Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE – SEMESTER- V EXAMINATION-SUMMER 2023

Subject Code: 3150501 Date: 26/06/2023

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)**	Define: 1) Mass Transfer 2) Equilibrium 3) Mass transfer Co-efficient	**03**
	(b)	Define molecular diffusion. Derive the equation for steady state diffusion of liquid A through non diffusing liquid B.	**04**
	(c)	Derive the equation which shows relationship between overall mass transfer coefficients (represented by K_y and K_x) and individual mass transfer coefficients (represented by k_y and k_x) with neat digram.	**07**
Q.2	**(a)**	State Fick's law of diffusion and prove that $D_{AB} = D_{BA}$**.**	**03**
	(b)	Explain the concept of penetration theory with neat sketch and suitable assumptions.	**04**
	(c)	Alcohol vapor is being absorbed from a mixture of alcohol vapor and water vapor by means of a nonvolatile solvent in which alcohol is soluble but water is not. The temperature is 97 ^{0}C and the total pressure is 760 mm Hg. The alcohol vapor can be considered to be diffusing through a film of alcohol-water-vapor mixture 0.1 mm thick. The mole % of alcohol in the vapor at the outside of the film is 80%, and that on the inside, next to the solvent is 10%. The diffusivity of alcohol-water-vapor mixture at 25 ^{0}C and 1 atm is 0.15 cm^2/ sec. Calculate the rate of diffusion of alcohol vapor in kg per hour if the area of the film is 10 m^2.Moleculer weight of Alcohol = 46 g/mol	**07**
		OR	
	(c)	At 293 K solubility of ammonia in water is given by Henry's law p=0.3672 C, where p is in atmosphere and C is in kmol/m^2. A mixture of 15 % ammonia and 85 % air by volume at 1 atm is in contact with an aqueous solution containing 0.147 gmol/lit. The air velocity is such that k_G/ k_L=0.9. Find the concentration of ammonia and partial pressure at interface.	**07**
Q.3	**(a)**	Explain the solvent selection criteria for Absorption.	**03**
	(b)	Give stepwise procedure for determining minimum liquid to gas ratio for absorbers.	**04**
	(c)	An air-NH_3 mixture containing 5% NH_3 is being scrubbed with water in a packed tower to recover 95% NH_3. G_1= 3000 kg/h m^2, Ls= 2500 kg/h m^2. Tower is maintained at 25 ^{0}C and 1 atm pressure. Find NTU and height of the tower. The equilibrium relation is given by y*= 0.98x, where x and y are mole fraction units. K_Ga= 65 kmol/h m^3 atm.	**07**
		OR	
Q.3	**(a)**	Define any **THREE**: 1) Tie-line 2) Binodal curve 3) Solutropic solution 4) Plait point	**03**
	(b)	Deduce equation of solvent to feed ratio for single stage liquid-liquid extraction.	**04**

(c) Water- dioxane solution is to be separated by extraction process using benzene as solvent. At 25 ^{0}C the equilibrium distribution of dioxane between water and benzene is as follows: **07**

Wt % of dioxane in water	5.1	18.9	25.2
Wt % of dioxane in benzene	5.2	22.5	32.0

At these concentrations water and benzene are substantially insoluble. 1000 kg of a 25% dioxane water solution is to be extracted to remove 95% of dioxane. The benzene is dioxane free. Calculate minimum solvent required in kg/ hr if the extraction is done in countercurrent fashion. Estimate the number of stages needed if 1.5 times the minimum amount of solvent is used.

Q.4 **(a)** Define: 1) Entrainment 2) Weeping 3) Channeling **03**

(b) With neat sketch discuss Wetted wall column for gas-liquid contact operation. **04**

(c) Calculate the rate of diffusion of acetic acid (A) across a film of non-diffusing water (B) solution 2 mm thick at 17^{0}C, when the concentration on the opposite sides of the film are 9% and 3% acid (by weight). The diffusivity of acetic acid in the solution is $0.95*10^{-9}$ m^2/sec. Density of 9% and 3% by weight acid are 1012 kg/ m^3 and 1003 kg/m^3 respectively. **07**

OR

Q.4 **(a)** Explain the concept of Equilateral –Triangular Coordinates in liquid liquid extraction. **03**

(b) Explain with neat sketch the working mechanism of Ballman Extractor. **04**

(c) Differentiate between tray tower and packed tower. **07**

Q.5 **(a)** Mention different types of packing for gas absorption operation and their selection criterion. **03**

(b) Explain Meir's super saturation theory of crystallization with neat sketch. **04**

(c) Calculate the yield of $MgSO_4*7H_2O$ crystals when 1000 kg saturated solution of $MgSO_4$ at 353 K (80^{0}C) is cooled to 303 K (30^{0}C), assuming 10 % of the water is lost by evaporation during cooling. **07**
Solubility of $MgSO_4$ at 353 K (80^{0}C) = 64.2 kg / 100 kg water
Solubility of $MgSO_4$ at 303 K (30^{0}C) = 40.8 kg / 100 kg water
Atomic weight: Mg=24, S=32, O=16, H=1

OR

Q.5 **(a)** Give unit of Diffusivity. How to predict the diffusivity in gases? **03**

(b) Explain mass, heat and momentum transfer analogies. **04**

(c) What is leaching? What are the industrial applications of leaching? Discuss the different types of equilibrium diagram for leaching **07**

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