Course: B. Tech in Chemical Engineering

Mass transfer Operation II Sample Questions each of 5 marks Graph paper required MTO II question bank

Subject Code: BTCHC 601 Semester VI

Q.1 A liquid mixture of benzene-toluene is to be distilled in a fractionating tower at 1 (12) atm pressure. The feed of 100 kg mol/hr is liquid, containing 45 mol % benzene and 55 mole percent toluene and enters at 327.6 K. A distillate containing 95 mole % benzene(rest toluene) and bottoms containing 10 mole % benzene(rest toluene) are to be obtained. The average heat capacity of the feed is 159 KJ/kgmolK and the average latent heat is 32099 KJ/kgmolK. Calculate molar rate of distillate and bottoms and number of trays using McCabe-Thiele method. Use reflux ratio 1.7 times minimum. The equilibrium data at 1 atm pressure is as follows

Temperature (C)	Mole fraction of benzene in	Mole fraction of benzene in
	liquid	vapor
80	1	1
85	0.78	0.9
90	0.581	0.777
95	0.411	0.632
100	0.258	0.456
105	0.13	0.261
110.6	0.0	0.0

Q.2 Write short notes on(4 + 4 + 4)

(a) Vapor liquid equilibria for distillation

(b) Ponchon Savarit method

(c) Analysis of distillation column with 1 side stream

Q.3 (a) A gas (B) – benzene (A) mixture is saturated at 1 atm pressure at 50 C. (4) Calculate absolute humidity if B is (i) nitrogen and (ii) carbon dioxide. The equilibrium vapour pressure of benzene at 50 C is 0.362 atm.

(b) Describe wet bulb temperature in	brief with neat diagram.	(4)
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(c) Describe any one type of cooling tower with neat diagram. (4)

Q. 4 (a)A wet solid of 150 kg is dried from a moisture content of 45 wt % to 10 wt%. The (4) critical moisture content is 15 wt % and equilibrium moisture content is zero. All above quantities are on dry basis. The falling rate is assumed to be zero and it takes 5 minutes to dry material in constant rate period. Find the total duration of drying.

(b) Describe any one type of drier with neat diagram.

(4)

(c) Describe the drying test for a material with suitable diagram . (4)

Q.5 (a) A salt solutions weighing 10000 kg with 30 weight percent sodium carbonate is (6) cooled to 20 C. The salt crystallizes the decahydrate. What will be the yield of the decahydrate crystals if the solubility is 21.5 kg anhydrous sodium carbonate per 100 kg of total water. Do this for following cases :

(i) Assume that no water is evaporated.

(ii) Assume that 3 % of the total weight of the solution is lost by evaporation of water in cooling.

(6)

(5)

(b) Describe the crystallization theories in detail.

Q.6 Write short notes on (4 + 4 + 4)

(a) Microfiltration

(b) Reverse osmosis

(c) Dialysis

Q.7 The distillation is used at 1 atm pressure to separate a feed containing 40 mole % (10) heptane and 60 mole % ethyl benzene to produce a distillate containing 96 mole % heptane and residue containing 99 mole % ethyl benzene.

(i) Using a reflux ratio of 2.8, determine the number of equilibrium stages needed for a saturated liquid feed by McCabe Thiele method.

(ii) Determine minimum reflux ratio.

(iii) Determine the number of equilibrium stages at total reflux.

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The ec	Juillorium	data	is as	snown	below.

У	Х	у	X
0	0	0.729	0.489
0.233	0.08	0.814	0.651
0.428	0.185	0.904	0.788
0.514	0.251	0.963	0.914
0.608	0.335	1.0	1.0

where y and x are mole fractions of heptane in vapor and liquid respectively.

- Q.8 Write short note on(3 + 3 + 4)
- (a) Minimum boiling azeotropes
- (b) Differential distillation
- (c) Ponchon Savarit method for distillation

Q.9 (a) Describe the design of cooling tower with associated equations. (5)

(c) Describe natural draft cooling tower with construction and working.

