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CS/B.Tech (BT-NEW)/SEM-5/CHE-514/2010-11

2010-11

TRANSFER OPERATION – II

Time Allotted : 3 Hours Full Marks : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

   i) The slope of operating line for the stripping section of distillation column is

      a) 0 b) ∞

      c) <1 d) >1.

   ii) For a saturated vapour in distillation, q value is

      a) 0 b) 1

      c) $0 < q < 1$ d) ∞.

   iii) For gas phase controlled mass transfer system

      a) Gas phase provides entire resistance

      b) Liquid phase provides entire resistance

      c) Inter-phase provides entire resistance

      d) Gas phase provides minimum resistance.

iv) The unit of mass transfer coefficient in the equation $N_A = K_y\left(y - y^*\right)$ is

a) $kmol/m^3/hr$ b) $kg/m^2/Pa$

c) $kmol/m^2/hr$ d) kg/m^2.

v) Mass diffusivity has the same unit of

a) Thermal diffusivity b) Kinematic viscosity

c) Both (a) and (b) d) None of these.

vi) Crystals can be formed by

a) Increasing the temperature of the solution

b) Decreasing the temperature of the solution

c) Removing water from the solution

d) Both (b) and (c).

vii) Leaching is

a) Gas-Liquid mass transfer

b) Gas-Solid mass transfer

c) Liquid-Liquid mass transfer

d) Solid-Liquid mass transfer.

viii) The dew point of an unsaturated mixture of vapour and gas does not depend on

a) The temperature of the mixture

b) The total pressure of the mixture

c) The composition of the mixture

d) All of these.

ix) At minimum reflux condition in a distillation column, the number of plates becomes

a) Minimum

b) Infinite

c) More than that predicted by McCabe – Thiele method

d) Less than that predicted by McCabe – Thiele method.

x) Rejection coefficient of an ultrafilter varies from

a) 0·95 to 0·98 b) 0 to 0·5

c) 0·5 to 0·75 d) 0·85 to 0·92.

xi) Osmotic pressure of a dilute solution is given by

a) $\prod = CRT\left(1 + B_1C + B_2C^2 + ...\right)$

b) $\prod = CR/T$

c) $\prod = CT/R$

d) $\prod = CRT$.

xii) The driving force for filtration is

a) Solid concentration difference between permeate and retentate

b) Filtrate pressure – Inlet pressure

c) Concentration polarization

d) None of these.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. What is batch distillation ? Derive the Rayleigh equation for simple distillation in a batch still with a sketch of the distillation unit. 2 + 3

3. A slab of paper pulp 100 cm × 100 cm × 1·5 cm is to be dried under constant drying condition from 66·7 to 30%. The value of equilibrium moisture to material is 0·5%. If critical moisture content is 60% and the rate of drying at critical point is 1·5 kg/hr m^2, calculate the drying time. The dry weight of each slab is 2·5 kg. All moisture contents are on wet basis. 5

4. How does the pressure varies within a packed bed absorption column ? Define flooding point, loading point, channelling in a packed bed column. 2 + 3

5. Explain the operation of fixed bed leaching and moving bed leaching and mention the industries where they are used. $2\frac{1}{2}+2\frac{1}{2}$

6. In a cross-flow ultrafiltration system used for filtration of proteins from a fermentation broth, gel resistance increases with protein concentration according to the following equation :

$R_g = 0 \cdot 5 + 0 \cdot 01(C)$, where C is in mg/L.

Pressure at the entrance of the system is P_i = 6 atm and at the exit is P_o = 2 atm. The shell side of the filter is open to the atmosphere, resulting in P_f = 1 atm. The membrane resistance is R_M = 0·5 atm/$\left(mg/m^2 \cdot h\right)$, and protein concentration in the broth is C = 100 mg/L. Determine :

i) the pressure drop across the membrane.

ii) filtration flux.

iii) rejection coefficient of the membrane for effluent protein concentration of C_f = 5 mg/L.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Calculate the rate of diffusion of acetic acid (A) across a film of non-diffusing water (B) solution 2 mm at 17° C, when the concentration by weight on the opposite sides of the film are 10% and 4% acid. The diffusivity of acetic acid in the solution is 0·000095 m^2/s. Densities of 10% and 4% acid (by weight) are 1013 kg/ m^3 and 1004 kg/ m^3, respectively.

b) Explain the analogy between heat transfer, mass transfer and momentum transfer with respect to their flux equation. 10 + 5

8. a) A feed of ethanol-water containing 60 wt% ethanol is to be distilled at 101·32 kPa pressure to give a distillate containing 85 wt% ethanol and a bottom containing 2 wt% ethanol. The feed rate is 10,000 kg/hr and its enthalpy is 116·3 kJ/kg. Feed is saturated liquid at its boiling point.

   i) Calculate the amount of distillate and bottoms.

   ii) Determine the minimum reflux ratio.

   iii) Using 2·0 times the minimum reflux ratio, determine the theoretical number of trays needed.

   Equilibrium data for ethanol-water mixture :

x	0	0·02	0·05	0·1	0·2	0·3	0·5	0·7	0·8	0·9	0·96	1·0
y	0	0·192	0·377	0·527	0·656	0·713	0·771	0·822	0·858	0·912	0·959	1·0

   b) What are Murphree efficiency and the overall plate efficiency ? 12 + 3

9. a) A hot solution containing 5000 kg of Na_2CO_3 and water with a concentration of 20% Na_2CO_3 is cooled to 293 K and crystal of Na_2CO_3, 10 H_2O is precipitated at 293 K, the solubility is 21·5 kg anhydrous/100 kg of total water. Calculate the yield of crystals obtained if 5% of the original water in the system evaporates on cooling.

   b) 150 kg of a nicotine-water solution containing 1% moisture is to be extracted with 220 kg of kerosene at 20° C. Water and kerosene are immiscible in each other. Determine the percentage of extraction of Nicotine after one stage operation. At dilute end of the system the equilibrium relationship is

   $$Y^* = 0 \cdot 798X$$

   where Y and X are expressed as kg nicotine/kg of kerosene & kg Nicotine/kg of water. 8 + 7

10. A tray tower is to be designed to absorb SO_2 from an air stream by using pure water at 293 K . The entering gas contains 20 mol% SO_2 and that leaving 2 mol% at a total pressure of 101·3 kPa. The air flow rate is 150 kg air/ hr.m^2 and the entering water flow rate is 6000 kg water/ hr.m^2. Assuming an overall tray efficiency of 25%, how many theoretical trays are needed ? Assume that the tower operates at 293 K. Equilibrium data is given by $Y^* = 20X$.

11. Experiments at 25° C were performed to determine the permeability of a cellulose acetate membrane. The laboratory test section has membrane (10g NaCl/L; density = 1004 kg solution/ m^3). The water recovery is assumed low so that the concentration C_1 in the entering feed solution flowing past the membrane and the concentration of the exit feed solution are essentially equal. The product solution contains C_2 = 0·39 kg NaCl/ m^3 (density = 997 kg solution/ m^3) and its measured flow rate is 1·92 × 10^{-8} m^3 solution/sec. A pressure differential of 5514 Pa is used. Calculate the permeability constant of the membrane and the solute rejection R.