Q. Code:300375

Reg. No. | | | | | | | | | | | | | |

B.E./ B. TECH.DEGREE EXAMINATIONS, MAY 2024

Fifth-Semester

CH18501 – MASS TRANSFER I

(Chemical Engineering)

(Regulation2018/2018A)

Psychrometric chart shall be provided

TIME:3 HOURS **MAX. MARKS: 100**

COURSE OUTCOMES	STATEMENT	RBT LEVEL
CO 1	Apply the principles of diffusion in measuring diffusivity.	**3**
CO 2	Calculate different types of Mass transfer co-efficient and identify the relation between them.	**3**
CO 3	Apply mass transfer concepts in designing humidification units.	**3**
CO 4	Calculate rate of drying using Mass transfer concepts.	**3**
CO 5	Apply mass transfer concepts in designing crystallization units.	**3**

PART- A(10x2=20Marks)

(Answer all Questions)

		CO	RBT LEVEL
1.	Differentiate Fick's first and second law.	**1**	**2**
2.	Mention the diffusivity range for gases, liquids and solids.	**1**	**2**
3.	Plot the curve of gas-liquid equilibrium for interphase mass transfer with the equation of the curve.	**2**	**2**
4.	Mention any two advantages of plate column.	**2**	**2**
5.	Differentiate adiabatic and evaporative cooling.	**3**	**3**
6.	Compare natural draft and forced draft cooling towers.	**3**	**2**
7.	Define Critical moisture.	**4**	**2**
8.	Mention any two examples for batch and continuous dryer each.	**4**	**2**
9.	Illustrate Super-solubility curve.	**5**	**2**
10.	State ΔL Law in crystallization process.	**5**	**2**

PART- B (5x 14=70Marks)

			Marks	CO	RBT LEVEL
11. (a)	**(i)**	Derive the flux equation for Difusion of gas A through a stagnant, non-diffusing gas B	**(8)**	**1**	**2**

	(ii)	Write a short note on Multicomponent diffusion.	**(6)**	**1**	**2**
		(OR)			
(b)	**(i)**	A tube of 2 cm inside diameter and 40 cm long is filled with CO_2 and H_2 at a total pressure of 2 atm at 0°C. The diffusion coefficient of the $CO_2 – H_2$ system under these conditions is 0.25 cm^2/s. If the partial pressure of CO_2 is 1.5 atm at one end of the tube and 0.5 atm at the other end, find the rate of diffusion in mol/h for the steady state counter diffusion where $N_B = -0.2\ N_A$	**(7)**	**1**	**2**
	(ii)	An ammonia (A) – water (B) solution at 278 K and 4.0 mm thick is in contact at one surface with an organic liquid at this interface. The concentration of ammonia in the organic phase is held constant and is such that the equilibrium concentration of ammonia in the water at this surface is 5.0 wt % ammonia (density of aqueous solution 991.7 kg/m^3) and the concentration of ammonia in water at the other end of the film 4.0 mm away is 12 wt %. (density = 961.7 kg/m^3). Water and the organic are insoluble in each other. The diffusion coefficient of NH_3 in water is 1.04×10^{-9} m^2/s. At steady state, calculate the flux, N_A in $kgmol/s.m^2$. Assume 100 kg of solution.	**(7)**	**1**	**2**
12. (a)	**(i)**	Discuss about the dimensionless group in Mass transfer and their corresponding analogies group in heat and momentum transfer.	**(8)**	**2**	**3**
	(ii)	Compare stage wise and differential contactors.	**(6)**	**2**	**3**
		(OR)			
(b)		In an experimental study of the absorption of ammonia by water in a wetted-wall column, the value of overall mass transfer coefficient, K_G, was found to be 2.75×10^{-6} $kmol/m^2.s.KPa$. At one point in the column, the composition of the gas and liquid phases were 8.0 and 0.115 mol% NH_3, respectively. The temperature was 300 K and the total pressure was 1 atm. 85% of the total resistance to mass transfer was found to be in the gas phase. At 300 K, Ammonia –water solutions follow Henry's law upto 5 mole% ammonia in the liquid, with m = 1.64 when the total pressure is 1 atm. Calculate the individual film coefficients and the interfacial concentrations. Interfacial concentrations lie on the equilibrium line.	**(14)**	**2**	**3**

13. (a) Apply enthalpy concept to design a cooling tower to determine its height. **(14) 3 3**

(OR)

(b) Air at a temperature of 30°C and a pressure of 100 kPA has a relative humidity of 80%. Calculate **(14) 3 3**

(i) the molal humidity of air.

(2 Marks)

(ii) the molal humidity of this air if its temperature is reduced to 15°C and its pressure increased to 200 kPa, condensing out some of the water.

(4 Marks)

(iii) the weight of water condensed from 100 m^3 of the original wet air in cooling to 15°C and compressing to 200 kPA.

(4 Marks)

(iv) the final volume of the wet air of part (iii).

(4 Marks)

14. (a) An insoluble wet granular material is dried in a pan 0.4 x 0.4 m and 25 mm deep. The material is 24 mm deep in the pan and the sides and bottom can be considered to be insulated. Heat transfer by convection from an air stream parallel to the surface at a velocity of 8 m/s. The air is at 65.6 °C and has a humidity of 0.010 kg H_2O/kg dry air. Estimate the rate of drying (kg of H_2O/h) for the constant rate period. **(14) 4 3**

(OR)

(b) A batch of wet solid is to be dried from a free moisture content of X_1 = 0.38 kg H_2O/ kg dry solid to X_2 = 0.04 kg H_2O/kg dry solid. The weight is 399 kg dry solid and area is 18.58 m^2 of top drying surface. Drying rate constant (R_c) is 1.51 kg $H_2O/(h.m^2)$ and critical moisture content is 0.195 kg H_2O/kg dry solid. Drying occurs in the constant-rate and falling-rate periods. In falling rate period moisture content and rate of drying varies as shown in Table 14b. Calculate the total drying time required. Also construct drying rate curve based on free moisture and attach to your answer booklet. **(14) 4 3**

Table 14b Falling rate period

X	0.195	0.15	0.1	0.065	0.05	0.04
R	1.51	1.21	0.9	0.71	0.37	0.27

			Marks	CO	RBT LEVEL
15. (a)	**(i)**	Write the design procedure of continuous crystallizer.	**(8)**	**5**	**3**
	(ii)	Discuss elaborately Circulating-liquid evaporator crystallizers.	**(6)**	**5**	**3**
		(OR)			
(b)	**(i)**	A saturated solution containing 1500 kg of potassium chloride at 360K is cooled in an open tank to 290K. If the density of the solution is 1200 kg/m^3 and the solubility of potassium chloride is 53.55 kg/100kg water at 360K and 34.5 kg/100kg water at 290K, calculate the capacity of the tank required and the mass of crystals obtained, neglecting loss of water by evaporation.	**(10)**	**5**	**3**
	(ii)	The heat required when 1 kgmol of $MgSO_4.7H_2O$ is absorbed isothermally (i.e., dissolved) at 291K in a large mass of water is 13.3 MJ. Calculate the heat of crystallisation per unit mass of the salt.	**(4)**	**5**	**3**

PART- C (1x 10=10Marks)

(Q.No.16 is compulsory)

		Marks	CO	RBT LEVEL
16.	Assess the role of spray dryer in various Food Processing Industries.	**(10)**	**4**	**5**

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