Syllabus for GATE:

XL - P : CHEMISTRY (COMPULSORY FOR ALL XL CANDIDATES)

Section 1: Atomic Structure and Periodicity

Planck's quantum theory, wave particle duality, uncertainty principle, comparison betweenBohr's model and quantum mechanical model of hydrogen atom, electronic configuration ofatoms and ions. Hund's rule and Pauli's exclusion principle.

Periodic table and periodic properties: ionization energy, electron affinity, electronegativity andatomic size.

Section 2: Structure and Bonding

Ionic and covalent bonding, MO and VB approaches for diatomic molecules, VSEPR theory andshape of molecules, hybridization, resonance, dipole moment, structure parameters such asbond length, bond angle and bond energy, hydrogen bonding and van der Waals interactions.Ionic solids, ionic radii and lattice energy (Born-Haber cycle).HSAB principle.

Section 3: s, p and d Block Elements

Oxides, halides and hydrides of alkali, alkaline earth metals, B, Al, Si, N, P, and S. Generalcharacteristics of 3d elements. Coordination complexes: valence bond and crystal field theory, color, geometry, magnetic properties and isomerism.

Section 4: Chemical Equilibria

Osmotic pressure, elevation of boiling point and depression of freezing point, ionic equilibria insolution, solubility product, common ion effect, hydrolysis of salts, pH, buffer and theirapplications. Equilibrium constants (Kc, Kp and Kx) for homogeneous reactions.

Section 5: Electrochemistry

Conductance, Kohlrausch law, cell potentials, EMF, Nernst equation, thermodynamic aspectsand their applications.

Section 6: Reaction Kinetics

Rate constant, order of reaction, molecularity, activation energy, zero, first and second orderkinetics, catalysis and elementary enzyme reactions.Reversible and irreversible inhibition ofenzymes.

Section 7: Thermodynamics

Qualitative treatment of state and path functions, First law, reversible and irreversibleprocesses, internal energy, enthalpy, Kirchoff equation, heat of reaction, Hess's law, heat offormation.Second law, entropy and free energy. Gibbs-Helmholtz equation, free energy changeand spontaneity, Free energy changes from equilibrium constant.

Section 8: Structure-Reactivity Correlations and Organic Reaction Mechanisms

Acids and bases, electronic and steric effects, Stereochemistry, optical and geometricalisomerism, tautomerism, conformers and concept of aromaticity. Elementary treatment of SN1,SN2, E1, E2 and radical reactions, Hoffmann/Saytzeff rules, addition reactions, Markownikoffrule and Kharasch effect. Elementary hydroboration reactions.Grignard's reagents and theiruses. Aromatic electrophilic substitutions, orientation effect as exemplified by various functionalgroups. Identification of common functional groups by chemical tests.

Section 9: Chemistry of Biomolecules

Amino acids, proteins, nucleic acids and nucleotides.Peptide sequencing by chemical andenzymatic proteolytic methods.DNA sequencing by chemical and enzymatic methods.Carbohydrates (upto hexoses only).Lipids (triglycerides only).Principles of biomoleculepurification-Ion exchange and gel filtration chromatography.Identification of these biomolecules and Beer-Lambert's law.

Optional Sections (Any 02)

XL - Q : BIOCHEMISTRY

Section 1: Organization of life; Importance of water; Structure and function of biomolecules: Amino acids,Carbohydrates, Lipids, Proteins and Nucleic acids; Protein structure, folding / misfolding and function; Myoglobin, Hemoglobin, Lysozyme, Ribonuclease A, Carboxypeptidase and Chymotrypsin.

Section 2: Enzyme kinetics, regulation and inhibition; Vitamins and Coenzymes; Bioenergetics andmetabolism; 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 containingcompounds: nitrogen fixation, amino acids and nucleotides. Photosynthesis, Calvin cycle.

Section 3: Biochemical separation techniques: ion exchange, size exclusion and affinity chromatography,centrifugation; Characterization of biomolecules by electrophoresis; DNA- protein and protein– protein interactions; UV-visible and fluorescence spectroscopy; Mass spectrometry.

Section 4: Cell structure and organelles; Biological membranes; Action potential; Transport acrossmembranes; Membrane assembly and Protein targeting; Signal transduction; Receptor-ligandinteraction; Hormones and neurotransmitters.

Section 5: DNA replication, transcription and translation; DNA damage and repair; Biochemical regulationof gene expression; Recombinant DNA technology and applications: PCR, site directedmutagenesis, DNA-microarray; Next generation sequencing; Gene silencing and editing.

Section 6: Immune system: Innate and adaptive; Cell of the immune system; Active and passive immunity;Complement system; Antibody structure, function and diversity; B cell and T Cell receptors; Bcell and T cell activation; Major histocompatibilty complex; Immunological techniques: Immunodiffusion, immune-electrophoresis, RIA and ELISA, flow cytometry; monoclonal antibodies and their applications.

