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

B.E / B.TECH. DEGREE EXAMINATION, MAY 2023

Fifth Semester

CH18501 – MASS TRANSFER 1

(Chemical Engineering)

(Regulation 2018)

(Psychrometric chart may be permitted)

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

CO1 Apply the principles of diffusion in measuring diffusivity.
CO2 Calculate different types of Mass transfer co-efficient and identify the relation between them.
CO3 Apply mass transfer concepts in designing humidification units.
CO4 Calculate rate of drying using Mass transfer concepts.
CO5 Apply mass transfer concepts in designing crystallization units.

PART- A (10x2=20Marks)

(Answer all Questions)

		CO	RBT LEVEL
1.	List any one example for Fick's first and second law of diffusion each.	**1**	**2**
2.	Infer the difference between molecular and total flux.	**1**	**2**
3.	Show the relationship between K_L and K_x.	**2**	**2**
4.	Differentiate between HTU and HETP.	**2**	**2**
5.	State Adiabatic saturation temperature and mention its significance.	**3**	**1**
6.	Classify different types of cooling tower and draw a sketch of anyone.	**3**	**1**
7.	Enumerate different types of dryers and list its application.	**4**	**1**
8.	Point out bound moisture and free moisture in drying rate curve and define them.	**4**	**1**
9.	Show the material and Energy balance of a Crystallizer.	**5**	**2**
10.	Brief secondary nucleation in Crystallization process.	**5**	**2**

PART- B (5x 14=70Marks)

			Marks	CO	RBT LEVEL
11. (a)	**(i)**	Derive the flux equation for equimolar counter diffusion.	**(9)**	**1**	**3**
	(ii)	Write a short note on Multi-component diffusion.	**(5)**	**1**	**3**

(OR)

(b)	**(i)**	A sphere of naphthalene having a radius of 2 mm is suspended in a large volume of still air at 318 K and 1.01325 X 10^5 Pa (1 atm). The surface temperature of naphthalene can be assumed to be at 318 K and its vapour pressure at 318 K is 0.555 mm Hg. The D_{AB} of naphthalene in air at 318 K is 5.9 X 10^{-6} m^2/s. Calculate the rate of evaporation of naphthalene from the surface.	**(7)**	**1**	**3**
	(ii)	A gas hydrogen at 17°C and 0.01 atm partial pressure is diffusing trough a membrane of vulcanized neoprene rubber 0.5mm thick. The pressure of H_2 on the other side of the neoprene is zero. Calculate the steady state flux, assuming that the only resistance to diffusion is in the membrane. The solubility S of H_2 gas in neoprene at 17 °C is 0.051 m^3 (at STP of 0 °C and 1 atm)/m^3 solid. atm and the diffusivity D_{AB} is 1X10^{-10} m^2/s at 17 °C.	**(7)**	**1**	**3**
12. (a)	**(i)**	Explain Penetration theory and surface renewal theory of Mass Transfer.	**(7)**	**2**	**3**
	(ii)	Illustrate any one differential contactor and explain its working principle with sketch.	**(7)**	**2**	**3**

(OR)

(b)		In an experimental study of absorption of ammonia by water in a wetted wall column, the overall gas phase mass transfer coefficient, K_G was estimated as 2.7 X 10^{-4} kmol/m^2 s atm. At one point in the column the gas contained 10 mol % ammonia and the liquid phase concentration was 6.4 X 10^{-2} kmol NH_3/ m^3 of solution. Temperature is 293 K and the total pressure is 1 atm. 85% of the resistance to mass transfer lies in gas phase. If Henry's law constant is 9.3 X 10^{-3} atm. m^3/kmol, calculate the individual film coefficient and the interfacial composition.	**(14)**	**2**	**3**
13. (a)		Derive the design equation of Cooling tower using enthalpy concept.	**(14)**	**3**	**3**

(OR)

(b)		Humid air is enclosed in a 2- litre flask at 40°C. The flask is slowly cooled. When the temperature reaches 20°C (dew point), drops of moisture become visible on the flask wall. Although the pressure in the flask changes when	**(14)**	**3**	**3**

the pressure drops, it remains close enough to 1 atm for the psychrometric chart to provide a close representation of the behavior of the system throughout the process.

i). Use the psychometric chart to estimate the relative humidity, absolute humidity, humid volume and wet bulb temperature of the air at 40ºC. (7 Marks)

ii). Calculate the mass of the water in the flask. (3 marks)

iii). Calculate the enthalpy change in J (joules) undergone by the air from 40ºC to 20ºC. (4 marks)

14. (a)	**(i)**	Sketch the rotary dryer and construct the mass and energy balance.	**(7)**	**4**	**3**
	(ii)	Explain elaborately the working mechanism of Spray dryer and list their applications.	**(7)**	**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 14 b. 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

15. (a)		Write the design procedure of Continuous Crystallizers.	**(14)**	**5**	**3**
		(OR)			
(b)		Glauber's salt, $Na_2SO_4.10H_2O$, is to be produced in a Swenson-Walker Crystalliser by cooling to 290K a solution of anhydrous Na_2SO_4, which is saturated at 300K. If cooling water enters and leaves the unit at 275K and 290K, respectively, and evaporation is negligible, calculate the sections of	**(14)**	**5**	**3**

crystalliser, each 3 m long, will be required to process 0.25 kg/s of the product. The solubilities of anhydrous Na_2SO_4 in water are 40 and 14 kg/100 kg water at 300K and 290K, respectively. The mean heat capacity of the liquor is 3.8 kJ/kg.K and the heat of crystallisation is 230 kJ/kg. For the crystallizer, the available heat transfer area is 3 m^2/m length, the overall heat transfer coefficient is 0.15 kW/m^2.K and the molecular weights of $Na_2SO_4.10H_2O$ and Na_2SO_4 are 322 and 142 kg/kgmol, respectively.

PART- C(1x 10=10Marks)

(Q.No.16 is compulsory)

			Marks	CO	RBT LEVEL
16.		Highlight the significance and applications of cooling tower in chemical Process industries and Heating, Ventilation and air conditioning (HVAC) system.	**(10)**	**1**	**3**

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