GUJARAT TECHNOLOGICAL UNIVERSITY

BE SEMESTER 5 – OLD PAPER – S22 TO S26 – QUESTION BANK

Subject Name & Code: Mass Transfer Operations I - 3150501

Chapter 1 – Introduction

Repeated Questions:

1. Separation Methods and Classification (Theory):

- **Q.** Discuss in brief about choice of separation methods. **(SUMMER 2022, 7 Marks; WINTER 2025, 4 Marks - factors affecting choice of separation method)**
- **Q.** Classify the mass transfer operations based on direct contact of two immiscible phases with examples / Discuss classification of mass transfer operations with examples. **(WINTER 2022, 3 Marks; WINTER 2023, 7 Marks)**

Other Important Questions:

1. Definitions and Principles (Theory):

- **Q.** Define: 1) Mass Transfer 2) Equilibrium 3) Mass transfer Co-efficient. **(SUMMER 2023, 3 Marks - multi-chapter definition; mapped here for convenience)**
- **Q.** Explain design principles of mass transfer equipment. **(SUMMER 2024)**
- **Q.** Discuss in detail about Steady State Concurrent processes. **(WINTER 2025, 7 Marks)**
- **Q.** Explain mass transfer operation between two immiscible phases. **(WINTER 2025, 3 Marks)**

Chapter 2 – Molecular Diffusion in Fluids

Repeated Questions:

1. Fick's Law and Steady State Diffusion (Theory and Derivations):

- **Q.** State/discuss Fick's law of diffusion and explain/discuss N and J flux; prove $D_{AB} = D_{BA}$ where asked. **(SUMMER 2022, 4 Marks; SUMMER 2022, 4 Marks; WINTER 2022, 4 Marks; SUMMER 2023, 3 Marks; WINTER 2023, 7 Marks; SUMMER 2025, 3 Marks; SUMMER 2025, 4 Marks; WINTER 2025, 3 Marks; SUMMER 2026, 4 Marks)**
- **Q.** Derive/deduce equation for steady state diffusion of A through non-diffusing B (gas/liquid phase). **(SUMMER 2022, 3 Marks; SUMMER 2023, 4 Marks; WINTER 2023, 7 Marks OR; SUMMER 2024, 7 Marks OR; SUMMER 2025, 7 Marks; WINTER 2025, 4 Marks)**
- **Q.** Derive equation for steady state equimolar counter diffusion (gas phase). **(WINTER 2023, 7 Marks OR; SUMMER 2026, 4 Marks)**

2. Diffusion Problems (Numerical):

- **Q.** Benzene/volatile organic compound stored in open tank with stagnant air film — calculate loss/rate of diffusion. **(SUMMER 2022, 7 Marks - calculate loss in Rs/day; SUMMER 2025, 7 Marks OR - calculate rate of diffusion in kmol/m²hr)**
- **Q.** Oxygen–nitrogen gas mixture — calculate flux/rate of diffusion for equimolar counter diffusion and/or non-diffusing nitrogen. **(SUMMER 2025, 7 Marks; SUMMER 2026, 7 Marks)**

Other Important Questions:

1. Diffusivity (Theory):

- **Q.** Give unit of diffusivity. How to predict diffusivity in gases? **(SUMMER 2023, 3 Marks OR)**
- **Q.** Briefly explain diffusivity of liquids. **(SUMMER 2025, 3 Marks OR)**
- **Q.** Explain diffusion in solids. **(WINTER 2023, 3 Marks OR)**