Q. 10 (b) With neat sketch, explain construction and working of any three dryers. (10)

Q.11(a)Describe nucleation theory in brief for crystallization. (3)

(c) Describe with neat diagram, any one type of crystallizer. (3)

- Q.12 Write short note on (4 + 3 + 3)
- (a) Applications of crystallization
- (b) law of crystal growth
- (c) Primary nucleation

Q.13 (a) It is required to design an RO module for production of 1500 m³ per day potable (6) water containing not more than 250 ppm salt from sea water containing 34 g salt per liter. A proprietary asymmetric cellulose acetate membrane with inherent salt rejection ability of 98 % is to be used. The water permeation coefficient is $0.043 \text{ m}^3/\text{m}^2$ dayatm. The recovery of feed water should be 35 % and operating pressure of 70 atm is suggested. The permeate side is essentially at atm pressure. If spiral wound modules of 5 m² effective membrane area each is used, how many modules in parallel are required? The osmotic pressure of 5 % brine is 39.5 atm(Take linear in salt concentration).

(b) With neat flowsheet explain RO water treatment plant.

(4)

- Q.14 Write short notes on (4 + 3 + 3)
- (a) Pervaporation
- (b) Applications of membrane separation operations
- (c) Membrane materials

Q.15 An equimolar liquid mixture of 100 kg mol/hr. of benzene-toluene is to be distilled (10) in a fractionating tower at 1 atm pressure and it enters at 327.6 K. A distillate containing 96 mole % benzene (rest toluene) and bottoms containing 10 mole % benzene (rest toluene) are to be obtained. The reflux ratio is 5. The average heat capacity of the feed is 159 KJ/kgmolK and the average latent heat is 32099 KJ/kgmolK. Calculate molar rate of distillate and bottoms and number of trays using McCabe-Thiele method. The equilibrium data at 1 atm pressure is as follows

Temperature (C)	Mole fraction of benzene in	Mole fraction of benzene in
	liquid	vapor
80	1	1
85	0.78	0.9
90	0.581	0.777
95	0.411	0.632
100	0.258	0.456
105	0.13	0.261
110.6	0.0	0.0

Q.16 Write short note on (3 + 3 + 4)

(a) Vapor liquid equilibria for distillation

(b) Batch distillation

(c) Energy composition method for distillation

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v	. 1 / (a			ucsign 0	COUTING		associated of	quations.	(5)
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(b) Explain adiabatic saturation temperature with neat diagram. (2)

(c) Describe induced draft cooling tower with construction and working. (3)

Q. 18 (a) A wet solid is dried from 40 to 8 percent moisture in 20,000 seconds. If the critical (5) and the equilibrium moisture contents are 15 and 4 percent respectively, how long will it take to dry the solid to 5 percent moisture under the same drying conditions? All moisture contents are on dry basis.

(b) With neat sketch, explain construction and working of (5) (i) tray dryer (ii) rotary dryer.

Q.19 (a) 10 Mg (i.e. 10000 kg) of a solution containing 0.3 kg Na_2CO_3 / kg solution is (6) cooled slowly to 293 K to form crystals of Na_2CO_3 , 10H₂O. What is the yield of the crystals if the solubility of Na_2CO_3 at 293 K is 21.5 kg/100 kg water and during cooling, 3 percent of the original solution is lost by evaporation?

(b)Describe solubility and super solubility curve for crystallization. (4)

Q.20 Write short note on (3 + 3 + 4)

(a) Oslo crystallizer

(b) law of crystal growth

(c) Primary nucleation

Q.21 Write short notes on (3 + 3 + 4)
(a) Membrane materials
(b) Ultrafiltration
(c) Dialysis

Q.22 Explain in detail simple distillation set-up with neat diagram. Derive Rayleigh equation.

Q.23 Discuss the operation of Equilibrium Flash Unit

Q.24 A mixture of 40 mole % isopropanol in water is to be flash vaporised at 1 atm and 70 mole % of the feed was flash vaporized. Calculate the composition of the liquid residue remaining in the still pot, and the average composition of the collected distillate. VLE data for this system, in mole fraction of isopropanol, at 1 atm are can be generated by taking average relative volatility as 2.5. Basis F = 100 mol.

Q.25It is desired to separate a feed mixture containing 40% heptane and 60 % ethyl benzene, such that 60% of the feed is distilled out. Estimate the composition of the residue and distillate when the distillation process is carried out using simple (differential distillation).

Equilibrium data is as follow:

X	0	0.08	0.185	0.25	0.33	0.5	0.65	0.79	0.8	0.88	1
У	0	0.23	0.43	0.52	0.60	0.72	0.81	0.81	0.91	0.98	1

Where x, y: Mole fraction of heptane in liquid and vapor phase respectively.