## XL – R: BOTANY

Section 1: Plant Systematics-Botanical nomenclature, history of plant taxonomy, diversity and classification of plants, APGsystem of plant classification; phylogenetics and cladistics, molecular taxonomy and DNA barcoding; Centers for plant taxonomy and herbaria in India.

Section 2: Plant Anatomy-Anatomy of root, stem and leaves, floral organs, embryo and young seedlings, Primary andsecondary meristems, stellar organization, vascular system and their ontogeny, xylem andphloem structure, secondary growth in plants and wood anatomy, plant cell structure anddifferences from animal cells.

Section 3: Plant development; cell and tissue morphogenesis-Life cycle of an angiosperm, development of male and female gametophyte; cell fatedetermination and tissue patterning; spacing mechanisms in trichomes and stomata. Embryogenesis, organization and function of shoot and root apical meristems. Transition to flowering: photoperiodism and vernalization, ABC model of floral organ patterning, pollengermination, double fertilization, seed development; Xylem and phloem cell differentiation, photomorphogenesis; phytochrome, cryptochrome, phototropin. Role of auxin, cytokinin, gibberellins, and brassinosteroids on plant development.

Section 4: Plant physiology and biochemistry-Plant water relations, mechanisms of uptake and transport of water, ions, solutes from soil to plants, apoplastic and symplastic transport mechanisms. Mechanism of stomatal movements, nitrogen metabolism, photosynthesis; C3, C4 and CAM cycles, photorespiration, respiration:glycolysis, TCA cycle and electron transport chain. Plant responses and mechanisms of abioticstresses including drought, salinity, freezing and heat stress, metal toxicity; role of abscisic acidin abiotic stresses. Structure and function of biomolecules (proteins, carbohydrates, lipids,nucleic acid), enzyme kinetics.Structure and biosynthesis of major plant secondary metabolites(alkaloids, terpenes, phenylpropanoids, flavonoids).Biosynthesis, mechanism of action and physiological effects of auxin, cytokinin, gibberellic acids, brassinosteroid, ethylene, strigolactone, abscisic acid, salicylic and jasmonic acid. Senescence and programmed celldeath.

Section 5: Genetics and genomics-Cell cycle and cell division. Principles of Mendelian inheritance, linkage, recombination, geneticmapping; extra chromosomal inheritance; Introduction to epigenetics; gene silencing- transgenesilencing, post transcriptional gene silencing, miRNA and siRNA; evolution and organization ofeukaryotic genome structure, gene expression, gene mutation and repair, chromosomal aberrations (numerical: euploidy and aneuploidy and structural: deletion, duplication, inversion, translocation), transposons. Model organisms for functional genetics and genomics; Introduction to transcriptomics, proteomics and metabolomics.

Section 6: Plant Breeding, Genetic Modification, Genome Editing-Principles, methods – selection, hybridization, heterosis; male sterility, genetic maps andmolecular markers, embryo rescue, haploid and doubled haploids, plant tissue culture: micro propagation, embryo culture and in vitro regeneration, somatic embryogenesis, artificial seed, cryopreservation, somaclonal variation, somatic cell hybridization, marker-assistedselection, gene transfer methods viz. direct and vector-mediated, generation of transgenicplants; Introduction to genome editing: CRISPR/Cas9, Cre-Lox system to generate chimeras;plastid transformation; chemical mutagenesis.

Section 7: Economic and applied Botany-A general account of economically and medicinally important plants- cereals, pulses, plantsyielding fibers, timber, sugar, beverages, oils, rubber, pigments, dyes, gums, drugs andnarcotics. Economic importance of algae, fungi, lichen and bacteria.Major Indian cash crops.Effect of industrialization on agricultural botany such as plastic on fiber economy. Genetically modified crops and its regulation eg.Bt cotton, Bt brinjal golden rice etc.

Section 8: Plant Pathology-Nature and classification of plant diseases, diseases of important crops caused by fungi,bacteria, nematodes and viruses, and their control measures (chemical and biological)mechanism(s) of pathogenesis, resistance: basal, systemic, induced systemic resistance, genefor gene concept. Molecular detection of pathogens; plant-microbe interactions: symbionts and mycorrhiza, pathogens and pests. Signaling pathways in plant defence response; salicylic acid(SA) and jasmonic acid (JA) in plant-pathogen and plant-herbivore interaction, necrosis; host-parasitic plant interaction (such as Cuscuta).

Section 9: Ecology and Environment-Ecosystems – types, dynamics, degradation, biogeochemical cycles, ecological succession;food webs and energy flow through ecosystem; vegetation types of the world, Indian vegetation types and

biogeographical zones, climate and flora endemism; pollution and global climatechange, speciation and extinction, biodiversity and conservation strategies, ecologicalhotspots, afforestation, habitat restoration; plant interactions with other organisms; epiphytes,parasites and endophytes.

## XL – S: MICROBIOLOGY

Section 1: Historical Perspective-Discovery of microbial world; Landmark discoveries relevant to the field of microbiology; Controversy over spontaneous generation; Role of microorganisms in transformation of organicmatter and in the causation of diseases.