2. Diffusion Problems (Numerical):

- **Q.** Ammonia is diffusing through a stagnant gas mixture consisting of 1/3 N_2 and 2/3 H_2 by volume. Total pressure 206.8 kN/m², temperature 54 °C. Calculate rate of diffusion through 0.5 mm film when concentration change is 10% to 5% by volume. Diffusivity 2.45×10^{-5} m²/s. **(SUMMER 2022, 4 Marks)**
- **Q.** A tube 1 cm inside diameter and 20 cm long is filled with CO_2 and H_2 at total pressure 2 atm at 0 °C. Diffusion coefficient 0.275 cm²/s. Partial pressure of CO_2 is 1.5 atm at one end and 0.5 atm at the other. Determine flux for: (i) steady state equimolar counter diffusion, (ii) steady state counter diffusion where $N_B = -0.75N_A$, (iii) steady state diffusion of CO_2 through stagnant H_2. **(WINTER 2022, 7 Marks)**
- **Q.** Discuss the effect of temperature and pressure on diffusivity for gases and liquids. For a gaseous system, $D_{AB} = 0.202$ cm²/s at 25 °C. Determine diffusivity (m²/s) at 40 °C if pressure is halved and other parameters remain constant. **(SUMMER 2024)**
- **Q.** Ethanol vapor diffusing through a layer of water vapor under equimolar counter diffusion at 35 °C and 1 atm. Molal concentration 80% and 10% across 0.3 mm film; diffusivity 0.18 cm²/s. (i) Determine rate of diffusion of alcohol and water vapor in kg/hr through 100 cm². (ii) If water vapor layer is stagnant, estimate rate of diffusion of alcohol vapor. **(SUMMER 2024, 7 Marks)**
- **Q.** Alcohol vapor absorbed from alcohol–water vapor mixture by nonvolatile solvent; 97 °C, 760 mm Hg, film 0.1 mm, mole% 80% and 10%, diffusivity at 25 °C and 1 atm 0.15 cm²/s. Calculate rate of diffusion of alcohol vapor in kg/hr for area 10 m²; MW alcohol = 46. **(SUMMER 2023, 7 Marks)**
- **Q.** Calculate rate of diffusion of acetic acid (A) across a film of non-diffusing water (B) solution 2 mm thick at 17 °C, concentrations 9% and 3% acid by weight. Diffusivity 0.95×10^{-9} m²/s; densities 1012 and 1003 kg/m³. **(SUMMER 2023, 7 Marks)**

- **Q.** Ammonia and air are in equimolar counter diffusion in cylindrical tube 3 mm diameter and 20 m length. Total pressure 1 atm, 25 °C. One end connected to large NH_3 reservoir and other open to atmosphere. Estimate mass transfer rates in kg/sec of ammonia and air. Diffusivity 0.28×10^{-4} m^2/sec. **(WINTER 2023, 7 Marks)**
- **Q.** Ammonia diffusing through inert air film 2 mm thick at 20 °C and 1 atm. Concentration 10% by volume on one side and zero on other. Determine mass flux. Estimate effect on rate if pressure increased to 10 atm. Diffusivity 0.185 cm^2/s. **(SUMMER 2024, 7 Marks)**
- **Q.** Methane diffuses at steady state through tube containing helium for equimolar counter diffusion. At point 1 partial pressure of methane 55 kPa; at point 2, 0.03 m apart, 15 kPa. Total pressure 101.325 kPa, 298 K, diffusivity 6.75×10^{-5} m^2/s. Calculate partial pressure of methane at point 0.02 m apart from point 1. **(WINTER 2025, 7 Marks)**
- **Q.** Oxygen (A) diffusing through carbon monoxide (B) under steady state with CO non-diffusing. Total pressure 1×10^5 N/m^2, 0 °C. Partial pressure of oxygen at two planes 2.0 mm apart: 13000 and 6500 N/m^2. Diffusivity 1.87×10^{-5} m^2/s. Calculate rate of diffusion of oxygen in kmol/s through each m^2. **(WINTER 2025, 7 Marks OR)**
- **Q.** Determine flux of butanol at 20 °C under unidirectional steady state through 0.1 cm thick water film when concentrations are 10% and 4% butanol by weight. Diffusivity 5.9×10^{-6} cm^2/s; densities 0.971 and 0.992 g/cc. Also determine flux if equimolar countercurrent diffusion occurs. **(SUMMER 2026, 7 Marks OR)**

Chapter 3 – Mass Transfer Coefficients

Repeated Questions:

