Exam Date & Time: 03-May-2024 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

IV Semester End Semester Examination

MASS TRANSFER -II [CHE 2222]

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

Descriptive Questions

Answer all the questions. Section Duration: 180 mins

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) Dilute ethanol-water solutions can be continuously rectified to give at best the mixtures containing 89.4 mole % ethanol at atmospheric pressure, since this is the composition of minimum boiling azeotrope in the binary system. Ethanol can be further purified either by using n-pentane as entrainer or ethylene glycol as solvent. Write short notes on the methods which uses the above-mentioned compounds in the purification of ethanol and comment on the most desirable method. (3)

C) What are the assumptions involved in Mc Cabe Thiele (MT) method? Discuss about the graphical and physical considerations in MT method which proves that its assumptions are justified. (3)

2) Nicotine (C) in a water (A) solution containing 1% nicotine is to be extracted with kerosene (B) at 20 °C. Water and kerosene are essentially insoluble. Determine the % extraction of nicotine if 100kg of feed solution is extracted using three stages using 50 kg solvent each.

A)

x' = kg nicotine/kg water	0.001011	0.00246	0.00502	0.00751	0.00998	0.0204
y'* = kg nicotine/kg kerosene	0.000807	0.00196	0.00456	0.00686	0.00913	0.01870

(4)

B) Explain heteroazeotropism and its significance in steam distillation with a suitable example. (3)

C) Derive an expression to theoretically calculate the minimum number of trays if the relative volatility remains reasonably constant throughout the column (provided x_D, x_W and α are known). (3)

3) A binary mixture (A and B) are fractionated using a fractionator which has 3 ideal plates. The feed enters between 2nd and the 3rd trays. The feed is a saturated vapor with mole fraction 0.005. The condenser used is a total condenser and the reflux is at its

A) bubble point. The molar rate of reflux is 1.3 moles/mole of feed and rate of vaporization in reboiler is 0.6 moles/mole of feed. The equation for equilibrium line is given as y = 12.6 x. Calculate the volume and concentration of distillate and the residue. (5)

B) Write a short note on any two solid-liquid contacting equipment which does not result in the clogging by fines with neat schematic diagram. (3)

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

4) 1000 kg of crushed oil seeds (19.5% oil, 80.5% meal) is extracted in a three-stage cross-current unit using 500 kg of pure hexane in each stage. Calculate the fraction of oil extracted. The equilibrium data are as follows:

A)

Overflow (100 kg) solution			Underflow (100 kg) slurry		
W_A (kg)	W_B (kg)	W_C (kg)	W'_A (kg)	W'_B (kg)	W'_C (kg)
0.3	99.7	0	67.2	32.8	0
0.45	90.6	8.95	67.1	29.94	2.96
0.54	84.54	14.92	66.93	28.11	4.96
0.70	74.47	24.83	66.58	25.06	8.36
0.77	69.46	29.77	66.26	23.62	10.12
0.91	60.44	38.65	65.75	20.9	13.35
0.99	54.45	44.56	65.33	19.07	15.6
1.19	44.46	54.35	64.39	16.02	19.59
1.28	38.50	60.22	63.77	14.13	22.10
1.28	34.55	64.17	63.23	12.87	23.90
1.48	24.63	73.89	61.54	9.61	28.85

(5)

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

C) 100 moles of benzene and toluene containing 50 mole% benzene is subjected to a differential distillation at atmospheric pressure till the composition of the benzene in the residue is 33% by mole. Calculate the total moles of the mixture distilled. Assume α = 2.4 (3)

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 (3)

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

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

C) Discuss about the effect of reflux ratio on the condenser and reboiler heat loads with a representation on H-x-y diagram (2)

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