

Note:

- i) Question no.1 is compulsory.
- ii) Attempt any **THREE** from question no. 2 to 6.
- iii) Assume suitable data whenever necessary.

Q1) Solve any Four**20**

- a) A refrigerator stands in a room where the air temperature is 30 °C. The surface temperature on the outside of the refrigerator is 25 °C. The sides are 30 mm thick and have an equivalent thermal conductivity of 0.1 W/m K. The heat transfer coefficient on the outside is 10 W/m²K. Assuming one dimensional conduction through the sides, calculate the net heat flow per m² and the surface temperature on the inside.
- b) Define and explain physical significance of Reynolds and Nusselt number.
- c) Explain Fin efficiency and Fin effectiveness. Explain in brief factors affecting fin effectiveness.
- d) Exhaust gases ($C_p=1.12$ kJ/kg °C) flowing through a tubular heat exchanger at the rate of 1000 Kg/hr are cooled from 300 °C to 120 °C. The cooling is affected by water ($C_p= 4.18$ kJ/Kg °C) that enters the system at 20 °C at the rate of 1200 Kg/hr. If the overall heat transfer coefficient is 140 W/m² K, what heat exchanger area is required to handle the load for parallel flow arrangement?
- e) Define intensity of radiation. What is solid angle? Explain.

Q2) a) Derive general equation of heat conduction in Cartesian coordinate system and reduce it to all three forms.**10**

- b) Air at atmospheric pressure and 20 °C flows with 5 m/s velocity through main duct of an air conditioning system. The duct is rectangular in cross-section and measures 40 cm x 80 cm. Determine heat loss per meter length of duct corresponding to unit temperature difference. The relevant thermo-physical properties of air are

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$$\nu = 15 \times 10^{-6} \text{ m}^2/\text{s}, \quad \alpha = 7.7 \times 10^{-6} \text{ m}^2/\text{hr}, \quad k = 0.026 \text{ W/m K}$$

Use Dittus Boelter correlation : $Nu = 0.023 \times (Re)^{0.8} \times (Pr)^{0.4}$ **Q3) a) Water flows at the rate of 65 kg/min through a double pipe counter flow heat exchanger. Water is heated from 50°C to 75°C by oil flowing through the tube. The specific heat of oil is 1.780 kJ/kg K. The oil enters at 115°C and leaves at 70°C. The overall heat transfer co-efficient is 340 W/m² K. Calculate the following****8**

- (i) Heat exchanger area
- (ii) Rate of heat transfer

Use LMTD method.

- b) The following data pertains to the junction of a thermocouple wire used to measure the temperature of a gas stream : 6
 $\rho = 8500 \text{ Kg/m}^3$; $C_p = 325 \text{ J/kg K}$; $k = 40 \text{ W/m K}$ and the heat transfer coefficient between the junction and gas $h = 215 \text{ W/m}^2 \text{ K}$.
 If thermocouple junction can be approximated as 1 mm diameter sphere, determine how long it will take for the thermocouple to read 99 percent of the initial temperature difference?

- c) Define the following terms: (i) Absorptivity (ii) Reflectivity (iii) Transmissivity. 6
 (iv) Emissivity. Explain Kirchoff's law.

- Q4)** a) A rod of 10 mm diameter and 70 mm length with thermal conductivity 15 W/m K protrudes from a surface at 180 °C. The rod is exposed to air at 30 °C with a convection coefficient of 25 W/m² K. How does the heat flow from this rod get affected if the same material volume is used for two fins of the same length? Assume short fin with end insulated. 8
 b) In which mode of heat transfer is the convection heat transfer coefficient usually higher, natural convection or forced convection? Why? 4
 c) Derive an expression for LMTD for parallel flow type heat exchanger. 8

- Q5)** a) Determine the radiant heat exchange in W/m² between two large parallel steel plates of emissivities 0.8 and 0.5 held at temperatures of 1000 K and 500 K respectively, if a thin copper plate of emissivity 0.1 is introduced as a radiation shield between the two plates. 10
 Take $\sigma = 5.67 \times 10^{-8} \text{ W/m}^2 \text{ K}^4$
 b) What do you mean by critical thickness of insulation? State its importance. Derive an expression for critical radius of insulation for sphere of thermal conductivity k and outside film coefficient h_o. 10

- Q6)** a) Draw a neat boiling curve for water showing different regions of boiling. Explain each regime in brief. 6
 b) Estimate the heat transfer from a 40W incandescent bulb at 125 °C to 25 °C in quiescent air. Approximate the bulb as a 50 mm diameter sphere. What percent of power is lost by free convection? The appropriate correlation for the convection coefficient is

$$Nu = 0.60 \times (Gr Pr)^{0.25}$$

The thermo-physical properties of air at mean film temperature are : $\nu = 20.55 \times 10^{-6} \text{ m}^2/\text{s}$,

$$k = 0.03 \text{ W/m K} , Pr = 0.693$$

- c) A 250 x 250 mm ingot casting, 1.5 m high and at 1025 K temperature, is stripped from its mold. The casting is made to stand on end on the floor of a large foundry whose wall, floor and roof can be assumed to be at 300 K temperature. Make calculation for the rate of radiant heat interchange between the casting and the room. The casting material has an emissivity of 0.85. 6
 Take $\sigma = 5.67 \times 10^{-8} \text{ W/m}^2 \text{ K}^4$