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

N.B.: **1) Question No. 1** is **compulsory**.
2) Attempt any **THREE** from **question no. 2 to 6**.
3) Use illustrative **diagrams** wherever **possible**.

Q1) Solve any **Four :** **20**

a) What do you mean by Fouling in heat exchanger?

b) Differentiate between drop wise and film wise condensation.

c) Define thermal resistance, thermal conductance, thermal conductivity and thermal contact resistance.

d) Define shape factor and state its physical significance.

e) Explain hydrodynamic and thermal boundary layer.

Q2) a) Derive 3 dimensional conduction equation in Cartesian co-ordinates for a homogeneous material, steady state conditions and without heat generation. **10**

b) A 100 mm diameter steam pipe is covered by two layers of lagging. The inside layer is 40 mm thick and has a thermal conductivity of 0.07 W/m K. The outside layer is 25 mm thick and has a thermal conductivity of 0.1 W/m K. The pipe carries steam at a pressure of 1.7 MN/m^2 with 230 ^{0}C temperature. The outside temperature of lagging is 24 ^{0}C. If the steam pipe is 20 m long, determine (a) The heat lost per hour, (b) The interface temperature of lagging.
Neglect the resistance of the steam pipe. **06**

c) Write a short note on 'Importance of numerical methods.' **04**

Q3) a) Derive expression for temperature distribution and heat dissipation in a straight fin of rectangular profile for infinitely long fin. **08**

b) 3000 kg of water is heated per hour from 30 to 70 ^{0}C by pumping it through a certain heated section of a 25 mm diameter tube. If the surface of the heated section is maintained at 110 ^{0}C, estimate length of the heated section and the rate of heat transfer from the tube to water. **08**
The thermo-physical properties of water are: ρ = 971.6 kg/m^3; $\mu = 0.355 \times 10^{-3}$ kg/m-s; k = 0.667 W/m-deg; Cp = 4195 J/kg-deg.
Use $Nu = 0.023 (Re)^{0.8} (pr)^{0.4}$.

c) What is meant by critical thickness of insulation? Explain its significance. **04**

Q4) a) With the help of Buckingham π theorem show that for a forced convection $Nu = C (Re)^m (Pr)^n$ **08**

b) A steel rod (k = 32 W/m K), 12 mm in diameter and 60 mm long with an insulated end is to be used as a spine. It is exposed to surrounding with a temperature of 60^0C and heat transfer coefficient of 55 W/m^2 K. The temperature at the base of fin is 95^0C. Determine (i) The fin efficiency, (ii) The temperature at the end of the spine, (iii) The heat dissipation. **08**

c) What are the assumptions for lumped capacity analysis? **04**

Q5) a) Derive the relationship between the effectiveness and the number of transfer units for a parallel flow heat exchanger. **10**

b) A sphere of 20 cm diameter made of cast iron initially at uniform temperature of 400^0C is quenched into oil. The oil bath temperature is 40^0C. If the temperature of the sphere is 100^0C after 5 min, find heat transfer coefficient on the surface of the sphere. Take Cp (C. I.) = 320 J/kg K, ρ (C. I.) = 7000 kg/m^3. Use lumped parameter analysis. **06**

c) For a hemispherical furnace, the flat floor is at 700 K and has an emissivity of 0.5. The hemispherical roof is at 1000 K and has emissivity of 0.25. Find net radiative heat transfer from floor to roof. **04**

Q6) a) State and explain Stefan Boltzman law and Kirchhoff's law. **04**

b) The radiative shape factor of the circular surface of thin hollow cylinder of 10 cm diameter and 10 cm length is 0.1716. What is the shape factor of the curved surface of the cylinder with respect to itself? **04**

c) Draw the boiling curve of water and identify the different boiling regimes. **04**

d) Water (C_p = 4200 J/kg °C) enters a counter flow heat exchanger at 38°C flowing at 0.076 kg/s. It is heated by oil (C_p = 1800 J/kg °C) flowing at the rate of 0.152 kg/s from an inlet temperature of 116°C. For an area of 1 m^2 and U = 340 W/m^2°C, determine the total heat transfer rate. **08**
