

III B.Tech. I Semester Supplementary Examinations, May -2005
MASS TRANSFER AND SEPARATION
(Bio-Technology)

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

Answer any FIVE Questions
All Questions carry equal marks

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1. Obtain an expression for the steady state Equimolar counter diffusion of two gases starting from fundamentals?
2. On the basis of colburn analogy, estimate the value of mass transfer coefficient for the absorption of Ammonia by the wet surface of a cylinder placed in a turbulent air stream flowing across the cylinder at 4.6 m/sec. Heat transfer tests for the same geometry and air velocity give heat transfer coefficient as 1.357×10^{-4} KJ.
 Data for air prandtl number = 0.74
 $C_p = 0.49 \times 10^{-3}$ KJ/Kg $^{\circ}$ K
 Density $\rho = 0.0012$ kg/m³ and for
 Dilute ammonia - air mixture Schmidt number is 0.61

3. A liquid mixture containing 50 mole percent n-heptane and 50 mole percent n-octane is subjected to a differential distillation at atmospheric pressure until the residual liquid contains 35 mole percent n-heptane. Using the equilibriums data determine the percentage of feed that is left over as residue.

X	0.50	0.46	0.42	0.38	0.34	0.32
Y	0.689	0.648	0.608	0.567	0.523	0.49

Where x = mole fraction n-heptane in liquid.

Y = mole fraction n-heptane in vapour.

4. A continuous fractionating column operating at atmospheric pressure is to separate a feed mixture containing 30% CS₂ and 70% CCl₄ into an overhead product of 95% CS₂ and a bottom product of 95 mole% CCl₄. The feed enters as a liquid at its boiling point. Assuming an overall plate efficiency of 70% and a reflux ratio of 3:1. Estimate the number of plates needed. All the compositions are in mole%.
 Equilibrium Data

X	0.0296	0.0615	0.258	0.39	0.532	0.663	0.758	0.860
Y	0.0823	0.1555	0.494	0.634	0.747	0.830	0.880	0.932

5. With the help of neat sketches, explain briefly the various types of commercial extraction equipment.
6. Give an account of the graphical method of calculation of the number of stages for counter-counter extraction in a solid-liquid extraction system.

7. Write on:

- (a) Adsorption wave and break through curve and
- (b) Pressure solving and thermal solving methods. BET Isotherm.

8. Write a brief note on counter current flow model for gas permeation.

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1. Calculate the rate of diffusion of hydrogen through Non diffusing Methane at 25⁰C and 101 KN/m² Pressure ($D_{AB} = 6.6 \times 10^{-5} \text{ m}^2/\text{sec}$).
The diffusional path is 5mm long and the concentration of Hydrogen at the two ends of the path in terms of partial pressure is 12KN/m² and 8.4 KN/m² respectively.
2. (a) Distinguish between Eddy and Molecular Diffusion?
(b) Explain Penetration Theory versus Two Film Theory?
3. Define various types of plate efficiency and relationship between them.
4. A rectification column is fed 100 kg mol/h of a mixture of 50 mol% Benzene and 50 mol% Toluene at 101.32 Kpa abs pressure. The feed is liquid at the boiling point. The distillate is to contain 90 mol% Benzene and the bottoms 10 mol% Benzene. The reflux ratio is 4.52:1. Calculate the kg mol/h distillate, kg mol/h bottoms and the number of theoretical trays needed using Mc Cabe Thiele Method.
5. Explain how the number of stages can be determined for immiscible solvents in cross current extraction?
6. Give an account of the graphical method of calculation of the number of stages for counter-counter extraction in a solid-liquid extraction system.
7. The sulphur content of an oil is to be reduced by percolation through a bed of adsorbent in laboratory tests with clay and oil in a representative percolation filter show the following instantaneous sulfur contents of the effluent oil as a function of the total oil passing through the filter.

B61 oil/ ton clay	0	10	20	50	100	200	300	400
% sulphur	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 percolation. The untreated oil has a sulphur content of 0.134% and a product containing 0.090% sulphur is desired.

- (a) If the effluent from the filter is composited, what yield of satisfactory product may obtained per ton of clay?
- (b) If the effluent from the filter is continuously and immediately with drawn and blending with just sufficient untreated oil to give the desired sulphur content in the blend. What quantity of product may be obtained per ton of clay?

8. A liquid containing solute A at a concentration $C_1 = 3 \times 10^{-2} \text{ kg mol/m}^3$ is flowing rapidly by a membrane of thickness $L = 3.0 \times 10^{-5} \text{ m}$. The distribution coefficient $K' = 1.5$ and $D_{AB} = 7.0 \times 10^{-11} \text{ m}^2/\text{s}$ in the membrane. The solute diffuses through the membrane and its concentration on the other side is $C_2 = 0.50 \times 10^{-2} \text{ kgmol/m}^3$. The mass transfer coefficient K_{C1} is large and can be considered as infinite and $K_{C2} = 2.02 \times 10^{-5} \text{ kmol/m}^2\text{s mol fraction}$. Calculate the flux and the concentrations at the membrane interfaces?

