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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

April 2024 Semester End Main Examinations

Programme: B.E. **Semester: IV**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 22CH4PCMT1 **Max Marks: 100**
Course: Mass Transfer-I

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. Use of steam table and humidity chart is allowed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	***CO***	***PO***	**Marks**
1	a)	Ammonia vapour is diffusing at a constant rate through a layer of 1 mm thickness of stagnant air. Conditions are such that the gas contains 50% by volume ammonia at one boundary of the stagnant layer. The ammonia diffusing to the other boundary is quickly absorbed and the concentration is negligible at that plane. The temperature is 295 K and the pressure atmospheric, and under this conditions diffusivity of ammonia in air is 1.8×10^{-5} m^2/s. Estimate the rate of diffusion of ammonia through the layer.	*CO 3*	*PO 2*	**10**
	b)	Derive the molar flux equation for which steady state diffusion of A through non diffusing B.	*CO 2*	*PO 2*	**10**
		OR			
2	a)	An ethanol(A)-water (B) solution in the form of a stagnant film 2 mm thick at 293 K is in contact at one surface with an organic solvent in which ethanol is soluble and water is insoluble i.e., N_B = 0. At point 1, the concentration of ethanol is 16.8 wt.% and solution density ρ_1 is 972.8 kg/m^3. At point 2, the concentration of ethanol is 6.8 wt.% and density ρ_2 is 988.1 kg/m^3. Diffusivity of ethanol is 0.740×10^{-9} m^2/s. Calculate the study sate flux N_A.	*CO 3*	*PO 2*	**10**
	b)	Describe the film theory with the help of a neat sketch.	*CO 1*	*PO 1*	**10**
		UNIT - II			
3	a)	The air stream is entering in a dryer which has dry bulb temperature of 60°C and the dew point of 26.7°C. i. Using humidity chart, determine the actual humidity, percentage humidity humid heat and humid volume?	*CO 4*	*PO 2*	**12**

ii. The outlet air stream from the dryer is allowed to contact with water in an adiabatic saturator. It is cooled and humidified to 90% saturation. Calculate the final values of humidity and temperature.

b) How is adiabatic humidification cooling operation carried out in spray chambers? Describe its phenomena with the help of diagram. — *CO 1* | *PO 1* | **08**

OR

4 a) What do you understand by the following terms and explain its significance with the respect to humidification/dehumidification process. — *CO 1* | *PO 1* | **12**

i. Psychrometric chart
ii. Wet bulb temperature
iii. Wet bulb depression
iv. Psychrometric ratio
v. Dew point temperature
vi. Dry bulb temperature

b) A water vapor-air mixture having a dry bulb temperature of T = 60°C is passed over a wet wick and the wet bulb temperature obtained as 29.5°C. What is the humidity of the mixture? — *CO 4* | *PO 2* | **08**

UNIT - III

5 a) The experimental data test on the tray-drying of sand with superheated steam is given in the below Table. Plot the drying rate curve for this test and identify the constant drying rate, falling drying rate regions, bound moisture, unbound moisture, and the critical moisture points on the graph. — *CO3* | *PO 2* | **12**

Data: Area of tray: 0.218 m^2; bed thickness: 25.4 mm; steam pressure: 3.5 bar; weight of dry sand: 12.3 kg.

Table: The experimental data of moisture content v/s time of drying.

S.NO.	Drying time (h)	Total moisture (kg)		S.NO.	Drying time (h)	Total moisture (kg)
1	0	2.070		14	3.25	0.707
2	0.25	1.943		15	3.5	0.630
3	0.5	1.835		16	3.75	0.535
4	0.75	1.740		17	4	0.430
5	1	1.631		18	4.25	0.353
6	1.25	1.527		19	4. 5	0.272
7	1.5	1.413		20	4.75	0.217
8	1.75	1.318		21	5	0.163
9	2	1.214		22	5.5	0.118
10	2.25	1.119		23	6	0.063
11	2.5	1.015		24	6.5	0.032
12	2.75	0.915		25	7	0.009
13	3	0.806		26	7.5	0.000

		b)	Analyze the effect of process variables such as air velocity, gas humidity, gas temperature and thickness of solid on the constant rate drying period?	*CO1*	*PO1*	**08**
			UNIT - IV			
	6	a)	Apply material balance around the single stage adsorption process and derive the operating line expression. Discuss the different Freundlich equilibrium curves with the help of a diagram for single stage absorption.	*CO2*	*PO2*	**10**
		b)	Explain the fixed bed absorption of solvent vapors at lower pressure with the help diagram.	*CO5*	*PO5*	**10**
			UNIT - V			
	7	a)	A salt solution on 10,000 kg with 30 wt.% of Na_2CO_3 is cooled to 293 K. The salt crystallizes as dehydrate. What will be the yield of $Na_2CO_3.10H_20$ if solubility is 21.5 kg anhydrous/100 kg total water? Assume no water is lost due to evaporation.	*CO3*	*PO2*	**10**
		b)	Describe the vacuum crystallizer with the help of diagram.	*CO5*	*PO5*	**10**

