TRANSFER OPERATION-II
(BIOT 3104)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) As the reflux ratio in a distillation coloumn is increased from the minimum, the
(a) slope of the operating line in stripping section increases
(b) number of plates decreases very slowly first and then more and more rapidly
(c) total cost first decreases
(d) liquid flow increases while the vapor flow decreases for a system.

(ii) With increase in pressure, the relative volatility for a binary system
(a) increases
(b) decreases
(c) remains same
(d) either (a) or (b), depends on the system.

(iii) Diffusion coefficient in a binary gas mixture at low pressure varies
(a) Directly with P (b) Inversely with P
(c) Directly with P^2 (d) Independent of P.

(iv) Molecular diffusion induced by temperature is
(a) eddy diffusion (b) thermal diffusion
(c) forced diffusion (d) none of the above.

(v) Diffusivity of a binary gas mixture is 2.83×10^{-5} m^2/s at 300K. What will be the approximate value of the diffusivity at 600K?
(a) $1.43\times10^{-5}m^2/s$ (b) $8\times10^{-5}m^2/s$
(c) $5.66\times10^{-5}m^2/s$ (d) $1.68\times10^{-5}m^2/s$.

(vi) For steady state diffusion of A through stagnant B, $N_A/(N_A+N_B)$ is
(a) 0. (b) 1
(c) ½ (d) ∞.

(vii) In absorption minimum operating line
(a) touches the equilibrium line
(b) has a slope of $(L/V)_{min}$
(c) shows the maximum possible liquid concentration
(d) All the above.

(viii) Which of the following is not an application of ultrafiltration?
(a)concentration (b) purification
(c) diafiltration (d) dialysis.

(ix) Packed columns are
(a)differential contact plant (b) stage contact plant
(c) gas-liquid contact plant (d) solid-liquid contact plant.

(x) The absorption factor is defined as
(a) L/mV (b) mL/V
(c) V/mL (d) LV/m.

Group – B

2. (a) Prove that $D_{AB}= D_{BA}$ for a gas.

(b) Water at 293K and 101.3kPa is contained in a narrow vertical tube. The level of liquid is maintained 150mm below the open end, across which air with a humidity of 0.002kg water/kg dry air is passed at 293K and 101.3KPa. If the diffusivity of water vapour in air is $2.5\times10^{-5}m^2/s$, and the vapour pressure of water is 2.34KPa, calculate the rate of evaporation of water. What will be the rate of evaporation if dry air is passed over the tube?

5 + 7 = 12

3. (a) CO_2 and O_2 experience equimolal counter diffusion in a circular tube whose length and diameter are 1m and 50mm respectively. The total pressure is 10atm and temperature is 25°C. The ends of the tube are connected to large chambers in which the species concentration are maintained at fixed values. The partial pressure of CO_2 at one end is 190mm of Hg and at the other end 95mm of Hg.
(i) Estimate the rate of mass transfer.
(ii) Find the partial pressure of CO_2 at 0.75m from the end where the partial pressure is 190mm of Hg. $D_{AB}= 2.1\times10^{-5}m^2/s$.

(b) Derive a relationship between overall mass transfer coefficients and local mass transfer coefficients.

(c) What is the significance of varying the slope of the operating line in gas absorption?

7 + 3 + 2 =12

Group – C

4. A 70 Kmol/hr methnol –water mixture containing 42 mol% methanol is distilled (flash) at atmospheric pressure to yield a residue of 27 mol%.
   (i) What is the composition of the distillate and how many moles of distillate and residue are obtained per hr?
   (ii) What is the maximum possible methanol content of the distillate?

   The equilibrium data for the given set of problem is:

x	0.0084	0.0258	0.068	0.137	0.24	0.48	0.57	0.74
y	0.103	0.227	0.391	0.568	0.68	0.79	0.82	0.90

8 + 4 = 12

5. (a) State the principle of Flash Distillation with diagram.

   (b) Derive the operating line equation for Flash Distillation.

   (c) Define relative volatility.

6 + 4 + 2= 12

Group – D

6. (a) Under the constant drying condition, a wet solid is dried from 30% to 4 % (on dry basis). The time taken is 4 hrs. The equilibrium moisture content is 2% (on dry basis). Critical moisture content is 10% (on dry basis). How long will it take to dry to 7% (on dry basis). Assume falling rate is linear. Use the following equation.

$$t = \frac{Ls}{A}\left[\frac{(X1-Xc)}{Rc} + \frac{(Xc-X*)}{Rc}\ln\frac{(Xc-X*)}{(X2-X*)}\right]$$

   (b) Derive the working formula for calculation of drying time under constant rate of drying.

8 + 4 = 12

7. An inlet water solution of 100 kg/hr containing 0.01 wt fraction nicotine in water is stripped with a kerosene stream of 200 kg/hr containing 0.0005 wt fraction nicotine in a countercurrent process. The water and kerosene are essentially immiscible with each other. It is desired to reduce the concentration of exit water to 0.0010 wt fraction nicotine.
   (i) Determine the wt fraction of nicotine in exit kerosene stream.
   (ii) Number of stages required for the process.

   The equilibrium data is:

X	0.001	0.00246	0.005	0.00746	0.00988	0.0202
y	0.000806	0.001959	0.00454	0.00682	0.00904	0.0185

   Where , x is the weight fraction of nicotine in water solution Y is the weight fraction of nicotine in kerosene solution.

4 + 8 = 12

Group – E

8. Experiments at 25°C were performed to determine the permeabilities of a cellulose-acetate membrane. The laboratory test section shown in figure has membrane area A= $2.00\times10^{-3}m^2$. The inlet feed solution concentration of NaCl is C_1=10.0kg NaCl/m^3 solution (10.0g NaCl/L, ρ_1= 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 solution (ρ_2= 997 kg solution/m^3) and its measured flow rate is 1.92×10^{-8} m^3 solution/s. A pressure differential of 54.42 atm is used. Calculate the permeability constants of the membrane and the solute rejection R. (Given π =7.48 atm).

12

9. (a) In a cross flow ultra filtration system used for filtration of proteins from a fermentation broth, gel resistance increases with protein concentration according to the following equation:
$R_G = 0.5+0.01C$, where C is in mg/L.
Pressure at the entrance system is P_i = 6atm and at the exit is P_0 = 2atm. The shell side of the filter is open to the atmosphere, resulting in P_f = 1atm. The membrane resistance is R_M = 0.5 atm/(mg/m^2 .h), and the protein concentration in the broth is C = 100mg/L. Determine:
    (i) The pressure drop across the membrane
    (ii) Filtration flux
    (iii) Rejection coefficient of the membrane for effluent protein concentration of C_i = 5mg/L.

    (b) Write a note on any one membrane separation process applied in biotechnology.

6 + 6 = 12

Department & Section	Submission Link
BT	https://classroom.google.com/c/MjQyMDU4ODMyNjY2/a/Mjc1OTEyMjE1NjEy/details