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 W/m^2 °C and 8 W/m^2 °C respectively. The walls of the freezer are composite construction, comprising of an inner layer of plastic (K = 1 W/m °C and thickness of 3 mm), and an outer layer of stainless steel (K = 16 W/m °C and thickness of 1mm). Sandwiched between these two layers is a layer of insulating material with K = 0.07 W/m °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 W/m°C. The cable runs through air at 20 °C and having heat transfer coefficient is 8.72 W/m^2 °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 W/m °C, 3 mm in diameter and 1m long has current flow = 200 amperes, ρ(resistivity) = 70 μΩ-cm. The wire is submerged in a liquid at 100 °C and the surface heat transfer coefficient is 2000 W/m² °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 300W/m °C, heat transfer coefficient, h = 20 W/m² °C cross sectional area of the fin = 2cm², perimeter of fin cross section = 4cm, temperature of the hot surface = 230 °C, ambient temperature = 30 ºC. 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 (ρ = 1.2 kg/m³, μ = 1.8 × 10⁻⁵ kg/ms)

ii) 0.05 kg/s of carbon dioxide gas at 400 K flowing in a 20mm diameter pipe (μ = 1.97 × 10⁻⁵ 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 ºC. The average Nusselt number over height of the wall for Natural convection is given by **[8]**

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

The properties for Nitrogen at a mean film temperature are given as ρ = 1.142 kg/m³, K = 0.026 W/m, ν = 15.63 × 10⁻⁶ m²/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 = 0.015×10^{-6} Ωm. Use the following properties of air at mean film temperature. **[10]**

$\nu = 18.65 \times 10^{-6}$ m²/s, K = 0.029 W/mK, Pr = 0.7

Use the following correlation

$$Nu_d = 0.683(\mathrm{Re}_d)^{0.47}(\mathrm{Pr})^{0.33}$$

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 ε = 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]**

i) Planck's Law

ii) 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 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]**

i) Direct transfer type parallel flow.

ii) Direct transfer type counter flow.

iii) Condenser.

iv) 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/m^2 °C and that for condensation on the outer surface is 15500 W/m^2 °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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