Ex/FTBE/T/325/2017

BACHELOR OF ENGINEERING (F.T.B.E.) EXAMINATION, 2017

(3rd Year, 2nd Semester)

MASS TRANSFER OPERATION I

Time : Three hours Full Marks : 100

Use a separate Answer-Script for each part

PART - I (60 MARKS)

All notation carry this usual meaning

Attempt any three Questions

1. a) Draw the flow diagram for the following extraction unit

   i) Single stage Extraction

   ii) Multi-stage Cross-corrent Extraction

   iii) Multi-stage Counter current Extraction 7

   b) Consideing multi-stage (with three units) Cross-current extraction, prove the following equation $x_3 = \frac{x_F}{(R_1/F + E_1K/F)(R_2/R_1 + E_2K/R_1)(R_3/R_2 + E_3K/R_2)}$ 6

   c) 150 Kg of nicotine-water solution containing 1% nicotine is to be extracted with 250 Kg of Kerosene are at 20^oC. Water and Kerosene are essentially immiscible in each other. Determine the percentage extraction of nicotine after one stage operation. At the dilute end of the system, the equilibrium relationship is $Y^* = 0.798\ X$ where Y and X are expressed as Kg nicotine/Kg Kerosene and Kg nicotine/Kg water, respectively. 7

2. a) What is distribution co-efficient ? Discuss it with two conditions namely dilute and concentrated solution. 6

   b) Within the region of ambivalence, what are consideration on which the selection of the phase to be dispersed upon. 5

   c) Mentin the classification of industrial liquid-liquid extraction. 6

   d) What is the difference between liquid-liquid extraction, liquid-solid extraction. 3

[Turn over

3. a) For counter-current leaching, prove the following equation

$$x_{n+1} = \frac{1}{1+\left(V_1 - L_o\right)/L_n} + \frac{V_1 x_1 - L_o x_o}{L_n + V_1 - L_o}$$ 7

b) Draw the flow diagram of counter current multistage leaching operation. 5

c) Discuss about triangular diagram consideing three components (A, B and C) and two phase in equilibrium.

d) Prove the following analogical equation $\frac{f}{z} = \frac{h}{C_p G} = \frac{k_c'}{U_{av}}$

Also mention when the analogy is not valid. 6+2

4. Write short notes on following : 4×5

a) Cross-current

b) Counter count

c) Prediction of theoretic stages in a counter-current operation

d) In which process, the solvent uses for liq-liq extraction needs less quantity and what is its effect ?

MASS TRANSFER OPERATION I

PART II (40 Marks)

Answer ***any two*** questions from this Part. $20 \times 2 = 40$

1. (a) Find the relation between the diffusivities of the components in a binary mixture.
   (b) Find the dimension of diffusivity.
   (c) In a gas system molecular diffusion is slow process, however you can make it faster-how ?
   (d) Hydrogen gas at 2 std. atm. pressure, 25^0Cf lows through a pipe made of unvulcanized rubber , with ID and OD 25 and 50 mm, respectively. The solubility of the hydrogen is reported to be 0.053cm^3(STP)/cm^3.atm. and the diffusivity of hydrogen through the rubber to be 1.8×10^{-6} cm^2/s. Estimate the rate of loss of hydrogen by diffusion per meter of pipe length. (3+2+2+13)

2. Acetic acid concentration at the opposite walls of a static film (2 mm thick) of non diffusing water are 10% and 5 % (by wt.), respectively. The diffusivity of the acid in the binary mixture of water and acid is 0.85×10^{-9} m^2/sec at 20^0C . Density of 9% and 4% acid solution are 1012kg/m^3 and 1005kg/m^3, respectively. Calculate the diffusional flux of the acid . (20)

3. Ammonia gas (A) diffuses through nitrogen gas (B) under steady state conditions with nitrogen non-diffusing. The total pressure is 1.013×10^5 Pa and the temperature is 298 K. The diffusion path is 0.15m. The partial pressure of ammonia at one point is 1.5×10^4 Pa and another point is 5×10^3 Pa. The D_{AB} for the mixture at 1.013×10^5 Pa and 298 K is 2.30×10^{-5} m^2/s. calculate (a) the flux of ammonia and (b) the equimolar counter diffusion flux, assuming that nitrogen also diffuses. (20)

4. In a tube containing a mixture of methane and helium, the partial pressure of methane is 60kPa and 20kPa at two different positions in the tube. The distance between the positions is 2cm.The ambient pressure and temperature are 1atm and 25^0C , respectively. The diffusivity of methane is 6.75×10^{-5}m^2/sec. Calculate (i) the flux of methane at steady state for counter diffusion case and (ii) calculate the partial pressure at a point 1cm apart from the first position. (20)

5. (a) Calculate the permeability coefficient of an amorphous PET film to O_2 at 23^0C given that the OTR through a 2.54×10^{-3} cm thick film with air on one side and inert gas on the other is 8.8×10^{-9} mL cm^{-2} s^{-1}. O_2 partial pressure difference across the film is 0.21 atm

   (b) A food powder with density of 1 is to be packaged in a plastic film that has a WVTR of 2.1 g m^{-2}day^{-1} at 25^0C and 75% RH. The initial moisture content of the powder is 3% and the critical moisture content is 7%. Assuming that each pack will contain 450 gms of powder and will be exposed to an external environment at 25^0C and 75% RH, calculate the shelf life if the shape of the packs are the same as those listed in the table. For simplicity , assume that the driving force for WVT remains constant and that there are no moisture gradient in the powder.

Surface areas of different package shapes, all with a volume of 450 mL

Shape	Surface area (cm^2)
Sphere	285
Cylinder	331
Cube	353
Rectangular	450