U.S.N.										

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

Autonomous Institute Affiliated to VTU

February 2025 Semester End Main Examinations

Programme: B.E. **Semester: IV**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 23CH4PCMT1 / 22CH4PCMT1 **Max Marks: 100**
Course: Mass Transfer-I

Instructions:
1. Answer any FIVE full questions, choosing one full question from each unit.
2. Use of Steam tables and humidity chart is permitted.
3. 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)	What is the application of the Wilkee-Lee equation? Write the equation and mention the various terms.	CO2	PO2	**04**
	b)	Derive an equation for steady-state equimolar counter diffusion for liquids.	CO2	PO2	**08**
	c)	A well located in the desert is 10 m deep to the water level and 1 m in diameter. The stagnant air and the water in the well are at 32°C and 1 atm pressure. A slight breeze of dry air is blowing across the top of the well. The partial pressure of water vapour in the air at the surface of the water is 45 mmHg. The diffusivity of water in air at 32°C and 1 atm is 0.06 m^2/h. Calculate the diffusion rate of water vapour in kg/s at steady-state from the surface of water in the well.	CO3	PO2	**08**
		OR			
2	a)	Show that the overall mass transfer coefficient K_y for a component transferring from gaseous phase to liquid phase, can be expressed as below. k_x and k_y individual phase mass transfer coefficient and slope of the equilibrium curve m´. $$\frac{1}{K_y} = \frac{1}{k_y} + \frac{m'}{k_x}$$	CO2	PO2	**06**
	b)	Ethanol vapour (A) diffusing in air (B) at 1 standard atmospheric pressure and 0 °C. Determine the diffusivity of A in B by Wilkee Lee Method. Data: • The boiling point of ethanol is 78.4°C • Molecular Separation Collision =r_{AB} = 0.416 nm and • $f\left(kT/\varepsilon_{AB}\right) = 0.6$	CO3	PO2	**07**
	c)	Derive the expression for diffusion rate through a solid cylindrical tube with inner and outer diameter, a_1 and a_2, respectively.	CO2	PO2	**07**
		UNIT - II			
3	a)	In a mixture of benzene vapour (A) and nitrogen gas (B) at a total pressure of 800 mmHg and a temperature of 60°C, the partial pressure of benzene is 100 mmHg. Express the benzene concentration in mole and volume fractions, absolute and molal absolute humidity.	CO4	PO2	**10**

		b)	Develop an equation for adiabatic saturation temperature curve.	*CO2*	*PO2*	**10**
			OR			
	4	a)	Discuss the various types of cooling towers with schematic diagrams. Mention any four industries where cooling towers are used.	*CO4*	*PO2*	**10**
		b)	For a moist air of dry bulb temperature 40 °C and absolute humidity 0.04 kg water/kg dry air, determine (i) vapor pressure, (ii) humid volume, (iii) partial pressure, (iv) percentage humidity, and (v) humid heat.	*CO4*	*PO2*	**10**
			UNIT - III			
	5	a)	Explain the working principle with a neat sketch and enlist the industrial applications of spray drier.	*CO5*	*PO5*	**10**
		b)	When a porous dry solid was dried under constant drying conditions in a batch drier, it took 3 hours to reduce the moisture content from 20% to 10%. The critical and equilibrium moisture contents were found to be 16% and 2%, respectively. All moisture contents are on a dry basis. Assuming that the drying rate during the falling period is proportional to the free moisture content, how long would it take to dry a sample of the above solid from 30% to 5% under the same drying conditions?	*CO5*	*PO5*	**10**
			OR			
	6	a)	Derive an equation to determine the time for a constant rate period.	*CO5*	*PO5*	**10**
		b)	Explain the classification of drying operations and explain one drying operation in detail	*CO5*	*PO5*	**10**
			UNIT - IV			
	7	a)	From basics, derive the intermediate concentration of a two-stage cross-current adsorption process. State all the assumptions made.	*CO2*	*PO2*	**10**
		b)	A liquid solution is to be decolorized by adsorption. The adsorption equilibrium is represented by $x = 0.65y^{0.25}$ where x is parts of color removed per part of adsorbent and y is the part of color present in 1000 parts of carrier. Calculate the percent removal of color from a solution containing 100 kg color carrying materials with an initial concentration of 1 part color per 3 parts of carrier and is treated with 15 kg adsorbent using a single stage crosscurrent adsorber.	*CO3*	*PO2*	**10**
			OR			
	8	a)	With a suitable example, explain the application of the Freundlich equation.	*CO2*	*PO2*	**10**
		b)	Using material balance equations, obtain an expression to find the minimum total adsorbent for the two-stage counter-current operation.	*CO3*	*PO2*	**10**
			UNIT - V			
	9	a)	Discuss the importance and limitations of Mier's supersaturation theory for crystallization.	*CO5*	*PO5*	**10**
		b)	A saturated solution of $MgSO_4$ at 90°C is cooled to 30°C in an evaporative crystalliser whose 10% material present is evaporated. Calculate the quantity of the original solution to be used for the production of 19,000 kg of $MgSO_4 \cdot 7H_2O$. Solubility of $MgSO_4$ at 90°C = 68.2 g/100 g of water and at 30°C = 40.8 g/100 g of water.	*CO5*	*PO5*	**10**
			OR			

	10	a)	What are the different methods of super-saturation? Explain.	*CO5*	*PO5*	**10**
		b)	Classify the crystallizer equipment based on the methods of obtaining super-saturation. With a neat figure, explain the working and applications of the Swenson walker crystallizer.	*CO*5	*PO5*	**10**

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