INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Mid-Spring Semester Examination, 2018 - 2019

***Subject* : Mass Transfer II** ***Subject No*.: CH 31010**

No. of Students: 93 ***Time*: 2 Hrs** ***Full Marks*: 30**

Department: Chemical Engineering **Closed Book and Notes**

***Instructions*:**

1. All Questions are compulsory.
2. Answer all questions of each part together.
3. Feel free to assume any missing data with proper justifications.
4. For Question Number 2 (Part A) please ask for graph paper (if required).
5. For Part B, please detach the Triangular Graph paper attached with question paper and attach it with the answer sheet.
6. Without the graph paper, no marks will be given in the corresponding questions in both parts.

PART A

Special requirement for Part A: Graph sheets need to be provided.

1. Explain illustratively and mathematically the contrasting differences between the film theory and the penetration theory of mass transfer. [5]
2. In a counter-current packed column, n-butanol flows down at a rate of 0.25 kg/m^2.s and is cooled from 330 to 295 K. Air at 290 K, initially free of n-butanol vapour is passed up the column at the rate of 0.7 m^3/m^2.s.
   (a) Draw the temperature-enthalpy curve; [6]
   (b) Calculate the exit condition of air: enthalpy, dry bulb and the adiabatic saturation temperature. [4]

   Data:

   Mass transfer coefficient per unit volume, 0.1 s^{-1}

   Lewis Number, 2.34

   Heat transfer coefficients, $h_L = 3\ h_G$

   Latent heat of vapourization of n-butanol, 252 kJ/kg

   Specific heat of liquid n-butanon, 2.5 kJ/kg.K

   Humid heat of gas, 1.05 kJ/kg.K

Temperature	Vap. Pressure of n-butanol (kPa)
95	0.59
300	0.86
305	1.27
310	1.75
315	2.48
320	3.32
325	4.49
330	5.99
335	7.89
340	10.36
345	14.97
350	17.50

PART B

3. The following equilibrium data is available for a ternary system. y and x are Wt fractions of C (solute) in the two equilibrium phases 1 and 2. A and B has their usual meaning.

Sl. No.	Liquid Phase 1		Liquid Phase 2	
	y	Wt. Fraction of A	x	Wt. fraction of A
1	0.0	0.12	0.0	0.86
2	0.07	0.10	0.04	0.84
3	0.13	0.11	0.10	0.80
4	0.24	0.14	0.18	0.73
5.	0.35	0.22	0.24	0.67
6.	0.38	0.30	0.32	0.57
7.	0.40	0.35	0.37	0.48

(a) Plot the ternary phase diagram in the form of a TRIANGULAR plot. (1)

(b) Identify the plate point. What is its composition? (1)

(c) For the above system you would like to run a 2 stage cross flow extractor, using a fresh solvent. The solvent flow rate for each stage is 30 Kg/ hr. The feed contains 40% solute and the feed flow rate is 50 Kg/hr. Draw the process on the graph paper, and identify the composition of each stream (including intermediate streams). (4)

(d) What is the final composition and quantity of the extract? (1)

(e) What is the limiting composition of C that can be extracted in this system using the same solvent as used above? Can you somehow extract a feed that has $x_F = 0.7$? (1+1)

Total Number in Question 1: 9

4. Graphically find out (use the same ternary graph) the amount S1 of a liquid Phase P1 having composition (x_A=0.13,x_B=0.04, x_C=0.83) which is mixed with 5 Kg of a second liquid phase P_2 having composition (x_A=0.06,x_B=0.22, x_C=0.72) to produce a mixture P_M with composition (x_A=0.10,x_B=0.10, x_C=0.80). What is the total mass of the mixture? (3)

5. (a) For a particular ternary system, the spread of the two phase zone increases with increase in temperature. What can you conclude? Justify (1)

   (b) Is dew point and bubble point same for a two component system? Answer with justification. Are they same for a single component system? (1.5+0.5)

Please detach the graph paper attached in the next page, and attach it with your answer script

End of Question Paper.

Best of Luck ☺

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