A **Reg. No. :** | | | | | | | | | | |

Question Paper Code: 55902

B.E. / B.Tech. DEGREE EXAMINATION, NOV 2019

Fifth Semester

Chemical Engineering

15UCH502 - MASS TRANSFER - I

(Use of Humidity Chart is permitted)

(Regulation 2015)

Duration: Three hours Maximum: 100 Marks

Answer ALL Questions

PART A - (10 x 1 = 10 Marks)

1. Diffusion coefficient in a binary gas mixture at low pressure varies CO1- R

   (a) directly with P (b) directly with P^2 (c) inversely with P (d) independent of P

2. In the absorption of ammonia from a mixture of ammonia and air in water, the mechanism of diffusion is CO1- U

   (a) Diffusion of A through stagnant B (b) Equimolar counter diffusion

   (c) Unsteady state diffusion (d) Knudsen diffusion

3. At 750K and 1 atm, the approximate value of the Schmidt number for air is CO2- App

   (a) 0.01 (b) 0.1 (c) 1 (d) 10

4. The true driving force for mass transfer between phases is CO2- R

   (a) Difference in concentration between phases

   (b) Difference in temperature and pressure

   (c) Difference in temperature , pressure and concentration

   (d) Difference in chemical potential of the components

5. The relative humidity of air can decrease even if the humidity is increased if the CO3- U

   (a) Temperature rises (b) Pressure rises

   (c) Temperature decreases (d) Air is adiabatically humidified

6. By reducing the wet bulb temperature approach, the height of the cooling tower CO3 R

(a) Increases (b) Decreases (c) Remains unaffected (d) Cannot be predicted

7. In the presence of saturated air CO4- App

(a) no moisture can be removed from the solid

(b) only unbound moisture can be removed

(c) only bound moisture can be removed

(d) moisture in fine capillaries within the solid can be removed

8. A material contains 20% water on wet basis. What is the moisture content of the material on dry basis. CO4- App

(a) 33.3% (b) 25% (c) 16.67% (d) 80%

9. Example for a substance that exhibits inverse solubility is CO5- R

(a) KNO_3 (b) NaCl (c) $Na_2SO_4.10H_2O$ (d) $MnSO_4.10H_2O$

10. Which one of the following is a circulating liquid evaporator crystalliser? CO5- R

(a) Swensen - Walker (b) Krystal (c) Draft-tube-baffle (d) Agitated batch

PART – B (5 x 2= 10 Marks)

11. Show that for molecular diffusion in a binary gas mixture, $D_{AB} = D_{BA}$ CO1- U

12. Prove that he mass transfer coefficients k_y and k_c are related as $k_y = k_c (P/RT)$ CO2- App

13. Distinguish between the wet bulb and adiabatic saturation temperature. CO3- App

14. How would you prevent case hardening in drying CO4- U

15. What are the different methods used for achieving super saturation. CO5- R

PART – C (5 x 16= 80 Marks)

16. (a) (i) Derive from fundamentals the expression for steady state diffusion of gas A through non diffusing B. CO1 App (8)

(ii) In an oxygen-Nitrogen gas mixture at 1 atm, 25^0C, the concentrations of oxygen at two planes 0.2 cm apart are 15% and 30% (by volume) respectively. Calculate the flux of oxygen when
(a) Nitrogen is non-diffusing
(b) Equimolal counter diffusion. Diffusivity of oxygen in nitrogen is 0.26 cm^2/s. CO1 App (8)

Or

(b) (i) Explain briefly the types of solid diffusion CO1- App (8)

(ii) Determine the rate of diffusion of acetic acid (A) across a film of non-diffusing water (B) solution 2mm thick at 17^0C, when the concentrations (by weight) on opposite sides of the film are 20% and 7% acid. The diffusivity of acetic acid in the solution is 0.000095 m^2/S. Density of 10% and 4% acid (by weight) are 1023 Kg/m^3 and 1008 Kg/m^3 respectively. CO1- App (8)

17. (a) (i) Give a detailed write up on different mass transfer theories used as model for explaining the turbulent mass transfer. CO2- App (8)

