fat and water soluble vitamins and minerals; role of water and electrolytes, rehydration therapy; assessment of nutritional status; lifecycle nutrition; sports nutrition; food fortification; effect of food processing and storage on nutrients; nutraceuticals and functional foods; nutrigenomics
- 3. Biochemistry:** cell structure and organization, biomolecules, enzymes, classification, nomenclature, structure, regulation of activity, kinetics, mechanism of catalysis; primary metabolic pathways of carbohydrates, proteins and fats, energy metabolism, structure and synthesis of nucleic acids and their role in protein synthesis, mutations, regulation of pathways, inborn errors in metabolism.
- 4. Microbiology:** including classification and taxonomy of microorganisms; growth and physiology; methods of microbial enumeration; microbial metabolism, microbiology of fermented foods, pathogenic/ toxigenic microorganisms, microorganisms involved in spoilage of foods, microbial genetics, microbes in industry.

5. **Food commodity science:** chemical composition of various food commodities like cereals, legumes, oilseeds, fruits, vegetables, tubers, plantation crops, meat, fish, poultry, milk etc.
6. **Fundamentals of food processing and preservation:** fundamental principles of food preservation by heat processing, low temperature storage, chemical preservatives –bio preservatives traditional methods, freezing, dehydration, non-thermal processes, packaging etc., Hurdle technology and use of enzymes in food industry.
7. **Food analysis:** principles of analysis of food constituents in raw and processed foods- chemical and instrumental methods.
8. **Fermentation science:** different types of industrially important fermentations, role of microbes and enzymes thereof, changes in the substrate involved in the fermentation, benefits/risks of fermentation
9. **Nutraceuticals & their functions**
10. **Human physiology**

Syllabus for Ph. D. (Sci.) in Mathematics Entrance Test

Calculus of single and multi variable, linear algebra, real analysis, group theory, metric space, topology, complex analysis, differential equation (o.d.e, p.d.e), interpolaton, solution of non-linear equations using various numerical methods, numerical differentiation and integration, numerical solution of initial initial and boundary value problems by using initial value integration method: such as Taylor series method, Euler's method, R.K. method etc.

Department of Fibres and Textile Processing Technology
Syllabus for Ph. D. (Textile Chemistry) Entrance examination (2022-2023)

Polymers and Fibres: Fibre forming polymers and their properties, Primary and secondary properties of fibres, Classification of fibres, Natural fibres and their properties, Synthetic Fibres, their synthesis and properties, swelling of fibres, micro denier fibres, Recent trends governing the fibre modifications, Identification of fibres.

Pretreatments: Desizing, scouring and bleaching of natural and synthetic fibres/fabrics, Oxidative and reductive bleaching agents, Hypochlorite and Hydrogen peroxide bleaching, Ecofriendly pretreatment processes, Continuous and combined pretreatment processes & Machinery, Pretreatment norms and their evaluation.

Colouration : Classification of colourants, Dyestuffs for natural and synthetic fibre/fabric and their application processes, Natural dyes and their application, Various dyeing machineries, Latest dyeing machines and dyeing techniques, Computer Colour Matching application, Basics of Printing of textiles, Ingredients of Print paste formulations and their relevance, Styles of printing, Methods of printing, Fixation of prints, Latest printing machines and printing techniques.

Finishing: Finishing of textiles, Chemical & Mechanical finishes, Speciality/Functional finishes, Application processes of finishing agents and their testing.

Testing: Physical/Mechanical testing of fibre/fabric, Wet fastness properties of dyed and printed textiles, Global test methods like ASTM, AATCC, ISO, etc, Testing of textile auxiliaries, Standard equipments to be used for testing of textile, parameters of importance, Methods for evaluation of auxiliaries as well as for their effectiveness or activity.

Environmental aspects of Textile Processing: Discharges from textile processing industry, its characteristics and treatment, Banned dyes, Red listed chemicals and their Eco friendly substitutes.

Syllabus for PhD Physics written test

- a) **Mathematical methods:** Functions of complex variable, complex integrals, Fourier and Laplace transforms, series expansions, second order linear differential equations, vector calculus, vector spaces and matrices, elementary probability theory, error analysis.
- b) **Classical Mechanics:** Newton's laws of motion, generalized co-ordinates, variational principle, Lagrangian and Hamiltonian formulations, central forces, small oscillations and normal modes, rigid body motion, special relativity: Lorentz transformations, relativistic kinematics, mass-energy equivalence.
- c) **Quantum Mechanics:** Wave-particle duality, Heisenberg's uncertainty principle, operators, eigenvalues and eigenfunctions, Schrodinger's equation for simple one-dimensional problems and central potentials, Hydrogen atom, orbital and spin angular momentum and their algebra, matrix formulation, commutator algebra, variational method, time-independent & time-dependent perturbation theories, quantum mechanical scattering theory.
- d) **Thermodynamics and Statistical Mechanics:** Laws of thermodynamics, kinetic theory, Maxwell-Boltzmann distribution, Maxwell's equations, Statistical approach to a system, Ensemble theory: canonical ensemble, grand-canonical ensemble, partition functions, classical and quantum statistics, Fermi and Bose gases.
- e) **Electromagnetic theory:** Electrostatics and magnetostatics, dielectrics and conductors, Biot-Savart's and Ampere's laws, Faraday's law, Maxwell's equations and continuity equation, Vector potentials, Lorentz and Coulomb Gauges, Poynting's theorem, electromagnetic wave propagation in media: reflection, refraction, interference, polarization.
- f) **Solid State Physics:** Crystal structure and diffraction, lattice vibrations in periodic structures and thermal properties of solids, Electrical properties of metals, Fermi distribution, band theory of solids, magnetism in matter, semiconductor physics, elements of superconductivity.
- g) **Electronics:** LCR circuits, transistors, operational amplifiers, timers, logic circuits, flip-flops, filters and oscillators, rectifiers, power supplies, optoelectronics and communication techniques.
- h) **Atomic and Molecular Physics:** Atomic spectra, many electron atoms: coupling schemes for spin and orbital angular momenta, effect of electric and magnetic field on atoms, Molecular spectra, Raman effect, lasers.
- i) **Nuclear physics:** Static properties of nuclei, radioactive decay, alpha, beta and gamma emission, liquid drop model, semi-empirical mass formula, Fermi Model, shell model, Fermi's theory of beta decay, nuclear reactions and conservation laws, elements of nuclear fission, particle accelerators and detectors.