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: Biotechnology **Duration: 3 hrs.**

Course Code: 23BT4PCHMT / 22BT4PCHMT **Max Marks: 100**

Course: Heat and Mass Transfer

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.

		UNIT - I	*CO*	*PO*	Marks
1	a)	Derive the equation for Log mean temperature difference for countercurrent flow in a heat exchanger.	*CO* 2	*PO1*	**10**
	b)	A furnace is constructed with 230 mm thick of fire brick, 115 mm of insulating brick and then 230 mm of building brick. The inside temperature of the furnace is 1213 K and the outside temperature is 318 K. The thermal conductivities of fire brick, insulating brick and building brick are 6.047, 0.581 and 2.33 W/m K. Estimate the heat lost per unit area and the temperature at the interfaces.	*CO* 3	*PO2*	**10**
		OR			
2	a)	Calculate the inside heat transfer coefficient for fluid flowing at a rate of 300 cm^3/s through a 20mm inside diameter tube of heat exchanger. Data: Viscosity of flowing fluid = 0.8 Ns/m^2 Density of flowing fluid = 1.1 g/cm^3 Specific heat of fluid = 1.26 kJ/ Kg K Thermal conductivity of fluid = 0.384 W/m K Viscosity at wall temperature = 1 N s/ m^2 Length of heat exchanger = 5 m	*CO* 3	*PO2*	**10**
	b)	Explain the construction and working principle of double pipe heat exchanger with a neat diagram.	*CO* 2	*PO1*	**10**
		UNIT - II			
3	a)	Describe the construction and working principle of horizontal tube evaporator. State its advantages and disadvantages.	*CO* 2	*PO1*	**10**
	b)	Dry steam at 373 K condenses on the outside surface of a horizontal pipe of 25mm O.D. The pipe surface is maintained at 357 K by circulating water through it. Determine mean heat	*CO* 3	*PO2*	**10**

			transfer coefficient, heat transfer per unit length of pipe and condensate rate per unit length of pipe. Properties of condensate at the film temperature of 350 K are: $\rho = 974$ kg/m^3, $\mu = 306 \times 10^{-6}$ kg/ m.s, $k = 0.668$ W/m.K, $\lambda = 2225$ kJ/kg, Assume that condensate film is laminar.			
			OR			
	4	a)	Explain with suitable diagrams, the working principle of forward feed and backward feed arrangement of multiple effect evaporator.	***CO*** 2	***PO1***	**10**
		b)	A solution containing 5% solids is to be concentrated to a level of 40% solids. Steam is available at a pressure of 0.2 MPa and saturation temperature of 393 K. Feed rate to the evaporator is 25000 kg/h. The evaporator is working at reduced pressure such that boiling point is 323 K. The overall heat transfer coefficient is 3.2 kW/m^{2}K. Estimate the steam economy and heat transfer surface area for: (i) Feed introduced at 293K (ii) Feed introduced at 308K Compare and interpret the results.	***CO*** 3	***PO2***	**10**
			UNIT - III			
	5	a)	In an oxygen-nirogen gas mixture at 101.3 kPa and 298 K, the concentrations of oxygen at two planes 2mm apart are 20% and 10% by volume respectively. Calculate the flux of diffusion of oxygen for the cases where (i) nitrogen is non-diffusing (ii) there is equimolar counter diffusion of the two given gases. Diffusivity of oxygen in nitrogen is 1.81 × 10-5 m2/s.	***CO*** 3	***PO2***	**10**
		b)	Explicate the two-film theory for mass transfer with suitable diagram. Derive equation for overall mass transfer coefficient and explain controlling film concept.	***CO*** 2	***PO1***	**10**
			OR			
	6	a)	Hydrochloric acid (A) at 283 K diffuses through a thin film of water (B) 4 mm thick. The Concentration of A at location 1 on one boundary of the film is 12 weight % (density $\rho_1 = 1060.7$ kg/m^3) and on other boundary, at location 2, is 4 weight % (density $\rho_2 = 1020.15$ kg/m^3). The diffusivity of HCL in water is 2.5×10^{-9} m^2/s. Calculate the flux of diffusion of A assuming water to be non-diffusing.	***CO*** 3	***PO2***	**10**
		b)	Derive equation for flux for steady state equimolar counterdiffusion of gas A and gas B.	***CO*** 2	***PO1***	**10**

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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>Illustrate the working principle of simple distillation with a neat diagram. Derive Rayleigh’s equation.</td><td>CO 2</td><td>PO1</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>A mixture of benzene and toluene containing 40 mole% of benzene is to be separated in a fractionating column to give a distillate containing 90 mole% of benzene and a bottom product containing 10 mole% of benzene. Feed is liquid at its bubble point. Using average relative volatility of 2.4, find out the number of theoretical stages required at total reflux.</td><td>CO 3</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>8</td><td>a)</td><td>100 kmol of a mixture containing 50 mole% n-heptane (more volatile) and 50 mole% n-octane is subjected to a differential distillation at atmospheric pressure, with 60 mole% of liquid distilled. Compute the composition of the composited distillate and the residue using Rayleigh equation.
Equilibrium data:
<table>
<tr><td>x</td><td>0.5</td><td>0.46</td><td>0.42</td><td>0.38</td><td>0.34</td><td>0.32</td></tr>
<tr><td>y</td><td>0.689</td><td>0.648</td><td>0.608</td><td>0.567</td><td>0.523</td><td>0.497</td></tr>
</table></td><td>CO 3</td><td>PO2</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>How is supercritical fluid extraction different from aqueous two-phase extraction? Describe protein purification by different types of ATPE.</td><td>CO 2</td><td>PO1</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>Discuss the process of nucleation and crystal growth in crystallization. What are the methods by which super-saturation can be obtained?</td><td>CO 2</td><td>PO1</td><td>10</td></tr>
<tr><td></td><td></td><td>b)</td><td>Differentiate Physical adsorption from Chemical adsorption. Describe in detail adsorption isotherms.</td><td>CO 1</td><td></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>Sketch and explicate the various stages in a drying rate curve.</td><td>CO 2</td><td>PO1</td><td>05</td></tr>
<tr><td></td><td></td><td>b)</td><td>Explain the principle for ion exchange process with a suitable application.</td><td>CO 2</td><td>PO1</td><td>05</td></tr>
<tr><td></td><td></td><td>c)</td><td>Discuss the working of drum dryer with a neat diagram.</td><td>CO 2</td><td>PO1</td><td>10</td></tr>
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