



Time: 3hours

Max. Marks: 75

Answer any FIVE questions All Questions Carry Equal Marks

- 1.a) Explain briefly unsteady state diffusion.
 - b) In an oxygen nitrogen gas mixture at 1.14575×10^5 N/m² and 35° C, the concentration of oxygen, at two planes 5 mm apart are 20% and 30% by volume respectively. Calculate the amount of oxygen diffused in 3 hrs when equimolar counter diffusion takes place. The diffusivity is 0.185×10^{-4} m²/s. [7+8]
- 2. Explain different mass transfer steps in transferring of Oxygen from Gas bubble to aerobic culture and also explain out all these resistance which are more rate controlling steps? [15]
- 3. Distillation column is to be designed to separate A and B continuously. The feed is 35% A and 65% B at its dew point. The distillate and the residue compositions are 0.95 and 0.025 respectively.

i) Find the quantities of distillate and bottoms per hour.

- ii) Find the number of equilibrium stages required in the column if the reflux ratio is 2.5.Assume the relative volatility as 2.25. [15]
- 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'=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. [15]
- 5.a) Explain single stage leaching with a flow chart.
- b) Write short notes on Vander Waals adsorption. [7+8]
- 6.a) Briefly explain the classification of driers.
- b) It is desired to dry a batch of 500 kg of wet solid from 30% to 6% moisture. The rate of drying may be assumed to be linear in the falling rate zone. Calculate the time required for drying. The critical and equilibrium moisture contents are 0.2 and 0.05 kg/kg of dry solids. The constant rate period drying rate is 1.5 kg/hr m² and the drying surface is 0.026 m² per kg of dry solid. [7+8]
- 7.a) Describe the basic principles of operations of reverse osmosis.
- b) Explain briefly various membrane modules used in the dialysis process. [7+8]
- 8.a) Explain the process of ammonia absorption in water and is there any methods available for same purpose.
 - b) What is LLE and write its use for extraction of penciline. [8+7]

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- 1.a) Explain molecular diffusion of biological solutes in gels.
 - b) Calculate the rate of diffusion of 'A' through non-diffusing 'B' at 25° C and 101 kN/m^2 pressure $D_{AB} = 6.6 \times 10^{-5} \text{m}^2/\text{s}$. the diffusional path is 5 mm long and the concentration of 'A' at the two ends of the path in terms of partial pressure is 12 kN/m^2 and 8.4 kN/m^2 respectively. [7+8]
- 2.a) Identify the resistances that are important for the transfer of oxygen from gas phase to a microorganism.
- b) What do you understand about the convective mass transfer and write its importance in bioprocess [9+6]
- 3. A mixture of 35 mole % A and 65 mole % B is to be separated in a fractionating column. The concentration of A in the distillate is 93 mole % and 96 mole % of A present in the feed is in the distillate. The feed is half vapor and the reflux ratio is to be 4.0. The relative volatility of A to B is 2.0.Calculate the number of theoretical plates in the column and locate the feed plate. [15]
- 4. Water-dioxane solution forms a minimum boiling azeotrope at atmospheric pressure with dioxane and may be used as an extraction solvent .At 25°C ,the equilibrium distribution of dioxane between water and benzene is as follows : Wt % dioxane in water 5.1 18.9 25.2 Wt % in dioxane benzene 5.2 22.5 32.0 At these concentrations water and benzene are substantially insoluable.1000kg of

a 25% dioxane water solution is to be extracted with benzene to remove 95% of the dioxane Initially the benzene is dioxane free

i) Calculate the benzene requirement for single batch operation

ii) If the extraction were done with equal amounts of solvent in 5 cross-current stages, how much solvent would be required? [15]

- 5.a) Discuss the mechanism of leaching and the factors which will influence the rate of leaching.
 - b) Write briefly about the importance of grinding in leaching. [11+4]
- 6.a) Explain briefly, what is meant by equilibrium, free and critical moisture contents of a wet solid.
 - b) A wet cake with a weight of 5 kg originally contains 50% moisture content on wet basis. The slab is $0.6m \times 1m \times 7.5$ cm thick. The equilibrium moisture content is 5% of the total weight. When in contact with air of 40° c and 20% humidity, the drying rate is given in the table below for contact with air of the above quality at a definite velocity. Drying is from one face. How long will it take to dry the slab to 15% moisture content on wet basis?

Wet slab weight, kg:	5	4	3.6	3.5	3.4	3.06	2.85		
Drying rate, kg/m ² hr:	5	5	4.5	4.0	3.5	2.0	1.04	[6+9]

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- 7.a) Explain dialysis with neat diagram.
 - b) Write short notes on effect of operating parameters in gas separation. [7+8]
- 8. Generally the purity of alcohol to use as fuel is around 99.6%. However, fermentation of sugar cane molasses yields only around 6-8% alcohol. What are the separation techniques or combination of separation techniques available for this purpose? Explain in detail with emphasis on energy requirement. [15]

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- 1.a) Explain molecular diffusion of biological solutes in liquid.
 - b) Oxygen (A) is diffusing through carbon monoxide (B) under steady state conditions, with the carbon monoxide non-diffusing and the total pressure is 1×10^5 N/m² and the temperature is 0⁰C.The partial pressure of oxygen at two planes 2 mm apart is, respectively,13,000 and 6,500 N/m².The diffusivity for the mixtures is 1.87×10^{-5} m²/s. Calculate the rate of diffusion of oxygen in k mol/s through each square meter of two planes. [7+8]
- 2.a) What is meant by "specific oxygen uptake rate"?
- b) What is the Sherwood number? How is it analogous to the Nusselt number?
- c) What happens to the mass transfer coefficient when the temperature is changed?

