Code No: RR310804 **Set No.1**

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. A water droplet with an initial diameter of 2.5 mm is suspended on a thin wire in a large volume of stationary air at 298 K, containing water vapor that exerts a partial pressure of 1.38 kPa. Estimate the time required for complete evaporation of the droplet if the total pressure is 101.3 kPa. Diffusivity of water vapor in air at standard conditions = 21.9 x 10^{-6} m^2/s. The vapor pressure of water at 298 K = 3140 N/m^2.

2. Discuss the following Mass Transfer Theories:
   (a) Film Theory
   (b) Boundary Layer Theory
   (c) Penetration Theory
   (d) Film-surface renewal theory

3. (a) Write short note on "Two-resistance theory".
   (b) Write the basic concept of equilibrium between two phases.

4. (a) Write short note on point efficiency.
   (b) Write short note on internals used in packed.
   (c) Write short note in flooding & loading.

5. Carbon disulphide is to be removed from CS_2—N_2 mixture by absorption. It is carried out at 1 std pressure and 24^0C and the partial pressure of CS_2in the gas entering is 50 mm of Hg. The gas is blown into the tower at a rate of 2000m^3/hr and gas coming out will contain 0.5% CS_2 by volume. Average mole wt of oil is 180. The oil enters the tower essentially stripped off all CS_2 and solution of oil and CS_2 are ideal. The vapor pressure of CS_2 at 24^0C is 345mm of Hg. Determine
   (a) The minimum L/G ratio.
   (b) The number of theoretical plates for L/G of 1.5 times the minimum.

6. (a) Describe Psychometric chart with neat sketch and define various terms in it.
   (b) A mixture of benzene vapor and nitrogen has a relative humidity of 60% at 297 K; the total pressure being 102.4 kN/m^2. If the mixture is cooled to 283 K, to what pressure must the mixture to be compressed in order to recover 75% of the benzene? The vapor pressure of benzene is 12.2 kN/m^2 and 6.05 kN/m^2 at 297 K and 283 K respectively.

7. (a) It is desired to dry a batch of 500 kg of wet solid from 30% to 6% moisture. The rate of drying may be assumed to be linear in the falling rate zone. Calculate the time required for drying. The critical and equilibrium moisture contents are 0.2 and 0.05 kg/kg of dry solids. The constant rate period drying rate is 1.5 kg/hr m^2 and the drying surface is 0.026 m^2 per kg of dry soild.

   (b) Derive the relationship between surface humidity and surface temperature during constant rate drying. Consider all modes of heat transfer.

8. (a) Explain the principle of humidification in cooling tower.

   (b) Discuss briefly break through curve in fixed bed drier.

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1. (a) Solute A is diffusing at steady state through a liquid film of thickness X. The concentrations of A at the left and right boundaries of the film are C_{A0} and C_{Ax} respectively, with $C_{A0} > C_{Ax}$. Derive the equation for concentration of A and determine the flux of A.

   (b) Ammonia gas (A) is diffusing through a uniform tube of 0.10 m long containing N_2 gas (B) at 1.0132×10^5 Pa pressure and 298 K. At point 1, $p_{A1} = 1.013 \times 10^4$ Pa and at point 2, $p_{A2} = 0.507 \times 10^4$ Pa. The diffusivity $D_{AB} = 0.23 \times 10^{-4}$ m^2/s. R = 8314 m^3 Pa/kg mol K. Calculate the molar flux of A at steady state. Repeat for B.

2. (a) Explain Reynolds analogy, and also find a relation between mass transfer coefficient and friction factor.

   (b) Write short notes on surface-removal theory of mass transfer.

3. A gas mixture A-air is fed into an absorption tower where absorption of the component A in water is taking place at 298 K and 2 std atm. Given that $k_L = 0.122$ k mol A / (hr.m^2)(mol A/m^3). $k_G = 1.32$ k mol A / hr.m^2.atm the equilibrium partial pressure of gas A over dilute solution of A in the water is given $p_{A,i} = 0.28$ ($c_{A,i}$), where $p_{A,i}$ is in atm while $c_{A,i}$ is expressed in terms of mol A/m^3. determine the values of the following mass transfer coefficients.

   (a) $\mathbf{k}_y$

   (b) $\mathbf{k}_c$ for gas film

   (c) $\mathbf{K}_L$

4. (a) Write short note on 'Geometric similarity'.

   (b) Discuss about mixing in gas-liquid contact equipment preferably baffled vessels.

