[3 Hours] **[Total Marks: 80]**

N. B.: (1) Question No. **1** is **Compulsory.**
(2) Attempt any **Three** questions out of the remaining **Five** questions.
(3) Figures to the **right** indicate **full** marks.
(4) Make **suitable** assumptions wherever **necessary.**

Q1	Answer the following sub-questions (**Any Five**)	**20**
(a)	One side of a copper block 4 cm thick is maintained at 175°C. The other side is covered with a layer of fiberglass 1.5 cm thick. The outside of the fiberglass is maintained at 80°C, and the total heat flow through the composite slab is 300 W. What is the area of the slab? (The thermal conductivity of copper is 401 W/m·K, and the thermal conductivity of fiberglass is 0.04 W/m·K.)	**4**
(b)	Hot liquid is flowing at a velocity of 2 m/s through a metallic pipe having an inner diameter of 3.5 cm and length 20 m. The temperature at the inlet of the pipe is 90◦C. calculate the heat transfer coefficient Following data is given for liquid at 90◦C: ρ = 950 kg/m3, Cp = 4.23 kJ/kg◦C, μ = 2.55x10-4 kg/ms, K = 0.685 W/m.◦C .	**4**
(c)	Write a note on U tube type heat exchanger.	**4**
(d)	Differentiate between Boiling and Condensation.	**4**
(e)	Differentiate between Forward and Backward Feed Evaporator	**4**
(f)	Derive an expression for radiation shield.	**4**
Q2		
(a)	Derive the expression for heat transfer through furnace wall made of three different materials in series. Assume K1, K2, K3, be the thermal conductivities of materials and X1, X2, X3, be the respective thickness. hi, and ho be the convective heat transfer coefficients for inside hot gas and ambient air respectively?	**10**
(b)	Water flows at 50°C inside a 2.5 cm inside diameter tube such that hi = 3500 W/m² °C. The tube has a wall thickness of 0.8 mm with a thermal conductivity of 16 W/m² °C. The outside of the tube loses heat by free convection with ho= 7.6 W/m2 °C. Calculate the overall heat-transfer coefficient and heat loss per unit length to surrounding air at 20°C.	**10**
Q3		
(a)	Derive an expression of LMTD for Counter Current Flow. Clearly state the assumption made.	**10**
(b)	Water flows in a tube of diameter 5 cm at a velocity of 10 m/s. The inlet and the outlet temperatures of water are 20°C and 60°C, respectively. If the tube wall is maintained at 80°C, calculate the (a) heat transfer coefficient, (b) the rate of heat transfer and (c) the length of the tube. Properties of water at average temperature: ρ = 995 kg/m3, Cp = 0.998 kJ/kg.K, ϑ = 0.657x10-6 m2/s, K = 628x10-3 W/m.K, Pr = 4.34.	**10**

Q4

(a) A heat exchanger is required to cool 55,000 kg/h of alcohol from 66°C to 40°C using 40,000 kg/h of water entering at 5°C. Calculate **10**

(i) Exit temperature of water
(ii) Heat transfer rate
(iii) Surface area required for: (a) Parallel flow type heat exchanger
(b) Counter flow type heat exchanger.

Take overall heat transfer coefficient, U=580 W/m^2.K, Cp (alcohol) = 3760 J/kg.K,
Cp (water) = 4180 J/kg.K.

(b) Find the heat transfer rate per unit area due to radiation between two infinitely long parallel planes. The first plane has an emissivity of 0.4 and is maintained at 473 K. The emissivity of the second plane is 0.2 and is maintained at 300 K. If a radiation shield having e = 0.5 is interposed between the given planes, find the percentage reduction in heat transfer rate and the steady sate temperature attained by the shield. **10**

Q5

(a) A steam condenser consists of 16 tubes arranged in 4 x 4 array. The tubes are 25 mm in diameter and 1.2 m long. Water flows through the tube at 65°C while steam condenses at 75°C over the tube surface. **10**
Find the rate of condensation, if (a) tubes are horizontal; (b) tube are vertical.
Take latent heat of steam as 2300 kJ/kg
Properties of water at 70°C:
ρ = 977.8 kg/m^3, Cp = 4.187 kJ/kg K, υ = 0.415x10-6 m^2/s, k = 0.668 W/m.K, β= 5.7x10^{-3} K^{-1}

(b) A pipe (k = 59 W/m.K) with an inner diameter of 3.75 cm and wall thickness of 0.318 cm is externally heated by steam at a temperature of 180°C. The water flows through the pipe with a velocity of 1.22 m/s. Calculate the length of pipe required to heat water from 30°C to 90°C. Assume the heat transfer coefficient on the steam side to be 11.3 kW/m² K. **10**
Properties of water at mean temperature (60°C):
ρ = 982kg/m3, Cp = 4.186 kJ/kg.K, μ = 528x10-6 kg/ms, Pr = 3.42, k = 0.645 W/m.K

Q6

(a) An aluminum rod of 12 mm in diameter and 100 mm long protrudes from a wall maintained at 550 K into the environment maintained at 288 K. Estimate heat loss by rod using that rod end is insulated. Also find the fin, efficiency and temperature at end of fin. **10**
Data: k aluminum = 200 W/mK, Heat Transfer Coefficient is 20 W/m^{2}K

(b) For Counter current flow heat exchanger Show that **10**

$$\varepsilon = \frac{1 - e^{-NTU(1-C)}}{1 - C \times e^{-NTU(1-C)}}$$