

**III B.Tech II Semester Supplementary Examinations,  
November/December 2005  
MASS TRANSFER OPERATIONS-II  
(Chemical Engineering)**

**Time: 3 hours****Max Marks: 80**

**Answer any FIVE Questions  
All Questions carry equal marks**

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1. (a) Draw the boiling diagram and equilibrium diagrams for a minimum boiling 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. A feed mixture composed of 42 wt % ethanol and 52 wt % water is to be fractionated at 760 mmHg to produce a distillate containing 89% by wt. ethanol and a residue containing 95% by wt. water. Using the given enthalpy concentration data and assuming a saturated liquid feed and bubble point reflux determine
  - (a) The minimum reflux ratio.
  - (b) The number of trays at twice the minimum reflux ratio.
  - (c) The minimum number of trays.

<u>Wt % ethanol</u>		$h_l$ KJ/kg.	$h_g$ KJ/kg.
Liquid	Vapor		
0	0	360	2300
10	52.7	320	2164
20	65.6	288	2024
30	71.3	270	1886
40	74.6	250	1746
50	77.1	246	1608
60	79.4	235	1468
70	82.2	222	1328
90	91.2	193	1052
100	100	188	916

[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. (a) Discuss about the applications of liquid extraction.

- (b) Write about the notation scheme used to describe the concentration and amounts of ternary mixtures for the purpose of discussing both equilibrium and material balances. [6+10]
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 the number of transfer units  $N_{tOR}$  if 20,000 kg/h of solvent is used.

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	31.1	10.8	58.1
46.40	37.1	16.5	36.2	15.1	48.7

[16]

6. (a) Define Leaching.  
 (b) What is lixiviation?  
 (c) What is decoction?  
 (d) Explain the applications of leaching operation with suitable examples. [2+2+2+10]
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) State the principles of ion exchange.  
 (b) Derive the equation to calculate the length of used bed. [6+10]

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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. A continuous fractionating column operates with reflux ratio 3.5 to separate 13600 kg/hr. to get a distillate containing 97% Benzene and bottoms containing 2% Benzene (all wt%). Calculate moles of distillate and residue if feed is at its boiling point and numbers of ideal stages required. The equilibrium data is as follows.

Mol. Fraction of benzene x	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Mol. Fraction of benzene y	0.21	0.35	0.51	0.64	0.72	0.79	0.86	0.91	0.96

[16]

3. (a) Describe thermosyphon reboilers with neat diagrams.  
(b) What do you understand by plate efficiency? Explain. [10+6]
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. Solute A is to be extracted counter currently from a mixture of A and B containing 40% by weight of A, using a solvent C. Raffinate should not contain more than 5% A. Evaluate minimum solvent per kg of feed and actual number of stages needed when actual solvent rate is twice the minimum and stage efficiency is 75%. The equilibrium test data available is

Extract layer, wt %		Raffinate layer, wt %	
C	B	C	B
95	2.5	2.5	92.5
85	2.9	3.0	87
75	3.5	5.5	65
65	5.0	8.5	50
55	10.0	15.0	40

[16]

6. (a) What is Shanks system of leaching?  
 (b) Explain countercurrent multiple contact shanks system.  
 (c) Explain briefly about extraction battery. [3+4+9]
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 adsorbents.  
 (c) What is absorption hysteresis? [4+8+8]
8. Write short notes on:  
 (a) The heatless adsorber  
 (b) Percolation in adsorption of liquids. [8+8]

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1. A binary mixture of benzene and toluene containing 40 mole % benzene is to be distilled at atmospheric pressure to recover 95% of the benzene. Estimate the molal percent of the mixture that should be distilled and the composition of the distillate obtained, if the distillation is carried out by

- (a) Simple equilibrium distillation
- (b) Differential distillation collecting all the distillate together

The average relative volatility of benzene to toluene in the temperature range involved is 2.5. [8+8]

2. Derive the relationship for the intersection of the operating lines corresponding to the rectifying and stripping sections of distillation column for various thermal conditions of the feed. [16]
3. Explain the methods of rectification of azeotropic mixtures in common use. [16]
4. Write about the various quantities to be considered in making a choice of solvent. [16]

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

- (a) Sieve tray tower
- (b) Pulsed column [16]

6. (a) With a schematic arrangement explain continuous horizontal extractor.
- (b) With a typical flow sheet arrangement explain the operation of a horizontal-filter leaching. [9+7]

7. (a) Compare the principle of adsorption and chromatography?
- (b) Explain about differential heat of adsorption? [10+6]

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) What is differential distillation? Derive Rayleigh equation.  
(b) Explain the T-x, y diagram with a neat sketch. [10+6]
2. A plant is to distill a mixture containing 80 mole% of methanol and water. The overhead product must contain 99.9 mole% methanol, while the bottom product should not contain more than 0.4% of methanol. Assuming that feed and the reflux are at their respective bubble points, calculate:
  - (a) The minimum number of ideal plates
  - (b) The minimum reflux ratio.
  - (c) The number of ideal stages if reflux ratio is 1.35

The equilibrium data is given below.

x	0.1	0.3	0.5	0.7	0.9
y	0.417	0.66	0.78	0.871	0.959

[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. Write about the use of rectangular coordinates to describe the concentrations in ternary systems. Also show how they can be used on solvent-free basis for two partly miscible liquid pairs. [16]
5. Discuss about the following equipment for liquid-liquid extraction with neat diagrams:
  - (a) Mixer-settler cascade
  - (b) Gravity settlers [16]
6. (a) With a neat sketch explain the construction and operation of Kennedy extractor.  
(b) Explain the method of calculation of stage efficiency in leaching.

- (c) In practice, stage efficiency is always less than 100 percent. Why? [11+3+2]
7. Experiments on decolorization of oil yielded the following equilibrium relationship:

$$y = 0.5 x^{0.5}$$

Where  $y$  = gm of color removed / gm of adsorbent

$x$  = color in the oil, gm of color/1000 gm of color-free oil 100kg oil containing / part of color to 3 parts of oil is agitated with 25kg of the adsorbent. Calculate the % of color removed if

- (a) all 25kg of adsorbent is used in one step.
- (b) 12.5 kg of adsorbent is used initially, followed by another 12.5kg of adsorbent. [16]
8. (a) Describe the process of ion exchange treatment in Higgins contactor with a schematic diagram.
- (b) Explain chromatographic separation of two solutes. [10+6]

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