Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- SEMESTER–V EXAMINATION – WINTER 2025

Subject Code:3150501 Date:19-11-2025

Subject Name: Mass Transfer Operations I

Time: 10:30 AM TO 01:00 PM Total Marks:70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

			MARKS
Q.1	**(a)**	Define: Plait point, selectivity and distribution coefficient in liquidliquid extraction	**03**
	(b)	Discuss the factors affecting choice of separation method	**04**
	(c)	Discuss in detail about Steady State Cocurrent processes	**07**
Q.2	**(a)**	Explain mass transfer operation between two immiscible phases	**03**
	(b)	Deduce an equation for molar flux for diffusion of component A through non-diffusing component B in case of steady state molecular diffusion for liquid phase	**04**
	(c)	With neat sketch, explain spray tower and sparged vessel as G-L equipment in brief.	**07**
		OR	
	(c)	Explain the following terms with respect to tray towers: (i) Flooding (ii)Priming (iii) Coning (iv)Weeping (v) Dumping (vi)Tray Spacing (vii)Theoretical Tray	**07**
Q.3	**(a)**	Compare N type flux and J type flux.	**03**
	(b)	Compare Penetration theory with surface renewal theory with reference to molecular diffusion	**04**
	(c)	Methane diffuses at steady state through a tube containing helium for the case equimolar counter diffusion. At point 1, the partial pressure of methane is 55 kPa and at point 2, 0.03 m apart is 15 kPa. The total pressure is 101.325 kPa and temperature is 298 k, at this temperature and pressure the value of diffusivity is 6.75×10^{-5} m^2 /s. Calculate the partial pressure of methane at point 0.02 m apart from point 1 for the above case	**07**
		OR	
Q.3	**(a)**	Explain mass, heat and momentum transfer analogies.	**03**
	(b)	Classify gas-liquid mass transfer operations with principle.	**04**
	(c)	Oxygen (A) is diffusing through carbon monoxide (B) under steady state condition with carbon monoxide non-diffusing. The total pressure is 1×10^5 N/m^2 and temperature is 0^0C. The partial pressure of oxygen at two planes 2.0 mm apart is respectively 13000 and 6500 N/m^2. The diffusivity for the mixture is 1.87×10^{-5} m^2 /s. Calculate the rate of diffusion of oxygen in kmol/s through each square meter of the two planes	**07**
Q.4	**(a)**	Define the following terms with respect to tray tower a) Priming b) Coning c) Weeping	**03**
	(b)	Explain the characteristics of fill for packed tower	**04**
	(c)	Explain “two resistance theory” briefly	**07**

OR

Q.4	**(a)**	Define the following terms with respect to tray tower a) Flooding b) Dumping c) Tray Spacing	**03**
	(b)	Explain mass, heat and momentum transfer analogies	**04**
	(c)	Explain the prevention of vortex formation in mechanically agitated vessel.	**07**
Q.5	**(a)**	Define: a) Absorption factor b) Crystallization c) selectivity of solvent	**03**
	(b)	Explain Meir's super saturation theory of crystallization.	**04**
	(c)	Explain Ternary liquid- liquid equilibrium and tie line	**07**

OR

Q.5	**(a)**	Define: a) Recoverability of solvent b) absorption c) striping	**03**
	(b)	Define super saturation and explain Meir's super saturation theory. Explain stages of crystallization. Explain stages or mechanism of crystallization.	**04**
	(c)	Discuss the system of three liquids- one pair partially soluble and the effect of temperature on ternary equilibria.	**07**

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GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V (NEW) EXAMINATION – WINTER 2023

Subject Code:3150501 Date:07-12-2023

Subject Name: Mass Transfer Operations I

Time:10:30 AM TO 01:00 PM Total Marks:70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

