

Total No. of Questions : 10]

SEAT No. :

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[Total No. of Pages : 4

T.E. (Mechanical) (Mech. S/W & Automobile)

HEAT TRANSFER

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

Time : 2½ Hours]

[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 indicates full marks.*

Q1) a) Differentiate between natural and forced convection. **[4]**

- b) A 1 m high and 1.5m wide double-pane window consists of two 4 mm thick layers of glass ($k = 0.026 \text{ W/m-K}$). The room is maintained at 20°C and the outside air is at 40°C . Take the convective heat transfer coefficient on the inside and the outside surface of the window as 10 and $40 \text{ W/m}^2\text{-K}$ respectively. **[6]**

Calculate:

- i) The rate of heat transfer through this window.
- ii) The temperature of the inside surface,

OR

Q2) An electric current of 34000 amp flows along a flat steel plate 1.25 cm thick and 10 cm wide. The resistivity of the steel material (ρ) is $12 \times 10^{-6} \text{ ohm-cm}$, and thermal conductivity (K) is 54 W/m-K . The temperature of one surface of the plate is 80°C and that of the other is 95°C . **[10]**

- i) Find the temperature distribution, across the plate.
- ii) Maximum temperature of the plate and its position.
- iii) The total amount of heat generate per meter length of plate.
- iv) Flow of heat from each surface of the plate.

Q3) a) What is physical significance of Biot number? Is the Biot number more likely to be larger for high conducting solids or poorly conducting ones? **[4]**

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- b) A steel ball having specific heat (C) 0.46 kJ/kg-K, thermal conductivity (k) 35 W/m-K and diameter of 50 mm. The steel ball initially at a uniform temperature of 450°C is suddenly placed in a controlled environment in which the temperature is maintained at 100°C. The convective heat transfer coefficient is 10 W/m²-K. Calculate the time required for the ball to attain a temperature of 150°C. [6]

OR

- Q4) a)** What is critical radius of insulation? Justify whether addition of insulation will increase the rate of heat transfer into the surrounding in the case of refrigerant suction line of 25 mm outer diameter, which is to be insulated using insulation of thermal conductivity 0.25 W/m-K. The surface heat transfer coefficients is 10 W/m²-K. [4]

- b) A 50 mm × 50 mm iron bar 0.4 m long is connected to the wall of two heated reservoirs, each at 120°C. The ambient air temperature is 35°C and the convective heat transfer coefficients is 17.4 W/m²-K. Calculate the rate of heat loss from the bar and the temperature of the bar midway between the reservoirs. The thermal conductivity of iron is 52 W/m-K. [6]

- Q5) a)** Explain significance of any three dimensionless numbers used in convection. [6]

- b) Explain the difference between the local and average heat transfer coefficient. [4]

- c) Water is passed through the annulus formed by two tubes of 0.05 m and 0.03 m in diameter at a velocity of 0.5 m/sec. If the inlet temperature of water is 20°C and 0.03 m diameter tube temperature is maintained at 80°C, find the heat transfer coefficient between the water and small tube surface. [6]

Take the following properties of water at 50°C.

$$\rho = 880 \text{ kg/m}^3; C_p = 2100 \text{ J/kg-K}; k = 0.12 \text{ W/m-K}; \nu = 3.6 \times 10^{-6} \text{ m}^2/\text{s}.$$

Use the following correlation:

$$Nu = 0.023 Re^{0.8} Pr^{0.4} \text{ for turbulent flow; } Nu = 3.66 \text{ for laminar flow}$$

OR

- Q6)** a) Write a short note on velocity boundary layer and thermal boundary layer. [6]
- b) Explain the mechanism of natural convection and force convection with suitable examples. [4]
- c) The maximum allowable surface temperature of an electrically heated vertical plate is 0.15m high and 0.1 m wide is 140°C. Estimate the maximum rate of heat dissipation by convection from both sides of the plate in an atmosphere at 20°C. [6]

Take following properties of air at 80°C:

$$\nu = 21.09 \times 10^{-6} \text{ m}^2/\text{s}, \text{Pr} = 0.692 \text{ and } k = 0.03 \text{ W/m-K}$$

Use following correlations: $\text{Nu} = 0.59 (\text{Ra})^{0.5}$

- Q7)** a) Write statement and mathematical expression of following laws of radiations in heat transfer. [4]
- i) Wein's Law ii) Lambert's cosine rule.
- b) What do you mean by radiation shape factor? List any four properties/rules of radiation shape factor. [6]
- c) Two very large parallel planes with emissivities 0.3 and 0.8 having temperatures 1000K and 600K, exchanges radiation energy. A polished aluminium radiation shield with emissivity (ϵ) 0.1 is placed between them to reduce radiation heat transfer between two planes. Determine. [6]
- i) The radiation heat loss without radiation shield.
- ii) The radiation heat loss with the radiation shield.
- iii) Percentage reduction in heat transfer rate after placing radiation shield.

OR

- Q8)** a) Define Radiosity and Irradiation. [4]
- b) Explain the concept of surface resistance and space resistance. [6]
- c) A black surface is emitting thermal radiation at 4727°C. Calculate heat flux due to thermal radiation from the black surface, maximum monochromatic emissive power and the wavelength at which it occurs. [6]

- Q9) a)** Derive an expression for LMTD of parallel flow heat exchanger. [6]
- b) In a chemical plant, a product is produced at 700°C ($C_p = 3.6 \text{ kJ/kg-K}$) at the rate of 1000 kg/min is to be cooled by using another liquid available at 100°C ($C_p = 4.2 \text{ kJ/kg-K}$) flowing in counter flow direction at a rate of 1200 kg/min . The surface area of the heat exchanger is 42 m^2 and overall heat transfer coefficient is $1000 \text{ W/m}^2\text{-K}$. Determine outlet temperature of both fluids. [8]
- c) Differentiate between dropwise condensation and filmwise condensation. [4]

OR

- Q10) a)** Draw a labeled sketch of pool boiling curve. Explain following terms with reference to this curve. [8]
- i) Nucleate boiling
- ii) Critical heat flux
- b) A counter flow shell and tube type heat exchanger is used to heat water at a rate of 0.8 kg/sec from 30°C to 80°C . With hot oil entering at 120°C and leaving at 85°C . Overall heat transfer coefficient is 125 W/m^2 . Calculate area of the heat exchanger required. Take specific heat of water as $4180 \text{ J/kg }^{\circ}\text{C}$. [6]
- c) Explain effectiveness and NTU for a heat exchanger. [4]