(ii) In a wetted wall column carbon dioxide is being absorbed from air by water flowing at 2 atm pressure and 25^0C. The mass transfer coefficient k_y has been estimated to be 6.78 $X10^{-5}$ kmol/m^2.S.mole fraction. Calculate the rate of absorption if the partial pressure of carbon dioxide at the interface is 0.2 atm and the air is pure. Also determine k_y and k_g. CO2- App (8)

Or

(b) (i) Illustrate the significance of operating line and equilibrium line for a steady state counter-current process. CO2- App (8)

(ii) The solid naphthalene is diffusing to a stream of air. Area of a thin plate is 1 m^2.The air is at 300K and 1 atm pressure. The diffusivity of naphthalene in in air at a given condition is 4 $x10^{-4}$ m^2/s.Vapour pressure of naphthalene at 300K is 0.5 mm Hg. The velocity of air is 60 cm/s.Data: μ = 0.0185 cP and ρ = 1.15 kg/m^3.If f= 0.072 $(N_{Re})^{-0.25}$, then determine the mass transfer coefficient K_c (in m/s). CO2- App (8)

18. (a) An air – water vapour sample has a dry bulb temperature of 55^o C and absolute humidity 0.033 kg water / kg dry air at 1 standard atmp pressure. Vapour pressure of water at 55^oC is 118 mm Hg, calculate CO3- Ana (16)

(i) Molal Humidity
(ii) Relative Humidity
(iv) Saturated humidity
(v) % Humidity
(vi) Humid volume
(vii) Humid heat
(viii) Enthalpy.

Or

(b) A mechanical draft cooling tower is to be designed to cool 75000 kg/hr of water from 45°C using 62500 kg of dry air per hour. 24°C is suggested as the design air wet bulb temperature. Calculate the number of transfer units and hence the height of the packed section if the height of a transfer unit for the condition stated above is 4 m. It may be assumed that the liquid phase resistance to heat transfer is negligible. Temperature t °C - saturated enthalpy in kcal/kg dry air (H) data is as follows: CO3- Ana (16)

t °C	24	29	32.5	38	43.5
H	20	25	28	36	46

19. (a) (i) A filter cake is dried for 7 hours from an initial moisture content of 35% to 8 % (wet basis).Calculate the time required in hours to dry the filter cake from 35% to 2% (wet basis) CO4- App (8)
Equilibrium moisture content is negligible and Critical moisture content is 10% on dry basis. Assume that the rate of drying in the falling rate period is directly proportional to the free moisture content.

(ii) Classify dryers and explain the construction and working of a spray dryer CO4- App (8)

Or

(b) (i) It takes 9 hours for a porous solid to reduce the moisture content from 45 to 10% when dried in a batch dryer under constant drying conditions. The critical moisture content was found to be 25% and the equilibrium moisture 3%.All moisture contents are on the dry basis. Assuming that the rate of drying during falling rate period is proportional to the free moisture content, how long should it take in hours to dry a sample of the same solid from 35% to 5% under the same drying conditions. CO4- App (8)

(ii) Explain the construction and working of a rotary dryer with a neat sketch. CO4- App (8)

20. (a) (i) Sodium nitrate solution at 50 ^{o}C contains 45 % by weight of sodium nitrate. CO5- U (8)

(a) Find the weight percentage of saturated solution of this solution

(b) Find out the weight of sodium nitrate crystals formed if 1000 kg of this solution is cooled to 10 ^{o}C (iii) Find out the percentage yield of this process. Data: Solubility at 50 ^{o}C = 104.1 g of $NaNO_3$/ 100 g of water. Solubility at 10 ^{o}C = 78 g of $NaNO_3$/ 100 g of water.

(ii) Explain Meir's supersaturation theory with a neat diagram CO5- U (8)

Or

(b) (i) A sodium carbonate solution available at a temperature of 40^{o}C with a solute content of 30%. Find out the weight of $Na_2CO_3.10H_2O$ crystal formed if 2000 kg of this solution is cooled to 10^{o}C. Also find out the yield. Solubility at 10^{o}C = 12.5 g of Na_2CO_3/100 g of water. CO5- U (8)

(ii) With a help of a neat sketch explain the construction and working of a Swenson-walker crystallizer. CO5- U (8)