Code No: NR310804 **NR**

III B.Tech I Semester Supplementary Examinations, May 2005
MASS TRANSFER OPERATIONS-I
(Chemical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. Equimolar counter diffusion is occurring at steady state in a tube 0.11 m long containing N_2 and CO gases at a total pressure of 1.0132 x 10^5 Pa absolute. The partial pressure of N_2 is 10.66576 x 10^3 Pa at one end and 1.33322 x 10^3 Pa at the other end. D_{AB}= 2.05 x 10^{-5} m^2/s. Calculate

   (a) the flux in kg mol/ $s.m^2$ for N_2 at 298 K

   (b) Repeat at 473 K. Does the flux increase?

   (c) Repeat at 298 K but for a total pressure of 3.03975 x 10^5 Pa. The partial pressure of N_2 remains at 10.66576 x 10^3 Pa and 1.33322 x 10^3 Pa. Does the flux change?

2. (a) Applying Fick's law of diffusion, derive an equation for steady state radial diffusion through a solid cylinder of inner and outer radii a_1 and a_2 respectively and of length l. State clearly the assumptions made.

   (b) Hydrogen gas at 2.0265 x $10^5 N/m^2$and 25^oC, flows through a pipe made of unvulcanized neoprene rubber, whose ID and OD are 25 and 50 mm, respectively. The solubility of the hydrogen is reported to be 0.053 m^3 (STP)/ (m^3)(1.01325 x $10^5 N/m^2$), and the diffusivity of hydrogen through the rubber to be 1.8 x 10^{-10} m^2/s. Estimate the rate of loss of hydrogen by diffusion per meter of pipe length.

3. Write a short note on Tray Towers providing a neat diagram of sieve - tray tower.

4. A tower packed with 0.5 cm raschig rings of 12m height is to be used for absorption of hydrogen sulfide (H_2S) from natural gas (may be treated as methane) by using monoethanolamine as a solvent. The operation is carried out at 30^oC and 1 atm pressure and counter currently. The entering gas contains 18% H_2S by volume. 90% of this has to be absorbed. The gas flow rate is $2000 m^3/m^2.hr$. Equilibrium line is straight in the operating limits and is given by Y = 1.1X. Operating line is also straight and parallel to equilibrium line.

   (a) Find the liquid flow rate

   (b) Find the number of stages and HETP.

5. An air-water mixture is at 55^oC DryBulb and 1 standard atmosphere pressure with an absolute humidity of 0.03 kg water/kg dry air. Tabulate its characteristics using the humidity chart.

6. A humidifier is employed to obtain 15000 Kg/hr of conditioned exit air at 49 $^\circ$C dry bulb and 32 $^\circ$C wet bulb temperature. This is achieved in three steps. The ambient air at 35 $^\circ$C and carrying 0.006 kg of liquid water per m^3 is heated using a preheater. This air is sent through a adiabatic spray chamber where it is saturated to 90% humidity. This humidified air is then reheated to the desired temperature of the exit air. Calculate the following: The temperature to which the air must be heated in the first stage. The temperature of the air as it emerges from the spray chamber.

7. A granular solid with dry bulb density of 1600 kg/m^3 is being dried in a batch drier in air at 65^0C with a humidity of 0.005 kg water per kg of dry air. The solids containing 0.5 kg water per kg of dry solid are in 2.54 cm pans insulated, so that heat and mass transfer occur to the top surfaces only. The solids are to be dried to a final moisture content of 0.02 kg water per kg of dry solid and have a critical moisture content of 0.01 kg of water per kg of dry solid. Air passes over the pans at a mass velocity of 1.7 kg/s.m^2. Heat transfer by conduction and radiation may be neglected. For this granular material equilibrium moisture content is zero. Calculate the drying time required and what would be the drying time if the air flow rate was raised to 25 kg/s.m^2.

8. Air containing 0.005 kg of water vapor per kg of dry air is heated to 52 $^\circ$C in a dryer and passed to the lower shelves. It leaves the shelves at 60% RH and is reheated to 52 $^\circ$C and passed over another set of shelves, again leaving at 60% RH. This is again repeated for 3^{rd} and 4^{th} set of shelves after which the air leaves the dryer. On the assumption that the material on each shelf has reached the wet bulb temperature and the heat losses from the dryer can be neglected. Determine the temperature of the material on each tray, amount of water removed in kg/h if 10000 m^3/min of moist air leaves the dryer. The temperature to which the inlet air has to be raised to carry out the drying in a single stage.

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