Q.1	**(a)**	Explain film theory for mass transfer coefficient.	**03**
	(b)	Differentiate between packed towers and tray tower.	**04**
	(c)	Derive Fick's law of diffusion and explain N_A and J_A. Also prove that For unidirectional binary diffusion $J_A=-J_B$.	**07**
Q.2	**(a)**	Define: (i)Flooding (ii)Priming (iii)Coning	**03**
	(b)	Explain material balance for single stage extraction.	**04**
	(c)	Discuss in detail classification of mass transfer operations and explain with examples.	**07**
		OR	
	(c)	Derive equations to calculate rate of steady state diffusion of 'A' through non-diffusing 'B' and also for steady state equimolal counter diffusion in case of gases.	**07**
Q.3	**(a)**	Explain Meir's theory for crystallization.	**03**
	(b)	Define (i)Weeping (ii) Dumping (iii)Tray Spacing (iv)Theoretical Tray	**04**
	(c)	Ammonia and air are in equimolal counter diffusion of each other in a cylindrical tube of 3 mm diameter and 20 m length. The total pressure is 1 atm and the temperature is 25 ^oC. One end of the tube is connected to a large reservoir of NH_3 and the other end of the tube is open to atmosphere. Estimate the mass transfer rates in kg/sec of ammonia and air. The mass diffusivity of mixture is 0.28×10^{-4} m^2/sec	**07**
		OR	
Q.3	**(a)**	Explain random packings and regular packing.	**03**
	(b)	Explain selection criteria of solvent for gas absorption.	**04**
	(c)	Explain equilateral–triangular co-ordinate, plaint point, tie line, one pair partially soluble system with examples and the mixture rule.	**07**
Q.4	**(a)**	Discuss construction and working of Sparged Vessel.	**03**
	(b)	Discuss local and overall mass transfer coefficients.	**04**
	(c)	Explain selection criteria of solvent for extraction.	**07**
		OR	
Q.4	**(a)**	What is Extraction? Give the industrial applications of Extraction.	**03**
	(b)	Explain mass, heat and momentum transfer analogies.	**04**
	(c)	Enlist different leaching equipment and explain any one in detail with neat figure.	**07**

Q.5	**(a)**	Explain preparation of solids for leaching.	**03**
	(b)	Explain material balance for single stage leaching.	**04**
	(c)	A gas mixture containing 3% by volume pentane vapour and 97 % inerts. The mixture is treated with a non-volatile absorption oil in an absorber and 97 % removal is required. The feed solvent is free from solute. The feed gas rate is 50 kmol/hr. equilibrium relation is Y=0.25X/(1+0.75X). where Y and X are mole ratio. Calculate minimum solvent required.	**07**

OR

Q.5	**(a)**	Explain diffusion in solids.	**03**
	(b)	Explain construction and working agitated tank crystallizer with the help of a neat sketch.	**04**
	(c)	5000 kg/hr of a SO_2-air mixture containing 5% by volume of SO_2 is to be scrubbed with 2,00,000 kg/hr of water in a packed tower. The exit concentration of SO_2 is reduced to 0.15%. The tower operates at 1 atm. The equilibrium relation is given by: Y = 30 X. Y = Mole SO_2 / Mole air; X = Mole SO_2 / Mole water If the packed height of tower (Z) is 0.42 m, Calculate the height of transfer unit (HTU).	**07**

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Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V (NEW) EXAMINATION – WINTER 2022

Subject Code:3150501 Date:06-01-2023

Subject Name:Mass Transfer Operations I

Time:10:30 AM TO 01:00 PM Total Marks:70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

			MARKS
Q.1	**(a)**	Classify the mass transfer operations based on direct contact of two immiscible phases with examples.	**03**
	(b)	Explain Fick's law in brief and prove $D_{AB} = D_{BA}$	**04**
	(c)	A tube 1 cm in inside diameter that is 20 cm long is filled with CO_2 and H_2 at a total pressure of 2 atm at 0°C. The diffusion coefficient of the CO_2 – H_2 system under these conditions is 0.275 cm^2/s. If the partial pressure of CO_2 is 1.5 atm at one end of the tube and 0.5 atm at the other end, determine flux for: i) steady state equimolar counter diffusion, ii) steady state counter diffusion where $N_B = -0.75\ N_A$, iii) steady state diffusion of CO_2 through stagnant H_2	**07**
Q.2	**(a)**	Define: Elusion, Solutropic solutions, Plait point	**03**
	(b)	Deduce an equation for molar flux for diffusion of component A through non-diffusing component B in case of steady state molecular diffusion for liquid phase.	**04**
	(c)	Enlist the tower internals for packed tower and explain their roles. Discuss about few types of packing. Also compare Tray tower with Packed tower.	**07**
		OR	
	(c)	With neat sketch, explain spray tower and sparged vessel as G-L equipment in brief.	**07**
Q.3	**(a)**	At high temperature, two pair partially soluble liquid system behaves like one pair partially soluble liquid system. Agree or not? Support the answer.	**03**
	(b)	Explain various equilibrium curves with reference to leaching.	**04**
	(c)	If 8000 kg/h of an acetic acid (C)- water (A) solution, containing 30% acid is to be counter currently extracted with isopropyl ether (B) to reduce the acid concentration to 2% in the solvent-free raffinate product, determine (a) the minimum amount of solvent which can be used and (b) the number of theoretical stages if 20 000 kg/h of solvent is used. Data is given as (% wt):	**07**

