P P SAVANI UNIVERSITY

Fourth Semester of B. Tech. Examination

May 2019

SECH2080 Mass Transfer Operations

22.05.2019, Wednesday **Time: 09:00 a.m. To 11:30 a.m.** **Maximum Marks: 60**

Instructions:

1. The question paper comprises of two sections.
2. Section I and II must be attempted in separate answer sheets.
3. Make suitable assumptions and draw neat figures wherever required.
4. Use of scientific calculator is allowed.

SECTION – I

Q - 1 MCQ (Any Five) **[05]**

(i) Diffusion is a process of

a) movement of particle from higher concentration to lower concentration
b) movement of particle through a semi-permeable membrane
c) refraction of particle
d) accumulation of particle on a solid surface

(ii) Fick's first law of diffusion for a binary mixture depends on

a) flux in moles/(area. time)
b) diffusion velocity relative to volume average velocity
c) driving potential in terms of the molar concentration
d) all of these

(iii) The unit of diffusion coefficient is

a) m^2/s
b) m/s
c) mole/(m^2.s)
d) none of these

(iv) For an air(A)-water vapour(B) mixture, the partial pressure of the air is 5 pa and the total pressure of the system is 15 pa. The absolute humidity in mass of air/mass of water vapour

a) 0.805
b) 0.311
c) 0.705
d) 0.411

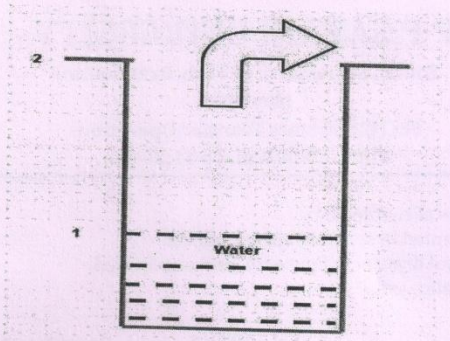
(v) The humidity is represented in

a) Humidity chart
b) Psychometric chart
c) Psychometric chart or humidity chart
d) All of the mentioned

(vi) By differencing the temperature, heat added or removed is

a) Sensible heat
b) Latent heat
c) Heat of vaporization
d) None of the mentioned

(vii) Given diagram shows diffusion of water vapor through air. Identify the correct statement



a) The water evaporates and diffuses downward
b) The water does not evaporates but diffuses upward
c) The water evaporates and diffuses upward
d) The water does not evaporates but diffuses downward

Q - 2 (a) A open bowl, 0.2 m in diameter, contains water at 350 K which is evaporating into the atmosphere. If the air currents are sufficiently strong to remove the water vapor as it is formed and if the resistance to is mass transfer in air is equivalent to that of a 5 mm layer for conditions of molecular diffusion, what will be the rate of Cooling due to evaporation? Water can be considered as well mixed and the water equivalent of the system can be taken as 22 kg. Diffusivity of water vapor in air can be taken as 0.10 cm^2/s. Vapor pressure of water at 350K is 50.5 KN/m^2. Take suitable value of Gas Constant (R) as per the unit. Latent Heat of vaporization of water at 350 K = 2270 KJ/Kg **[05]**

Q - 2 (b) Nitrogen (A) is diffusing through Carbon dioxide (B) under Steady state conditions, with the Carbon dioxide non-diffusing. The total pressure is 4.5×10^5 N/m^2, and temperature 28 °C. The partial pressure of Oxygen at two planes 3.0 mm apart is, respectively, 12,500 and 56,250 N/m^2. The diffusivity for the mixture is 2.04×10^{-5} m^2/s. Calculate the rate of diffusion of oxygen in kmol/s through each square meter of the two planes. **[05]**

OR

Q - 2 (a) In a rectification column, Acetone is diffusing from gas to liquid and methanol from liquid to gas at 40 °C and 101.3 KN/m^2 pressure under condition of equal molar counter diffusion. At one point in the column, molal concentration of Acetone on the two sides of a gas film 0.9 mm thick are 60 % and 30 % respectively. Assume the diffusivity of methanol-acetone vapour under the operating conditions to be 0.25×10^{-5} m^2/s, estimate the rate of diffusion of acetone and methanol in kg/hr across an area of 0.15 m^2. Molecular weight of Acetone and methanol is 58 and 32 g/mol respectively. **[05]**

Q - 2 (b) A service attendant accidentally spills 85 litres of gasoline which quickly spreads over a level surface of area 5 m^2. Estimate the time required for the gasoline to evaporate into the stagnant air above the surface of the liquid. The diffusivity of gasoline in air is 0.42 m^2/h. The air temperature is 398 K. Evaporation may be assumed to take place through a film of air of 6 m thickness. Vapour pressure of gasoline at 398 K is 72 mm Hg. The density of gasoline is 720 kg/m^3 and molecular weight of gasoline is 200. The operation takes place at 1 atm pressure. **[05]**

Q - 3 (a) Discuss with equations the penetration theory for mass transfer coefficient along with its assumptions. **[05]**

Q - 3 (b) Conditioned air at 323 K and 70 % saturation is to be supplied for a laboratory of size 3 m x 10 m x 4 m with no facilities for recirculation. The air conditioner takes the outside **[05]**

air at 333 K and 80 % saturation, refrigerates and separates out the condensed water and reheats the air using steam at 1 atm. Find the volume of air needed at the entry conditions. Also compute the weight of water condensed in the conditioners.
NOTE – Use Psychrometric chart to calculate the parameters.

