

Printed Pages : 7



ECH-501

(Following Paper ID and Roll No. to be filled in your Answer Book)

**PAPER ID : 151502**

Roll No.

--	--	--	--	--	--	--	--	--	--

**B. Tech.**(SEM. V) (ODD SEM.) THEORY  
EXAMINATION, 2014-15**MASS TRANSFER OPERATIONS - I**

Time : 3 Hours]

[Total Marks : 100

1 Attempt any FOUR parts : **5x4=20**

- (a) In an oxygen-Nitrogen gas mixture at 1 std atm, 25° C, the concentrations of oxygen at two planes 2 mm apart are 10 and 20 vol%, respectively. Calculate the flux of diffusion of the oxygen for the case where the nitrogen is non-diffusing.
- (b) Ammonia is diffused through stagnant solution containing of  $\frac{1}{3}$  N<sub>2</sub> and  $\frac{2}{3}$  H<sub>2</sub> by volume. The total pressure is 206.8 Kpa and the temperature is 54° C. Calculate the rate of diffusion of the ammonia through a film of gas 0.5 mm thick when the concentration changes across the film is 10-5% ammonia by volume.

- (c) Discuss in detail about penetration theory for mass transfer coefficient.
- (d) Derive the relation between overall mass transfer coefficient and individual mass transfer coefficient when the mass transfer is both gas phase and liquid phase controlled.
- (e) What is the effective thickness of gas film for the evaporation of water into air in a 2-in-diameter wetted wall column at Reynolds number of 10,000 and a temperature of 40° C. Repeat the calculation of ethanol under the same conditions. At 1 atm the diffusivities are 0.228 cm<sup>2</sup>/s for water in air and 0.145 cm<sup>2</sup>/s for ethanol in air.
- (f) Briefly explain the mass transfer in fluidized bed.

2 Attempt any TWO parts :

**10x2=20**

- (a) A plant manufacturing dry ice will burn coke in air to produce a flue gas which when cooled and cleaned will contain 15% CO<sub>2</sub> , 6% O<sub>2</sub>, 79% N<sub>2</sub>. The gas will be blown into a sieve tray tower, scrubber at 1.2 std atm and 25° C to be scrubbed with a 30% mono ethanol amide solution entering at 25° C. The scrubbing liquid which is recycled from a

stripper will contain 0.05 mole  $\text{CO}_2$ /mole soln. The gas leaving the scrubber is to contain 2%  $\text{CO}_2$ . Assume isothermal operation. Determine the minimum liquid to gas ratio in mole/mole and the number of kilograms of solution to enter the absorber per cubic meter of entering gas for a L/G ratio of 1.2 times the minimum.

- (b) A packed tower is designed to absorb sulphur dioxide from air by scrubbing the gas with water. The entering gas is 18.6%  $\text{SO}_2$  by volume. The water flow is to be 2.3 times the minimum. The air flow rate ( $\text{SO}_2$  free basis) is  $1100 \text{ m}^3/\text{hr}$ . The temperature is  $30^\circ \text{C}$  and the total pressure is 2 atm. The equilibrium data is governed by  $y = 21.8 x$ , where  $y$  and  $x$  are in mole fraction units, Compute the number of overall gas phase transfer units.
- (c) Compare tray tower with packed tower.

**3** Attempt any TWO parts : **10x2=20**

- (a) Partial pressure of water vapour in a mixture of air – water vapour at a total pressure of 106.6 kPa and a temperature of  $60^\circ \text{C}$  is 13.3 kPa. Express the concentration of water vapour in (i) absolute humidity, (ii) mole fraction, (iii) volume fraction, (iv) relative humidity and (v) g water/ $\text{m}^3$  mixture. Assume vapour pressure is 20.6 kPa at  $60^\circ \text{C}$ .

- (b) In a plant for the recovery of acetone which has been used as a solvent, the acetone is evaporated into a stream of nitrogen gas. A mixture of acetone vapor and nitrogen flows through a duct, 0.3 by 0.3 m cross section. The pressure and temperature at one point in the duct are 800 mmHg, 40° C, and at this point the average velocity is 3 m/s. A wet bulb thermometer (wick wet with acetone) indicates a temperature at this point of 27° C. Calculate the kilograms of acetone per second carried by the duct.
- (c) Derive equation for adiabatic saturation curves.
- 4 Attempt any TWO parts : **10x2=20**
- (a) A cake of a crystalline precipitate is to be dried by drawing air through the cake. The particles of the cake are nonporous, of average diameter 0.2 mm, and since they are insoluble in water have a negligible equilibrium-moisture content. The cake is 18 mm thick, and the apparent density is 1350 kg dry solid/m<sup>3</sup>. It is to be

dried from 2.5 to 0.1% moisture. The air will enter the cake at 0.24 kg dry air/(m<sup>2</sup> bed cross section).s (= 177 lb/ft<sup>2</sup>h), at a dry-bulb temperature 32° C and 50% humidity. Estimate the time of drying

(NOTE: Psychrometric charts can be used)

- (b) A wet slab of material weighing 5 kg originally contains 50% moisture on wet basis. The slab is 1 m × 0.6 m × 7.5 cm thick. The equilibrium moisture is 5% on wet basis. When in contact with air, the drying rate is given in the table below. Drying takes place from one face only.
- (i) Plot the drying rate curve and find the critical moisture content.

Wet slab wt, kg	5	4	3.6	3.5	3.4	3.06	2.85
Drying rate, kg/hr.m <sup>2</sup>	5	5	4.5	4	3.5	2	1
X, Dry basis	1	0.6	0.44	0.4	0.36	0.224	0.14

- (ii) How long will it take to dry the wet slab to 15% moisture on wet basis ?
- (c) Write short notes on
- (i) Typical rate of drying curve
- (ii) Drum dryer

5 Attempt any TWO parts :

10x2=20

- (a) A hot solution containing 1000 kg of  $\text{MgSO}_4$  and water having a concentration of 30 wt%  $\text{MgSO}_4$  is cooled to 288.8 K, where crystals of  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$  are precipitated. The solubility at 288.8 K is 24.5 wt% anhydrous  $\text{MgSO}_4$  in the solution. Calculate the yield of crystals obtained if 5% of the original water in the system evaporates on cooling.
- (b) How much feed is required when 10000 kg of crystal as  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  is produced per hour by a simple vacuum crystallizer. The feed containing 40 parts of  $\text{FeSO}_4$  per 100 parts of total water, enters the crystallizer at 80°C. The crystallizer vacuum is such that crystallizer temperature of 30°C can be produced.

DATA : Saturated solution at 30°C contains 30 parts of  $\text{FeSO}_4$  per 100 parts of total water vapour enthalpy is 612 cal/g (neglect superheat). The enthalpies of saturated solution, the crystals leaving the crystallizer and feed are :

-1.33, -50.56 and 26.002 cal/g.

- (c) Write short notes on
- (i) Krystal crystallizer
  - (ii) Draft tube baffle (DTB) crystallizer.
-