Aqueous phase			Ether phase		
Acetic acid	water	Ether	Acetic acid	water	Ether
0.69	98.1	1.2	0.18	0.5	99.3
1.41	97.1	1.5	0.37	0.7	98.9
2.89	95.5	1.6	0.79	0.8	98.4
6.42	91.7	1.9	1.93	1	97.1
13.3	84.4	2.3	4.82	1.9	93.3
25.5	71.1	3.4	11.4	3.9	84.7
36.7	58.9	4.4	21.6	6.9	71.5
44.3	45.1	10.6	31.1	10.8	58.1
46.3	37.1	16.5	36.2	15.1	48.7

OR

Q.3 **(a)** Cite few industrial examples of liquid-liquid extraction with appropriate solvent. Discuss selectivity as selection parameter for solvent and for single stage, find distribution coefficient if feed, pure solvent and extract amounts are 500, 400 and 600 kg respectively. Feed and extract has 45% and 30 % solute respectively. **03**

(b) Explain how pre-treatment and agitation affect the leaching operation? Also justify the statement "High temperature is not always preferable for leaching." **04**

(c) Pure isopropyl ether of 450 kg/h is being used to extract an aqueous solution of 30 wt % acetic acid by counter-current multistage extraction. Rate of aqueous solution is one third of solvent rate. The exit acid concentration in the aqueous phase is 10 wt %. Calculate the number of stages required. Data on wt % basis is as given in Q 3 (c). **07**

Q.4 **(a)** Explain absorption and stripping by stating appropriate industrial examples. Also differentiate between physical and chemical absorption. **03**

(b) Discuss selection criteria for solvent in liquid-liquid extraction. **04**

(c) State various theories of mass transfer co-efficient and discuss film theory at length. Also derive its equation. **07**

OR

Q.4 **(a)** With reference to absorption, discuss minimum liquid to gas ratio. **03**

(b) Brief about the working of rotating disc contactor. **04**

(c) Discuss interphase mass transfer. Explain in detail about Overall and individual mass transfer coefficients. Also derive interrelationship between these. **07**

Q.5 **(a)** Define: Absorption factor, HETP, NTU **03**

(b) Define super saturation and discuss Mier's theory. **04**

(c) A gas stream (1 kmol/s) containing 90 mol% N_2 and 10% CO_2 is passed through an absorber, in which pure and cool water at 5 ºC is used as a solvent. The operation is assumed to be isothermal at 5 ºC and isobaric at 10 atm. The liquid flow rate is 1.5 times the minimum liquid flow rate. Determine the number of equilibrium stages required to absorb 92 % of CO_2. Equilibrium relation is y = 87.6x. **07**

OR

Q.5 **(a)** With reference to crystallization, explain nucleation and crystal grown. **03**

(b) The solubility of copper sulphate in water at 80 °C is 55 g $CuSO_4$ per 100 g of water and that at 30 °C is 25 g $CuSO_4$ / 100 g water. One ton of saturated solution at 80 °C is slowly cooled down to 30 °C. 5 % water is lost by evaporation. Determine weight of crystals and mother liquor. Hydrated form is represented as $CuSO_4 \cdot 5H_2O$. **04**

(c) A gas containing 4 % cyclohexane and rest inert has to be treated with non volatile absorption oil in a packed tower. It is required to remove 98 % of cyclohexane of the gas. The feed solvent is free from cyclohexane. If the feed gas rate is 80 kmol/hour, calculate the minimum solvent rate. Equilibrium relation is given Y = 0.2X / (1+0.8X) **07**

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