

Total No. of Questions : 10]

SEAT No. :

**P2840**

**[4958]-1013**

[Total No. of Pages : 4

**T.E.(Mechanical)**

**HEAT TRANSFER**

**(2012 Course) (Semester-I) (302042)(End Semester)**

*Time : 2½Hours]*

*[Max. Marks : 70*

*Instructions to the candidates:*

- 1) *Solve Q.1 or Q.2,Q.3 or Q.4,Q.5 or Q.6,Q.7 or Q.8,Q.9 or Q.10.*
- 2) *Draw neat diagrams wherever necessary.*
- 3) *Use of scientific calculator is allowed.*
- 4) *Assume suitable data wherever necessary.*
- 5) *Figures to the right indicate full marks.*

**Q1) a)** Derive an expression for critical radius of insulation of sphere. **[6]**

- b) A 2 kW resistance heater wire whose thermal conductivity is 15 W/m. °C has a diameter of 4 mm and length of 0.5 m. It is used for boiling water. If the outer surface temperature of wire is 105 °C, determine the temperature at the centre of the wire. **[4]**

OR

**Q2) a)** Prove that  $\frac{\theta}{\theta_i} = \frac{T - T_\infty}{T_i - T_\infty} = \exp\left[-\left(\frac{hA_s}{\rho V C_p}\right)t\right]$  with usual notations. **[6]**

- b) Explain the concept of Thermal Resistance. **[4]**

**Q3) a)** What is response and time constant of a thermocouple? **[4]**

- b) The temperature distribution across a wall of 1 m thick at a certain instant of time is given as  $T(x) = a + bx + cx^2$  where T is in degrees Celsius and x is in meters, while  $a = 800$  °C,  $b = -350$  °C/m, and  $c = -60$  °C/m<sup>2</sup>. A uniform heat generation,  $= 1000$  W/m<sup>3</sup>, is present in the wall of area 10m<sup>2</sup> having the properties  $= 1600$ kg/m<sup>3</sup>,  $k = 40$  W/m.K, and  $c_p = 4$ kJ/kg.K. Determine: **[6]**

- i) the rate of heat transfer entering the wall ( $x=0$ ) and leaving the wall ( $x = 1$ m)
- ii) the rate of change of energy storage in the wall.

OR

**P.T.O.**

**Q4) a)** Derive the three dimensional heat diffusion equation in Cartesian co-ordinates from first principles. [6]

b) Calculate the temperature at the tip of fin of a 3 mm diameter, 3 cm long fin if fin is made up of [4]

i) Copper ( $k = 350 \text{ W/m.K}$ ) and

ii) Teflon ( $k = 0.35 \text{ W/m.K}$ )

Take temperature at the fin base =  $120^\circ\text{C}$ , ambient temperature =  $20^\circ\text{C}$   
 $h = 10 \text{ W/m}^2.\text{K}$

**Q5) a)** Define and give the significance of following dimensionless numbers used in Natural Convection. [6]

i) Prandtl Number,

ii) Grashof Number

b) Explain: Local and Average heat transfer coefficient. [5]

c) Consider a  $0.6\text{-m} \times 0.6\text{-m}$  thin square plate in a room at  $30^\circ\text{C}$ . One side of the plate is maintained at a temperature of  $90^\circ\text{C}$ , while the other side is insulated. Determine the rate of heat transfer from the plate by natural convection if the plate is vertical.

Use following correlation.

$$\text{Nu} = 0.59 \text{ Ra} L^{1/4}$$

Properties of air at  $60^\circ\text{C}$ :  $k = 0.02808 \text{ W/m.K}$ ,  $\text{Pr} = 0.7202$ ,

$$\nu = 1.896 \times 10^{-5} \text{ m}^2/\text{s} \quad [6]$$

OR

**Q6) a)** Differentiate : Natural convection and Forced convection. [5]

b) Explain concept of velocity and thermal boundary layer. [6]

c) A 25-cm-diameter stainless steel ball ( $\rho = 8055 \text{ kg/m}^3$ ,  $c_p = 480 \text{ J/kg.K}$ ) is removed from the oven at a uniform temperature of  $300^\circ\text{C}$ . The ball is then subjected to the flow of air at 1 atm pressure and  $25^\circ\text{C}$  with a velocity of  $3 \text{ m/s}$ . The surface temperature of the ball eventually drops to  $200^\circ\text{C}$ . Determine the average convection heat transfer coefficient during this cooling process and estimate how long the process will take.

$$\text{Nu} = 2 + [0.4 \times \text{Re}^{1/2} + 0.06 \times \text{Re}^{2/3}] \text{Pr}^{0.4} (\mu_\infty / \mu_s)^{1/4}$$

The properties of air at the free-stream temperature of  $25^\circ\text{C}$  and 1 atm:

$$k = 0.02551 \text{ W/m.K}, \nu = 1.562 \times 10^{-5} \text{ m}^2/\text{s}, \mu = 1.849 \times 10^{-5} \text{ kg/m.s} \text{ Pr} = 0.7296$$

$$\text{Take } \mu_s = 2.76 \times 10^{-5} \text{ kg/m.s} \quad [6]$$



- Q10)** a) Derive an expression for effectiveness of parallel flow heat exchanger. [7]
- b) Compare: Film wise and drop wise condensation. [4]
- c) Cold water enters a counter-flow heat exchanger at  $10^{\circ}\text{C}$  at a rate of 8 kg/s, where it is heated by a hot-water stream that enters the heat exchanger at  $70^{\circ}\text{C}$  at a rate of 2kg/s, Assuming the specific heat of water to remain constant at  $C_p=4.18\text{kJ/kg.K}$ , determine the maximum heat transfer rate and the outlet temperatures of the cold-and the hot-water streams for this limiting case. [6]

