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

T 3356

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2008.

Sixth Semester

(Regulation 2004)

Mechanical Engineering

ME 1351 — HEAT AND MASS TRANSFER

(Common to B.E. (Part-Time) Fifth Semester Regulation 2005)

Time : Three hours Maximum : 100 marks

Heat and Mass Transfer Data Books, Steam Tables are permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. A temperature difference of 500°C is applied across a fire-clay brick. 10 cm thick having a thermal conductivity of 1.0 W/m.K. Find the heat transfer rate per unit area.

2. Write the general 3-D heat conduction equation in cylindrical coordinates.

3. Biot number is the ratio between ———— and ————.

4. Define bulk temperature.

5. A vertical flat plate is maintained at a temperature lower than the surrounding fluid. Draw the velocity and temperature profiles assuming natural convection.

6. What is burnout point? Why is it called so?

7. What is a compact heat exchanger? Give examples.

8. What is thermal radiation and what is its wavelength band?

9. What are radiation shields?

10. Explain the physical meaning of Schmidt number.

PART B — (5 × 16 = 80 marks)

11. (a) A composite wall is formed of a 2.5 cm copper plate (k = 355 W/m.K), a 3.2 mm layer of asbestos (k = 0.110 W/m.K) and a 5 cm layer of fiber plate (k = 0.049 W/m.K). The wall is subjected to an overall temperature difference of 560°C (560°C on the Cu plate side and 0°C on the fiber plate side). Estimate the heat flux through this composite wall and the interface temperature between asbestos and fiber plate.

Or

(b) When a thermocouple is moved from one medium to another medium at a different temperature, sufficient time must be given to the thermocouple to come to thermal equilibrium with the new conditions before a reading is taken. Consider a 0.1-cm-diameter copper thermocouple wire originally at 150°C. Find the temperature response (i.e., an approximate plot of temperature Vs time for intervals of 0, 40 and 120 seconds) when this wire is suddenly immersed in

(i) water at 40°C (h = 80 $W/m^2.K$)

(ii) air at 40°C (h = 40 $W/m^2.K$)

Assume unit length of wire.

12. (a) Air at 400 K and 1 atm pressure flows at a speed of 1.5 m/s over a flat plate of 2 m long. The plate is maintained at a uniform temperature of 300 K. If the plate has a width of 0.5 m, estimate the heat transfer coefficient and the rate of heat transfer from the air stream to the plate. Also estimate the drag force acting on the plate.

Or

(b) Cylindrical cans of 150 mm length and 65 mm diameter are to be cooled from an initial temperature of 20°C by placing them in a cooler containing air at a temperature of 1°C and a pressure of 1 bar. Determine the cooling rates when the cans are kept in

(i) horizontal position

(ii) vertical position.

13. (a) Water is to be boiled at atmospheric pressure in a mechanically polished stainless steel pan placed on top of a heating unit. The inner surface of the bottom of the pan is maintained at 108°C. The diameter of the bottom of the pan is 30 cm. Assuming Csf = 0.0130. calculate

(i) the rate of heat transfer to the water, and

(ii) the rate of evaporation of water.

Or

(b) Define effectiveness of a heat exchanger. Derive an expression for the effectiveness of a double pipe parallel flow heat exchanger. State the assumptions made.

14. (a) (i) Discuss briefly the variation of black body emissive power with wavelength for different temperatures. (8)

(ii) The spectral emissivity function of an opaque surface at 800 K is approximated as

$$\varepsilon_\lambda = \begin{cases} \varepsilon_1 = 0.30 & 0 \le \lambda < 3\,\mu m \\ \varepsilon_2 = 0.80 & 3\,\mu m \le \lambda < 7\,\mu m \\ \varepsilon_3 = 0.10 & 7\,\mu m \le \lambda < \infty \end{cases}$$

Calculate the average emissivity of the surface and its emissive power. (8)

Or

(b) Explain briefly the following : (5 + 5 + 6)

(i) Specular and diffuse reflection

(ii) Reflectivity and transmissivity

(iii) Reciprocity rule and summation rule.

15. (a) Discuss briefly the following : (4 + 6 + 6)

(i) Fick's law of diffusion

(ii) Equimolar counter diffusion

(iii) Evaporation process in the atmosphere.

Or

(b) (i) What are the assumptions made in the 1-D transient mass diffusion problems? (4)

(ii) An open pan, 20 cm diameter and 8 cm deep contains water at 25°C and is exposed to dry atmospheric air. Estimate the diffusion coefficient of water in air, if the rate of diffusion of water is 8.54×10^{-4} kg/h. (12)