1. Theories of Mass Transfer (Theory):

- **Q.** State assumptions of film theory and derive relation for mass transfer coefficient / Explain film theory for mass transfer coefficient / Discuss film theory at length with derivation and limitations. **(SUMMER 2022, 7 Marks OR; WINTER 2022; WINTER 2023, 3 Marks; SUMMER 2026, 7 Marks)**
- **Q.** Compare penetration theory with surface renewal theory / explain penetration theory with assumptions. **(SUMMER 2023, 4 Marks; WINTER 2025, 4 Marks)**
- **Q.** Explain mass, heat and momentum transfer analogies. **(SUMMER 2023, 4 Marks OR; WINTER 2023, 4 Marks OR; WINTER 2025, 3 Marks; WINTER 2025, 4 Marks OR - second set)**

Other Important Questions:

1. Mass Transfer Coefficients (Theory):

- **Q.** Interrelate k_G, k_C, k_Y with F-type MTC for gaseous phase. Also mention their units. **(SUMMER 2024, 4 Marks)**

Chapter 4 – Inter Phase Mass Transfer

Repeated Questions:

1. Overall and Individual Mass Transfer Coefficients (Theory):

- **Q.** Derive/explain relationship between overall mass transfer coefficients (K_y, K_x) and individual mass transfer coefficients (k_y, k_x) / two-film resistance theory / overall and local MTC / interphase mass transfer. **(SUMMER 2022, 3 Marks; WINTER 2022, 7 Marks OR; SUMMER 2023, 7 Marks; WINTER 2023, 4 Marks; SUMMER 2024, 7 Marks OR; SUMMER 2025, 4 Marks OR; WINTER 2025, 7 Marks)**

2. Numerical Problems:

- **Q.** At 293 K solubility of ammonia in water is given by Henry's law p = 0.3672C, where p is atm and C is kmol/m³. A mixture of 15% ammonia and 85% air by volume at 1 atm contacts aqueous solution containing 0.147 gmol/lit. k_G/k_L = 0.9. Find concentration of ammonia and partial pressure at interface. **(SUMMER 2023, 7 Marks - alternative/second Q2c)**

Other Important Questions:

1. Numerical Problems:

- **Q.** In a wetted wall column, CO_2 is absorbed from air by water flowing at 2 atm and 25 °C. MTC $k_y = 6.78 \times 10^{-5}$ kmol/m²s mole fraction. Determine rate of absorption if partial pressure of CO_2 at interface is 0.2 atm and air is pure. Also determine k_y and k_g. **(SUMMER 2024)**

Chapter 5 – Gas Absorption

Repeated Questions:

1. Absorption Principles and Design (Theory):

- **Q.** Explain/discuss solvent selection criteria for absorption. **(SUMMER 2022, 4 Marks OR; SUMMER 2023, 3 Marks; WINTER 2023, 4 Marks OR)**
- **Q.** Give stepwise procedure / discuss method for determining minimum liquid-to-gas ratio for absorbers, with neat sketch where asked. **(WINTER 2022, 3 Marks OR; SUMMER 2023, 4 Marks; SUMMER 2024, 7 Marks OR; SUMMER 2025, 4 Marks; SUMMER 2026, 4 Marks OR)**
- **Q.** Define/explain absorption factor, HETP, NTU, stripping factor. **(WINTER 2022, 3 Marks; SUMMER 2024, 3 Marks - Coning, HETP, Weeping; SUMMER 2025, 3 Marks; WINTER 2025, 3 Marks OR; WINTER 2025, 3 Marks; SUMMER 2026, 3 Marks OR)**
- **Q.** Compare/differentiate absorption and stripping; physical and chemical absorption; absorption at low T/high P. **(WINTER 2022; SUMMER 2024, 7 Marks OR; WINTER 2025, 3 Marks OR; SUMMER 2026, 3 Marks)**

