

III B.Tech II Semester Regular Examinations, Apr/May 2006
MASS TRANSFER OPERATIONS-II
(Chemical Engineering)

Time: 3 hours

Max Marks: 80

Answer any FIVE Questions
 All Questions carry equal marks

1. (a) An ethanol-water mixture containing 36% by weight of ethanol is differentially distilled at 1 atmosphere pressure and the mixture is reduced to a maximum ethanol concentration of 6 mole%. Determine the composition of the distillate. Molecular weight of ethanol may be taken as 46.

The VLE data are:

Mole fraction of ethanol in Liquid "x"	0.18	0.16	0.14	0.12	0.10	0.08	0.06
Mole fraction of ethanol in Liquid "y"	0.517	0.502	0.485	0.464	0.438	0.405	0.353

- (b) Explain the pressure-temperature-concentration phase diagram for a binary mixture with a neat schematic. [10+6]
2. Explain the step-by-step procedure for the calculation of theoretical number of plates of a distillation column by McCabe-Thiele method. Mention the assumption made and its limitations. [16]
3. An equimolar binary mixture of completely miscible components is to be separated in a packed distillation column operated at atmospheric pressure. The relative volatility is 1.2. The distillate product to be obtained should contain 95 mole% of the more volatile component bottom product contains 5 mole % of the mole volatile component. Compute for this case, the number of transfer units required if the column is operated at total reflux. [16]
4. Discuss multistage cross current extraction and explain how it is shown on a triangular chart. Indicate how the quantities and compositions of extract and raffinate are computed. For a given separation indicate how the number of equilibrium stages required is found. [16]
5. If 8000 kg/h of an acetic acid (C)-water (A) solution, containing 30 % acid, is to be counter currently extracted with isopropyl ether (B) to reduce the acid concentration to 2 % in the solvent free raffinate product, determine
- (a) The minimum amount of solvent which can be used and
- (b) The number of theoretical stages if 20,000 kg/h of solvent is used.

The equilibrium data are given below.

Water layer, wt %			Isopropyl ether layer wt%		
Wt% acetic acid 100x	Water	Isopropylether	Acetic acid 100y*	Water	Isopropylether
0.69	98.1	1.2	0.18	0.5	99.3
1.41	97.1	1.5	0.37	0.7	98.9
2.89	95.5	1.6	0.79	0.8	98.4
6.42	91.7	1.9	1.93	1.0	97.1
13.30	84.4	2.3	4.82	1.9	93.3
25.50	71.1	3.4	11.40	3.9	84.7
36.70	58.9	4.4	21.60	6.9	71.5
44.30	45.1	10.6	31.10	10.8	58.1
46.40	37.1	16.5	36.20	15.1	48.7

[16]

6. Sugar is to be extracted from wet sliced sugar beet in a countercurrent leaching unit using water as the solvent. The wet beet is to be treated at the rate of 10,000 kg/hr and has the following composition in mass fraction: water = 0.28, sugar = 0.32, pulp = 0.40. The final extract is to be 30% sugar by weight and 90% of the total sugar is to be recovered. Estimate the number of ideal stages required assuming that 1kg of pulp retains 3kg of solution in all stages. How much water is used? [16]
7. (a) Differentiate van der Waals adsorption isotherm and chemisorption
 (b) Define adsorption?
 (c) List out the properties of Adsorbents? [8+2+6]
8. (a) Derive the rate of adsorption in fixed beds?
 (b) What are the factors determining rate of ion exchange? [10+6]

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1. (a) Draw the boiling diagram and equilibrium diagrams for a minimum boiling azeotrope and maximum boiling azeotrope.
(b) With the help of the above diagrams explain what is a minimum boiling azeotrope and maximum boiling azeotrope. [8+8]
2. Derive Operating line equations for enriching and stripping section in the distillation column using Ponchon Savarit method. [16]
3. (a) What is an azeotrope? Give few examples.
(b) What is the importance of extractive distillation.
(c) With neat figure explain the process of extractive distillation. Mention its application in the industries. [4+4+8]
4. Discuss multistage cross current extraction and explain how it is shown on a triangular chart. Indicate how the quantities and compositions of extract and raffinate are computed. For a given separation indicate how the number of equilibrium stages required is found. [16]
5. Discuss about the following equipment for liquid-liquid extraction with neat diagrams:
(a) Mixer-settler cascade
(b) Gravity settlers [16]
6. (a) What is effect of temperature on leaching?
(b) Seeds containing 20% by weight of oil are extracted in a countercurrent plant with 90% of the oil recovered in a solution containing 50% by weight of oil. If the seeds are extracted with fresh solvent and one kg of solution is removed in the underflow in association with every two kg of insoluble matter, how much solvent per kg of seeds is used and how many stages are required. [4+12]
7. (a) Prove that for cross current two stage treatment of liquid solutions by contact filtration, when the adsorption isotherm is linear, the least total adsorbent results if the amount used in this stages are equal. Explain.
(b) Discuss about the effect of temperature and pressure on adsorption. [10+6]
8. (a) List out the steps involved in the design of fixed bed ion exchange column
(b) What are ion exchange materials? Explain. [10+6]

