The entrance exam question paper would be prepared as per UGC Regulations 2016

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of Centre</th>
<th>Sub. Code &amp; Sub. Code Number</th>
<th>Syllabus for Entrance Examination</th>
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<tbody>
<tr>
<td>1</td>
<td>School of Biotechnology</td>
<td>Biotechnology – SBTH (904)</td>
<td>Syllabus for Ph.D. Entrance Examination (Biotechnology)</td>
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<td>Chemistry</td>
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<td>Chemical periodicity, Structure and bonding, Concepts of acids and bases, Properties and functions of metals and non-metals, Transition elements and coordination compounds, Characterisation of inorganic compounds, Analytical chemistry, Nuclear chemistry, Polymer chemistry, Molecular spectroscopy, Chemical thermodynamics, Electrochemistry, Chemical kinetics, Colloids and surfaces, numerical problems related to mole concept, pH, dissociation constants, emf, rate constant etc. IUPAC nomenclature of organic molecules, isomerism, Principles of stereochemistry, Aromaticity, Organic reactive intermediates, Organic reaction mechanism, Common named reactions and rearrangements, Organic transformations and reagents: Functional group interconversion, Asymmetric synthesis, common heterocyclic compounds containing one or two heteroatoms (O, N, S), Chemistry of natural products: (Carbohydrates, proteins and peptides, fatty acids, nucleic acids etc.), Structure determination of organic compounds.</td>
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<td>Physics and Mathematics</td>
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<td>Class XIIth Syllabus (As per CBSE)</td>
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<td>Amino Acids, Peptides and Proteins</td>
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<td>Nucleic Acids, Carbohydrates and Lipids</td>
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<td>Enzyme Kinetics and Inhibition</td>
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<td>Introduction about enzymes, classification, activity, cofactors</td>
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<td>Chemical Kinetics</td>
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<td>Regulation of enzyme activity by various factors such as pH, temperature etc.</td>
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<td>Enzyme Inhibition-various types with examples</td>
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<td>Kinetics of enzyme inhibition</td>
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<td>Enzyme activity and purification-sub cellular fractionation and specific activity</td>
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<td>Enzymes: Mechanism, Structure and Regulation</td>
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<td>Substrate specificity of enzymes</td>
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<td>Functional Groups Essential for Catalysis</td>
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<td>Reaction Mechanism of Enzyme Active sites</td>
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<td>Regulatory Enzymes</td>
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<td>Introduction to Metabolism</td>
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<td>Paper will be OBJECTIVE type</td>
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Metabolic Pathways
Organic Reaction Mechanisms
Experimental Approaches to the study of Metabolism
Thermodynamics of Phosphate compounds
Oxidation-Reduction Reactions

Carbohydrate Metabolism
  Glycolysis
  Fermentation: The Anaerobic Fate of Pyruvate
  Metabolism of Hexoses Other than Glucose

Glycogen Breakdown & Synthesis
Gluconeogenesis
Pentose Phosphate pathway
Metabolic Regulation and Control

Citric Acid Cycle
  Cyclic Overview
  Metabolic Sources of Acetyl Coenzyme A
  Enzymes of the Citric Acid Cycle
  Regulation of the Citric Acid Cycle

  Electron Transport and Oxidative Phosphorylation
  The Mitochondrion
  Electron Transport
  Oxidative Phosphorylation
  Control of ATP Production

Lipid metabolism
  Lipid Digestion, Absorption and Transport
  Fatty Acid Oxidation & Biosynthesis
  Ketone Bodies
  Regulation of Fatty Acid Metabolism

Amino Acid Metabolism
  Role of essential amino acids
  Amino Acid Deamination
  The Urea Cycle
  Metabolic Breakdown of Individual Amino Acids
  Amino Acids as Biosynthetic Precursors
Amino Acids Biosynthesis
Nitrogen Fixation

Nucleotide Metabolism
Synthesis of Purine Ribonucleotides
Synthesis of Pyrimidine Ribonucleotides
Formation of Deoxyribonucleotides
Nucleotide Degradation
Biosynthesis of Nucleotide Coenzymes

Glycoproteins & Glycolipids

Hormones & Vitamins

Metabolic disorders and diseases

Integration of Metabolism & Organ Specialization
Major Pathways and Strategies of Energy Metabolism: A Summary
Organ Specialization & Metabolic Homeostasis

Structural Biology and Biophysical Chemistry

Interactions in Biological Systems
Intra and inter molecular forces, electrostatic interactions
and hydrogen bonding interactions
van der Waals and hydrophobic interactions
Disulfide bridges
Role of water and weak interactions