2. Minimum Solvent Rate (Numerical):

- **Q.** Gas containing 4% cyclohexane and rest inert treated with nonvolatile absorption oil in packed tower; remove 98%; feed solvent free; feed gas 80 kmol/hr; equilibrium Y = 0.2X/(1 + 0.8X). Calculate minimum solvent rate (and actual liquid rate if 1.8 times L_{min} where asked). **(WINTER 2022, 7 Marks OR; SUMMER 2026, 7 Marks)**

Other Important Questions:

1. Theory:

- **Q.** State characteristics of ideal solution. **(SUMMER 2022, 3 Marks OR)**
- **Q.** Differentiate between physical and chemical adsorption and cite examples. "Absorption is preferable at low T and high P." True or false? Justify. **(SUMMER 2026, 3 Marks)**

2. Numerical Problems:

- **Q.** A coal gas is to be freed of light oil by scrubbing with wash oil. Gas in 0.250 m^3/s at 26 °C, P_t = 1.07×10^5 N/m^2, containing 2.0% by volume light oil vapors (assumed benzene), 95% removal required. Wash oil enters at 26 °C containing 0.005 mole fraction benzene, average MW 260. Oil circulation rate 1.5 times minimum. Wash oil–benzene solutions ideal. At 26 °C vapor pressure of benzene 13330 N/m^2. Compute oil circulation rate analytically. **(SUMMER 2022, 7 Marks OR)**
- **Q.** Air–NH_3 mixture containing 5% NH_3 scrubbed with water in packed tower to recover 95% NH_3. G_1 = 3000 kg/h m^2, L_s = 2500 kg/h m^2, 25 °C, 1 atm. Equilibrium y* = 0.98x. K_Ga = 65 kmol/h m^3 atm. Find NTU and height of tower. **(SUMMER 2023, 7 Marks)**
- **Q.** Gas stream 1 kmol/s containing 90 mol% N_2 and 10% CO_2 passed through absorber using pure cool water at 5 °C, isothermal at 5 °C and isobaric at 10 atm. Liquid flow 1.5 times minimum. Determine number of equilibrium stages to absorb 92% CO_2. Equilibrium y = 87.6x. **(WINTER 2022, 7 Marks)**
- **Q.** Gas mixture containing 3% by volume pentane vapor and 97% inerts treated with nonvolatile absorption oil; 97% removal required. Feed solvent free from solute; feed gas 50 kmol/hr; equilibrium Y = 0.25X/(1 + 0.75X). Calculate minimum solvent required. **(WINTER 2023, 7 Marks)**
- **Q.** 5000 kg/hr SO_2–air mixture containing 5% by volume SO_2 scrubbed with 2,00,000 kg/hr water in packed tower; exit SO_2 0.15%; 1 atm; equilibrium Y = 30X; packed height Z = 0.42 m. Calculate HTU. **(WINTER 2023, 7 Marks OR)**
- **Q.** Air–NH_3 mixture containing 20 mole% NH_3 treated with water in packed tower to recover NH_3. Inlet gas rate 700 kg/h m^2. Water used 1.5 times minimum and enters with 2% NH_3. 90% NH_3 absorbed. Determine G_s, inlet/outlet mole ratio of ammonia in gas and liquid streams. Also

mention steps to determine number of stages graphically for countercurrent absorber. **(SUMMER 2024, 7 Marks)**

- **Q.** Tower packed with 0.5 cm Raschig rings of 12 m height for absorption of H_2S from natural gas using monoethanolamine. Countercurrent at 30 °C and 1 atm. Entering gas contains 18% H_2S by volume; 90% absorbed. Gas flow rate 2000 m^3/m^2hr. Equilibrium y = 1.1x; operating line straight and parallel to equilibrium line. Calculate liquid flow rate. **(SUMMER 2025, 7 Marks)**
- **Q.** Packed tower to absorb SO_2 from air by scrubbing with water. Entry and exit gas concentrations 20% and 0.5% SO_2 by volume; entering water SO_2-free. Actual water flow twice minimum. Air flow rate (SO_2-free basis) 975 kg/hr m^2. 30 °C, 2 atm. Equilibrium y = 21.8x. Compute number of gas transfer units. **(SUMMER 2025, 7 Marks OR)**

