

A candidate appearing in the XL paper has to answer the following sections

- **CHEMISTRY Section H – (Compulsory)**
- **GA – GENERAL APTITUDE (Compulsory)**
- **XL SECTIONS I TO M (Any Two)**

The choice of two sections from I to M can be made during the examination after viewing the questions. Only two optional sections can be answered by the candidate. A candidate wishing to change midway of the examination to another optional section must first choose to deselect one of the previously chosen optional sections (I to M).

## XL- SECTION H. CHEMISTRY (Compulsory)

**Atomic structure and periodicity :** Planck's quantum theory, wave particle duality, uncertainty principle, quantum mechanical model of hydrogen atom; electronic configuration of atoms; periodic table and periodic properties; ionization energy, electron affinity, electronegativity, atomic size.

**Structure and bonding :** Ionic and covalent bonding, M.O. and V.B. approaches for diatomic molecules, VSEPR theory & shape of molecules, hybridisation, resonance, dipole moment, structure parameters such as bond length, bond angle & bond energy, hydrogen bonding, van der Waals interactions. Ionic solids, ionic radii, lattice energy (Born-Haber Cycle).

**S.P. and D Block Elements :** Oxides, halides and hydrides of alkali and alkaline earth metals, B, Al, Si, N, P, and S, general characteristics of 3d elements, coordination complexes: valence bond and crystal field theory, color, geometry and magnetic properties.

**Chemical Equilibria:** Colligative properties of solutions, ionic equilibria in solution, solubility product, common ion effect, hydrolysis of salts, pH, buffer and their applications in chemical analysis, equilibrium constants ( $K_c$ ,  $K_p$  and  $K_x$ ) for homogeneous reactions,

**Electrochemistry:** Conductance, Kohlrausch law, Half Cell potentials, emf, Nernst equation, galvanic cells, thermodynamic aspects and their applications.

**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, Kirchoff's equation, heat of reaction, Hess law, heat of formation, Second law, entropy, free energy, & work function. Gibbs-Helmholtz equation, Clausius-Clapeyron equation, free energy change & equilibrium constant, Trouton's rule, Third law of thermodynamics.

**Basis of Organic Reactions Mechanism :** Elementary treatment of  $SN_1$ ,  $SN_2$ ,  $E_1$  and  $E_2$  reactions, Hoffmann and Saytzeff rules, Addition reactions, Markonikoff rule and Kharash effect, Diels-Alder reaction, aromatic electrophilic substitution, orientation effect as exemplified by various functional groups. Identification of functional groups by chemical tests.

**Structure-Reactivity Correlations:** Acids and bases, electronic and steric effects, optical and geometrical isomerism, tautomerism, conformers, concept of aromaticity.



### XL- SECTION I. BIOCHEMISTRY

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

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

DNA replication, transcription & 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.

### XL SECTION J. BIOTECHNOLOGY

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 & BAC. Architecture of plant genome; plant tissue culture techniques; methods of gene transfer into plant cells & 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 and 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 and therapeutic proteins; hybridoma technology and gene knockout; stem cells and its application in organ synthesis; gene therapy; transgenic animals and molecular pharming.

**Industrial Bioprocesses:** microbial production of organic acids, amino acids, proteins, polysaccharides, lipids, polyhydroxyalkanoates, antibiotics & pharmaceuticals; methods and applications of immobilization of cells & enzymes; kinetics of soluble & 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.

Bioinformatics; genomics; proteomics and computational biology.

### XL SECTION K. BOTANY

**Plant Systematics :** Systems of classification (non-phylogenetic vs. phylogenetic - outline), plant groups, molecular systematics.

**Plant Anatomy :** Plant cell structure, organization, organelles, cytoskeleton, cell wall and membranes; anatomy of root, stem and leaves, meristems, vascular system, their ontogeny, structure and functions, secondary growth in plants and stellar organization.

**Morphogenesis & Development:** Cell cycle, cell division, life cycle of an angiosperm, pollination, fertilization, embryogenesis, seed formation, seed storage proteins, seed dormancy and germination.

Concept of cellular totipotency, clonal propagation; organogenesis and somatic embryogenesis, artificial seed, somaclonal variation, secondary metabolism in plant cell culture, embryo culture, in vitro fertilization.

**Physiology and Biochemistry :** Plant water relations, transport of minerals and solutes, stress physiology, stomatal physiology, signal transduction, N<sub>2</sub> metabolism, photosynthesis, photorespiration; respiration, Flowering: photoperiodism and vernalization, biochemical mechanisms involved in flowering; molecular mechanism of senescence and aging, biosynthesis, mechanism of action and physiological effects of plant growth regulators, structure and function of biomolecules, (proteins, carbohydrates, lipids, nucleic acid), enzyme kinetics.

**Genetics:** Principles of Mendelian inheritance, linkage, recombination, genetic mapping; extrachromosomal inheritance; prokaryotic and eukaryotic genome organization, regulation of gene expression, gene mutation and repair, chromosomal aberrations (numerical and structural), transposons.

