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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