Chapter 6 – Equipment for Gas Liquid Operations

Repeated Questions:

1. Tray Towers and Packed Towers (Theory):

- **Q.** Compare/differentiate tray tower and packed tower. **(WINTER 2022, 7 Marks; SUMMER 2023, 7 Marks OR; WINTER 2023, 4 Marks; SUMMER 2024, 7 Marks; SUMMER 2026, 7 Marks)**
- **Q.** Packed tower internals, types of packing, selection criteria, random/regular packings, characteristics of fill. **(WINTER 2022, 7 Marks; SUMMER 2023, 3 Marks; WINTER 2023, 3 Marks OR; SUMMER 2024, 7 Marks; SUMMER 2025, 4 Marks; WINTER 2025, 4 Marks; SUMMER 2026, 7 Marks)**
- **Q.** Tray tower terms/problems: flooding, loading, priming, coning, weeping, dumping, tray spacing, theoretical tray, entrainment, channeling, liquid hold-up, tray efficiency. **(SUMMER 2022, 4 Marks - loading and flooding; SUMMER 2023, 3 Marks; WINTER 2023, 3 Marks; WINTER 2023, 4 Marks; SUMMER 2024, 3 Marks; SUMMER 2025, 3 Marks; WINTER 2025, 3 Marks; WINTER 2025, 3 Marks OR - second set; WINTER 2025, 7 Marks OR; SUMMER 2026, 3 Marks)**

2. Other Gas–Liquid Equipment (Theory):

- **Q.** Spray tower and sparged vessel / sparged vessel construction and working as G–L equipment. **(WINTER 2022, 7 Marks OR; WINTER 2023, 3 Marks; WINTER 2025, 7 Marks)**
- **Q.** Classify gas–liquid mass transfer operations / gas–liquid equipment in detail with examples/principle. **(SUMMER 2024, 7 Marks; SUMMER 2025, 4 Marks; WINTER 2025, 4 Marks OR; SUMMER 2026)**

Other Important Questions:

1. Equipment and Working (Theory):

- **Q.** Expound briefly with neat sketch the working of tray tower and problems associated with its working. **(SUMMER 2022, 7 Marks)**
- **Q.** With neat sketch discuss wetted wall column for gas–liquid contact operation. **(SUMMER 2023, 4 Marks)**
- **Q.** Explain function of: down spout, weir, entrainment eliminator. **(SUMMER 2025, 3 Marks OR)**
- **Q.** Explain working of Venturi scrubber. **(SUMMER 2025, 4 Marks)**
- **Q.** Discuss bubble cap trays briefly. **(SUMMER 2025, 3 Marks OR)**
- **Q.** Explain prevention of vortex formation in mechanically agitated vessel. **(WINTER 2025, 7 Marks OR - second set)**

Chapter 7 – Liquid-Liquid Extraction

Repeated Questions:

1. Equilibrium, Solvent Selection and Single-Stage Extraction (Theory):

- **Q.** Ternary liquid–liquid equilibrium, equilateral-triangular coordinates, plait point, tie line, mixture rule, systems of three liquids—one pair/two pairs partially soluble, effect of temperature. **(SUMMER 2022, 3 Marks; SUMMER 2022, 4 Marks; WINTER 2022, 3 Marks; SUMMER 2023, 3 Marks OR; WINTER 2023, 7 Marks OR; SUMMER 2024, 3 Marks OR; SUMMER 2024, 3 Marks; SUMMER 2025, 3 Marks; WINTER 2025, 3 Marks; WINTER 2025, 7 Marks; WINTER 2025, 7 Marks OR; SUMMER 2026, 3 Marks; SUMMER 2026, 4 Marks)**
- **Q.** At high temperature, two-pair partially soluble liquid system behaves like one-pair partially soluble liquid system. Agree or not? Support the answer. **(WINTER 2022, 3 Marks; SUMMER 2026, 4 Marks)**
- **Q.** Selection criteria for solvent in liquid–liquid extraction / characteristics of good solvent / solvent solubility effect. **(SUMMER 2022, 3 Marks; WINTER 2022; WINTER 2023, 7 Marks; SUMMER 2025, 3 Marks; SUMMER 2025, 3 Marks; SUMMER 2026, 3 Marks OR)**
- **Q.** Single-stage extraction: material balance, equations for extract/raffinate, solvent-to-feed ratio, distribution coefficient. **(WINTER 2022, 3 Marks - second set; SUMMER 2023, 4 Marks; WINTER 2023, 4 Marks; SUMMER 2025, 7 Marks; SUMMER 2026, 3 Marks OR)**
- **Q.** Ballman extractor working mechanism with neat sketch. **(SUMMER 2023, 4 Marks OR; SUMMER 2024, 4 Marks OR)**

