Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V (NEW) EXAMINATION – SUMMER 2024

Subject Code: 3150501 Date:18-05-2024

Subject Name: Mass Transfer Operations I

Time:02:30 PM TO 05:00 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)**	Explain design principles of mass transfer equipment.	**03**
	(b)	Discuss the effect of temperature and pressure on diffusivity for gases and liquids. For a gaseous system, D_{AB} = 0.202 cm^2/s at 25 °C. Determine diffusivity (m^2/s) of that system at 40 °C if pressure is halved and other parameters remain constant.	**04**
	(c)	Ethanol vapor is diffusing through a layer of water vapor under equimolar counter diffusion at 35 ºC and 1 atm. pressure. The molal concentration of alcohol on the two sides of the gas film (water vapor) 0.3 mm thick are 80% and 10% respectively. Assuming the diffusivity of alcohol–water vapor to be 0.18 cm^2/s, (i) Determine the rate of diffusion of alcohol and water vapor in kg/hr through an area of 100 cm^2 (ii) if the water vapor layer is stagnant, estimate the rate of diffusion of alcohol vapor.	**07**
Q.2	**(a)**	Define: Decoction, Stripping factor, Plait point	**03**
	(b)	Compare and contrast N and J type of flux.	**04**
	(c)	Classify Gas-Liquid equipment in details and compare packed tower with tray tower. Also compare random and regular packings.	**07**
		OR	
	(c)	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 as well as gaseous phase.	**07**
Q.3	**(a)**	In a wetted wall column, Carbon dioxide is being absorbed from air by water flowing at 2 atm and 25 ºC. The MTC k_y' is to be $6.78*10^{-5}$ $kmol/m^2s$ mole fraction. Determine rate of absorption if partial pressure of carbon dioxide at interface is 0.2 atm and the air is pure. Also determine k_y and k_g.	**03**
	(b)	For a multistage counter-current liquid extraction operation, carry out material balance and explain it.	**04**
	(c)	If 1000 kg/h of a nicotine (C)-water (A) solution containing 1% nicotine is to be counter currently extracted with kerosene at 20°C to reduce the nicotine content to 0.1%, determine (a) the minimum kerosene rate and (b) the number of theoretical stages required if 1150 kg of kerosene is used per hour	**07**

x (kg nicotine/ kg water)	0	0.001011	0.00246	0.00502	0.00751	0.00998	0.0204
y* (kg nicotine/ kg water)	0	0.000807	0.001961	0.00456	0.00686	0.00913	0.01870

OR

Q.3	**(a)**	Discuss in detail the pre-treatment as parameter affecting leaching.	**03**
	(b)	Interrelate k_G, k_C, k_y with F type MTC for gaseous phase. Also mention their units.	**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 given: **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

Q.4 **(a)** Explain the effect of temperature on the ternary diagram for a system of three liquids with one pair partially soluble **03**

(b) Brief about the Shanks system for leaching. **04**

(c) Ammonia is diffusing through an inert air film 2 mm thick at a temperature of 20 ºC and a pressure of 1 atm. The concentration of ammonia is 10% by volume on one side of the film and zero on the other side. Determine the mass flux. Estimate the effect on the rate of diffusion if the pressure is increased to 10 atm. The diffusivity of NH_3 in air at 20°C and 1 atm. is 0.185 cm^2/s. **07**

OR

Q.4 **(a)** Explain selectivity and distribution coefficient. Explain equilateral triangular co-ordinate and the mixture rule. **03**

(b) Brief about the working of Ballman extractor. **04**

(c) Explain Interphase mass transfer in detail. Also derive expression for overall and local mass transfer coefficient. **07**

Q.5 **(a)** Define: Coning, HETP, Weeping **03**

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

(c) An air–NH_3 mixture containing 20 mole % of NH_3 is being treated with water in a packed tower to recover NH_3. The inlet gas rate is 700 kg/hm^2. The water used is 1.5 times the minimum and enters the tower with 2% of NH_3. Under these conditions, 90% of NH_3 is absorbed from the feed. Determine Gs, inlet and outlet mole ratio of ammonia in gas stream and liquid stream. **07**

Also mention steps in detail to determine number stages graphically for a counter current absorber.

OR

Q.5 **(a)** Write a brief note on steps of crystallization. **03**

(b) A solution of sodium carbonate available at a temperature of 40°C with a solute content of 30%. Calculate the weight of Na_2CO_3* $10H_2O$ crystal formed if 2000 kg of this solution is cooled to 10°C. Also determine the yield. **04**

Data: Solubility at 10°C = 12.5 gm of Na_2CO_3/100 gm of water

(c) Compare absorption and stripping. For absorption, discuss Minimum L/G. Also mention step to find L_{min}/G using proper diagram. **07**

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