OR

Q - 3 (a) Define F-type mass transfer coefficients. Also derive the steady state relationship diffusion of A through Non-diffusing B. **[05]**

$$F = K_G P_{BM} = K_y \left(P_{BM}/P_t\right) = K_c (P_{BM}/RT)$$

Q - 3 (b) Hot air is being used to dry a wet materials. The hot air enters the drier at a total pressure of 100 KPa and at 300 K. The partial pressure of water vapour in the incoming air is 3 KPa. At the exit of the drier, the temperature is 290 K and the pressure is 95 KPa. In the outgoing air, partial pressure of water vapour is 15 KPa. Calculate the absolute humidity of incoming air and outgoing air. Also calculate the kg of moisture picked up per 1000 m^3 of entering air. **[05]**

Q - 4 Attempt any one.

(i) What do you understand by Adiabatic saturation temperature and which are the factors affecting Wet bulb temperature. **[05]**

(ii) Derive the relation for steady state molecular diffusion in liquid for the case of equimolal counter diffusion.

SECTION – II

Q - 1 MCQ/Short Question (Any Five) **[05]**

(i) Define supersaturation.

(ii) Define equilibrium moisture content.

(iii) If the solid is dried from all the surfaces in the absence of radiation using hot air, the surface temperature of the solid will be equal to
a) Wet bulb temperature of the air
b) dry bulb temp. of the air
c) boiling point of water
d) Dew point of the air

(iv) Snow is formed by
a) Freezing of liquid water
b) Cooling of ice
c) Crystallization of solid particles in a vapour
d) All of the above

(v) If the moisture content of the wet solid on dry basis is twice the moisture content on wet basis, then the moisture content on dry basis should be
a) 1 times of kg moisture/kg dry solid
b) 0.5 times of kg moisture/kg dry solid
c) 2 times of kg moisture/kg dry solid
d) 1.5 times of kg moisture/kg dry solid

(vi) In a cooling tower, it is desired to cool water from t_{L2} to t_{L1} with air having dry bulb temperature t_{G1} and wet bulb temperature t_{W1}. Which one of the following is correct for feasible operation?
a) $t_{G1} < t_{L1}$
b) $t_{W1} > t_{L1}$
c) $t_{W1} < t_{L1}$
d) $t_{G1} > t_{L1}$

(vii) At what condition the fluid is called supercritical.

Q - 2 (a)	State and discuss about the various equations for time of drying.	[05]
Q - 2 (b)	Discuss the mechanism of cross circulation drying and state the equations associated with it.	[05]

OR

Q - 2 (a)	A wet solid is dried from 35 % moisture content to 10 % moisture content under constant drying conditions in 5 hours. If the equilibrium moisture content is 4 %, critical moisture content is 14 %. How long will it take to dry it to 6 % moisture content under the same conditions? All the moisture content are on wet basis.	[05]

Hint : - Use equation :- $\theta = \frac{m_s}{AN_c} = \left\{(X_a - X_c) + (X_c - X^*) \ln \frac{(X_c - X^*)}{(X_b - X^*)}\right\}$

Q - 2 (b)	Write a short note on drum dryer.	[05]
Q - 3 (a)	State and discuss the various methods of achieving the supersaturation.	[05]
Q - 3 (b)	Discuss in short about various types of solubility curves with suitable examples.	[05]

OR

Q - 3 (a)	Common salt solution contains 20 % sodium chloride and 80 % water by weight. To recover 90 % of dissolved salt, it is proposed to evaporate a part of water and then carry out the crystallization at 303 K. At 303 K, the solubility of Sodium chloride in water is 40 kg per 100 kg of water. Calculate (1) weight of water to be evaporated per 1000 kg of original solution (2) Weight of mother liquor left after crystallization.	[05]
Q - 3 (b)	Explain the construction, working principle and applications of continuous vacuum crystallizer.	[05]
Q - 4	Attempt any one.	[05]
(i)	State the advantages and disadvantages of super critical solvents over conventional liquid solvents.	
(ii)	Explain in short the ROSE process for extraction of heavy oil.	

****