

Chemical Engineering

(Syllabus for Written Test)

Section 1. Process Control and Process System Engineering

Process Control of first and higher order systems, closed and open loop response, transfer functions and dynamic responses of various systems to step, impulse and sinusoidal disturbances, systems with inverse response, controller modes (P, PI, and PID), types of control valves-linear, equal percentage and quick opening valve, transducer dynamics,transient response, frequency response(Bode's plot), design of control systems, Mathematical Modelling of control systems, Dynamic Behavior of Chemical Processes: Stability Analysis: Routh analysis, Advanced control techniques, controller tuning, cascade, ratio, feed forward, adaptive control, selective controls.

Section 2. Thermodynamics and Molecular Simulation

Fundamental concepts and definitions. PVT relationships of pure substances. First law of Thermodynamics. Application of first law to different processes. Second law of Thermodynamics and its applications. Relations among thermodynamic properties. Equation of State and residual properties, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients. Stability and phase transition in thermodynamics systems, Properties of solutions, Vapor-liquid equilibrium. Chemical reaction equilibrium. Elementary, classical statistical mechanics, elementary concepts of temperature, ensembles and fluctuations, partition function, ensemble averaging, ergodicity. Molecular Dynamics Methodology - Force Field, Integrating Algorithms, Periodic Box and Minimum Image Convention. Monte Carlo simulation.

Section 3. Biochemical Engineering

Fermentation process, Cell cultivations, Measurement of cell number and cell mass, Cell immobilization, Growth curve, Cell Growth in Batch Fermenters and Continuous Stirred-Tank Fermenters, DNA and RNA, Clonal stability, Recombinant DNA, gene transfer and rearrangement. Sterilization methods, thermal death kinetics, design criterion, Enzyme kinetics: Effect of pH, temperature and shear on enzyme activity, Effective Diffusivities in Biological Gels. Kinetics of Enzymatic Hydrolysis of Cellulose, DNS Reagent Preparation, Enzyme Assay: Filter Paper Activity, calibration curve for glucose assay. Selection, scale-up, operation, and control of bioreactors, Determination of Oxygen-Absorption rate, Shear sensitive mixing.

Section 4. AI & ML and Data Analytics in Chemical Engineering

Types of machine learning, use of machine learning, difference between AI, machine learning, and deep learning, real-life examples of machine learning and the different elements of machine learning. Steps in machine learning: Data pre-processing. Model evaluation matrices, Over-fitting and under-fitting. Chemical and bioreactor modelling by machine learning algorithm, Building machine learning models: Regression learner in MATLAB, Steps to build a ML Model, Central limit theorem, confidence interval, z-test, t-test, chi-squared test.

Section 5. Risk Assessment and Hazard Analysis

Consequence Analysis – Fire and Explosion models: Risk analysis- Radiation intensity calculation and its effect to plant, people & property. HAZOP study – Case studies – Pumping system – Reactor System – Mass transfer system - Risk assessment techniques and methods - Contaminated Site Assessment / Human Health Risk Assessment - Environmental Quality Guidelines / Preliminary Quantitative Risk Assessment - Air Quality Risk Assessment - Risk Assessment in Support of Environmental Assessment - Perception of risk - Vulnerability assessment. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets (MSDS). Hazard identification – Safety Audits – Checklists – What if Analysis– Event tree and Fault tree Analysis – Past accident analysis.