5. NH_3 is absorbed from a gas by water in a absorber under atmospheric pressure. The initial NH_3 concentration in the gas is 0.03 kg mole / kg mole of inert gas. 90% NH_3 is to be removed from the input stream. The water leaving the absorber contains 0.02 kg mole/ kg mole of water. A constant temperature is maintained in the absorber by removing heat from it. Determine the number of transfer units required for the above job.

X kg moles of NH_3/kg mole of water	0	0.005	0.01	0.0125	0.015	0.02
Y kg moles of NH_3/kg mole of inert gas	0	0.0045	0.0102	0.0138	0.0183	0.0273

6. Air at 38^{o}C, 70% saturated with water vapor is heated to 82.4^{o}C and passed through a dryer where it gets adiabatically cooled to 54.4^{o}C and humidified to 40% saturation. The air leaving the dryer is cooled in a cooler to 26.6^{o}C and reheated to 38^{o}C. Determine:
   (a) Molar humidity of air entering the first heater,
   (b) Molar humidity and % saturation of air leaving the first heater,
   (c) Molar humidity of air leaving the dryer,
   (d) Water evaporated in the dryer per kg mole of air entering.

   The vapor pressure of water is as follows:

Temperature ^{o}C	26.6	38	54.4	82.4
Vapor pressure, mmHg	26.2	49	115	388.4

7. (a) Explain the following terms in drying
      i. Critical moisture content,
      ii. Constant rate period,
      iii. Falling rate period
      iv. Initial adjustment.
   (b) A batch of solids is dried from 25 to 6% moisture under conditions identical to those for which the following applies. The initial weight of the wet solid is 160 kg and the drying surface is 1 m^2/40 kg dry weight. Determine the time for drying in the constant rate period.
   Data: Xc = 0.2kg moisture/1kg dry solid
   N_c=0.3$\times 10^{-3}$ rate of drying.

8. Write short noteson dehumidifies and prove that Murphere shape efficiency for dehumidifies as $E_{MG} = 1 - e^{-NtG}$, where N_{tG} in the number of gas phase transfer units.

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Code No: RR310804 **Set No.3**

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. (a) Ammonia is diffusing through a 0.5 mm thick stagnant film composed of one third nitrogen and two third hydrogen by volume. If the diffusion process occurs at 327 K and 2.068 MPa, Calculate the rate of diffusion of ammonia through the film across the concentration of ammonia changes from 10 % to 5 % by volume.
   $D_{NH3-N2} = 24.1 \times 10^{-6}\, m^2/sec$ at 293 K and 1 std atm
   $D_{NH3-H2} = 84.9 \times 10^{-6}\, m^2/sec$ at 293 K and 1 std atm
   (b) Explain the procedure to evaluate a relation between N_A and N_B for various cases.

2. (a) Write about Mass, Heat and Momentum analogies.
   (b) Explain the physical significance of the mass transfer coefficients.

3. Desorption of A from a liquid solution into an air stream is taking place in a mass transfer tower at certain operating temperature and pressure. At particular point in the tower, analysis reports reveals $p_{A,G}$= 12 mm Hg: $c_{A,L}$= 4 kmol/m^3
   the overall gas coefficient K_G = 0.269 k mol A/ (hr.m^2.atm)
   If Henry's law is satisfied by the system and if 56 % of total mass transfer resistance is encountered in the gas film, calculate the
   (a) Gas film coefficient, k_G
   (b) Liquid film coefficient k_L
   (c) Molar flux of A
   Take Henry's law constant = 7.5×10^{-3} atm/molA.m^3 solution.

4. (a) Write about operating characteristics of sieve trays.
   (b) Write about mechanical agitation of single phase liquids, considering vortex formation.

5. A solvent is to be recovered from a gas stream by absorption with clean water in a plate column. The solvent enters at a concentration of 2% by volume and the maximum allowable loss is 0.1%. A liquid rate of 1.3 times the minimum rate is employed. Estimate the number of stages required. Equilibrium diagram $P_e = 0.02$ x; where P_e equilibrium pressure of the solvent kN/m^2 and x the mole fraction of the solvent in water.

