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Motilal Nehru National Institute of Technology Allahabad
Prayagraj - 211004, [India]

End Semester Examination Odd Semester (Session 2020-21)

Programme Name: B.Tech.

Semester: V

Course Code: CH15102

Course Name: Mass Transfer-II

Branch: Chemical Engineering

Student Reg. No.:

Duration: 2 Hours

Max. Marks: 40

Instructions:

1. Solve the questions as per the given sequence
2. Attempt all the questions

Question 1:

a) Why are major distillation operations carried out at constant pressure? Why high pressure is not favorable for distillation operation?

2 Marks

b) What will be the vapor-liquid equilibrium behavior of an ideal binary mixture at isothermal condition?

2 Marks

c) A mixture of two components A and B follow the Roults law. Vapour pressure of A and B are P_A^{sat} and P_B^{sat} in kPa, respectively:

$$\ln P_A^{sat} = 14.27 - \frac{2945}{T + 224}$$
$$\ln P_B^{sat} = 14.20 - \frac{2973}{T + 209}$$

If the bubble point of a mixture of A and B is 77°C at a total pressure of 83 KPa, find the composition of the first vapour that forms.

2 Marks

d) A continuous enriching column is separating a mixture of A and B (A is more volatile than B) with 93 mole% A as distillate product. The liquid overflowing from two adjacent plates in the enriching section contain 59.2 mole% and 51 mol% A, respectively. Reflux is at bubble point. Relative volatility can be taken 2.3. Calculate the reflux ratio.

2 Marks

Question 2:

a) How is fractionation column different from differential/flash distillation column?

2 Marks

b) What is the role of partial condenser in fractionation column? Why is it replaced from total condenser?

2 Marks

c) A mixture of 35 mole% methanol and 65 mole% water was prepared by a chemical engineer and passed to differential distillation column. At atmospheric pressure, 62 mole% of the mixture is distilled. Calculate the composition of the composited distillate and the residue.

Table 1: Equilibrium data

x	0.05	0.1	0.2	0.3	0.4	0.5
y	0.25	0.40	0.55	0.65	0.70	0.75

4 Marks

Question 3:

a) A mixture of 45 mole% heptane and 55 mole% ethyl benzene is distilled at atmospheric pressure to produce a top product containing 95 mole% heptane and bottom product containing 97 mole% ethylbenzene. Calculate: (i) Minimum reflux ratio, (ii) Number of theoretical stages for $R=2.3$, (iii) Minimum number of theoretical stages at total reflux, (iv) Heat load on condenser and reboiler in KJ/h for a feed rate of 5500 kg/h.

4 Marks

b) A component mixture of 33 mole% A and 67 mole% of B is separated in fractionation column. Concentration of component A is observed 91 mole% in the top product and 94 mole % of all A in the top product. Feed is the mixture of half vapour and half liquid with the reflux ratio of 4. Relative

Question 4:

a) In liquid-liquid extraction, which one is more favourable operation in multistage cross-current or multistage counter-current operation?

2 Marks

b) What are the major differences between liquid-liquid equipments and leaching equipments?

2 Marks

c) A pyridine-water mixture of 2500 kg containing 55% pyridine is extracted with equal weight of pure chlorobenzene. Raffinate is used as a feed for the next stages where equal weight of solvent to raffinate weight is used. Calculate: (i) theoretical stages, (ii) total quantity of solvent required to reduce the pyridine concentration to 3%. Use rectangular coordinates.

4 Marks**Question 5:**

a) Soyabean oil is to be extracted from crushed soyabean in a counter-current extraction unit using hexane

3

Table 3: Equilibrium tie line data in weight percent are

Pyridine	Chlorobenzene	water	Pyridine	Chlorobenzene	water
0	99.95	0.05	0	0.08	99.92
11.05	88.28	0.07	5.02	0.16	94.82
18.95	79.90	1.15	11.05	0.24	88.71
24.10	74.28	1.62	18.90	0.38	80.72
28.60	69.15	2.25	25.05	0.58	73.92
31.55	65.58	2.87	36.15	1.85	62.05
35.05	61.00	3.95	44.95	4.18	50.87
40.60	53.00	6.40	53.20	8.90	37.90
49.00	37.80	13.20	49.00	37.80	13.20

as a solvent. Mass flow rate of crushed soyabean to the unit is 400 kg/h. Fresh crushed soyabean contain 18% oil and are to be extracted to a composition 1.5% oil (on solvent free basis). Hexane containing 3% oil to be used as a solvent is fed to the unit at the rate of 250 kg/h. Calculate: (i) number of theoretical stage required, (ii) percent recovery of the oil.

Table 4: The entrainment data are as follows:

Concentration, kg oil/kg solution	0	0.1	0.2	0.3	0.4	0.5	0.6
Solution retained, kg solution/kg exhausted soyabean	0.28	0.34	0.40	0.47	0.55	0.66	0.80

4 Marks

b) A 28.2% by weight anhydrous sodium sulphate is fed to a crystallization unit with 6500 kg of an aqueous solution at 102°C. During the cooling operation, 4.5% of initial water is lost by evaporation. As a result, Na₂SO₄·10H₂O crystals are formed. Calculate the yield of crystals and quantity of mother liquor if the mother liquor is found to contain 18.1% by weight anhydrous Na₂SO₄.

4 Marks