**Plant Breeding and Genetic Modification :** Principles, methods – selection, hybridization, heterosis; male sterility, genetic maps and molecular markers, sporophytic and gametophytic self incompatibility, haploidy, triploidy, somatic cell hybridization, marker-assisted selection, gene transfer methods viz. direct and vector-mediated, plastid transformation, transgenic plants and their application in agriculture, molecular pharming, plantibodies.

**Economic Botany :** A general account of economically and medicinally important plants- cereals, pulses, plants yielding fibers, timber, sugar, beverages, oils, rubber, pigments, dyes, gums, drugs and narcotics. Economic importance of algae, fungi, lichen and bacteria.

**Plant Pathology :** Nature and classification of plant diseases, diseases of important crops caused by fungi, bacteria and viruses, and their control measures, mechanism(s) of pathogenesis and resistance, molecular detection of pathogens; plant-microbe beneficial interactions.

**Ecology and Environment :** Ecosystems-types, dynamics, degradation, ecological succession; food chains and energy flow; vegetation types of the world, pollution and global warming, speciation and extinction, conservation strategies, cryopreservation, phytoremediation.

## **XL- SECTION L : MICROBIOLOGY**

**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 & electron-microscopy.

**Microbial Taxonomy and Diversity:** 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, Capsules, Cell inclusions like endospores and gas vesicles; Eukaryotic cell organelles: Endoplasmic reticulum, Golgi apparatus, mitochondria and chloroplasts.

**Microbial Growth :** Definition of growth, Growth curve, Mathematical expression of exponential growth phase; Measurement of growth & growth yields; Synchronous growth; Continuous culture; Effect of environmental factors on growth.

**Control of Micro-organisms:** Effect of physical and chemical agents; Evaluation of effectiveness of antimicrobial agents.

**Microbial Metabolism :** Energetics: redox reactions and electron carriers; An overview of metabolism; Glycolysis; Pentose-phosphate pathway; Entner-Doudoroff pathway; Glyoxalate pathway; The citric acid cycle; Fermentation; Aerobic and anaerobic respiration; Chemolithotrophy; Photosynthesis; Calvin cycle; Biosynthetic pathway for fatty acids synthesis; Common regulatory mechanisms in synthesis of amino acids; Regulation of major metabolic pathways.

**Microbial Diseases and Host Pathogen Interaction :** *Normal microbiota; Classification of infectious diseases; Reservoirs of infection; Nosocomial infection; Emerging infectious diseases; Mechanism of microbial pathogenicity; Nonspecific defense of host; Antigens and antibodies; Humoral and cell mediated immunity; Vaccines; Immune deficiency; Human diseases caused by viruses, bacteria, and pathogenic fungi.*

**Chemotherapy/Antibiotics:** General characteristics of antimicrobial drugs; Antibiotics: Classification, mode of action and resistance; Antifungal and antiviral drugs.

**Microbial Genetics :** Types of mutation; UV and chemical mutagens; Selection of mutants; Ames test for mutagenesis; Bacterial genetic system: transformation, conjugation, transduction, recombination, plasmids, transposons; DNA repair; Regulation of gene expression: repression and induction; Operon model; Bacterial genome with special reference to E.coli; Phage  $\lambda$  and its life cycle; RNA phages; RNA viruses; Retroviruses; Basic concept of microbial genomics.

**Microbial Ecology:** Microbial interactions; Carbon, sulphur and nitrogen cycles; Soil microorganisms associated with vascular plants.

**Animal world:** Animal diversity, distribution, systematics and classification of animals, phylogenetic relationships.

**Evolution:** Origin and history of life on earth, theories of evolution, natural selection, adaptation, speciation.

**Genetics:** Principles of inheritance, molecular basis of heredity, mutations, cytoplasmic inheritance, linkage and mapping of genes.

**Biochemistry and Molecular Biology :** Nucleic acids, proteins, lipids and carbohydrates; replication, transcription and translation; regulation of gene expression, organization of genome, Krebs's cycle, glycolysis, enzyme catalysis, hormones and their actions, vitamins.

**Cell Biology :** Structure of cell, cellular organelles and their structure and function, cell cycle, cell division, chromosomes and chromatin structure. Eukaryotic gene organization and expression (Basic principles of signal transduction).

**Animal Anatomy and Physiology :** Comparative physiology, the respiratory system, circulatory system, digestive system, the nervous system, the excretory system, the endocrine system, the reproductive system, the skeletal system, osmoregulation.

**Parasitology and Immunology :** Nature of parasite, host-parasite relation, protozoan and helminthic parasites, the immune response, cellular and humoral immune response, evolution of the immune system.

**Development Biology :** Embryonic development, cellular differentiation, organogenesis, metamorphosis, genetic basis of development, stem cells.

**Ecology :** The ecosystem, habitats, the food chain, population dynamics, species diversity, zoogeography, biogeochemical cycles, conservation biology.

**Animal Behaviour :** Types of behaviours, courtship, mating and territoriality, instinct, learning and memory, social behaviour across the animal taxa, communication, pheromones, evolution of animal behaviour.

