Syllabus for Entrance Examination – M. Chem. Engg.

2024-25

Material and Energy Balances Computations:
Units and Dimensions
Mole concept, composition relationship and stoichiometry
Applications of Laws of Conservation of Mass and Energy to single and Multistage processes.
Behavior of gases and vapors
Material balances for reacting systems
Psychrometry: humidity and air-conditioning calculations.
Fuels and combustion
Unsteady state material balances
Material and energy balances for complete plants

1. Transport Phenomena:

Fluid Statics and applications to engineering importance.
Equations of Continuity and Motion (Cartesian, cylindrical, and spherical coordinates) in laminar flows and its applications for the calculation of velocity profiles, shear stresses, power, etc. in various engineering applications.
Basics of Turbulent flows, equations of continuity and motion for turbulent flows: Reynolds averaging, Bossinesque hypothesis, Prandtl mixing length theory, Introduction to various types of turbulence models. Turbulent pipe flow, basis of Universal velocity profile and its use. Introduction to turbulent heat and mass transfer.
Boundary Layer Flows: Blasius equations and solution, Von-Karman integral equations and solutions, Boundary layer separation: skin and form drag.
Fundamentals of mass transfer: Molecular diffusion in fluids, mass transfer coefficients, and interface mass transfer, steady state theories of mass transfer, Whitman's two-film theory, and its variations.
Bernoulli's Equation and engineering applications, Pressure drop in pipes and Fittings, Piping design and fluid moving machinery such as pumps, blowers, compressors, vacuum systems, etc.
Particle Dynamics, Flow through Fixed and Fluidized Beds,
Gas – liquid Two phase flow: types of flow regimes, Regime maps, estimation of pressure drop and hold-
Blending: Theories of homogenization, criteria for mixing, equipment and performance expressions of rate processes, mixing power estimation for impeller and liquid jets, impeller types and flow patterns.
Steady state and unsteady state conduction, Fourier's law, Concepts of resistance to heat transfer and the heat transfer coefficient. Heat transfer in Cartesian, cylindrical and spherical coordinate systems, Insulation, critical radius.
Convective heat transfers in laminar and turbulent boundary layers. Theories of heat transfer and analogy between momentum and heat transfer. Heat transfer by natural convection.
Heat transfer in laminar and turbulent flow in circular pipes: Double pipe heat exchangers: Concurrent, counter-current and cross flows, mean temperature difference, NTU – epsilon method for exchanger evaluation.
Shell and tube heat exchangers: Basic construction and features, TEMA exchanger types, their nomenclature, choice of exchanger type, correction to mean temperature difference due to cross flow, multipass exchangers. Design methods for shell and tube heat exchangers such as Kern Method, Bell – Delaware method
Finned tube exchangers, air-cooled cross flow exchangers and their process design aspects
Compact Exchangers: Plate, Plate fin, Spiral, etc.: Construction, features, advantages, limitations and their process design aspects
Condensation of vapors: theoretical prediction of heat transfer coefficients, practical aspects, horizontal versus vertical condensation outside tubes, condensation inside tubes, Process Design aspects of total condensers, condensers with de-superheating and sub cooling, condensers of multicomponent mixture, condensation of vapors in presence of non-condensables.
Heat transfer to boiling liquids: Process design aspects of evaporators, natural and forced circulation reboilers
Heat transfer in agitated vessels: coils, jackets, limpet coils, calculation of heat transfer coefficients, heating and cooling times, applications to batch reactors and batch processes.

2. Reaction Engineering:

Kinetics of homogeneous reactions, Interpretation of batch reactor data, Single ideal reactors, Design for single and multiple reactions, Temperature and pressure effects.
Non ideal flow, Micro and macromixing of fluids.
Non-Catalytic Fluid-particle reactions.
Homogeneous and Heterogeneous Catalysis, Kinetics of Solid Catalyzed Reactions. Design of gas – solid catalytic reactors.

