Exam Date & Time: 19-Jun-2024 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

MASS TRANSFER II

MASS TRANSFER -II [CHE 2222]

Marks: 50 **Duration: 180 mins.**

Part A

Answer all the questions.

1) Consider Ponchon-Savarit method. Derive the theoretical expressions to determine heat load on condenser, reboiler and the hypothetic stream with a neat schematic diagram (marking all the streams). Also discuss about the significance of the hypothetic stream. (4)

A)

B) Compare and contrast Azeotropic and Extractive distillation with examples. (3)

C) What is the significance of introducing open steam in a distillation column? Also derive an expression to determine the slope of the lower operating line. (3)

2)

A) Heptane and Octane form nearly an ideal solution. A mixture containing 40 mole% Heptane and 60 mole% Octane, which is at 30°C is to be continuously flash-vaporized at 1 atm standard pressure to vaporize 70 mole % of the feed. What will be the composition of the vapor and liquid and the temperature in the flash drum if we assume that the streams are in equilibrium?

Given: Boiling points of Heptane and Octane are 98.4°C and 125°C

T°C	x	y
105	0.655	0.810
110	0.487	0.674
115	0.312	0.492
120	0.1571	0.279

(4)

B) Consider two binary mixtures of C and D with concentration 0.6 and 0.8 and enthalpies 500 kcal/mole and 10,000 kcal/mole respectively. When the two mixtures are mixed (2)

together. The resulting solution has a concentration of 0.68. Compute the enthalpy of the mixture.

C) Write a short note on (i) Bollman and (ii) Hildebrand extractors with neat schematic diagrams. (4)

3) Derive Fenske's Equation to calculate the minimum number of stages in a distillation column. (3)

A)

B) A binary distillation column is operating under conditions specified below:

Feed rate = 350 kmol/h; Overhead product rate = 150 kmol/h;

Mole fraction of more volatile component in overhead product = 0.97

Mole fraction of bottom product = 0.02

Bottom product rate = 200 kmol/h (5)

Reflux ratio = 3.5

In the stripping section it was found that the mole fraction of the more volatile component in the vapor leaving a plate is 0.33 while its mole fraction in the liquid coming out from the same plate is 0.25. Assuming constant molar overflow, determine whether the feed is vapor, liquid or partially vaporized.

C) Write a short note on delayed and early feed entry in a distillation column with a schematic representation. (2)

4) 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

A) 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. (5)

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

B) Write a shot note on the four steps involved in the extraction process with a neat block diagram. (2)

C) Compute the vapor liquid equilibria data at a constant pressure of 1 atm for the mixtures (3)

of n-heptane with n-octane, which is expected to form ideal solutions. Also the calculate the average relative volatility for the given conditions.
Given: n-Heptane: Boiling point = 98.4 degree C; A' = 15.877, B' = 2911.32, C' = 226.65;
n-octane: Boiling point = 128.6 degree C; A' = 15.9635, B' = 3128.75, C' = 209.85

5) A feed of 1000 kg aqueous solution of pyridine per hour (50% by mass) is to be extracted with pure benzene to reduce the solute content in the raffinate to 2%. Determine the minimum solvent rate.

A)

Water layer		Benzene layer	
Pyridine (mass %)	Benzene (mass %)	Pyridine (mass %)	Benzene (mass %)
1.17	0	3.28	94.54
3.55	0	9.75	87.46
7.39	0	18.35	79.49
13.46	0.15	26.99	71.31
22.78	0.25	31.42	66.46
32.15	0.44	34.32	64.48
42.47	2.38	36.85	59.35
48.87	3.99	39.45	56.43
49.82	4.28	39.27	55.72
56.05	19.56	48.39	40.05

(3)

B) Determine the number of ideal stages required if the solvent rate is 1.3 times the minimum for the data given in question 5A. (5)

C) Write a short note on Type 1 and Type 2 systems of three liquids for extraction process with a sample representation of triangular coordinates. (2)

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