2. Multistage Extraction (Numerical):

- **Q.** Pure isopropyl ether 450 kg/h used to extract aqueous 30 wt% acetic acid by countercurrent multistage extraction. Aqueous rate one third of solvent rate. Exit acid concentration 10 wt%. Calculate number of stages required. Data on wt% basis given. [Diagram required – refer to the original question paper] **(WINTER 2022, 7 Marks - second set; SUMMER 2024, 7 Marks - second set; SUMMER 2026, 7 Marks OR)**

Other Important Questions:

1. Theory:

- **Q.** Explain material balance for multistage counter-current liquid extraction operation. **(SUMMER 2024, 4 Marks)**
- **Q.** Brief about working of rotating disc contactor. **(WINTER 2022, 4 Marks OR)**
- **Q.** What is extraction? Give industrial applications of extraction. **(WINTER 2023, 3 Marks OR)**
- **Q.** Enlist different industrial liquid extraction equipment and explain any one in detail with neat sketch. **(SUMMER 2026, 7 Marks OR)**

2. Numerical Problems:

- **Q.** If 8000 kg/h of acetic acid–water solution containing 30% acid is to be countercurrently extracted with isopropyl ether to reduce acid concentration to 2% in solvent-free raffinate, determine (a) minimum amount of solvent and (b) number of theoretical stages if 20000 kg/h solvent is used. Data given on wt% basis. [Diagram required – refer to the original question paper] **(WINTER 2022, 7 Marks)**
- **Q.** Water–dioxane solution separated by extraction using benzene. At 25 °C equilibrium distribution data given. 1000 kg of 25% dioxane–water solution extracted to remove 95% dioxane; benzene dioxane-free. Calculate minimum solvent required in kg/hr for countercurrent extraction. Estimate number of stages if 1.5 times minimum solvent used. [Diagram required – refer to the original question paper] **(SUMMER 2023, 7 Marks)**
- **Q.** A solution of nicotine in water containing 1% nicotine extracted with kerosene at 293 K. Water and kerosene essentially insoluble; equilibrium $y' = 0.9x'$. Determine % extraction if 100 kg feed

solution extracted with 150 kg solvent. Repeat for three theoretical stages using 50 kg solvent each. **(SUMMER 2022, 7 Marks OR)**

- **Q.** 1000 kg/h nicotine–water solution containing 1% nicotine countercurrently extracted with kerosene at 20 °C to reduce nicotine to 0.1%. Determine (a) minimum kerosene rate and (b) number of theoretical stages if 1150 kg kerosene/h used. [Diagram required – refer to the original question paper] **(SUMMER 2024, 7 Marks)**

Chapter 8 – Leaching

Repeated Questions:

