Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

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

Subject Code:3150501 Date:28-11-2024

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)**	Discuss the factors affecting choice of separation method.	**03**
	(b)	Discuss Molecular diffusion and Eddy diffusion with examples. List out factors upon which Diffusivity depends?	**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)**	Discuss about Knudsen Diffusion and Pore Diffusion.	**03**
	(b)	Explain material balance for multi stage leaching.	**04**
	(c)	The effective diffusivities for passage of O_2 and N_2 at 20^0C through a 2-mm thick piece of unglazed porcelain were measured by determining the counter current diffusion fluxes at 1.0 and 0.01 std atm pressure. The diffusivities at 1.0 std atm are D_{H2}-$D_{N2,\,eff}$ = $5.3*10^{-6}$ m^2/s and $D_{K,H2,\,eff}$ = $1.17*10^{-5}$ m^2/s. Estimate (a) Equivalent pore diameter of solid (b) Diffusion fluxes for O_2-N_2 mixtures at a total pressure of 0.1 std atm, 20^0 C, with mole fractions of O_2=0.8 And 0.2 on either side of the porcelain. [D_{H2}-D_{N2} at 20^0C,1 std atm=$7.63*10^{-5}$ m^2/s, D_{O2}-D_{N2} at STP =$1.81*10^{-5}$ m^2/s]	**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)**	Define Loading, Flooding and Channeling for packed tower.	**03**
	(b)	Classify the mass transfer operations based on direct contact of two immiscible phases with examples.	**04**
	(c)	Justify that average mass transfer co-efficient for liquid phase is directly proportional to $D_{AB}^{0.5}$ for different solutes.	**07**
		OR	
Q.3	**(a)**	Explain Meir's Super saturation theory for Crystallization.	**03**
	(b)	Explain the following terms: HETP, HTU, NTU, Efficiency of tray	**04**
	(c)	Explain equilateral–triangular co-ordinate, plaint point, tieline, one pair partially soluble system with examples and the mixture rule.	**07**
Q.4	**(a)**	Discuss Venturi Scrubber with neat diagram.	**03**
	(b)	Show that overall resistance in diffusion between two phases follows two resistance theory.	**04**
	(c)	Discuss about minimum liquid-gas ratio for absorbers in detail.	**07**

OR

Q.4 **(a)** Explain Counter current multiple contact, Shanks system for leaching. **03**

(b) 1. Discuss: Operating lines for Absorbers and Stripers. **04**

2. Draw neat diagrams of any two industrial liquid liquid extractors.

(c) An air – ammonia mixture containing 5% ammonia by volume is absorbed in water in a packed column operated at 293 K and 101.325 kPa so as to recover 98% ammonia. If the inert gas mass velocity to column is 1200 kg/(m^2h). Calculate the mass velocity of water to this column if column is operated at 1.25 times the minimum liquid rate to column. Also calculate the composition of liquid leaving column corresponding to this condition. The Equilibrium relationship to this condition is y = 1.154 x. Where x and y are mole fraction of solute. **07**

Q.5 **(a)** Discuss various operation characteristics of sieve trays. **03**

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

(c) The equilibrium tie-line data for the system water (A) – chlorobenzene (B) – pyridine (C) at 25^{o}C are given in weight %. Plot the equilibrium data on the following co-ordinate system: (i) x and y against weight fraction B (ii) x against y. **07**

Chlorobenzene layer			Water layer		
Pyridine	Chlorobenzene	Water	Pyridine	Chlorobenzene	Water
0	99.95	0.05	0	0.08	99.92
11.05	88.28	0.67	5.02	0.16	84.82
18.95	79.9	1.15	11.05	0.24	88.71
24.1	74.28	1.62	18.9	0.38	80.72
28.6	69.15	2.25	25.5	0.58	73.92
31.55	65.58	2.87	36.1	1.85	62.05
35.05	61	3.95	44.95	4.18	50.87
40.60	53	6.4	53.2	8.9	37.90
49.0	37.8	13.2	49	37.8	13.2

OR

Q.5 **(a)** Mention Necessary driving force for crystallizer. Also List out different methods for achieving it. **03**

(b) Give significance of Nucleation. Discuss Solubility curves for crystallization. **04**

(c) Calculate the yield of MgSO4.7H2O crystals when 1000 kg saturated solution of $MgSO_4$ at 353 K is cooled to 303 K assuming 10 % of the water is lost by evaporation during cooling. **07**

Data: Solubility of $MgSO_4$ at 353 K = 64.2 kg/100 kg water.

Solubility of $MgSO_4$ at 303 K = 40.8 kg/100 kg water.

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