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1. Obtain an expression for the steady state Equimolar counter diffusion of two gases starting from fundamentals?
2. (a) Distinguish between Eddy and Molecular Diffusion?
 (b) Explain Penetration Theory versus Two Film Theory?
3. A solution of CCl_4 and CS_2 containing 50% wt each is to be continuously fractionated at 1 atm at the rate of 4000 kg/hr. Distillate product is to contain 95% wt CS_2 and residue 0.5%. The feed will be 30% mole vapourised before it enters the tower. Total condenser will be used and reflux returned at bubble point. Determine
 - (a) Product rates.
 - (b) Theoretical trays for a reflux ratio of twice the minimum. The equilibrium data is as follows.

X	0.11	0.26	0.39	0.53	0.66	0.76	0.86
Y	0.27	0.49	0.63	0.75	0.83	0.88	0.93

4. A rectification column is fed 100 kg mol/h of a mixture of 50 mol% Benzene and 50 mol% Toluene at 101.32 Kpa abs pressure. The feed is liquid at the boiling point. The distillate is to contain 90 mol% Benzene and the bottoms 10 mol% Benzene. The reflux ratio is 4.52:1. Calculate the kg mol/h distillate, kg mol/h bottoms and the number of theoretical trays needed using Mc Cabe Thiele Method.
5. A 25% (weight%) solution of dioxane in water is to be continuously extracted in counter current fashion with Benzene to remove 95% of the dioxane in feed. If the feed rate is 1000 kg/hr estimate the
 - (a) Minimum solvent required and
 - (b) Theoretical stages needed if 900 kg/hr of solvent is used

Wt% Dioxane in water	5.1	18.9	25.2
Wt% Dioxane in Benzene	5.2	22.5	32.0

6. A counter current multiple contact extraction system is treat 50 tons/hr of wet mass fraction. Water ~ 0.48 , pulp ~ 0.04 , and sugar ~ 0.20 . The strong solution leaving the system is to contain 0.15 mass fraction of sugar and 97% sugar in the sliced beets is to be removed. Determine the number of cells required assuming equilibrium between the under flow and overflow from each cell, if each ton of pulp retains 3 tons of water.
7. The sulphur content of an oil is to be reduced by perception through a bed of adsorbent in laboratory tests with clay and oil in a representative percolation filter show the following instantaneous sulfur contents of the effluent oil as a function of the total oil passing through the filter.

B61 oil/ ton clay	0	10	20	50	100	200	300	400
% sulphur	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 percolation. The untreated oil has a sulphur content of 0.134% and a product containing 0.090% sulphur is desired.

- (a) If the effluent from the filter is composited, what yield of satisfactory product may obtained per ton of clay?
- (b) If the effluent from the filter is continuously and immediately with drawn and blending with just sufficient untreated oil to give the desired sulphur content in the blend. What quantity of product may be obtained per ton of clay?
8. Write on different types of membranes.

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1. Obtain an expression for the steady state Equimolal counter diffusion of two gases starting from fundamentals?
2. (a) Distinguish between Eddy and Molecular Diffusion?
 (b) Explain Penetration Theory versus Two Film Theory?
3. Describe with a neat sketch the working of a batch distillation unit and state its fields of application?
4. A rectification column is fed 100 kg mol/h of a mixture of 50 mol% Benzene and 50 mol% Toluene at 101.32 Kpa abs pressure. The feed is liquid at the boiling point. The distillate is to contain 90 mol% Benzene and the bottoms 10 mol% Benzene. The reflux ratio is 4.52:1. Calculate the kg mol/h distillate, kg mol/h bottoms and the number of theoretical trays needed using Mc Cabe Thiele Method.
5. A kerosene flow of 100 kg/h contains 1.4 wt% nicotine and is to be stripped with pure water in a counter current multistage tower. It is desired to remove 90% of the nicotine using a water rate of 1.5 times the minimum, determine the number of theoretical stages required.

X	0.001010	0.00246	0.005	0.00746	0.00988	0.0202
Y	0.000806	0.001959	0.00454	0.00682	0.00904	0.0185

X = wt. fraction of Nicotine in the water solution

Y = wt. fraction of Nicotine in the Kerosene

6. 2000 kg of waxed paper per day are to be dewaxed in a continuous counter solvent. The waxed paper contains by weight 25% paraffin wax and 75% paper pulp. The extracted pulp is put through a dryer to evaporate the kerosene. The pulp which retains the unextracted wax after evaporation must not contain over 0.2 kg of wax per 100 kg of wax free pulp. The kerosene used for extraction contains 0.05 kg of wax per 100 kg of was free kerosene. Experiments show that the pulp retains 2.0 kg of kerosene per kg of kerosene and was free pulp as it is transferred from cell to cell. The extract from the battery is to contain 5 kg of wax per 100 kg of wax free kerosene. How many stages are required?
7. (a) Equilibrium isotherm data for adsorption of glucose from an aqueous solution to activated Alumina are as follows.

C (g/m ³)	0.004	0.0087	0.019	0.027	0.094	0.195
q (g solute /g Alumina)	0.026	0.053	0.075	0.082	0.123	0.129

- (b) Determine the isotherm that fits the data and give the constants of the equation using the given units.
8. Explain the process of electro dialysis as applied for the treatment of Brackish water with a neat sketch.