Structure of Proteins
Conformational properties of polypeptides
Primary and secondary structure (α-helix and β-sheet structures etc.)
Tertiary and quaternary structure
Structural features of membrane proteins
Secondary and tertiary structure prediction of protein conformation

Multiple equilibrium
Titrations of proteins to evaluate net and total charge
Scatchard and Hill plots
Folding-unfolding equilibrium and denaturation of proteins
Effect of temperature and solvent conditions on the thermodynamics of protein folding-unfolding equilibrium
Kinetics of protein folding

Techniques for the study of Macromolecular structure
Analytical Ultracentrifugation: Sedimentation velocity and equilibrium, determination of molecular weights
Microcalorimetry (DSC and ITC) and its applications
Circular Dichroism spectroscopy
UV, Visible and Fluorescence spectroscopy
X-ray diffraction
Nuclear Magnetic Resonance (NMR)
Mass Spectrometry

Microbiology
Bacterial diversity
How to classify bacteria
Chemical/Biochemical reactions
Nutrient preference and other biochemical properties
16S rRNA based classification
Three domain classification of microorganisms
Microbial ecology
Carbon and Nitrogen cycles
Phosphorus and Sulfur cycles
Manganese and Mercury cycles
Interaction between elemental cycles
Biogeochemical cycles in relation to climate change
Diversity of bacterial flora in humans
Diversity of microorganisms associated with different anatomical areas in humans
Alterations in microbiome diversity with disease
Structure and Function of the Prokaryotic cell
Peptidoglycan structure and biosynthesis
Cell surface proteins and their role in bacterial pathogenesis
Structure and biosynthesis of cell surface organelles
Chaperone -- Usher pili in Gram negative bacteria
Covalent anchorage of cell-surface proteins in gram positive bacteria
Ultrastructure and assembly of motility structures: Type IV pili and bacterial flagellum
Atomic structure of the bacterial ribosome
Bacterial Host-Parasite relationships
Mechanism of bacterial pathogenesis
Bacterial structure in relation to pathogenicity
Bacterial protein toxins/endotoxins
Antimicrobial agents used in the treatment of infectious disease
Mechanism of antibiotic action
Antibiotic resistance

Virology
Basic concepts of virus structure
Helical, icosahedral and Complex structures
Viral genome replication
Viral entry to exit from the infected cells with reference to VSV, adenovirus and retrovirus
Cellular defences against virus infections
Strategies devised by viruses to escape the innate and adaptive immune responses
Antiviral chemotherapy
Antiviral drugs targeting attachment to release of virus particles and their mechanism of action
Modern approaches of virus control
Antisense RNA,siRNA,ribozymes, miRNA
Introduction to eukaryotic viral vectors

Industrial Microbiology
Isolation and Presentation of Microorganism
Improvement of strains
Primary metabolism
Secondary Metabolism
Recombinant proteins
Sterilization
Media Design
Scale up principles

Prokaryotic Molecular Biology
Brief introduction to molecular biology & processes. Denaturation and renaturation of DNA. Tm. GC content from Tm. Renaturation kinetics of DNA and complexity of DNA. Cot curves. DNA-DNA hybridization-relatedness of difference genes and species.

Bacterial Genome organization:
Evolution of genome, Genome content, C-value paradox, Packing ratio, density of genome. Bacterial genome. Short and long range organization, Proteins associated with bacterial genome and their function.

Bacteriophages: Genome and infection and Biology


Insertion sequences and Transposons


Replication.


Enzymes of DNA replication: DNA polymerases: DNA polymerase I not the primary enzyme. Its other role in maintenance of DNA integrity. Processivity, direction of DNA polymerization, fidelity, E. coli DNA polymerase I and its components, Klonev fragment and other domains.


DNA recombination.


Mutations and Repair.


Transcription.

Processing of tRNA and rRNA. Cleavage of T7 early mRNAs by RNase III. Control at the processing level. Regulation of transcription in bacteria: Introduction and repression. Represser as a regulatory molecule. Coordinated control of gene clusters. Positive and negative regulation: Regulation of transcription of lac, trp, ara, his, and gal operons. Regulation through catabolite repression. CAP protein as a positive control factor.

Transcriptional regulation in bacteriophage Lambda: Lytic and lysogenic switch. Role of various regulatory proteins.