6. (a) Explain the concept of wet bulb temperature with neat sketch.
   (b) Moist air at 300 K has wet bulb temperature of 290 K. If the latent heat of vaporization of water at 290 K is 2458 kJ/kg, estimate the humidity of the air and the percentage relative humidity. The total pressure is 101.3 kN/m^2 and h_c/k_y= 1.09x10^3. Further, the Antoine's equation for water is: $\log p^{sat} = 8.07 - \frac{1730.63}{T-39.58}$, where p is in mmHg and T is in K

7. A wet granular dry material is dried in a pan 0.5 x 0.5 m and 25.4 mm deep. All the sides and the bottom of the pan are insulated. An air stream flowing parallel to the surface at a velocity of 7 m/s and it has 70^{o}C as dry bulb temperature and 29^{o}C as wet bulb temperature. Calculate the time required to dry a batch of this material from moisture content of 0.35 kg of water per kg of dry solid to 0.2 kg of water per kg of dry solid. The equilibrium moisture content is 0.01 kg of water per kg of dry solid. The equilibrium moisture content is 0.01 kg of water per kg of dry solid. The density of dry solid may be taken as 1300 kg/m^3.

8. Write short noteson dehumidifies and prove that Murphere shape efficiency for dehumidifies as $E_{MG} = 1 - e^{-NtG}$, where N_{tG} in the number of gas phase transfer units.

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Code No: RR310804 **Set No.4**

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
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1. (a) A narrow tube is partially filled with a liquid and maintained at a constant temperature. A gentle stream of gas is passing across the open end of the tube. As the liquid evaporates the level drops slowly. At a given time t, the level is z from the top. Derive an equation to calculate the value of the diffusivity of the liquid vapor in the gas.

   (b) An Arnold cell is used to measure the diffusivity of acetone in air at 20^oC and 100 kPa pressure. At time t = 0, the liquid acetone surface is 11 mm from the top of the tube and after 8 hours of operation the liquid surface drops to 20.5 mm. If the concentration of acetone in air that flows over the tube is zero, what is the diffusivity of acetone in air? At 20^oC the vapor pressure of acetone is 24 kPa and the density of acetone is 790 kg/m^3.

2. Explain the various four theories of mass transfer for turbulent flow.

3. A wetted wall absorption tower, 2.54 cm ID, is fed with water as the wall liquid and an ammonia-Air mixture as the central core gas. At a particular level in the tower the ammonia concentration in the bulk gas is 0.8 mole fraction, that in the bulk liquid 0.05 mole fraction. The temperature = 26.7^0C, the pressure std atm. The rates of flow are such that the local mass transfer coefficient in the liquid, from a correlation obtained with dilute solutions is $k_L = 2.87 \times 10^{-5}$ k mol /m^2.sec.(k mol/m^3). And the local Sherwood Number for the gas is 40. the diffusivity of ammonia in air = 2.297×10^{-5} m^2/sec. compute the local mass transfer flux for the absorption of ammonia, ignoring the vaporization of water.

   The equilibrium distribution data for ammonia are taken from those at 26.7^0C.

NH_3 mole fraction x_A	Partial pressure of NH_3 (N/m^2) p_A
0	0
0.05	7,171
0.1	13,652
0.25	59,917
0.3	93,220

4. Briefly explain the design and importance of tray spacing, tower diameter, down spot, weirs in tray tower.

5. Ammonia is to be removed from air-NH_3 mixture containing 20% of volume ammonia in counter current absorber using water at 1 std atm and 20^0C. The absorber

is to be designed to remove 99.5% by volume of ammonia in the entering gas. Calculate the minimum water rate and the number of theoretical plates necessary for absorption, if 1.2 times the minimum water rate is used for a gas rate of 1kg/s. Equilibrium data:

Partial pressure of ammonia, mm Hg	12	18	32	50	70	166
gm.NH_3/100 gm water	2	3	5	7.5	10	20

6. 5kg/s of water are to be cooled from 25^0C to 15^0C air with a wet bulb temperature of 10^0C is to be used at 50% more than the minimum rate. Calculate the height of tower required. The equilibrium data of water temperature, t_l in ^{0}c and enthalpy of air saturated at the temperature $t_l(^0c)$ h^* kJ/kg are given as follows

t_l	10	15	17	19	21	23	25
h^*	29	41.5	47.9	54.3	61	68	75.5

7. (a) A wet material with initial moisture content of 30% is dried in a batch drier using hot air. It is found that 5 hr are required to bring down the moisture content to 10%. The critical moisture content and the equilibrium moisture content of the solid are 15% and 2% respectively. Estimate the time to dry the same material to final moisture content 5%. State the assumptions made for the calculation of the time of drying during falling rate period.

   (b) Write short notes on through circulation drying.

8. (a) Discuss working principles of spray drier.

   (b) Explain with neat figure construction and working of spray chamber.

   (c) Write short noted on hydrodynamic flow of gases.

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