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: 23CH4PCHTR / 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 permitted.

		UNIT - I	*CO*	*PO*	Marks
1	a)	Derive an expression for rate of heat transfer through a furnace wall made of three different materials in series. Assume k_1, k_2 and k_3 to be the thermal conductivities of materials and x_1, x_2 and x_3 the respective thicknesses. Assume hot face and cold face temperatures to be T_1 and T_2 respectively.	*CO1*	*PO2*	**12**
	b)	A layer of pulverized cork 152 mm thick is used as a layer of thermal insulation in a flat wall. The temperature on the cold side of the cork is 4.4°C, and that of the warm side is 82.2°C. The thermal conductivity of the cork at 0°C is 0.036 W/m·°C, and that at 93.3°C is 0.055 W/m·°C. The area of the wall is 2.32 m². What is the rate of heat flow through the wall in watts?	*CO1*	*PO2*	**8**
		OR			
2	a)	State Fourier's law of heat conduction and explain its physical significance.	*CO1*	*PO2*	**6**
	b)	The walls of a house in a cold region consist of three layers — an outer brickwork of 15 cm thickness and an inner wooden panel of 1.2 cm thickness. The intermediate layer is made of an insulating material 7 cm thick. The thermal conductivities of the brick and the wood used are 0.70 W/m·°C and 0.18 W/m·°C, respectively. The inside and outside temperatures of the composite wall are 21°C and –15°C, respectively. If the layer of insulation offers twice the thermal resistance of the brick wall, calculate: i. The rate of heat loss per unit area of the wall, and ii. The thermal conductivity of the insulating material	*CO1*	*PO2*	**10**
	c)	Explain the term thermal conductivity and thermal diffusivity.	*CO1*	*PO2*	**4**

			UNIT - II			
	3	a)	Describe the important requirements of an insulating material and derive an expression for finding critical radius of insulation of a steam pipe.	*CO2*	*PO2*	**12**
		b)	Calculate the critical radius of insulation for asbestos [k = 0.17 W/(m^2 ·K)] surrounding a pipe and exposed to the room air at 293 K with h = 3.0 W/m^2 ·K. Calculate the heat loss from a 473 K, 50 mm diameter pipe when covered with the critical radius of insulation and without insulation. Would any fibre glass insulation having a thermal conductivity of 0.04 W/(m·K) cause decrease in heat transfer?	*CO2*	*PO2*	**8**
			OR			
	4	a)	Enlist and explain the different types of extended surface with neat diagrams.	*CO2*	*PO2*	**8**
		b)	A 3 inch schedule 40 carbon steel pipe (actual i.d. = 78 mm, wall thickness = 5.5 mm) has eight longitudinal fins of 1.5 mm thickness. Each fin extends 30 mm from the pipe wall. The thermal conductivity of the fin material is 45 W/m °C. If the wall temperature, the ambient temperature, and the surface heat transfer coefficient are 150°C, 28°C, and 75 W/m² °C respectively, calculate the percentage increase in the rate of heat transfer for the finned tube over the plain tube.	*CO2*	*PO2*	**12**
			UNIT - III			
	5	a)	Define co-current and counter current flow with neat sketches.	*CO3*	*PO3*	**8**
		b)	Derive the expression for log mean temperature difference (LMTD) in counter-current flow heat exchanger. State the assumptions.	*CO3*	*PO3*	**12**
			OR			
	6	a)	State and derive the relationship between overall heat transfer coefficient and individual heat transfer coefficients.	*CO3*	*PO3*	**12**
		b)	Methyl alcohol flowing in the inner pipe of a double-pipe exchanger is cooled with water flowing in the jacket. The inner pipe is made from 25-mm Schedule 40 steel pipe. The thermal conductivity of steel is 45 W/m·°C. The individual coefficients and fouling factors are given in table. What is the overall heat transfer coefficient, based on the outside area of the inner pipe? Use the standard dimensions for a 1-inch Schedule 40 steel pipe: the inner diameter 0.0874 ft, the outer diameter 0.1096 ft, and the wall thickness 0.0111 ft.	*CO3*	*PO3*	**8**

			Coefficient — W/m^2 °C			
			Alcohol coefficient, h_i — 1020			
			Water coefficient, h_o — 1700			
			Inside fouling factor h_{di} — 5680			
			Outside fouling factor h_{do} — 2840			
			UNIT - IV			
	7	a)	With a neat diagram explain the effect of interfacial tension on bubble formation during boiling.	*CO3*	*PO3*	**4**
		b)	Derive an expression for material and enthalpy balances for a single-effect evaporator.	*CO3*	*PO3*	**12**
		c)	What id boiling point rise? Explain briefly.	*CO3*	*PO3*	**4**
			OR			
	8	a)	Explain the construction and working of a triple-effect evaporator a neat sketch.	*CO3*	*PO3*	**12**
		b)	A triple-effect evaporator is concentrating a liquid that has no appreciable elevation in boiling point. The temperature of the steam to the first effect is 108°C, the boiling point of the solution in the last effect is 52°C. The overall heat-transfer coefficients, in $W/m^2 \cdot °C$, are 2500 in the first effect, 2000 in the second effect, and 1000 in the third effect. At what temperatures will the liquid boil in the first and second effects?	*CO3*	*PO3*	**8**
			UNIT - V			
	9	a)	State and explain the laws of black body radiation.	*CO4*	*PO2*	**10**
		b)	Calculate the heat loss by radiation from an unlagged horizontal steam pipe, 50 mm outer diameter at 377 K to air at 283 K ,ε = 0.9.	*CO4*	*PO2*	**5**
		c)	A small blackbody has a total hemispherical emissive power of 4 kW/m^2. Determine its surface temperature and the wavelength of emission maximum. In which range of the spectrum does this wavelength fall?	*CO4*	*PO2*	**5**
			OR			
	10	a)	Derive an expression for the net radiative heat exchange per unit area between two large parallel plates.	*CO4*	*PO2*	**12**
		b)	Calculate the loss of heat by radiation from a steel tube of diameter 70 mm and 3 m long at a temperature of 500 K (227°C), if the tube is located in a square brick conduit 0.3 m side at 300 K (27°C). Assume e for steel as 0.79 and for brick conduit as 0.93.	*CO4*	*PO2*	**8**

******