

Total No. of Questions : 10]

SEAT No. :

P2923

[Total No. of Pages : 4

[5669]-512

T.E. (Mechanical Engineering)

HEAT TRANSFER

(2015 Pattern)

Time : 2.30 Hours]

[Max. Marks : 70

Instructions to the candidates:

- 1) *Answer Q.1 Or Q.2, Q.3 or Q.4, Q.5 or Q.6, Q.7 or Q.8 and Q.9 or Q.10.*
- 2) *Neat diagrams must be drawn wherever necessary.*
- 3) *Figures to the right indicate full marks.*
- 4) *Use of logarithmic tables slide rule, mollier charts, electronic pocket calculator and steam tables in allowed.*
- 5) *Assume suitable data, if necessary.*

- Q1)** a) Explain variation of thermal conductivity of metals and non-metals with temperature. **[4]**
- b) An Industrial freezer is designed to operate with an internal air temperature of -20°C when the external air temperature is 25°C and the internal and external heat transfer coefficients are $12\text{ W/m}^2\text{C}$ and $8\text{ W/m}^2\text{C}$ respectively. The walls of the freezer are composite construction, comprising of an inner layer of plastic ($K = 1\text{ W/m}^{\circ}\text{C}$ and thickness of 3 mm), and an outer layer of stainless steel ($K = 16\text{ W/m}^{\circ}\text{C}$ and thickness of 1mm). Sandwiched between these two layers is a layer of insulating material with $K = 0.07\text{ W/m}^{\circ}\text{C}$. Find the thickness of insulation that is required to reduce the heat loss to 15 W/m^2 . **[6]**

OR

- Q2)** a) Explain Thermal Contact Resistance. **[4]**
- b) An electrical cable of 6.5 mm diameter at a temperature of 60°C is to be insulated by a material having $k = 0.174\text{ W/m}^{\circ}\text{C}$. The cable runs through air at 20°C and having heat transfer coefficient is $8.72\text{ W/m}^2\text{C}$. Find the thickness of insulation, so that heat dissipated is maximum and heat dissipated at this thickness of insulation per meter length of the cable. **[6]**
- Q3)** a) Explain the significance of dimensionless parameters used in transient heat conduction. **[4]**

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- b) The electric wire of thermal conductivity $k = 20 \text{ W/m } ^\circ\text{C}$, 3 mm in diameter and 1m long has current flow = 200 amperes, $\rho(\text{resistivity}) = 70 \mu\Omega\text{-cm}$. The wire is submerged in a liquid at 100°C and the surface heat transfer coefficient is $2000 \text{ W/m}^2\text{ }^\circ\text{C}$. Calculate the center temperature of the wire. [6]

OR

- Q4) a)** Fins are provided to increase the heat transfer rate from a hot surface. Which of the following arrangements will have the maximum heat transfer rate

- i) 8 fins with 16 cm length or
- ii) 16 fins with 8 cm in length

Take conductivity of fin material as $300 \text{ W/m } ^\circ\text{C}$, heat transfer coefficient, $h = 20 \text{ W/m}^2\text{ }^\circ\text{C}$ cross sectional area of the fin = 2 cm^2 , perimeter of fin cross section = 4 cm , temperature of the hot surface = 230°C , ambient temperature = 30°C . Assume fins of insulated ends. [6]

- b) What is the purpose of insulation? List any two insulating materials with their thermal conductivity values. [4]

- Q5) a)** Calculate appropriate Reynolds numbers and state if the flow is laminar or turbulent for the followings : [4]

- i) The roof of coach 6m long, travelling at 100 km/hr in air ($\rho = 1.2 \text{ kg/m}^3$, $\mu = 1.8 \times 10^{-5} \text{ kg/ms}$)
- ii) 0.05 kg/s of carbon dioxide gas at 400 K flowing in a 20mm diameter pipe ($\mu = 1.97 \times 10^{-5} \text{ kg/ms}$)