3. Thermodynamics:

Definition of terms and fundamental concepts (Thermodynamic properties, Phase rule, phase diagrams)
Pressure - volume - temperature relationships of pure fluids.
Calculations of enthalpy, entropy, free energy, from measurable properties
Thermodynamic properties of pure fluids, estimation of properties.
Calculation of Phase equilibrium using volumetric properties
Vapor - liquid equilibrium in miscible Binary and multicomponent systems.
Models for liquid phase. Prediction and correlation of activity coefficients.
Calculations of flash, isobaric X-Y diagrams. Modified Raoults Law
Group contribution methods for activity coefficients.
Vapor - liquid equilibria in systems with partially miscible liquid phase. Liquid - liquid equilibria.
Solubility of gases in non-polar and polar liquids, and aqueous solutions. Effect of temperature, pressure on solubility of gases.
Solubility of solids in liquids.
Chemical reaction equilibria in homogeneous and heterogeneous systems.

4. Unit Operations:

Absorption: Solubility, choice of solvent, concept of rate approach and stagewise approach, countercurrent and co-current multistage operations, dilute and concentrated systems, process design of absorption equipments, performance evaluation of absorbers. Plate and packed columns, packing characteristics / selection.
Distillation: Fundamentals of vapors - liquid equilibrium, Henry's, Raoult's and Dalton's laws; boiling point and dew point curves, X - Y and T-X-Y diagram, partial vaporization / condensation, performance evaluation of distillation columns including reboilers and condensers Flash; differential and steam distillation, staged calculation using McCabe -Thiele method. Batch distillation - Binary systems, constant product / constant reflux operation. Advanced topics in batch distillation. Distillation: Staged calculations using enthalpy - concentration diagram, multicomponent distillation
Design aspects of packed columns: sizing, packing selection, design of other internals, efficiency calculations,
Design aspects of tray columns: regime of operation in tray towers, sizing of tray towers, efficiency and entrainment calculations
Drying: Wet bulb, dry bulb and adiabatic saturation temperatures, humidity, drying mechanism, drying rate curves, estimation of drying time and process design of dryers e.g. spray, rotary, tunnel, tray, fluid bed and thin film, performance evaluation of dryers
Humidification/Dehumidification and Cooling Tower: Definitions, usage of psychometric chart, temp/humidity, enthalpy/humidity chart, air conditioning, method of changing humidity and equipments, cooling tower process design, counter-current, co-current and cross current, mass and heat balances in bulk and interfaces, estimation of air quality, performance evaluation of cooling towers.
Filtration and Centrifugation: Mechanism of filtration, basic equation, constant volume, constant pressure filtration, rate expressions with cake and filter cloth resistances, compressible and incompressible cakes, process design of filtration equipments and their performance evaluation, plate and frame, Nutsch, rotary, vacuum. Theory of centrifugal separation, design equations, centrifuge types, and performance evaluation.
Leaching: Solid-liquid extraction: Solid - liquid equilibria, efficiency, performance evaluation
Liquid-Liquid Extraction Solvent selections, ternary liquid equilibria, staged calculations, spray columns, packed, and plate columns, multistage extraction columns, mixer - settlers, analysis on solvent - free basis. Performance evaluation of extractors
Adsorptive Separations and Ion Exchange: Adsorption isotherms, industrial adsorbents with their characteristics, breakthrough curve, adsorption columns

Membrane Separation Processes: Fundamentals, gas separations, Microfiltration, ultrafiltration, Reverse osmosis, nanofiltration, pervaporation, membrane modules, design of membrane systems

Crystallization: Theory of solubility and crystallization, phase diagram (temp/solubility relationship), population balance analysis, method of moments for rate expressions for, volume, area and length growth, CSD distribution, MSMPR operation, evaporative and cooling (rate expressions), most dominant size, ideal classified bed, melt crystallization, process design of crystallizers and their operation.