B.E. CHEMICAL ENGINEERING THIRD YEAR SECOND SEMESTER - 2023

SEPARATION PROCESSES- II

Time : 3hours **Full Marks : 50**

Part -I

Use Separate Answer scripts for each Part
Answer all

Clearly mention all the assumptions
Assume any missing data and mention it clearly

Question/CO	CO1	CO2	CO3	CO4
Q1	20		5	
Q2		20		5
Total Marks distribution	20	20	5	5

1. i) One thousand kg/h of a 45 wt% acetone-in-water solution is to be extracted at 25°C in a continuous, counter-current system with pure 1,1,2-trichloroethane to obtain a raffinate containing 10wt% acetone. Using the following equilibrium data, determine: (a) the minimum flow rate of solvent; (b) the number of stages required for a solvent rate equal to 1.5 times minimum; (c) the flow rate and composition of each stream leaving each stage. **[20]**

	Acetone, Weight Fraction	Water, Weight Fraction	Trichloroethane, Weight Fraction
Extract	0.60	0.13	0.27
	0.50	0.04	0.46
	0.40	0.03	0.57
	0.30	0.02	0.68
	0.20	0.015	0.785
	0.10	0.01	0.89
Raffinate	0.55	0.35	0.10
	0.50	0.43	0.07
	0.40	0.57	0.03
	0.30	0.68	0.02
	0.20	0.79	0.01
	0.10	0.895	0.005

The tie-line data are:

Raffinate, Weight Fraction Acetone	Extract, Weight Fraction Acetone
0.44	0.56
0.29	0.40
0.12	0.18

ii) Write down the important properties of solvent which affect the liquid liquid extraction. **[5]**

2. i) Derive am expression for length of unused bed. What is mass transfer zone in fixed bed adsorber? **[10]**

ii) How velocity of concentration front is related to slope of the isotherm. Derive an expression for the same. **[5]**

iii) Water containing 3.3 mg/L of trichloroethylene (TCE) is to be treated with activated carbon to obtain an effluent with only 0.01 mg TCEL. At 25°C, adsorption equilibrium data for TCE on activated carbon are correlated with the following Freundlich equation:

$q = 67\ c^{0.564}$

where, q = mg TCE/g carbon and c = mg TCE/L solution

The TCE is to be removed by slurry adsorption using a powdered form of the activated carbon. Given $K_La = 2 \times 10^{-4}$ time^{-1}

(a) Determine the minimum amount of adsorbent needed.

(b) For operation in the continuous mode using twice the minimum amount of adsorbent, determine the required residence time. **[10]**

Course Outcomes:

From this particular course, students should be able to

CO1:Understand&Analyze the equilibrium diagrams and **Formulate** mass balance and/or energy balance equations to solve staged, mass transfer based separation processes (K2, K4, K5)

CO2: Evaluate &Formulate various governing equations for different operational condition of mass transfer driven separation processes (K2, K3, K5, K6)

CO3: Apply theoretical background and **Choose** various mass transfer equipments as per applications (K2, K3)

CO4: Recognize themechanism of the steps involved in the processes and **Describe** the design methodologies of the equipments(K5, K2)

Ref. No. : Ex/Che/PC/B/T/323/(S) 2023

B.E. CHEMICAL ENGINEERING THIRD YEAR SECOND SEMESTER SUPPLEMENTARY EXAM-2023

SEPARATION PROCESS-II

PART-II

Time: 3 Hours Full Marks: 50

Use separate answer-scripts for each part

*Answer **Question 1** and **Any One** from the rest*
Clearly mention all the assumptions
Assume any missing data and mention it clearly
Clearly mention your name and roll number on the answer script as well on the graphs
Graphs need to be hand drawn

	Q. No 1	Q. No 2	Q. No 3
CO1	20		
CO2		10	10
CO 3	5	10	
CO 4		5	15

1. a) A continuous fractionating column is to be designed for separating 10,000 kg per hour of a liquid mixture containing 40 mole percent methanol and 60 mole percent water into an overhead product containing 97 mole percent methanol and a bottom product having 98 mole percent water. A mole reflux ratio of 3 is used. Calculate

(i) Moles of overhead product obtained per hour and (ii) number of ideal plates and location of the feed plate if the feed is at its bubble point.

Equilibrium data as follows-

x	0.1	0. 2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
y	0.417	0.579	0.669	0.729	0.78	0.825	0.871	0.915	0.959
Temp	100	96.4	93.5	91.2	89.3	87.7	84.4	78	73.1

b) Describe the significance of boil up ratio and reflux ratio for a distillation column.

20+5

2. a) Batch distillation 100 kmol of a 60 mole% benzene–toluene mixture is subjected to batch distillation until a 30 mole% residue is obtained. How many kg of distillate is obtained, and what is its benzene content?

	1	2	3	4	5	6	7
x	0.6	0.55	0.50	0.45	0.40	0.35	0.30
y	0.79	0.75	0.71	0.67	0.62	0.57	0.51

10

b) Mention the feature of invariant crystals and McCabe ΔL law related to crystal growth

5

c) Derive the model equation of Mixed suspension-Mixed product removal model **10**

3. a) Explain the principle of minimum-boiling and maximum-boiling azeotropes. **5**

b) Explain the overall column efficiency and plate efficiency of distillation column. **5**

c) In a crystallizer, crystals of $Na_2CO_3 \cdot 10H_2O$ are dropped into a saturated solution of Na_2CO_3 in water at 100°C. What percent of the Na_2CO_3 in the $Na_2CO_3 \cdot H_2O$ is recovered in the precipitated solid? The precipitated solid is $Na_2CO_3 \cdot H_2O$.

Data at 100°C: the saturated solution is 31.2% Na_2CO_3; molecular weight of Na_2CO_3 is 106

15