Translation

Eukaryotic Molecular Biology & Molecular Genetics
Dynamic genome – 3D cell, dynamic genome architecture in nuclear space, chromatin movement, microscopes, microarrays and chromosome capture assays. Chromatin mobility and principle of nuclear organization, Nuclear architecture and gene-gene interaction, gene kissing, transcription factories, structural constraints on chromatin mobility.
Nuclear Matrix and gene regulation: Nuclear matrix, nuclear matrix proteins, nuclear-matris, structure and function. DNA Binding Properties of the Nuclear Matrix and Individual Matrix Prose.
Ins. Association of chromosome territories with the nuclear matrix. Disruption of human chromosome territories correlates with the release of a subset of nuclear matrix proteins, nuclear matrix targeting, signal, higher order chromatin structure and nuclear matrix. Transcriptional repression and nuclear lamina matrix expression of globin gene.
Programmed cell death: Apoptotic and necrotic cell death, apoptotic and anti-apoptotic genes, tumor suppressor genes, cell fate through decision between cell cycle arrest and apoptosis.
Gene regulation and disease: order vs disorder in transcriptional regulation, network dysfunction and disease, transcriptional therapeutics in diseases control.

Cell Biology
Composition and organization of biological membranes:
Membrane lipids: Properties and how they affect the curvature and fluidity of the membrane lipid rafts: composition, a platform for organization of signaling complexes.
Membrane proteins: Properties and orientation in biological membranes.
Membrane asymmetry.
Practice questions and discussion.
Cellular transport mechanisms:
Principles of transport of small molecules across membranes: organization and functioning of carriers and channels, membrane excitability.
Practice questions and discussion.
Protein transport across membranes:
Transport across nuclear pore
Transport across ER and from ER to other organelles by vesicular transport
Post-translational modifications of proteins and their role in protein transport
Endocytosis, phagocytosis, exocytosis
Practice questions and discussion

Cell cycle
Components of cell cycle regulatory mechanisms: Cyclin-CDK complexes, CKIs and ubiquitin ligases in cell cycle regulation
Cell Cycle control mechanisms: Checkpoints, Regulation and maintenance of G1, control of genome replication, DNA damage and cell cycle regulation
Cell cycle defects and cancer
Practice questions and discussion

Cell Signalling

Proteolysis based signaling (Wnt, Notch, Hedgehog): Structural and functional basis for normal and abnormal signaling

Cross-Talk Between Different Intracellular Pathways: Interactions between GPCRs and tyrosine kinase receptors; cross-cascade signaling of proteins involved in gene transcription.
(Example: Cross talk between pattern-recognition receptors and Toll-like receptors.

Molecular biology of ionic signaling: Calcium signaling in excitation-contraction coupling in cardiomyocytes; Neutrophils and inflammation

Cytoskeleton:
Cytoskeleton networks: actin, Microtubules and intermediate filaments.
Physical and biochemical properties of extracellular matrices: Collagen, Fibronectin (Tensional homeostasis and fibrosis)
Role of cytoskeleton network and extracellular matrix in cell migration, cell polarity, and cancer

Cell junctions:
Type of junctions: tight junction, anchoring junction, and
Communicating junction
Composition and function of junctions
Cell junctions: tissue development, and disease

Analytical Techniques
Concept of pH buffer and solutions
Electrophoresis techniques
Chromatography techniques
Protein and DNA estimation
Sequencing of proteins and DNA
Spectroscopic techniques (UV – Visible, IR fluorescence, CD, NMR and Mass Spectrometry)

GENETIC ENGINEERING AND ITS APPLICATIONS

Introduction to genetic engineering, general workflow, potentials and its limitations.
Host, vector and steps in cloning. Cloning of cDNA, and construction of cDNA library.
Analysis of a cloned DNA fragment using restriction digestion and DNA sequencing.
Concept, strategies, general workflow and variant of the PCR.
The use of PCR in gene recombination, deletion, insertion and site directed mutagenesis.
PCR in molecular diagnostics: Detection of the pathogens, and its potentials
PCR based diagnostics of the minimum residual disease (MRD) with case study
Application of real time (RT) PCR in the study of gene expression.
Use of genetic engineering for recombinant protein technology
Expression of foreign gene in E. coli, Baculovirus and Pichia expression systems.
Inclusion bodies formation and strategies for the production of soluble proteins.
Cell synchronization and its importance in the genetic engineering.
Methods of introduction of DNA into mammalian cells.
Transient and stable integration of foreign DNA into mammalian cells.
The viral vectors and their use in gene delivery
The Adeno viral vector, unarmed Herpes and vaccinia viral vectors and their importance
Principles and methods of the gene targeting for model organism.
Strategies for Gene knockouts in animals.
Gene disorder and Gene therapy
The packaging of retroviral vectors and helper cells for gene therapy
Development of animal models for gene therapy.
Detection of mutations in neoplastic diseases
Immuno – Suicide gene therapy in neoplastic diseases.
Somatic and germ line gene therapy in vivo and ex-vivo experiments, Bioethics
Role of integrated OMICS in the genetic engineering
Importance of computational tools and system biology for genetic engineering
Use of genome wide screening in the functional genomics
Recent breakthrough and advances in the genome engineering.
Recent trends and development in the gene therapy.
Plant Genetic Engineering: Introduction to plant tissues culture; Agrobacterium infection biology; Explant selection and regeneration; Plant transformation (Agrobacterium-mediated, Microprojectile bombardment-mediated and Floral-dip method of plant transformation); Transgenic Selection and Regeneration; Discussion.
Applications of plant genetic engineering: Understanding issues encountered in plant biotechnology Germplasm Improvement; Plant and human health; Plant Molecular farming (Bioreactors); Bio-fortification; Discussion. Precise genome engineering.
Immunology