1. Leaching Principles and Equipment (Theory):

- **Q.** Explain equilibrium diagrams/curves in leaching with neat sketch; discuss types. **(SUMMER 2022, 3 Marks; WINTER 2022, 4 Marks; SUMMER 2023, 7 Marks OR; SUMMER 2025, 7 Marks OR)**
- **Q.** Preparation of solids for leaching / pre-treatment affecting leaching. **(SUMMER 2022, 3 Marks; WINTER 2023, 3 Marks)**
- **Q.** Effect of pre-treatment, agitation and temperature on leaching; justify "High temperature is not always preferable for leaching." **(WINTER 2022, 4 Marks; SUMMER 2024, 3 Marks - second set; SUMMER 2026, 4 Marks OR)**
- **Q.** Explain Shanks system with neat sketch. **(SUMMER 2022, 4 Marks OR; SUMMER 2024, 4 Marks; SUMMER 2026, 4 Marks)**
- **Q.** Enlist leaching equipment and explain any one/Bollman/Rotocell in detail with neat sketch. **(SUMMER 2022, 7 Marks; WINTER 2023, 7 Marks OR; SUMMER 2025, 7 Marks; SUMMER 2026, 7 Marks - second set)**

Other Important Questions:

1. Theory:

- **Q.** Write a short note on heap leaching. **(SUMMER 2022, 3 Marks OR)**
- **Q.** Explain material balance for single stage leaching. **(WINTER 2023, 4 Marks)**
- **Q.** Discuss working of agitated vessels for leaching batch process. **(SUMMER 2025, 7 Marks OR)**

2. Numerical Problems:

- **Q.** 1000 kg crushed oil seed (19.5% oil and 80.5% meal) extracted with 1500 kg pure hexane in single-stage batch extraction vessel. Determine coordinates of point M1 representing mixture of solid–solvent. **(SUMMER 2026, 3 Marks)**

Chapter 9 – Crystallization

Repeated Questions:

1. Supersaturation and Crystallization Mechanism (Theory):

- **Q.** Define supersaturation and discuss Miers' super saturation theory of crystallization with neat sketch. **(SUMMER 2023, 4 Marks; WINTER 2023, 3 Marks; SUMMER 2024, 4 Marks; WINTER 2025, 4 Marks OR; WINTER 2025, 4 Marks; SUMMER 2026, 4 Marks)**
- **Q.** Define supersaturation and state techniques to achieve it; stages/mechanism of crystallization; nucleation and crystal growth. **(SUMMER 2022, 3 Marks OR; WINTER 2022, 3 Marks OR; SUMMER 2024, 3 Marks OR; WINTER 2025, 4 Marks OR; SUMMER 2026, 3 Marks - second set)**
- **Q.** Crystallization equipment: Oslo Krystal evaporative crystallizer / Swenson-Walker crystallizer / agitated tank crystallizer. **(SUMMER 2022, 4 Marks OR; WINTER 2023, 4 Marks OR; SUMMER 2025, 4 Marks OR; SUMMER 2026, 7 Marks)**

2. Crystal Yield (Numerical):

- **Q.** Calculate yield of $MgSO_4 \cdot 7H_2O$ crystals when 1000 kg saturated solution of $MgSO_4$ at 353 K is cooled to 303 K, assuming 10% water lost by evaporation. Solubility at 353 K = 64.2 kg/100 kg water; at 303 K = 40.8 kg/100 kg water. **(SUMMER 2022, 7 Marks OR; SUMMER 2023, 7 Marks)**
- **Q.** Solubility of copper sulphate in water at 80 °C is 55 g $CuSO_4$/100 g water and at 30 °C is 25 g $CuSO_4$/100 g water. One ton saturated solution at 80 °C slowly cooled to 30 °C; 5% water lost by evaporation. Determine weight of crystals and mother liquor. Hydrated form $CuSO_4 \cdot 5H_2O$. **(WINTER 2022, 4 Marks OR; SUMMER 2026, 4 Marks - second set)**

Other Important Questions:

1. Crystal Yield (Numerical):

- **Q.** A solution of sodium carbonate available at 40 °C with solute content 30%. Calculate weight of $Na_2CO_3 \cdot 10H_2O$ crystal formed if 2000 kg of this solution is cooled to 10 °C. Also determine yield. Solubility at 10 °C = 12.5 g Na_2CO_3/100 g water. **(SUMMER 2024, 4 Marks OR)**

****