**Harcourt Butler Technical University, Kanpur**
**Syllabus of the Written Test of "Biochemical Engineering" Discipline for the Post of Assistant Professor (Contractual)**

### Module 1: Process Calculations and Thermodynamics

Steady and unsteady state mass and energy balances including multiphase, multi component, reacting and non-reacting systems. Use of tie components; recycle, bypass and purge calculations; Gibb's phase rule and degree of freedom analysis. First and Second laws of thermodynamics. Applications of first law to close and open systems. Second law and Entropy. Thermodynamic properties of pure substances: Equation of State and residual properties, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibrium.

### Module 2: Fluid Mechanics

Fluid statics, surface tension, Newtonian and non-Newtonian fluids, transport properties, shell balances including differential form of Bernoulli equation and energy balance, equation of continuity, equation of motion, equation of mechanical energy, Macroscopic friction factors, dimensional analysis and similitude, flow through pipeline systems, velocity profiles, flow meters, pumps and compressors, elementary boundary layer theory, flow past immersed bodies including packed and fluidized beds, Turbulent flow: fluctuating velocity, universal velocity profile.

### Module 3: Heat Transfer

Equation of energy, steady and unsteady heat conduction, convection and radiation, thermal boundary layer and heat transfer coefficients, boiling, condensation and evaporation; types of heat exchangers and evaporators and their process calculations; design of double pipe, shell and tube heat exchangers, and single and multiple effect evaporators.

### Module 4: Mass Transfer

Fick's laws, molecular diffusion in fluids, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass transfer analogies; stage wise and continuous contacting and stage efficiencies; HTU NTU concepts; design and operation of equipment for distillation, absorption, leaching, liquid extraction, drying, humidification, dehumidification and adsorption, membrane separations (micro filtration, ultra-filtration, nano-filtration and reverse osmosis).

### Module 5: General Biology and Biochemistry

Biomolecules including carbohydrates, proteins, lipids and nucleic acids; structure and function of biological macromolecules. Biological membranes, membrane transport, membrane channels, pumps and molecular motors. Metabolism and regulation of carbohydrates, lipids, amino acids and nucleic acids. Photosynthesis, respiration and electron transport chain. Enzyme classification, catalytic and regulatory mechanisms, Michaelis-Menten kinetics and enzyme inhibition.

### Module 6: Cellular and Molecular Biology

Gene interaction, linkage, recombination and chromosome mapping, extra-chromosomal inheritance, transformation, transduction, conjugation, horizontal gene transfer, transposable elements, chromosomal variations, genetic disorders, population genetics, epigenetics, adaptive and neutral evolution, genetic drift, species and speciation.

Cell Biology including prokaryotic and eukaryotic cell structure, cell cycle and growth control, cell communication, signal transduction, post-translational modifications, protein trafficking, cell death, autophagy and extracellular matrix.

Molecular Biology including molecular structure of genes and chromosomes, mutations and mutagenesis, regulation of gene expression, DNA replication, transcription, RNA processing and splicing, translation and their regulatory mechanisms, non-coding RNA, microRNA, RNA interference, DNA damage and repair mechanisms.

**Module 7: Bioprocess Engineering Principles**

Engineering principles applied to biological systems including material and energy balances for reactive and non-reactive systems, recycle, bypass and purge processes, stoichiometry of growth and product formation, degree of reduction, electron balance and theoretical oxygen demand.

Classical thermodynamics and bioenergetics including laws of thermodynamics, solution thermodynamics, phase equilibria, reaction equilibria, ligand binding, membrane potential and energetics of metabolic pathways, oxidation and reduction reactions.

**Module 8: Bioprocess Engineering**

Bioreaction engineering including rate laws, zero-order and first-order kinetics, ideal reactors such as batch, mixed flow and plug flow reactors, enzyme immobilization, diffusion effects, Thiele modulus, effectiveness factor, Damköhler number, kinetics of cell growth, substrate utilization and product formation, structured and unstructured models, batch, fed-batch and continuous processes, microbial and enzyme reactors, optimization and scale-up.

Bioreactors and their control including bioreactor components, agitators, aerators, baffles, probes, valves, oxygen transfer, KLa determination, heat transfer, heat exchangers, instrumentation, online and offline monitoring, pH, temperature and dissolved oxygen probes, tachometer, load cells, feedback, feedforward, cascade, adaptive and PID control systems and computer applications in bioreactor control.

Upstream processing including media formulation and optimization, sterilization of air and media. Downstream processing including membrane filtration, ultrafiltration, centrifugation, cell disruption, chromatography techniques such as ion exchange, gel filtration, hydrophobic interaction, affinity chromatography, GC, HPLC, extraction, adsorption and drying.

**Module 9: Microbial /Enzyme Technology**

Isolation, screening, selection and identification of industrially important microorganisms; methodologies of isolation and screening; primary and secondary screening methods; microbial strain improvement; preservation and maintenance of cultures; industrially important microorganisms and their products.

Microbial growth and growth kinetics including batch culture, specific growth rate, substrate saturation constant, yield coefficient, Monod kinetics, substrate affinity, continuous culture, dilution rate, washout phenomenon, fed-batch culture, maintenance coefficient, product yield, growth-associated and non-growth-associated products. Industrial sterilization, direct and indirect methods and death kinetics.

Fermentation technology including primary and secondary metabolites, production of alcohol, acetone-butanol, citric acid, acetic acid, lactic acid, amino acids, vitamins, antibiotics, industrial enzymes, single-cell protein, bread, beer and cheese production, fermented dairy products and distilled beverages.

**Module 10: Plant & Environmental Biotechnology**

Plant biotechnology including totipotency, plant regeneration, plant growth regulators, tissue culture, cell suspension culture, secondary metabolite production, hairy root culture, artificial seeds, soma clonal variation, protoplast culture and fusion, somatic hybrids, cybrids, transgenic plants, marker genes and plastid transformation.

Microbial biotechnology including production of biomass, biofuels, bioplastics, industrial enzymes, antibiotics, recombinant proteins and metabolites, food, clinical and industrial microbiology and screening strategies for new products.

Industrial pollution, air, water and soil pollutants, xenobiotics, biomagnification, recalcitrant compounds, hydrocarbons, pesticides, phenolics, heavy metals, pollutant detection and environmental laws.

Biodegradation and bioremediation including biodegradation processes, influencing factors, biodegradative enzymes, catabolic plasmids, molecular approaches, biogeochemical cycles, bioleaching and biodegradation of hydrocarbons, cellulose, lignin, phenols and pesticides.

Industrial wastewater treatment including wastewater characterization, BOD, COD, TOC, nitrogen analysis, bacteriological analysis of drinking water, primary, secondary and tertiary treatment methods, activated sludge process, nitrification, denitrification, trickling filters, rotating biological contactors, UASB reactors, oxidation lagoons and advanced treatment processes.

Solid waste management including municipal and industrial waste management, landfills, composting, vermicomposting, anaerobic digestion, methanogenesis, biogas production and household waste treatment.

Note: In addition to the above, the paper would be of GATE level/syllabus.