Code No: R05320801 **Set No. 1**

III B.Tech II Semester Regular Examinations, Apr/May 2008
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. An absorption column is to be designed for reducing the concentration of a toxic vapour in an air emission from 1% to 0.02 mole%. The column will operate at 20 ^{0}C and 0.5 bar gauge pressure. The scrubbing liquor flow rate is 1.3 times the minimum. The gas-liquid equilibrium relation (p = Hx) is linear and the Henry's law constant is 10 bar. How many trays are required to achieve this separation if the overall tray efficiency is 40%? [16]

2. (a) Explain briefly the procedure for estimation of packed tower height for absorption.
   (b) What is HETP and in what way this helps in design of a packed column. [10+6]

3. 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=6045y where x is the kg of solute per kg of water and y is the kg of solute per kg of kerosene. Calculate the final concentration in the final raffinate if the extractions done in 3 simple equilibrium contacts using 5kg solvent per kg of initial solution in each stage. [16]

4. Two solutions, feed F at the rate of 7,500 kg/h containing 50 wt% acetone and 50 wt% water, and feed F' at the rate of 7,500 kg/h containing 25 wt% acetone and 75 wt% water, are to be extracted in a countercurrent system with 5,000 kg/h of 1,1,2-trichloroethane at 25 ^{0}C to give a raffinate containing 10 wt% acetone. Calculate the number of equilibrium stages required and the stage to which each feed should be introduced, using a right-triangle diagram. Equilibrium data are given in the following table: [16]

	Acetone, weight fraction	Water, weight fraction	Trichloroethane, weight fraction
Extract	0.60	0.13	0.27
	0.50	0.04	0.46
	0.40	0.03	0.57
	0.30	0.02	0.68
	0.2.	0.015	0.785
	0.10	0.01	0.89
Raffinate	0.55	0.35	0.10
	0.50	0.43	0.07
	0.40	0.57	0.03
	0.30	0.68	0.02
	0.20	0.79	0.02
	0.10	0.895	0.005

The tie-line data are:

Raffinate, Weight Fraction Acetone	Extract, Weight Fraction Acetone
0.44	0.56
0.29	0.40
0.12	0.18

5. (a) Explain the concept of HETP and HTU.
   (b) With the help of a neat sketch explain the construction and working of centrifugal extractor. [8+8]

6. The equilibrium adsorption of acetone vapor on an activated carbon at 30^0C is given by the following data:

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

The vapor pressure of acetone at 30^0C is 283 mmHg.
A 1-1 flask contains air and acetone vapor at 1 std atm and 30^0C, with a relative saturation of the vapor of 35%. After 2 g of fresh activated carbon has been introduced into the flask, the flask is sealed. Compute the final vapor concentration at 30^0C and the final pre3ssure. Neglect the adsorption of air. [16]

7. (a) Explain the working of Higgin‘s contactor with a neat sketch.
   (b) Distinguish between fluidized and teeter beds. [8+8]

8. (a) Distinguish between insitu leaching and heap leaching.
   (b) Distinguish between Dorr thickner and Dorr agitator.
   (c) Write short notes on preparation of solids for leaching. [5+5+6]

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Code No: R05320801 **Set No. 2**

III B.Tech II Semester Regular Examinations, Apr/May 2008
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 coal gas is freed of its light oil content (benzene) by absorption into an a absorbent oil. The inlet gas contains 2% benzene by volume and 95% removal is required. Inlet gas flow rate=0.25cu.m/s; Pressure =1.07 $\times 10^5$N/sq.m; Temperature = 26 ^{0}C; Oil inlet flow rate (L_s) =1.787$\times$ 10 $^{-3}$ k mol/s; Solute content of inlet oil=0.005 mole fraction benzene; Average molecular weight of oil = 260. Equilibrium data Y=0.125 x (mole fraction units). Determine the number of trays required

   (a) Graphically,

   (b) By Kremser equation. [16]

2. Water containing 6 ppm trichloroethane (TCE) is to purified by stripping with air at 20 ^{0}C. The product must contain less than 4.5 ppb TCE to meet emission standards. Calculate the minimum air rate in standard cubic meters of air per cubic meter of water and the number of transfer units if the air rate is the 1.6 times the minimum value. Henry's law coefficient for TCE in water at 20 ^{0}C is 0.0075 m^{3}atm/mol. Assume density of water is 1 gm/cc. [16]

3. It is required to extract picric acid from a dilute aqueous solution containing 0.1 mole picric acid per litre of solution using benzene as solvent with a recovery of 80% of the picric acid originally present .Determine the quantity of benzene required per litre of aqueous solution by employing

   (a) single stage extraction and

   (b) three stage extraction (cross current) using equal amounts of fresh solvent in each stage. The equilibrium data for benzene - picric acid - water system at 25 ^{0}C is given by

$C_B \times 10^2$	0.0932	0.225	1	2	5	10	18
m= C_B/C_A	2.23	1.45	1.705	0.505	0.32	0.24	0.187

   where C_B, C_A are the equilibrium concentrations of picric acid in benzene and aqueous phases respectively in mole per litre. Assume benzene-water are completely immiscible. [16]

4. Explain in detail for the estimation of number of stages for continuous counter current extraction with out reflux using rectangular graph sheets and also write the relevant equations. [16]

5. (a) Explain the concept of HETP and HTU.

