GD

INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Mid-Autumn Semester Examination, 2016-2017

Subject : Mass Transfer - I *Subject No.*: CH31001

Time: 2 Hrs *Full Marks*: 30

Instructions : (1) Use relevant equations and diagrams, wherever necessary.
(2) Any missing data may be assumed suitably giving proper justification.
(3) **No questions will be entertained in the examination hall.**

Answer ALL Questions.

1. Water contained in a narrow tube diffuses through the tube. Surface of water is 15 cm below the top of the tube. Moisture free air is flowing at the top of the tube. The tube is kept at a constant temperature of 20^0C and the pressure is atmospheric. Water Diffusion coefficient of water in the air in these conditions is 0.25×10^{-4} m^2/s. Water vapor pressure at temperature 20 ^{0}C is 0.023 atm.
(i) Estimate molar water flux. Derive the necessary equation
(ii) Estimate mass transfer coefficients when driving force is expressed in terms of(a) partial pressure, (b) concentration and (c) mole fractions.
(iii) Derive an equation to determine the decrease in water level with time when the liquid surface level slowly decreases in the tube.
(iv) Explain how this equation can be used to determine the diffusivity of water in the air.
(4+2+3+1)

2. SO_2 gas is absorbed into water from a gas stream flowing over a pool of water. The water pool contains 100 kmoles of water and is well mixed The surface area of the pool is 1.5 m^2. The mole fraction of the SO_2 in the gas phase is constant at 0.085 due to high circulation rate and the initial mole fraction of SO_2 in the water is 0.0. The final mole fraction of SO_2 in the water is required to be 0.001. At equilibrium, y=Hx where H=49.7. The gas and liquid phase mass transfer coefficients are 9.9 and 8.1 kmol/hr. m^2 respectively, when the driving force is expressed in terms of mole fraction.
(i) Calculate the time needed to reach a final mole fraction of 0.001 in the liquid pool.
(ii) Determine the relative mass transfer resistance and decide which side is the rate determining step.
(iii) Estimate the concentration of SO_2 at the gas side and liquid side of the interface.
(iv) Draw schematically the concentration distribution of SO_2 in the gas, liquid and interface.
(v) What would be your strategy to substantially increase the rate of SO_2 absorption-explain .
(4+2+2+1+1)

3. (a) Write the expression obtained using Boundary Layer theory for estimating the mass transfer coefficients. Explain the significance of each dimensionless numbers appeared in the expression.
(b) List the factors which affect the (i) gas phase and (ii) liquid phase diffusivities.
(c) What is Knudsen diffusivity? At what condition will Knudsen Diffusion occur?
(d) How the film theory and penetration theory account the fact that the rate of mass transfer increases with the increasing turbulence?
(e) Draw the operating line along with the equilibrium line for (i) concurrent, (ii) countercurrent and (iii) stagewise equipments. (5X2)