(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID 2104 Roll No. | | | | | | | | | | |

B. Tech

(SEMESTER-V) THEORY EXAMINATION, 2012-13

HEAT & MASS TRANSFER

Time : 3 Hours] *[Total Marks : 100*

Note : (1) Use of heat transfer data book is permitted.

(2) In case of missing data, assume the missing data suitably and state the assumption made.

Section – A

1. Attempt **all** question parts. **10 × 2 = 20**

(a) What is the mechanism of Radiation heat transfer ?

(b) What is the concept of thermal resistance ?

(c) Distinguish between Fin effectiveness and Fin efficiency.

(d) What is mean by lumped system analysis ?

(e) Distinguish between hydrodynamic boundary layer and thermal boundary layer.

(f) What is Grashoff number ?

(g) What is Kirchhoff's law ? Discuss its relevance.

(h) Distinguish between emissive power and emissivity.

(i) What are the various boiling modes ?

(j) What is Fick's Law of Diffusion ?

Section – B

2. Attempt any **three** parts : **3 × 10 = 30**

(a) (i) Discuss the effect of temperature on thermal conductivity of metals. **5**

(ii) Give the one dimensional time dependent heat conduction equation in rectangular, cylindrical and spherical co-ordinate systems. **5**

(b) A very long 25 mm diameter copper rod extends from a surface at 120 °C. Atmospheric temperature is 25 °C. K = 380 w/mK for copper. Heat transfer coefficient over rod is 10 w /m^2K. Determine the heat loss from the rod. How long the rod should be in order to be considered infinite ? **10**

(c) Atmospheric air at 100 Kpa and 10 °C is flowing over a plate at a velocity of 3 m/s. The plate is 30 cm wide and at a temperature of 60 °C. Calculate at 30 cm from leading edge (i) boundary layer thickness (ii) thermal boundary layer thickness (iii) local heat transfer coefficient (iv) total drag force and (v) heat transfer from plate. **10**

(d) Two large parallel plates at temperatures 1000 K and 600 K have emissivity of 0.5 and 0.8 respectively. A radiation shield having emissivity 0.1 on one side and 0.05 on other side is placed between the plates. Determine the percentage reduction in heat transfer rate. **10**

(e) A counter flow heat exchanger is used to cool 55000 kg/hr of a liquid from 66 °C to 40 °C using 40000 kg/hr of water entering at 5 °C. Determine the surface area required. Assume C_p(liquid) = 3760 J/kg K C_p(water) = 4180 J/kg K, overall heat transfer coefficient U = 580 w/m^2 K. **10**

Section – C

Attempt all questions in this section : **5 × 10 = 50**

3. Attempt any **two** parts : **2 × 5 = 10**

(a) A steel ball of 50 mm diameter and 900 °C is placed in still air at temperature of 30 °C. Calculate the initial rate of cooling of ball in °C/min. Take h = 30 W/m^2 K, ρ_{steel} = 7800 kg/m^3, C = 2 kJ/kg. K, neglect internal thermal resistance. **5**

(b) Explain the analogy between momentum and heat transfer in turbulent flow over a flat surface. **5**

(c) Describe the natural convection process over a vertical plate indicating the laminar and turbulent boundary layers along with the variation of temperature and velocity within the boundary layer. **5**

4. Attempt any **one** part : **1 × 10 = 10**

(a) A hollow cylinder with inner radius of 30 mm and outer radius of 50 mm is heated at the inner surface at a rate of 10^5 w/m^2 and dissipater heat by convection from outer surface into a fluid at 80 °C with heat transfer coefficient of 400 W/m^{2}K. The thermal conductivity of the cylinder is 15 W/mk. Determine the inside and outside surface temperature of the cylinder. **10**

(b) An electric cable of 20 mm diameter is insulated with rubber and is exposed to atmosphere at 30 °C. Determine the most economical thickness of rubber insulation (K = 0.175 W/m K) when cable surface temperature with and without insulation is 70 °C. Determine also the percentage increase in heat dissipation and current carrying capacity when most economical thickness is provided. Assume h = 9.3 W/m^2 K. **10**

5. Attempt any **one** part : **1 × 10 = 10**

(a) Water is heated in a tube of 0.02 m inner diameter at a flow rate of 0.01 kg/s from 10 °C to 40 °C. The outside of the tube is covered with an insulated electric heating element that produces a uniform heat flux of 15000 W/m^2 over the surface. Determine (i) Reynolds Number (ii) The heat transfer coefficient and (iii) The length of pipe needed for a 30 °C increase in average temperature. **10**

(b) Describe the various regimes of pool boiling in detail. **10**

6. Attempt any **one** part : **1 × 10 = 10**

(a) Saturated steam at 90 °C and 70 Kpa is condensed on outer surface of a 1.5 m long and 2.5 m diameter vertical tube maintained at uniform temperature of 70 °C. Assuming filmwise condensation calculate the heat transfer rate on the tube surface. **10**

(b) A mercury thermometer is used to measure the temperature of hot gas flowing through a pipe by a oil well made of steel (K = 40 W/mk.). Determine the percentage error in temperature measurement of thermometer reads 150 °C. The temperature of the pipe wall is 80 °C. The well is 10 cm long and 2 mm thick. Assume h = 40 W/m^2 K. **10**

7. Attempt any two parts : **2 × 5 = 10**

(a) Hydrogen gas is maintained at a pressure of 2.4 bar and 1 bar on opposite of a plastic membrane 0.3 mm thick. The binary diffusion coefficient of hydrogen in the plastic is 8.7×10^{-8} m^2/s. The solubility of hydrogen in the membrane is 1.5×10^{-3} kg mol/m^3 bar. Determine at a temperature of 25 °C

(i) Molar concentration of hydrogen on opposite faces of membrane and

(ii) Molar and mass diffusion flux of hydrogen through the membrane. **5**

(b) Derive an expression for critical insulation thickness on a cylinder. **5**

(c) Describe the working of a heat pipe and its relevance. **5**