(b) With the help of a neat sketch explain the construction and working of centrifugal extractor. [8+8]

6. (a) Explain about various Industrial adsorbents.

   (b) Prove that for crosscurrent two-stage treatment of liquid solutions by contact filtration, when the adsorption isotherm is linear, the least total adsorbent results if the amounts used in each stage are equal. [6+10]

7. (a) Explain the working of Higgin‘s contactor with a neat sketch.

   (b) Distinguish between fluidized and teeter beds. [8+8]

8. A 1 meter diameter tank fitted with a false bottom and canvas filter is partly fitted with 10 kg (dry weight) of sea sand wet with sea water. The sand is allowed to drain until it stops dripping whereupon 750 kg of fresh water is added and recirculate to reach a uniform salt concentration Estimate the salt concentration of the wash water. The sand particle have an average size of 0.4 mm, particle density of 8660kg/cu.m. and a bulk density of 1490 kg/cu.m. ad surface tension of 0.0736N/m. The sea water contains 3.5% salt and its density is 1018 kg/cu.m. [16]

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Code No: R05320801 **Set No. 3**

III B.Tech II Semester Regular Examinations, Apr/May 2008
MASS TRANSFER OPERATIONS-II
(Chemical Engineering)

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

Answer any FIVE Questions
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1. A packed tower is to be designed for the absorption of 98% of the ammonia (A) from an air-ammonia mixture containing 4% ammonia at a rate of 4200 Nm^3 (normal cubic meter) per hour using water as the solvent. The tower operates at 105.1 kPa and 303 K. The equilibrium data for NH 3-water system at 303 K are given below:

Partial Pressure of NH 3 (mm of Hg)	19.3	29.6	40.1	51.0	79.5	110
Kg NH 3 per 100 kg water	2	3	4	5	7.5	10

   (a) Calculate and plot the equilibrium data as x_A vs. p_A, x_A vs y_A and X_A vs Y_A. Up to what value of pNH_3 can the Henry's law be used to describe the equilibrium?

   (b) Calculate the minimum liquid rate for the absorption (the inlet water is NH_3-free). [16]

2. It is required to absorb 97% of the solute from a feed gas of concentration 8% by volume. The gas enters the column at a rate of 100 kmol/h. A column of suitable diameter with ten ideal trays is available. It is necessary to select one of two solvents otherwise suitable otherwise suitable. The following data are supplied. Solvent 1: molecular weight = 200; equilibrium relation, Y = 2.5X; cost, Rs 50 per kg. Solvent 2: molecular weight = 1340; equilibrium relation, Y = 1.5X; cost, Rs 30 per kg. Pumping and spillage loss is estimated to be 0.001% of the circulation rate for both the solvents. But solvent 2, thought cheaper, is volatile and 0.004% of it is lost in the stripping column. Which solvent will you recommend? [16]

3. (a) What are the various parameters to be considered in making a choice of Solvent.

   (b) Write short on the fields of applications of liquid-liquid extraction. [8+8]

4. (a) Write short notes on fractional extraction with the help of flow chart.

   (b) Explain the procedure for the estimation of number of stages for counter current extraction of immiscible liquids. [8+8]

5. An aqueous solution contains 25% acetone by weight together with a small amount of an undesired contaminant. For the purpose of later process, it is necessary to have the acetone dissolved in water without impurity. To accomplish this, the solution will be extracted counter currently with trichloroethane, which extracts the acetone but not impurity. The extract will then be counter currently extracted with pure

water in a second extractor to give the desired product water solution and the recovered solvent will be returned to the first extractor. It is required to obtained 98% of the acetone in the final product. Water and trichloroethane are insoluble over the acetone concentration range involved, and the distribution coefficient (kg acetone /kg trichloroethnae)/(kg acetone /kg water) =1.65 = constant.

(a) What is the largest concentration of acetone possible in the recovered solvent?

(b) If the recovered solvent contains 0.005 kg acetone/kg trichloroethane, if 1 kg of trichloroethane /kg of water is used in the first extractor and if the packed height of the column in both the extractors is same what concentration of acetone in the final product will result? [16]

6. (a) Discuss in detail about Adsorption equilibrium.

(b) Explain about adsorption Hysterisis.

(c) For adsorption from dilute liquid solutions in stagewise countercurrent operations, where the Freundlich equation describes the adsorption equilibrium, derive analytical expressions in terms of n,m, Y_o and Y_N, for the minimum adsorbent/solvent ratio when fresh adsorbent is used. [4+4+8]

7. The sulfur content of an oil is to be reduced by percolation through a bed of adsorbent clay. Laboratory tests with the clay and oil in a representative percolation filter show the following instantaneous sulfur contents of the effluent oil as function of the total oil passing through the filter

$10\ m^3$ oil / kg clay	0	1.752	3.504	8.760	17.52	35.04	52.56	70.08
% Sulfur	0.011	0.020	0.041	0.067	0.0935	0.118	0.126	0.129

Assume that the specific gravity of the oil is unchanged during the percolating. The untreated oil has a sulfur content of 0.134%, and a product containing 0.090% sulfur is desired.

