Ex/Che/PC/B/T/323/2022

B. E. CHEMICAL ENGINEERING EXAMINATION, 2022

(3r Year, 2nd Semester)

SEPARATION PROCESS II

Time : Three hours Full Marks : 100

(50 marks for each Part)

Use Separate Answer scripts For each Part

PART - I

*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	3	CO 3+ CO 4	10	CO 3	5
CO2	15	CO1+ CO2	15	CO 4	5
CO 3	5			CO1+ CO2	15
CO 4	2				

1. a) What is bimodal solubility curve in liquid- liquid extraction process? Explain the types of liquid- liquid equilibrium and explain the significance of plait point with a neat diagram?

5+3+2=10

b) A feed of 100 kg/min of 1.2 wt% mixture of acetic acid in water is to be extracted with 1-butanol at 1 atm and 26.7°C. The desired outlet concentration in the exiting stream is 0.1 wt% of acetic acid The solvent of pure 1-butanol is fed contercurrently to the feed with the flow rate of 75 kg/min Determine the composition of the exiting 1-butanol phase (i.e. the extract phase). Also find the number of equilibrium contacts (stages) needed. The equilibrium relation at 26.7°C is $y = 1.613x$

15

2. a) Briefly discuss the characteristic features of solvent for its application in liquid-liquid extraction process and mention the significance of 'critical solution temperature'.

6+4= **10**

b) Describe with neat diagram the design equation of fixed bed adsorption column using the concept of mass transfer zone, break through point and length of unused bed.

5+4+6=15

[Turn over

3. a) Explain the effect of temperature on different types of liquid- liquid equilibrium. **5**

(b) Mention the design calculations for a single stage mixer settler device using equilibrium plot on equilateral triangular coordinates **5**

c) Breakthrough data of acetone in air flowing through a bed of adsorbent are given in Table 1.

Time (min)	C/Co	Time (min)	C/Co	Time (min)	C/Co
180	0	215	0.210	245	0.743
187.5	0	220	0.285	250	0.825
191	0.005	225	0.372	255	0.892
195	0.018	230	0.460	260	0.948
205	0.091	235	0.553	265	0.98
210	0.143	240	0.655	270	0.992

Calculate

(i) Breakthrough time if breakthrough concentration is 2.5% of feed concentration.

(ii) The velocity of stoichiometric front and fraction of bed utilised.

(iii) The length of unused bed.

15

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(3rd Year, 2nd Semester)

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(50 marks for each Part)

Use Separate Answer scripts For each Part

PART - II

Answer Q1 and any one from Q2 and Q3

Clearly mention all the assumptions

Assume any missing data and mention it clearly

Question/CO	**CO1**	**CO2**	**CO3**	**CO4**
Q1	**20**	**5**		
Q2		**10**	**5**	**5**
Q3		**10**	**5**	**5**
Total Marks distribution	**20**	**15**	**5**	**5**

1. i) A solvent A is to be recovered by distillation from its water solution. It is necessary to produce an overhead product containing 95 mol% A and to recover 95% of the A in the feed. The feed is available at the plant site in two streams, one containing 40 mol% A and the other 60 mol% A. Each stream will provide 50 kmol/h of component A, and each will be fed into the column as saturated liquid. Since the less volatile component is water, it has been proposed to supply the necessary heat in the form of open steam. For the preliminary design, it has been suggested that the operating reflux ratio, L/D, be 1.33 times the minimum value. A total condenser will be employed. Assume pinch to be occur at the top feed location, i.e., minimum reflux is controlled by the upper feed. How many plates will be required, and what will be the bottoms composition? The relative volatility may be assumed to be constant at 3.0. **[20]**

ii) What is an azeotrope? Explain with the help of a diagram what is positive deviation from ideality? **[5]**

2. i) 10kmol of a feed having 70mol% benzene and 30mol% toluene is batch distilled at 1atm. Calculate the moles of distillate produced and the composition of the bottom product if distillation is done until (a) 80 mol% of the feed benzene leaves with the vapor, (b) the still pot contains 30mol% benzene, (c) 50mol% of the feed is vaporized. Relative volatility is 2.5. **[10]**

[Turn over

ii) Briefly mention different steps involved in crystallization process. **[5]**

iii) Derive an expression relating nucleation rate and mass rate of production of crystals using MSMPR model. Clearly mention necessary assumptions for MSMPR model. **[10]**

3. i) Derive Rayleigh equation for binary mixture in batch distillation. **[10]**

ii) Derive an expression relating crystal growth rate and overall mass transfer resistance for crystallization operation. **[5]**

iii) The feed to a continuous crystallizer that can be simulated with the MSMPR model is 5,000 kg/h of 40 wt% sodium acetate in water. Monoclinic crystals of the trihydrate are formed. The pressure in the crystallizer and the heat-transfer rate in the associated heat exchanger are such that 20% of the water in the feed is evaporated at a crystallizer temperature of 40°C. The crystal growth rate, G, is 0.0002 m/h and a predominant crystal size, Lpr, of 20 mesh is desired (opening is 0.833mm). Determine the: (a) kg/h of crystals in the exiting magma; (b) kg/h of mother liquor in the exiting magma; and (c) volume in m^3 of magma in the crystallizer if density of the crystals = 1.45 g/cm^3 and density of the mother liquor = 1.20 g/cm^3. **[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)