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April 2024 Semester End Main Examinations

Programme: B.E. **Semester: IV**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 22CH4PCTD2 **Max Marks: 100**
Course: Process Engineering Thermodynamics-II

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

			CO	PO	Marks
		UNIT - I			
1	a)	Show that - ΔA = W. Explain the significance of the equation-ΔG = W-PV.	CO1	PO1	**05**
	b)	Derive and explain the significance of Gibbs free energy change and the fundamental property relation.	CO1	PO1	**05**
	c)	Derive Clausius - Clapeyron equation. What are the applications of the equation?	CO2	PO2	**10**
		OR			
2	a)	With a neat diagram, explain P-H and H-S diagram.	CO4	PO3	**10**
	b)	Derive entropy and heat capacity relationships at constant (T, V) and constant (P, T). Deduce the equation $C_p - C_v = R$ for ideal gases.	CO2	PO2	**10**
		UNIT - II			
3	a)	Explain the relation between residual property and fugacity coefficient of a mixture.	CO3	PO2	**10**
	b)	Derive and discuss Lewis Randal rule and Henry's law with graphical representations.	CO3	PO2	**10**
		OR			
4	a)	Show that ΔG = Σ xi ($\overline{G_i}$ - G_i^o) and ΔS_{mixing} = -RTΣ xi Ln(1/x_i), where x is mole fraction.	CO6	PO3	**10**
	b)	The volume of a solution prepared from $MgSO_4$ and 1 kg of H_2O varies with molality according to the expression $V = 1.00121 \times 10^{-3} + 34.09 \times 10^{-6}(m - 0.070)^2$ Where, m is the molality of the solution in mole / kg and V is the volume in m^3. Calculate the partial molar volume of the salt and solvent when m = 0.05 mole / kg.	CO3	PO2	**10**

<table>
<tr><td></td><td></td><td></td><td>UNIT - III</td><td></td><td></td><td></td></tr>
<tr><td></td><td>5</td><td>a)</td><td>With a neat diagram explain T-xy diagram.</td><td>CO6</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>A vapour mixture of benzene (1) and toluene (2) with 0.75 mole fraction benzene initially at 130^0C and 750 Torr is cooled at constant pressure. Find the temperature at which condensation occurs and the composition of liquid that forms.
The vapour pressure of benzene-toluene are given by
Log $p_1^s = 6.8798 - \frac{1196.760}{T+219.161}$ and log $p_2^s = 6.9508 - \frac{1342.310}{T+219.187}$
Where T is in ^{0}C and P^s is in Torr</td><td>CO3</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td>UNIT - IV</td><td></td><td></td><td></td></tr>
<tr><td></td><td>6</td><td>a)</td><td>Explain thermodynamic consistency tests using slope of lnγ curve, co-existence equation and area test.</td><td>CO6</td><td>PO3</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>At a pressure of 101.3 kPa, ethyl acetate (1) and ethyl alcohol (2) form an azeotrope containing 53.90 mole % ethyl acetate at 345 K.
i) Determine Van Laar constants
ii) Determine the composition of vapour in equilibrium with a liquid composition 60 mole % alcohol and 40 mole % acetate at boiling temperature of 329.5 K.
<table>
<tr><td>Saturation vapour pressure of component, kPa</td><td>Ethyl acetate</td><td>Ethyl achohol</td></tr>
<tr><td>345</td><td>84.77</td><td>78.74</td></tr>
<tr><td>329.5</td><td>47.78</td><td>39.72</td></tr>
</table></td><td>CO3</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td>UNIT - V</td><td></td><td></td><td></td></tr>
<tr><td></td><td>7</td><td>a)</td><td>Explain the effect of temperature on equilibrium temperature with the help of supporting equations. .</td><td>CO2</td><td>PO2</td><td>06</td></tr>
<tr><td></td><td></td><td>b)</td><td>Distinguish between ΔG and ΔG^0 and derive $\Delta G^0 = - RT \ln K$.</td><td>CO2</td><td>PO2</td><td>06</td></tr>
<tr><td></td><td></td><td>c)</td><td>The following gas phase reactions occur in a mixture initially containing 2 moles ethane and 3 moles steam.
1) $CH_4 + H_2O \rightarrow CO + 3H_2$
2) $CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$
Derive the expressions for the mole fractions of the components in terms of the extent of reaction.</td><td>CO5</td><td>PO3</td><td>08</td></tr>
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April 2024 Semester End Main Examinations

Programme: B.E. **Semester: IV**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 22CH4PCHTR **Max Marks: 100**
Course: Process Heat Transfer