(a) If the effluent from the filter is composited, what yield of satisfactory product can be obtained per kg of clay?

(b) If the effluent from the filter is continually and immediately withdrawn and blended with just sufficient untreated oil to give desired sulfur content in the blend, what quantity of product can be obtained per kg of clay? [16]

8. (a) Comment of the nature of equilibrium data generally used in solid-liquid extraction.

(b) Oil from fish livers is to be continuously and counter current extracted using ethyl ether as solvent. The quantity of solution retained by the granulated livers is given below :

Kg. oil/kg. soln. :	0.00	0.10	0.20	0.30	0.40	0.50	0.65	0.72
Kg. soln./kg.oil-free liver :	0.205	0.242	0.286	0.339	0.405	0.489	0.672	0.810

The liver contains 0.257 mass fraction oil. If 95% of the oil is to be extracted and the strong solution obtained from the system is to contain 0.70 mass fraction oil, determine.

i. The quantity and composition of the discharge solids.

ii. Kg. of oil-free ether required per 100kg. of fresh liver.

iii. The number of ideal stages required. [4+12]

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Code No: R05320801 **Set No. 4**

III B.Tech II Semester Regular Examinations, Apr/May 2008
MASS TRANSFER OPERATIONS-II
(Chemical Engineering)

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

Answer any FIVE Questions
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1. (a) In absorption, what is a solute?
   (b) Can absorption be accompanied by a temperature change? Why?
   (c) What is the difference between physical absorption and chemical (reactive) absorption? Explain with suitable examples and also mention advantages and disadvantages. [4+4+8]

2. Show that Z= H_{toG} N_{toG} for an absorber. [16]

3. It is required to extract picric acid from a dilute aqueous solution containing 0.1 mole picric acid per litre of solution using benzene as solvent with a recovery of 80% of the picric acid originally present .Determine the quantity of benzene required per litre of aqueous solution by employing
   (a) single stage extraction and
   (b) three stage extraction (cross current) using equal amounts of fresh solvent in each stage. The equilibrium data for benzene - picric acid - water system at 25 ^{0}C is given by

$C_B \times 10^2$	0.0932	0.225	1	2	5	10	18
m= C_B/C_A	2.23	1.45	1.705	0.505	0.32	0.24	0.187

   where C_B, C_A are the equilibrium concentrations of picric acid in benzene and aqueous phases respectively in mole per litre. Assume benzene-water are completely immiscible. [16]

4. (a) Explain continuous counter current extraction with reflux with the help of flow chart.
   (b) Explain how to estimate minimum solvent amount for continuous counter current extraction without reflux for different cases. [8+8]

5. An aqueous solution contains 25% acetone by weight together with a small amount of an undesired contaminant. For the purpose of later process, it is necessary to have the acetone dissolved in water without impurity. To accomplish this, the solution will be extracted counter currently with trichloroethane, which extracts the acetone but not impurity. The extract will then be counter currently extracted with pure water in a second extractor to give the desired product water solution and the recovered solvent will be returned to the first extractor. It is required to obtained 98% of the acetone in the final product. Water and trichloroethane are insoluble over the acetone concentration range involved, and the distribution coefficient (kg acetone /kg trichloroethnae)/(kg acetone /kg water) =1.65 = constant.

(a) What is the largest concentration of acetone possible in the recovered solvent?

(b) If the recovered solvent contains 0.005 kg acetone/kg trichloroethane, if 1 kg of trichloroethane /kg of water is used in the first extractor and if the packed height of the column in both the extractors is same what concentration of acetone in the final product will result? [16]

6. (a) Discuss in detail about Adsorption equilibrium.

(b) Explain about adsorption Hysterisis.

(c) For adsorption from dilute liquid solutions in stagewise countercurrent operations, where the Freundlich equation describes the adsorption equilibrium, derive analytical expressions in terms of n,m, Y_o and Y_N, for the minimum adsorbent/solvent ratio when fresh adsorbent is used. [4+4+8]

7. (a) Write short notes on Ion Exchange.

(b) A batch of water containing residual chlorine from a treating proess, at a concentration 12 ppm, is to be treated with activated carbon at 25^0C to reduce the chlorine concentration to 0.5 ppm. The carbon consists of 30-mesh granules, density = 561 kg/m^3 (35 lb/ft^3) = mass of particle/gross volume of particle. Adsorbate diffusional resistance is expected to be small relative to that in the liquid. The equilibrium distribution coefficient = c*/X = 0.80 (kg Cl_2/m^3 liquid)/(kgCl_2/kgC) = 0.05 (kg Cl_2/ft^3 liquid)/(kg Cl_2/kg C). [8+8]

8. (a) For a multistage counter current leaching operation show how by graphical method and composition of raffinate, extract cnbe obtained along with number of stages.

(b) Write note on various types of equilibrium diagrams for a solid liquid systems fopr leaching operation. [8+8]

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