Reg. No. : | | | | | | | | | | | |

Q 2409

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2007.

Sixth Semester

Mechanical Engineering

ME 340 — HEAT AND MASS TRANSFER

Time : Three hours   Maximum : 100 marks

(Use of Steam Tables, Mollier Chart and HMT Data Book is permitted)

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. What is the mechanism of heat conduction in solids?

2. What are boundary and initial conditions?

3. Why Heisler charts cannot be used for the case of Biot number approaching zero? What is the alternative for solving this typical case?

4. State and prove the Kirchoff's law of radiation.

5. State how the radiation from gases is different from the radiation from surfaces.

6. Define Grashof number, and explain its significance in natural convection heat transfer.

7. Define the velocity and thermal boundary layer thickness.

8. State the difference between the film wise and drop wise condensation.

9. Draw the temperature variations in parallel flow and counter flow heat exchangers.

10. State Fick's law of mass diffusion, and indicate its limitations?

PART B — ($5 \times 16 = 80$ marks)

11. (a) (i) Derive an expression for steady state one dimensional heat conduction through a hollow cylinder. (4)

(ii) A composite wall is made up of a steel plate 1.5 cm thick lined inside with silica brick 20 cm thick and on the outside with magnesite brick 20 cm thick. The temperature on in side edge of the wall is 750°C and on the outside is 100°C. Find the heat transferred through the wall per square meter of wall surface and the interface temperatures. The conductivities of silica brick, steel and magnesite brick are 2.3×10^{-3} kW/m°C, 0.0197 kW/m°C and 5.805×10^{-3} kW /m°C respectively. It is required that the heat flow be reduced by 60% by means of an air gap between steel and magnesite brick. Estimate the width of the air gap if the thermal conductivity of the air is 4.64×10^{-5} kW/m°C. (12)

Or

(b) (i) An aluminium rod 25 mm in diameter and 150 mm long protrudes from a wall which is maintained at 260°C. The rod is exposed to an environment at 16°C. The convection heat transfer coefficient is 15 W/m^{2}k. Calculate the heat loss by the rod. Assume the conductivity of the aluminium as 204 W/m°C. (8)

(ii) A thermocouple bead of 2 mm diameter (spherical) of material density 8500 kg/m^3, thermal conductivity 20 W/mk and specific heat 0.4 kJ/kg K, initially at 25°C is suddenly exposed to gases at 200°C with a convection coefficient of 300 W/m^{2}k. Calculate the temperature of the bead after 5 seconds. (8)

12. (a) (i) Explain radiation shape factor and the important laws associated with the shape factor. (6)

(ii) Two very large parallel planes with emissivities of 0.3 and 0.8 exchange heat by radiation. Find the percentage reduction in heat transfer when a polished aluminium radiation shield of emissivity 0.04 is interposed between them. (10)

Or

(b) (i) Derive the expression for the radiant heat exchange between two real surfaces, using the definition of irradiation and radiosity. (8)

(ii) Two long coaxial cylinders of 0.3 m and 0.4 m diameter are at 600°C and 400°C. The surface emissivities for both are 0.6. The inner cylinder is hotter one. Determine the heat exchange by radiation per unit length. (8)

13. (a) (i) Derive the following expression for forced convection through dimensional analysis "$Nu = C.(Re)^m (Pr)^n$", where Nu-Nusselt number, Re- Reynolds number, Pr- Prandtl number, C, m and n are constants. (10)

(ii) Air at 60°C flows over a flat plate maintained at 140°C with a free stream velocity of 6 m/sec. Using values of the properties of air extracted from standard tables, determine the average heat transfer coefficient for the plate 1 m long. (6)

Or

(b) (i) Bring out the difference between the free and forced convection heat transfer. (6)

(ii) A square plate 60 cm side and at 120°C is exposed to air at 20°C. Find out the heat loss from both the sides of the plate by free convection, when the plate is kept vertical and also when the plate is kept horizontal. (10)

14. (a) (i) Explain briefly the various regimes of pool boiling. (8)

(ii) Dry saturated steam at 100°C condenses on a surface at 96°C. The surface is a vertical tube of height 1 m. Determine the film thickness and local heat transfer coefficient at a distance of 0.3 m from the top. (8)

Or

(b) (i) What is meant by fouling factor? Discuss the salient features of the correction factor. (6)

(ii) A single shell pass, four tube pass heat exchanger is used to cool lubricating oil from 70°C to 45°C at a rate of 15 kg/sec. Water at 25°C is used at a flow rate of 15 kg/sec. Determine the area required if the overall heat transfer coefficient has a value of 150 $W/m^{2}°C$. The oil has a specific heat of 2.3 kJ/kg °C. (10)

15. (a) (i) Define the diffusion coefficient and also specify the similarities between convection heat and mass transfer. (6)

(ii) Determine the mass of water vapour diffusing through a column of height 10 m, if the total pressure is 1 atm and the partial pressure of water vapour at the bottom is 0.1 atm and at the top is 0.03 atm. The diffusion coefficient is 0.26×10^{-4} m²/sec. Consider unit area. (10)

Or

(b) (i) Derive an expression for isothermal equimolal counter diffusion mass transfer. (8)

(ii) Air at 25°C and at atmospheric pressure flows with a velocity of 3 m/sec inside a 10 mm diameter tube of 1 meter length. The inside surface of tube contains deposits of naphthalene. Determine the average mass transfer coefficient. (Assume the diffusion coefficient for naphthalene-air as 0.62×10^{-5} m^2/sec.). (8)