U.S.N.										

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

Autonomous Institute Affiliated to VTU

June 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. Missing data, if any, may be suitably assumed.
3. Use of Psychometric chart is permitted.

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)	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. Mention the type of problem and calculate the diffusion rate in kg/s at steady state from the surface of water in the well.	*CO3*	*PO2*	**10**
	b)	Derive an equation for steady-state equimolar counter diffusion for liquids.	*CO2*	*PO2*	**10**
		OR			
2	a)	What is the application of the Wilkee-Lee equation? Write the equation and mention the various terms.	*CO2*	*PO2*	**05**
	b)	Discuss about the diffusion through polymers mentioning the temperature dependence equation.	*CO2*	*PO2*	**05**
	c)	Derive an equation to find the molar flux of gas 'A' when two gases (A and B) diffuse counter-currently. State your assumptions explicitly.	*CO2*	*PO2*	**10**
		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, and find absolute and molal absolute humidity.	*CO4*	*PO2*	**10**

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<tr><td></td><td></td><td>b)</td><td>Develop an equation for adiabatic saturation temperature curve from basics.</td><td>CO1</td><td>PO1</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td></td><td>4</td><td>a)</td><td>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.</td><td>CO4</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>Discuss the different types of cooling towers with schematic diagrams. Mention any four industries where cooling towers are used.</td><td>CO5</td><td>PO5</td><td>10</td></tr>
<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>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?</td><td>CO3</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>Explain the working principle of a spray drier with a figure. Discuss the industrial applications of spray driers.</td><td>CO3</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td></td><td>6</td><td>a)</td><td>A batch of solids is to be dried from 25 to 6% moisture. The initial weight of the wet solid is 160 kg and the drying surface is 1 m^2/40 kg dry weight. The following data is available. Critical moisture content = 0.2 kg water/kg dry solid, critical rate of drying = 0.3×10^{-3} kg/m^2s. Determine the time for drying, for falling rate period use the following data.
<table>
<tr><td>X</td><td>0.2</td><td>0.18</td><td>0.16</td><td>0.14</td><td>0.12</td><td>0.1</td><td>0.09</td><td>0.08</td></tr>
<tr><td>N×10³ (kg/m^2s)</td><td>0.3</td><td>0.266</td><td>0.239</td><td>0.208</td><td>0.180</td><td>0.15</td><td>0.097</td><td>0.07</td></tr>
</table></td><td>CO3</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>Derive an expression for evaluating the total drying time for all the cases of drying.</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>7</td><td>a)</td><td>The equilibrium adsorption of acetone vapour on a powder sample of activated carbon at 30 °C is given by,
<table>
<tr><td>g adsorbed/g carbon</td><td>0</td><td>0.1</td><td>0.2</td><td>0.3</td><td>0.35</td></tr>
<tr><td>Partial pressure of acetone (mmHg)</td><td>0</td><td>2.0</td><td>12.0</td><td>42.0</td><td>92.0</td></tr>
</table>
A litre flask contains air and acetone vapour at 1 atm and 30 °C with the partial pressure of acetone 100 mmHg. Two gram of fresh activated carbon powder is introduced into the flask and</td><td>CO3</td><td>PO2</td><td>12</td></tr>
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			sealed. Compute the final vapour concentration at 30 °C and the pressure inside the flask. Neglect the adsorption of air.			
		b)	From basics, show that for a two-stage cross-current adsorption process, the following equation is obtained. $\left(1-\frac{1}{n}\right)=\left(\frac{Y_1}{Y_2}\right)^{1/n}-\frac{1}{n}\left(\frac{Y_0}{Y_1}\right)$. State all the assumptions made.	*CO3*	*PO2*	**08**
			OR			
	8	a)	What are the characteristics of a good adsorbent?	*CO1*	*PO1*	**04**
		b)	Explain the application of Freundlich adsorption isotherm.	*CO1*	*PO1*	**06**
		c)	Experiments on decolourisation of oil yield the following equilibrium relationship: $Y = 0.5X^{0.5}$; where Y = g colour removed/ 1000g colour free oil, X = colour in oil, g colour/1000g colour free oil 100kg oil containing 1 part of colour to 3 parts of oil is agitated with 25kg of adsorbent. Calculate the percentage colour removed if 25kg of adsorbent is used in one step.	*CO3*	*PO2*	**10**
			UNIT - V			
	9	a)	A saturated solution of $MgSO_4$ at 90°C is cooled to 30°C in an evaporative crystallizer. The 10% of 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.	*CO3*	*PO2*	**10**
		b)	Discuss the importance and limitations of Mier's supersaturation theory in crystallization.	*CO1*	*PO1*	**10**
			OR			
	10	a)	A simple vacuum crystallizer is to produce 7500 kg/h of $FeSO_4.7H_2O$ crystals. The feed is a solution containing 38.9 parts per 100 parts of water at 70 °C. The crystallizer operates at a temperature of 27 °C. Neglecting boiling point raise, determine the amount of feed solution required. **Data:** The solubility of $FeSO_4.7H_2O$ crystals at 27 °C is 30.2 parts per 100 parts water Enthalpy values: Feed solution: +109.2 kJ/kg, crystals: –214.2 kJ/kg and saturated solution (at 27 °C) = –5.5 kJ/kg and molecular weight of $FeSO_4$ = 151.9 kg/kmol	*CO3*	*PO2*	**10**
		b)	Classify the crystallizers based on the method of supersaturation. Explain the working principle of any one crystallizer.	*CO5*	*PO5*	**10**

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