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Roll No.....

MECM-101

M.E./M.Tech. I Semester

Examination, June 2017

Separation Process

Time : Three Hours

Maximum Marks : 70

Note: i) Answer any five questions.
ii) All questions carry equal marks.

1. Spheres of porous clay 12 mm diameter were thoroughly impregnated with an aqueous solution of sodium chloride, concentration being 0.15 gm/cm^3. When exposed to a running supply of fresh water at 18°C, the spheres lost 60% of their salt content in 2.25 hr.
At 18°C the average diffusivity of NaCl in water is 1.36×10^{-9} m^2/s. Assume $F_0 = 0.1175\phi$.
Estimate the time of removal of 80% of the dissolved solute if the spheres were impregnated with an aqueous solution of ethanol, concentration being 0.17 gm/cm^3 when exposed to a running supply of water containing 0.01 gm/cm^3 of ethanol at 18°C. The average diffusivity of ethanol in water at 18°C is 0.53×10^{-9}m^2/s. Assume $F_0 = 0.933\phi$

2. A test tube of 2.0 cm in diameter and 15 cm tall is partly filled with a solution of alkaline pyrogallate. The depth of the empty space above the solution is 5 cm. The temperature is 25°C and the total pressure is 1 atm. Air may be assumed to contain 21% O_2 and 79% N_2. The diffusivity of O_2 in N_2 at the given conditions is 0.21 cm^2/s. Calculate the rate of absorption of O_2 from air in the solution in kg/s at steady state if air flows gently over the open end of test tube.

3. a) Derive Chilton-Colburn equation regarding analogy between heat and mass transfer.

   b) A gas is flowing at a mass velocity of 10,000 kg/(hr)(m^2) has a Reynold's number of 20,000 in a smooth pipe. If the specific heat, viscosity and thermal conductivity of the gas are 1.675 kJ/kg k, 1.0×10^{-5} kg/ms, and 0.0249 W/mk respectively, determine the heat transfer coefficient of the flowing gas.

4. Determine the individual mass transfer coefficient for a gas in a scrubber when benzene vapour is being absorbed from the coke gas in the following conditions: grid packing with bars 12.5×100 mm in size having a spacing of $b = 25$ mm is used (for such packing equivalent diameter = 2b=0.05m), the velocity of the gas calculated for the entire cross-section of the scrubber is 0.95 ms, the density of the gas is 0.5 kg/m^3, the dynamic viscosity of the gas is 0.013 MPa.s, the coefficient of diffusion of benzene in the gas is 16×10^{-6} m^2/s. Consider that the film conditions prevail in the column.

5. a) Explain the concept of boundary layer giving various sections of it. What is the significance of boundary layer and why it plays a vital role in transfer processes?

   b) Derive the momentum equation for transfer processes. Write its importance in solving various transfer problems.

6. a) Describe diffusion type model for membrane processes with complete equations.

b) Give an account of the equations used for quantitative estimation of mass transfer rate in membrane processes. How much error is generally expected?

7. a) A reverse osmosis membrane to be used at 25°C for a NaCl feed solution containing 2.5 g NaCl/L (2.5 kg NaCl/m^3, ρ = 999 kg/m^3) has a water permeability constant $A_w = 4.81 \times 10^{-4}$ kg/8m^2 atm and a solute (NaCl) permeability constant $A_s = 4.42 \times 10^{-7}$ m/s (Al). Calculate the water flux and solute flux through the membrane using a ΔP =27.20 atm and the solute rejection R. Also calculate the C_2 of the product solution.

b) Give few examples of polymer membranes. What are the advantages and disadvantages of having polymer membranes?

8. a) In detail, describe a method for the calculation of number of plates for a given separation for a multicomponent system.

b) What are Azeotropes? What are the different types of Azeotropes? Explain with the help of VLE relationship. How such mixtures are separated by distillation?

c) Derive the Fenske equation for minimum number of plates for multicomponent mixtures.

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