[5+5+5]

3. A fractionating column receives an equimolar mixture of styrene and ethyl benzene at a rate of 120kmol/h. the purity of the top product (ethyl benzene) and that of the bottom product (styrene) must not be less than 98% and 99.5% respectively. Determine

a) the minimum external reflux ratio

- b) the minimum number of ideal trays required for the required above separation,
- c) the number of ideal trays and the feed-tray location if the actual reflux ratio is twice the minimum and the feed is a saturated liquid, [15]

Х	0.055	0.078	0.115	0.139	0.2405	0.2715	0.335	0.460	0.545	0.755	0.874	0.965
Y	0.090	0.120	0.162	0.201	0.318	0.355	0.4055	0.535	0.630	0.825	0.910	0.975

4. 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°C is given by

$\dot{C}_{B} \times 10^{2}$	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. [15]

- 5.a) Discuss the mechanism of leaching.
 - b) Describe the different types of leaching equipments. [6+9]

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- 6.a) A wet solid is to be dried from 20% moisture (wet basis). The weight of bone dry solid is 56 kg/m². Determine the time of drying to get final moisture content of 5% moisture (wet basis). Drying rate data are as follows: kg water /kg dry solid 0.3 0.2 0.18 0.15 0.14 0.11 0.07 0.02 kg water evaporated/m²hr 1.22 1.22 1.123 0.98 0.78 0.49 0.24 0.0
 - b) Explain the mechanism of drying during the constant rate and falling rate periods. [9+6]
- 7.a) Write the advantages of membrane separation processes over the conventional separation process.
 - b) Describe the industrial applications of membrane gas separation. [8+7]
- 8. What is crystallization and write the application of crystallization process for the manufacture of citric acid? [15]





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- 1 a) Name few unit operations where diffusion of liquids and gases occurs in solids.
 - b) Diffusion of CO₂ occurs at steady state in a tube 0.2 m long having a diameter of 0.01 m and containing N₂ at 298 K. the total pressure is constant at 1.01×10^5 Pa .the partial pressure of CO₂ at one end is 4.56 mmHg and 76 mmHg at the other end. The diffusivity D_{AB} is 1.67×10^{-5} m²/sec at 298 K. calculate the flux of CO₂ in gas for equimolar counter diffusion. [6+9]
- 2. Describe the process of oxygen transfer methodology from the air bubble to the cell or cluster of cells in fermentation broths. [15]

3. A mixture of acetone and phenol (40 mass% acetone) is flashed consecutively in a cascade consisting two flash drums at 1 atm. The feed enters at a rate of 3000 kg/h and half of it is flashed in the first flash drum. The liquid from the first drum is heated and flashed again in the second drum. What fraction of the feed entering the second drum should be vaporized so that the residue contains not more than 1 mass % acetone? the vapour-liquid equilibrium data of the acetone-phenol system are given below. [15]

X:	0.01	0.04	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	0.96	0.99
Y:	0.67	0.776	0.852	0.91	0.94	0.962	0.98	0.99	0.991	0.994	0.997	0.999	0.9996

4. Nicotine (C) in a water (A) solution containing 1% nicotine is to be extracted with kerosene (B) at 20°C. Water and kerosene are essentially insoluble. (a) Determine the percentage extraction of nicotine if 100 kg of feed solution is extracted once 150 kg solvent. (b) Repeat for three theoretical extractions using 50 kg solvent each [15]

S.No	x'=kg nicotine /kg water	x'=kg nicotine /kg kerosene
1	0	0
2	0.001011	0.000807
3	0.00246	0.001961
4	0.00502	0.00456
5	0.00751	0.00686
6	0.00998	0.00913
7	0.0204	0.01870

- 5.a) Define leaching?
 - b) What is lixiviation?
 - c) What is decoction?
 - d) Write short notes on applications of leaching operation.

[15]

- 6.a) Explain the in detail about tray drier with neat sketch.
 - b) A porous solid is dried in a batch dryer under constant drying conditions. Six hours are required to reduce the moisture content from 3% to 10%. The critical moisture content was found to be 16% and equilibrium moisture 2%. All moisture contents are on the dry basis. Assuming that the rate of drying during the falling rate period is proportional to the free moisture content, how long should it take to dry a sample of the same solid from 35% to 6% under the same drying conditions? [6+9]
- 7.a) How do you separate the mixture of gases using membranes? Explain its operating principle.
 - b) Explain briefly dialysis process.

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[8+7]

8. Explain in detail about the role of mass transfer operation in production of penciline. [15]

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