Bachelor of Engineering in Food Technologt and Biochemical Engg. Examination, 2018

(3rd Year, 2ndSemester)

Mass Transfer Operation - I

Time : Three hours | Full Marks : 100

(50 marks for each Part)

Use a separate Answer-Script for each Part

PART - I

Any Three Questions from Q. No. 1 – 4 and Q. No. 5 is compulsory.

Q.No.1.

a) With the help of concentration in the solid phase, which is expressed as q [kg absorbate (solute) / kg absorbent (solid)], and in the fluid phase (gas or liquid) as C (kg absorbate / m^3 fluid), define the following equation with a neat diagram of adsorption isotherm [q *vs* C] :

i) Henry's Isotherm Equation
ii) Freundlich Isotherm Equation
iii) Langmuir Isotherm Equation (05)

b) Discuss the temperature effect on adsorption and desorption. (2.5)

c) Explain the difference between absorbtion and adsorption. (2.5)

Q.No.2.

a) Explain the Distribution Co-efficient for both the dilute and the concentrated solution. (03)

b) With a help of an equilateral triangular co-ordinate, draw the equilibrium data of three component system and explain all the inherent phases mass fraction and component percentage at major locations based on the triangular diagram. (03)

c) With the region of ambivalence, the selection of the phase to be dispersed depends on various consideration. Explain those considerations briefly. (04)

Q.No.3.

Differentiate between the following two operating lines (considering both mass balance and component balance) : (10)

$$y_{n+1} = \frac{L_n x_n}{V_{n+1}} + \frac{V_1 y_1 - L_0 x_0}{V_{n+1}}$$

$$x_{n+1} = \frac{y_n}{1 + \frac{V_1 - L_0}{L_n}} + \frac{V_1 x_1 - L_0 x_0}{L_n + V_1 - L_0}$$

Q.No.4.

a) Draw the following diagrams depicting the Feed, Solvent, Raffinate and Extract for both input and output of each stage, mentioning all details so as to make total material balance and component balance for the entire stages involved in the system.

i) Single Stage Extraction System
ii) Multistage Cross-current System
iii) Multistage Counter-current System (06)

b) Prove the following equation (considering the multistage cross-current System) :

$$x_3 = \frac{x_F}{\left(\frac{R_1}{F} + \frac{E_1 K}{F}\right)\left(\frac{R_2}{R_1} + \frac{E_2 K}{R_1}\right)\left(\frac{R_3}{R_2} + \frac{E_3 K}{R_2}\right)}$$

(04)

[Turn over

Q.No.5. (Attempt any two questions) (10 X 2)

a) It is desired to absorb 90 % of the acetone in a gas containing 1.0 mol % acetone in air in a counter – current stage tower. The total inlet gas flow to the tower is 30 *kgmol/h* and the total inlet pure water flow to be used to absorb the acetone is 90 *kgmol* H_2O/h. the process is to operate isothermally at 300*K* and a total pressure of 101.3 kP_A. The equilibrium relation for the Acetone (A) in the gas-liquid is $y_A = 2.53\ x_A$. Determine the number of theoretical stages required for this separation.

b) Keeping all the parameters same as above, find the number of theoretical stages required for the purpose using Analytical Method and conclude your view on the subject using both the method, namely, Graphical method and Analytical method.

c) 150 kg of nicotine-water solution containing 1 % nicotine is to be extracted with 250 kg of kerosene at 20 °C. 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.

Ref. No. : Ex/FTBE/T/325/2018

B.E. FOOD TECHNOLOGY AND BIO-CHEMICAL ENGINEERING

THIRD YEAR SECOND SEMESTER EXAM 2018

Mass Transfer Operation I

Time: 3 hrs. Full Marks : 100

Part – II (Marks 50)

1. Answer any one from the following (a) and (b)

a. (i) State Fick's first law of diffusion and find the dimension of diffusivity.

(ii) Find the relation between the diffusivities of the components in a binary mixture.

(iii) In a gas system molecular diffusion is slow process, however you can make it faster-how ?

(2+1)+ 5+2

b. Derive mathematical expression of rate of diffusion of a gaseous component with respect to its partial pressure difference at two different points in a two-component gas mixture for one diffusing another non-diffusing system. 10

2. Answer any two from the following (a) , (b) and (c)

a. Oxygen is diffusing through non-diffusing carbon monoxide under steady state condition. The total ambient pressure 10^5N/m^2 and the temperature is 0^0C. The partial pressure of oxygen at two planes 3mm apart is 14,000 and 7000N/m^2, respectively. The diffusivity for the mixture is 1.9 x 10^{-5}m^2/sec. Calculate the rate of diffusion of oxygen in kmole /sec-m^2. 12.5

b. Hydrochloric acid (A) concentration at the opposite walls of a static film (4 mm thick) of non diffusing water (B) are 12% and 4 % (by wt.), respectively. The diffusivity of the acid in the binary mixture of water and acid is 2.5 x 10^{-9}/sec at 20^0C . Density of 12% and 4% acid solution are 1050kg/m^3 and 1020kg/m^3, respectively. Calculate the diffusion flux of the acid at 20^0C. 12.5

c. 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 x 10^{-6} cm^2/s. Estimate the rate of loss of hydrogen (in gms) by diffusion per meter of pipe length per hour. 12.5

3. Answer any one from the following (a) and (b)

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

(ii) Find out the unit of permeability in SI system. 12 + 3

b. A carbonated beverage is packaged in a PET bottle with oxygen permeability of 0.30x10^{-11} ml(STP).cm/cm^2.sec.cmHg. The surface area of the bottle is 720cm^2 and thickness of the wall is 0.046cm and holds 1litre of beverage. Calculate the shelf life of the beverage in the bottle. Assume that air contains 21% oxygen and density of oxygen is 1.40x10^{-3}gm/ml. The maximum limit of quantity of oxygen in the beverage at its acceptable form is 5ppm. 15