Q.26 Explain the relation of Reflux ratio and economics of the fractionation distillation column.

Q.27 Explain in detail the operation and temperature profiles of a continuous rectification distillation column with neat diagram.

Q.28 A mixture of benzene and toluene containing 40 mole % of benzene is to be separated in continuous fractional column to get 90 % of benzene at the top and bottom product with 5 mole % benzene. The feed enters the column at its boiling point (saturated liquid). Reflux ratio was 3. Calculate the number of stages required to separate the mixture. Determine the feed plate location. VLE data for this system, in mole fraction of benzene at 1 atm are

X	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
У	0	0.22	0.4	0.52	0.62	0.72	0.8	0.85	0.91	0.96	1

Q.29 An equimolar mixture of benzene and toluene is to be separated in continuous fractional column to get 90 % of benzene at the top and bottom product with 5 mole % benzene. A total reflux condition was used. Calculate the number of stages required to separate the mixture to get desired purity

VLE data for this system, in mole fraction of benzene at 1 atm are.

X	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
У	0	0.22	0.4	0.52	0.62	0.72	0.8	0.85	0.91	0.96	1

Q.30 A mixture Benzene (MVC) / Toluene with a mole fraction x_F = 0.4 should be separated in a plate column in a distillate (D) and a Bottoms stream (B) with mole fraction resp. x_D = 0.96 and x_B =0.04. The constant of relative volatility α of the mixture, whose behaviour can be considered ideal, is 2.42. Calculate the minimum number of stages N_{min} applying the Fenske equation.

Q.31 It is desired to separate a mixture of 50% vapor and 50% saturated liquid in a plate type distillation column. The feed contains 45 mole % of A and the top product is to contain 96 mole% of A. The bottom product is to contain 5 mole% of A. Determine the minimum reflux ratio and the number of theoretical plates needed if reflux ratio of twice the minimum is used. Use McCabe Thiele's Method.

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x	0	0.1	0.16	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
У	0	0.215	0.30	0.52	0.62	0.72	0.78	0.89	0.89	0.95	1

Equilibrium data is as follow:

Where x, y: Mole fraction of heptane in liquid and vapor phase respectively.

Q.32 Describe the design procedure of cooling tower. Draw a neat diagram of cooling tower.

Q.33 What is mean by dry bulb temperature and wet bulb temperature. How to calculate humidity by knowing these two temperatures.

Q.34 An air water vapor mixture has a dry bulb temperature of 55 °C and an absolute humidity 0.03 kg water/kg dry air at 1 standard atm pressure. Vapor pressure of water at 55 °C is 118 mm Hg, calculate the relative humidity and humid heat.

Q.35 Explain the drying characteristics curves.

Q.36 What is mean by equilibrium moisture content, critical moisture content and bound moisture and unbound moisture.

Q.37 Explain in detail with neat diagram: fluid bed dryer. Write down the advantages and disadvantages.

Q.38 Explain in detail with neat diagram: rotary dryer. Write down the advantages and disadvantages.

Q.39 Explain in detail with neat diagram: turbo tray dryer. Write down the advantages and disadvantages.

Q.40 Explain in detail with neat diagram: spray dryer. Write down the advantages and disadvantages.

Q.41 A laboratory test on tray dryer shows that it requires 8 hours to reduce the moisture content of a wet solid from 28% to 2 %. The critical moisture content is 6% and equilibrium moisture content is 0.2%. Assume falling rate period is linear. Calculate the drying time required to dry the same wet solid in tray dryer from 28% to 0.5 %. All moisture contents are expressed in dry basis form.

Q.42 Explain the theory of crystal growth in detail.

Q.43 Explain in detail with neat diagram: MSMPR CRYSTALLIZER (Forced Circulation crystallizer. Write down the advantages and disadvantages.

Q.44 Explain in detail with neat diagram: Draft Tube and Baffle type Crystallizer. Write down the advantages and disadvantages.

Q.45 Explain in detail with neat diagram: Oslo Crystallizer. Write down the advantages and disadvantages.

Q.46 What are the different types of membranes according to the structure and shape of the membrane?

Q.47 Explain the reverse osmosis (RO) process with neat diagram. What are the advantages and disadvantages of RO system?

Q.48Classify the different membranes separation processes based on different driving force and separation size range. What are the specific examples for the same?

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