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: 19CH4DCMT1 **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. Humidity chart is permitted.

		UNIT - I	CO	PO	Marks
1	a)	Explain Fick's law of diffusion. What are the two types of mass transfer fluxes used?	CO1	PO1	**04**
	b)	Ethanol vapors (A) diffusing in air (B) at 1 std. atm. pressure and 0°C. Determine the diffusivity of A in B. Given data: Boiling point of ethanol is 78.4°C, $r_{AB} = 0.416$ and kT/ε_{AB} 1.49.	CO2	PO2	**06**
	c)	Derive an equation for steady-state equimolar counter diffusion for liquids.	CO2	PO2	**10**
		OR			
2	a)	Prove that $\frac{1}{K_y} = \frac{1}{k_y} + \frac{m'}{k_x}$. Where K is overall M T coefficient, k is individual & M is the slope	CO	PO	**10**
	b)	Solute A is absorbed from a gas mixture of A and B with liquid flowing as thin film downward along the wall of a tower. At a certain point in the tower, the bulk gas concentration is 0.38 mole fraction and bulk liquid concentration is 0.1 mole fraction. Solute A is moving and B is stagnant in the gas phase and gets absorbed in a non-diffusing liquid. Use the equilibrium data and find the interface compositions in both liquid and gas phase. Considering the solution to be dilute, estimate flux conditions. Data is given as follows.	CO3	PO2	**10**

x_A	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35
y_A	0	0.022	0.052	0.087	0.131	0.181	0.265	0.385

$k_y = 1.465 \times 10^{-3}$ kmol/m^2 s mole fraction and $k_x = 1.967 \times 10^{-3}$ kmol/m^2 s mole fraction

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<tr><td></td><td></td><td></td><td>UNIT - II</td><td></td><td></td><td></td></tr>
<tr><td></td><td>3</td><td>a)</td><td>Develop an equation for adiabatic saturation temperature curve from basics.</td><td>CO4</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>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.</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>4</td><td>a)</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>b)</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></td><td>UNIT - III</td><td></td><td></td><td></td></tr>
<tr><td></td><td>5</td><td>a)</td><td>Derive an equation to determine the time for constant rate period.</td><td>CO3</td><td>PO2</td><td>05</td></tr>
<tr><td></td><td></td><td>b)</td><td>Explain the classification of drying operations.</td><td>CO5</td><td>PO5</td><td>05</td></tr>
<tr><td></td><td></td><td>c)</td><td>When a porous dry solid was dried under constant drying conditions, in a batch drier, it took 5 hours to reduce the moister content from 30% to 10%. The critical moisture content was found to be 16% and equilibrium moisture content 2%. All the moisture contents are on dry basis. Assuming that the rate of drying during the falling rate period is proportional to the free moisture content, how long would it take to dry a sample of above solids to dry from 36% to 6% under same drying conditions?</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>Explain the drying rate curves.</td><td>CO3</td><td>PO2</td><td>05</td></tr>
<tr><td></td><td></td><td>b)</td><td>Discuss the mechanism of batch drying.</td><td>CO3</td><td>PO2</td><td>05</td></tr>
<tr><td></td><td></td><td>c)</td><td>1400 kg (bone dry) of a granular solid is to be dried under constant drying conditions from moisture content of 0.2 kg/kg dry solid to a final moisture content of 0.02 kg/kg dry solid. The drying surface is given as 0.0615 m^2/kg dry solid. Under the same conditions, the following rates were previously known. Estimate the time required for drying. Given N_C = 1.71 kg/m^2h and X_C = 0.14.
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<tr><td>Moisture content X = kg/kg dry solid</td><td>0.3</td><td>0.2</td><td>0.14</td><td>0.096</td><td>0.056</td><td>0.046</td><td>0.026</td><td>0.016</td></tr>
<tr><td>Rate of drying, kg/m^2h</td><td>1.71</td><td>1.71</td><td>1.71</td><td>1.46</td><td>1.26</td><td>0.88</td><td>0.54</td><td>0.376</td></tr>
</table></td><td>CO3</td><td>PO2</td><td>10</td></tr>
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<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 sealed. Compute the final vapour concentration at 30 °C and the pressure inside the flask. Neglect the adsorption of air.</td><td>CO3</td><td>PO2</td><td>12</td></tr>
<tr><td></td><td></td><td>b)</td><td>Explain the application of Freundlich adsorption isotherm.</td><td>CO3</td><td>PO2</td><td>08</td></tr>
<tr><td></td><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td></td><td>8</td><td>a)</td><td>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.</td><td>CO3</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>Using material balance equations, obtain an expression to find the minimum total adsorbent for the two-stage counter-current operation.</td><td>CO</td><td>PO</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>9</td><td>a)</td><td>An aqueous solution of sodium sulfate containing 28% Na_2SO_4 is cooled to 20°C and left undisturbed so that $Na_2SO_4{\cdot}10H_2O$ crystals are formed. Calculate how much crystals will be deposited from a 500 kg original solution. What will be the yield of crystallization? Data: the solubility of $Na_2SO_4{\cdot}10H_2O$ at 20°C is 19.4 kg/100 kg H_2O.</td><td>CO3</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>What are the different methods of super-saturation? Explain.</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>10</td><td>a)</td><td>A batch of 1000 kg of KCl is dissolved in sufficient water to make a saturated solution at 353 K, where the solubility is given as 54 parts of KCl per 100 parts of water. (i) What is the weight of water required? (ii) What is the yield of crystals if the above solution is cooled to 293 K, if 5% of the original water evaporates on cooling? At 293 K the solubility of KCl is 0.456 g mol of KCl per 100 g of water.</td><td>CO3</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>Classify the crystallizers based on the method of supersaturation. Explain the working principle of any one crystallizer.</td><td>CO5</td><td>PO5</td><td>10</td></tr>
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