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1. (a) A feed mixture of benzene and toluene containing 30 mole% of benzene is to be distilled in a batch still by differential distillation process. A distillate product having an average composition of 45mole% benzene is to be obtained. Calculate the quantity of residue if 100 moles are taken in the batch initially. The equilibrium data is given below:

"x"	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
"y"	0.21	0.35	0.51	0.64	0.72	0.79	0.86	0.91	0.96

- (b) Explain the principles of flash vaporization. [10+6]
2. Derive Operating line equations for enriching and stripping section in the distillation column using Ponchon Savarit method. [16]
3. Write a brief note on the application of :
- (a) Condensers and Reflux Accumulators
 - (b) Multiple Feeds
 - (c) Side Streams [8+4+4]
4. (a) What is plait point ? Estimate the number of degrees of freedom of the system at the plait point?
- (b) What is the effect of temperature on ternary equilibria? Explain with neat sketch. [6+10]
5. With the help of a neat diagram describe the continuous countercurrent extraction with reflux. Explain the graphical determination of number equilibrium stages required for a given separation on triangular coordinates. [16]
6. (a) Explain percolation method of leaching.
- (b) Describe the different types of tanks used in percolation operation.
- (c) Describe the sequence of procedures to be followed in percolation tank operation. [2+10+4]
7. (a) Explain about the theories of adsorption
- (b) Discuss about the nature and characteristics of adsorbents used in industry. List at least four industrial absorbents.
- (c) What is absorption hysteresis? [4+8+8]

8. (a) What is the role of adsorption in waste water treatment? Explain.
(b) What will be the effect of feed concentration on the break through curve.
[8+8]

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1. (a) A liquid mixture of

- i. 50 mole% n-heptane
- ii. and 50 mole% n-octane

were subjected to differential distillation at atmospheric pressure with 70 mole% of the liquid distilled. Compute the composition of the composite distillate and the residue.

"x"	1.00	0.50	0.46	0.42	0.38	0.34	0.32	0.00
"y"	1.00	0.689	0.648	0.608	0.567	0.523	0.497	0.00

- (b) What is relative volatility? How is it computed? [12+4]

2. (a) Define reflux and reflux ratio

- (b) Explain the importance of reflux in a distillation column.

- (c) How will you calculate the optimum reflux ratio? [4+6+6]

3. (a) What is a partial condenser? Represent graphically. Write the material balance equations.

- (b) What is the effect of cold reflux in distillation operation with the help of mathematical equating. [8+8]

4. A solute is recovered from an aqueous solution containing 20% of the solute by weight using kerosene as the solvent. The distribution of the solute in water and kerosene may be described by $x' = 6.45y'$ where x' is the kg of solute per kg of water and y' is the kg of solute per kg of kerosene. Calculate the following:

- (a) The final concentration in the final raffinate if the extraction is done in 3 simple equilibrium contacts using 5 kg solvent per kg of initial solution in each stage.

- (b) The number of equivalent theoretical contacts necessary to obtain the concentration of solute in the final raffinate as 3.5% by weight with the extraction done by counter current stage contacting using 6 kg of kerosene per kg of aqueous solution. [16]

5. Discuss about the following equipment for liquid-liquid extraction with neat diagrams:

- (a) Sieve tray tower

(b) Pulsed column [16]

6. Explain Continuous-Countercurrent Decantation (CCD).

(a) with simple flow sheet

(b) flow sheet with intermediate agitation and filtration of washed solids.

[8+8]

7. The equilibrium adsorption of acetone vapor on an activated carbon at 30degC is given by the following data

g adsorbed/g Carbon	0	0.1	0.2	0.3	0.35
Partial pressure acetone mmHg	0	2	12	42	92

The vapor pressure of acetone at 30deg C is 283 mm Hg. A 1-liter flask contains air and acetone vapor of 35%. After 2 gms of fresh activated carbon has been introduced in to the flask, the flask is sealed. Compute the final vapor concentration at 30 deg C and the final pressure. Neglect the adsorption of air. [16]

8. (a) Draw and explain the working principle involved in a Adsorber for solvent vapor at high pressures ?

(b) Explain the term LUB? How do you calculate?

[12+4]