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. Use of steam tables is allowed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	*CO*	*PO*	Marks
1	a)	Explain the modes of heat transfer by mentioning the fundamental laws associated with each of them.	*1*	*1*	**04**
	b)	Explain thermal conductivity and its variation for different materials also remark on its variation under different conditions.	*1*	*1*	**06**
	c)	A cold storage room has walls made of 200 mm of brick on the outside, 80 mm of plastic foam, and finally 20 mm of wood on the inside. The outside and inside air temperatures are -25°C and 3°C, respectively. If the outside and inside convective heat transfer coefficients are 10 and 30 W/m^2 °C respectively, and the thermal conductivities of brick, foam and wood are 1.0, 0.02 and 0.17 W/m °C, respectively, determine: i. Overall heat transfer coefficient ii. The rate of heat removed by refrigeration if the total wall area is 100 m^2	*3*	*2*	**10**
		UNIT - II			
2	a)	What is critical thickness of insulation? Write its application.	*4*	*2*	**04**
	b)	Explain how fins can increase the rate of heat transfer. Mention the most common types of fins and sketch them. Write some practical examples of fins.	*4*	*2*	**08**
	c)	Pin fins are provided to increase the heat transfer rate from a hot surface. Which of the following arrangement will give higher heat transfer rate? I. 6 fins of 10 cm length II. 12 fins of 5 cm length Data: k = 200 W/m°C, h = 20 W/m^2 °C, A_{cs}= 2 cm^2, P = 4 cm, temperature at fin base, T_o = 23°C and T_a = 40°C	*4*	*2*	**08**

			OR			
	3	a)	Briefly explain optimum thickness of insulation.	*4*	*2*	**04**
		b)	Derive the expression for the temperature distribution and heat dissipation from a fin insulated at the tip.	*4*	*2*	**08**
		c)	A wire of 6.5 mm diameter at a temperature of 60°C is to be insulated by a material having k = 0.174 W/m°C. Convection heat transfer coefficient (h_o) = 8.722 W/m^2°C. The ambient temperature is 20°C. For maximum heat loss, what is the minimum thickness of insulation and heat loss per meter length? Also, find percentage increase in the heat dissipation.	*4*	*2*	**08**
			UNIT - III			
	4	a)	Explain the concept of LMTD and derive LMTD expression for counter flow heat exchanger. Write all the assumptions.	*5*	*3*	**10**
		b)	A parallel flow heat exchanger has its tubes of 5 cm internal and 6 cm external diameter. The air flows inside the tubes and receives heat from hot gases circulated in the annular space of the tube at the rate of 100 kW. Inside and outside heat transfer coefficients are 250 W/m^2K and 400 W/m^2 K, respectively. Inlet temperature of hot gases is 500°C, outlet temperature of hot gases is 300°C, inlet temperature of air is 50°C, and exit temperature of air is 140°C. Neglecting the thermal resistance of the tube. Calculate: i. Overall heat transfer coefficient based on outer surface area. ii. Length of the tube required to affect the heat transfer rates. iii. If each tube is 3 m length find the number of tubes required.	*5*	*3*	**10**
			OR			
	5	a)	Illustrate by sketch the different regimes of boiling heat transfer phenomena.	*5*	*3*	**06**
		b)	Discuss the different types of processes of condensation of vapors on a solid surface.	*5*	*3*	**06**
		c)	Saturated steam at 120°C condenses on a 2 cm OD vertical tube which is 20 cm long. The tube wall is maintained at a temperature of 119°C. Calculate the average heat transfer coefficient and the thickness of the condensate film at the base of the tube. Assume Nusselt's solution is valid. Data: $P_{sat} = 1.985\ bar, \rho_w = 943\frac{kg}{m^3},\ h_{fg} = 2202.2\frac{kJ}{kg}$, $k_w = 0686\ \frac{W}{m\ K}$, and $\mu = 237.3\ \times 10^{-6} Ns/m^2$	*5*	*3*	**08**

			UNIT - IV			
	6	a)	How evaporators are classified? What are the characteristics of the solution which are important in design and operation of evaporators and how do these characteristics affect the evaporation process?	*5*	*3*	**08**
		b)	A single effect evaporator is used to concentrate 15000kg/h of a 20% solution of caustic soda to 60 % concentration. Heating medium is dry and saturated steam at 125°C. The vapor space pressure is 100mm Hg (absolute). Find out the steam consumption, steam economy and the heat transfer area if the following data is available. Feed temperature = 37°C, BPE = 52°C, $(C_p)_{feed}$ = 0.92, $(C_p)_{product}$ = 0.75, and overall heat transfer Coefficient U_o=1200W/m^2 °C	*5*	*3*	**12**
			UNIT - V			
	7	a)	State and prove Kirchhoff's law of radiation.	*2*	*2*	**06**
		b)	Explicit the use of radiation shields in radiative heat transfer.	*1*	*1*	**04**
		c)	Calculate the following for an industrial furnace in the form of a black body and emitting radiation at 2500°C. I. Monochromatic emissive power at 1.2 micrometer length. II. Wavelength at which the emission is maximum. III. Maximum emissive power. IV. Total emissive power, and V. Total emissive power of the furnace if it is assumed as a real surface with emissivity equal to 0.9.	*3*	*3*	**10**

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