- b) List various dimensionless numbers in Natural and forced convection. Also state their expressions. [4]

- c) Estimate the heat loss from a vertical wall exposed to Nitrogen at 1 atm & 4°C . The wall is 2m high and 2.5m wide and is maintained at 56°C . The average Nusselt number over height of the wall for Natural convection is given by [8]

$$Nu_H = 0.13(Gr Pr)^{1/3}$$

The properties for Nitrogen at a mean film temperature are given as $\rho = 1.142 \text{ kg/m}^3$, $K = 0.026 \text{ W/m}$, $\nu = 15.63 \times 10^{-6} \text{ m}^2/\text{s}$, $Pr = 0.713$.

OR

- Q6)** a) Explain with neat sketch mechanism of formation of thermal boundary layer when cold air blown over a hot flat plate. [6]
- b) A metallic bar 2.5cm in diameter carrying current and should be maintained at 85 °C which is achieved by allowing the air at 30 °C to flow at 2.5m/s perpendicular to its axis. Find the heat transfer coefficient on the surface of the bar and permissible current flow. Take resistivity of the metallic bar = $0.015 \times 10^{-6} \Omega\text{m}$. Use the following properties of air at mean film temperature. [10]

$$\nu = 18.65 \times 10^{-6} \text{ m}^2/\text{s}, K = 0.029 \text{ W/mK}, \text{Pr} = 0.7$$

Use the following correlation

$$Nu_d = 0.683 (Re_d)^{0.47} (Pr)^{0.33}$$

- Q7)** a) State and explain any four rules regarding radiation shape factor. [8]
- b) Liquid oxygen (Boiling Temperature = -182°C) is to be stored in spherical container of 30cm diameter. The system is insulated by an evacuated space between inner space and surrounding 45cm inner diameter concentric sphere. For both spheres $\epsilon = 0.03$ and temperature of the outer sphere is 30°C . Estimate the rate of heat flow by radiation to the oxygen in the container and rate of evaporation of liquid oxygen if its latent heat is 220 kJ/kg. [8]

OR

- Q8)** a) Explain “Surface resistance” and “Space resistance”. Construct radiation network for two gray surfaces exchanging radiant energy. Give the formula for the radiant heat exchange between them. [6]
- b) Write the statements and mathematical expressions of the following laws in radiation heat transfer : [4]
- Planck’s Law
 - Lambert’s cosine law.
- c) Determine the radiant heat exchange between two large parallel steel plates of emissivity 0.8 and 0.5 held at temperature of 1000 K and 500 K respectively, if a thin copper plate of emissivity 0.1 is introduced as a radiation shield between two plates. [6]
- Q9)** a) Explain the six regimes of pool boiling with the help of neat curve. [8]
- b) What is fouling? What are the factors causing fouling? [4]
- c) Air cooled condenser of 1 TR split air-conditioner rejects heat 4.2 kW. The ambient temperature is 30°C whereas condensing temperature of the refrigerant is 45°C . Calculate the temperature rise of the air as it flows over the condenser tubes. Take for condenser $UA = 350 \text{ W/K}$. [6]

OR

- Q10)** a) Differentiate between Film wise condensation and Drop wise condensation. [4]
- b) Draw labelled temperature profiles of the following types of heat exchangers : [4]
- Direct transfer type parallel flow.
 - Direct transfer type counter flow.
 - Condenser.
 - Evaporator.
- c) A steam condenser consists of 3000 brass tubes of 20mm diameter. Cooling water enters the tube at 20 °C with a mean flow rate of 3000kg/s. The heat transfer coefficient on the inner surface is 11270 W/m² °C and that for condensation on the outer surface is 15500 W/m² °C. The steam condenses at 50 °C and the condenser load is 230 MW. The latent heat of steam is 2380 KJ/kg. Assuming counter flow arrangement, Calculate the tube length per pass if two tube passes are used. If flow arrangement is parallel what is the effect on LMTD of steam condenser. [10]

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