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.
Branch: Chemical Engineering
Course Code: 23CH4PCHTR / 22CH4PCHTR
Course: Process Heat Transfer

Semester: IV
Duration: 3 hrs.
Max Marks: 100

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 table 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.

			CO	*PO*	*Marks*
		UNIT - I			
1	a)	Explain the governing equations of the three modes of heat transfer: conduction, convection, and radiation.	*CO1*	*PO1*	**06**
	b)	A composite wall consists of two layers, A and B. Layer A has a thickness of 0.1 m and thermal conductivity of 1.5 W/m K. Layer B has a thickness of 0.2 m and thermal conductivity of 0.5 W/m K. The temperature difference across the composite wall is 40°C. Calculate the heat transfer rate per unit area.	*CO 3*	*PO2*	**04**
	c)	A furnace wall is made up of three layers, one is fire brick, one is insulating layer and one is red brick. The inner and outer surfaces temperature is at 870°C and 40°C respectively. The conductive heat transfer coefficients of the layers are 1.163, 0.14 and 0.87 W/m °C and the thicknesses are 22 cm, 7.5 cm and 11 cm, respectively Find the rat of heat loss per sq. meter and the interface surfaces.	*CO3*	*PO3*	**10**
		OR			
2	a)	Derive an equation for the heat loss through a composite wall, stating all assumptions.	*CO 1*	*PO 2*	**10**
	b)	Derive an equation for steady state heat transfer through a hollow cylinder.	*CO 1*	*PO2*	**10**
		UNIT – II			
3	a)	Define critical thickness of insulation. Derive an equation to find the critical radius of insulation for a sphere.	*CO4*	*PO2*	**10**
	b)	Calculate the critical radius of insulation for asbestos (k = 0.17 W/m·°C) surrounding a pipe and exposed to room air at (20°C) with (h = 3.0 W/m^2°C). Calculate the heat loss from a (200°C), 5 cm diameter pipe when covered with the critical radius of insulation and without insulation.	*CO 4*	*PO2*	**10**
		OR			
4	a)	A rectangular fin is attached to a base plate which is at a temperature T_O. the surrounding air temperature is T_∞. Derive an equation to determine the temperature profile when the fin is very long, and the temperature at the end of the fin is essentially that of the surrounding fluid.	*CO4*	*PO2*	**12**

		b)	A very long rod 5 mm in diameter has one end maintained at 100°C. The surface of the rod is exposed to ambient air at 25 °C with a convection heat transfer coefficient of (100 $W/m^2.K$). Determine the temperature distributions along rods constructed from pure copper thermal conductivity is k= 398 W/m.K. What are the corresponding heat losses from the rod?	*CO4*	*PO2*	**08**
			UNIT – III			
	5	a)	What is overall heat transfer coefficient? Derive the expression of the overall heat transfer coefficient for the case of fluids flowing inside and outside a tube.	*CO5*	*PO3*	**10**
		b)	In a parallel flow double pipe heat exchanger water flows through the inner pipe and is heated from 20°C to 70°C. oil flowing through the annulus is cooled from 200 °C to 100 °C. It is desired to cool the oil to a lower exit temperature by increasing the length of the heat exchanger. Determine the minimum temperature to which the oil may be cooled.	*CO5*	*PO3*	**10**
			OR			
	6	a)	Illustrate and briefly explain the different regimes of boiling heat transfer curve for water.	*CO5*	*PO3*	**10**
		b)	An oil cooler for a lubrication system has to cool 1000 kg/h of oil (C_p=2.09 kJ/kg°C from 80 to 40°C by using a cooling water flow of 1000 kg/h at 30°C. Give your choice for a parallel flow or counter flow heat exchanger with reason. Calculate the surface area of heat exchanger, if the overall heat transfer coefficient is 24 W/m^{2}°C and Take C_p of water is 4.18kJ/kg °C.	*CO5*	*PO3*	**10**
			UNIT – IV			
	7	a)	A single effect evaporator is used to concentrate 9070 kg/h of 20% caustic soda solution to 50% solids. The gauge pressure of steam is 1.37atm. The absolute pressure in the vapor space is 100 mm Hg. There is a BPE of 22.78 °C. The overall heat transfer coefficient is estimated to be 1400 W/m^{2}°C and the feed temperature is 37.8 °C. Calculate the (a) Amount of steam consumed (b) Economy (c) Heating surface required. **Data:** Enthalpy of feed at 37.8 °C = 127.9245 kJ/kg, Enthalpy of thick liquor = 514.0239 kJ/kg, Enthalpy of Vapour = 2672.46 kJ/kg, Heat of vaporization of steam at 1.37 atm = 2184.0201 kJ/ kg & Condensation temperature of steam = 126.11 °C	*CO5*	*PO3*	**10**
		b)	With the help of a neat sketch, explain the working of any one natural circulation evaporator.	*CO5*	*PO3*	**10**
			OR			
	8	a)	What are the characteristics of the feed solution which are important in the design and operation of evaporators? How do these affect the evaporation?	*CO 3*	*PO3*	**08**
		b)	Explain boiling point elevation and its significance.	*CO 3*	*PO3*	**06**
		c)	Elucidate the significance of economy and capacity of evaporators.	*CO3*	*PO3*	**06**
			UNIT - V			
	9	a)	Explain the surface emission radiation properties.	*CO2*	*PO3*	**12**

		b)	Assuming the sun to be a block body emitting radiation with maximum intensity at λ=0.49 μm, calculate the following: (i) The surface temperature of the sun. (ii) The heat flux at surface of the sun.	*CO2*	*PO3*	**08**
			OR			
	10	a)	Derive an equation to find the rate of radiation energy exchanged between two parallel plates.	*CO4*	*PO2*	**08**
		b)	A black body of total area 0.045 m^2 is completely enclosed in a space bounded by 5 cm thick walls of surface area 0.5 m^2 and k=0.92 W/m K. Calculate the temperature of the black body if the inner and outer surface temperatures of the enclosing walls are 215 °C and 30 °C respectively.	*CO 4*	*PO2*	**08**
		c)	Write about the significance of Stefen- Boltzman and Kirchhoff's law in radiation.	*CO 4*	*PO2*	**04**

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