Section 2: Methods in Microbiology-Pure culture techniques; Principles of microbial nutrition; Enrichment culture techniques forisolation of microorganisms; antigen and antibody detection methods for microbial diagnosis;Light-, phase contrast-, fluorescence- and electron-microscopy; PCR, real-time PCR forquantitation of microbes; Next generation sequencing technologies in microbiology.

Section 3: 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 andphylogeny.

Section 4: Prokaryotic Cells: Structure and Function-Prokaryotic Cells: cell walls, cell membranes and their biosynthesis, mechanisms of solutetransport across membranes, Flagella and Pili, Capsules, Cell inclusions like endospores andgas vesicles; Bacterial locomotion, including positive and negative chemotaxis.

Section 5: Microbial Growth-Definition of growth; Growth curve; Mathematical expression of exponential growth phase;Measurement of growth and growth yields; Synchronous growth; Continuous culture; Effect ofenvironmental factors on growth; Bacterial biofilm and biofouling.

Section 6: Control of Micro-organisms-Disinfection and sterilization: principles, methods and assessment of efficacy.

Section 7: Microbial Metabolism-Energetics: redox reactions and electron carriers; Electron transport and oxidativephosphorylation; 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 pathwayfor fatty acids synthesis; Common regulatory mechanisms in synthesis of amino acids;Regulation of major metabolic pathways.

Section 8: Microbial Diseases and Host Pathogen Interaction-Normal microbiota; Classification of infectious diseases; Reservoirs of infection; Nosocomialinfection; Opportunistic infections; Emerging infectious diseases; Mechanism of microbial pathogenicity; Nonspecific defence of host; Antigens and antibodies; Humoral and cell mediated immunity; Vaccines; passive immunization; Immune deficiency; Human diseases caused byviruses, bacteria, and pathogenic fungi.

Section 9: Chemotherapy/Antibiotics-General characteristics of antimicrobial drugs; Antibiotics: Classification molecular mechanismof mode of action and resistance; Antifungal and antiviral drugs.

Section 10: Microbial Genetics-Types of mutation; UV and chemical mutagens; Selection of mutants; Ames test formutagenesis; Bacterial genetic system: transformation, conjugation, transduction,recombination, plasmids, transposons; DNA repair; Regulation of gene expression: repressionand induction; Operon model; Bacterial genome with special reference to E.coli; Phage λ and its life cycle; RNA ; mutation in virus genomes, virus recombination and reassortment; Basicconcept of microbial genomics.

Section 11: Microbial Ecology-Microbial interactions; Carbon, sulphur and nitrogen cycles; Soil microorganisms associatedwith vascular plants; Bioremediation; Uncultivable microorganisms; basic concept of metagenomics and metatranscriptomics.

## XL – T: ZOOLOGY

Section 1: Animal Diversity-Distribution, systematics and classification of animals, phylogenetic relationships (based onclassical and molecular phylogenetic tools).

Section 2: Evolution-Origin and history of life on earth, theories of evolution, natural selection, adaptation, speciation.

Section 3: Genetics-Basic Principles of inheritance, molecular basis of heredity, sex determination and sex-linkedcharacteristics, cytoplasmic inheritance, linkage, recombination and mapping of genes ineukaryotes, population genetics, genetic disorders, roles of model organisms in understandinggenetic principles.

Section 4: Biochemistry and Molecular Biology-Nucleic acids, proteins, lipids and carbohydrates; replication, transcription and translation,Krebscycle, glycolysis, enzyme catalysis, hormones and their actions, roles of vitamins and minerals.

Section 5: Cell Biology-Basic principles of cellular microscopy, structure of cell, cytoskeletal organization, cellularorganelles and their structure and function, cell cycle, cell division, chromosomes and chromatinstructure.

Section 6: Gene expression in Eukaryotes-Eukaryotic genome organization and regulation of gene expression, transposable elements.

Section 7: Animal Anatomy and Physiology-Comparative physiology, the respiratory system, Muscular system, circulatory system, digestivesystem, the nervous system, the excretory system, the endocrine system, the reproductivesystem, the skeletal system.

Section 8: Parasitology and Immunology-Nature of parasite, host-parasite relation, protozoan and helminthic parasites, the immuneresponse, cellular and humoral immune response.

Section 9: Development Biology-Gametogenesis, Embryonic development, cellular differentiation, organogenesis,metamorphosis, Model organisms used in developmental biology, genetic and molecular basisof development, stem cells.

Section 10: Ecology-The ecosystem, Animal distribution, ecological niche and its contribution to ecological diversity,the food chain, population dynamics, species diversity, zoogeography, biogeochemical cycles,conservation biology, ecotoxicology.

Section 11: Animal Behaviour-Type of behaviours, courtship, mating and territoriality, instinct, learning and memory, socialbehaviour across the animal taxa, communication, pheromones, evolution of behavior in animals.