Introduction to the Immune System
Historical background, cellular and molecular components of immune system

Innate Immunity
Innate immune cells, Pathogen associated molecular pattern (PAMP), Pathogen recognition receptors (PRR), Type 1 IFN, Interferon Stimulated Genes (ISGs), Complement system.

The Recognition of Antigen
Structure of a typical antibody molecule, Antigen recognition by T cell and B cells, Generation of lymphocyte antigen receptors, TCR gene rearrangement, Antigen presentation to lymphocytes, MHC/HLA complex.

The Development and Survival of Lymphocyte
The development of T lymphocytes in the thymus, Development of B lymphocytes, Positive and negative selection of T cells, Maturation of lymphocytes in peripheral lymphoid tissue

The Adaptive Immune Response
T cell mediated immunity, Entry of naive T cells and APCs into peripheral lymphoid organs, Naive T cells priming by pathogen-activated dendritic cells, T cell-mediated toxicity, Macrophage activation by TH1 cells, humoral immune response, Immunological memory, Cytokines

Immune system in Disease
Self tolerance, autoimmune diseases, transplant rejection, allergy and anaphylactic shock, AIDS immunology

Immune aging
Immunosenescence, Immune-exhaustion during aging and chronic infection, Gut Immunology

NK cells and Diseases
Inhibitory receptors, KIR receptors, CTL responses in cancer, Immunotherapy

Characterization of lymphocytes specificity, frequency and function
Lymphocyte isolation, ELISPOT assay, Multicolor flow cytometry, HLA-tetramer assay

Plant Biotechnology

Prologue to Plant’s World
Plant and human society; Growth and development; Plant hormones;
Photosynthesis

An Introduction to Plant Genetics
Plant genome organisation; Polyploidy; Genetic diversity; Molecular markers and mapping; Phylogenetics and genomics; Breeding and methods; Discussion; Forward vs. reverse genetics.

**Basic Aspects/Techniques of Plant Tissue Culture**
Introduction; Totipotency and Regeneration; Nutritional media and growth regulators; Problems in plant tissue culture; Discussion.

**Transgenic Crops**
Global status of transgenic crops; Traits under development; Case Studies; Challenges; Discussion

**Applications**
Plant Molecular farming (Bioreactors); Renewable energy crops and biofuels; Bio-fortification for Human Health; Discussion

**Safety and Regulations**
Understanding issues encountered in plant biotechnology; Risk assessment; Environmental impact and gene flow; Regulation and labelling; Discussion.

**Bioinformatics**
Biological Databases

Pairwise and Multiple sequence alignments

Genome Analysis
Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Human genome project

**Bioprocess Technology**
Introduction: A systems approach to Biology
Introduction to material and energy balances
Elemental balances in biological systems: Degrees of reductance
Energy balance in biological systems: Enthalpy efficiencies
Growth kinetics in batch systems
Growth and substrate utilization in continuous systems
Concept of maintenance
Product formation in anaerobic systems
Product formation kinetics
Continuous reactor systems with recycle
Fed batch reactors
Feed design in fed batch reactors and its analysis
Heat transfer in bioreactors
Mass transfer in bioreactors: Concept Kn, a
K.a estimation methods
Scale up principles

Downstream Processing


Product isolation – extraction, principle of extraction, partition coefficient, extraction factor, batch extraction, cascades, idealized stage operation, differential extraction, height of a transfer unit, number of transfer units, adsorption, adsorption isotherms, batch adsorption, adsorption in a CSTR.

Product Purification – Chromatography, yield and purity and resolution


Membrane filtration: tangential flow filtration, micro-filtration, ultra-filtration, reverse osmosis. Transport equations, gel layer formation, osmotic pressure. Time required for filtration in T.F.F. Polishing - Crystallization – separation, purity, nucleation, crystal growth, characteristic length, crystal size distribution, dominant crystal length.

Lyophilisation and drying.