Exam Date & Time: 01-Dec-2023 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

V Semester End Semester Examination
Mass Transfer II (CHE 3152)

MASS TRANSFER- II [CHE 3152]

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

Descriptive Questions

Answer all the questions. Section Duration: 180 mins

1) A) A mixture containing 100 mol (50 mol% A and 50 mol% B) is distilled by differential distillation at 1 atm until 40 mol is distilled. What is the average composition of the distillate and the residue? The equilibrium data are as follows, where x and y are mole fractions of the more volatile component:

Also calculate the composition of residue and distillate if the same mixture is distilled by flash vaporization (5)

x	1	0.867	0.594	0.398	0.254	0.145	0.059	0
y	1	0.984	0.925	0.836	0.701	0.521	0.271	0

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) Compare and contrast the role of the solvent in extractive distillation and extraction process. Also comment on the advantages of extraction over extractive distillation. (2)

2) A) A solution of carbon tetrachloride and carbon disulfide containing 50 wt% each is to be continuously fractionated at standard atmospheric pressure at the rate of 5500kg/h. The distillate product is to contain 92 wt % carbon disulfide, the residue 0.8 wt %. The feed will be 40 mol% vaporized before it enters the tower. A total condenser will be used, and the reflux will be returned at the bubble point. Determine the minimum reflux ratio.The equilibrium data (x,y* = mole fraction CS_2) is as follows: (4)

T (°C)	x	y*

76.7	0	0
74.9	0.0296	0.0823
73.1	0.0615	0.1555
70.3	0.1106	0.2660
68.6	0.1435	0.3325
63.8	0.2585	0.4950
59.3	0.3908	0.6340
55.3	0.5318	0.7470
52.3	0.6630	0.8290
50.4	0.7574	0.8780
48.5	0.8604	0.9320
46.3	1	1

B) 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. (4)

C) Identify the appropriate and economical pressure driven membrane processes for the separation of following mixtures:

i. Clarification of apple juice

ii. Desalination of sea water (2)

iii. Reduction of alcohol content of beer

iv. Removal of ionic substance from water

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 (5)

A) mole fraction 0.005. The condenser used is a total condenser and the reflux is at its 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.

B) Discuss about spiral wound membranes and bundle of hollow fibres with schematic representation. Which among these is generally used in RO systems? (3)

C) Discuss about the minimum and maximum boiling azeotropes with suitable examples. (2)

4) 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. (Use rectangular coordinate system)

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 4A. (5)

C) Discuss about the principle of steam distillation and its industrial applications (any 2) (2)

5) 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 using Ponchon Savarit method. The equilibrium data are as follows:

A)

(5)

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

B) For extraction of dioxane from water, benzene is used as an extraction solvent. The equilibrium distribution of dioxane between water and benzene is as given below:

Weight % dioxane in water	5.1	18.9	25.2
Weight % dioxane in benzene	5.2	22.5	32

(3)

At these concentrations, water and benzene are insoluble. 1000 kg of solution containing 25% dioxane is to be extracted with benzene to remove 95% of the dioxane. The dioxane free benzene is used as the solvent. Calculate the solvent requirement for the single stage operation.

C) Write a short note on any one solid-liquid contacting equipment which operates in counter-current mixing with a neat schematic diagram (2)

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