D 27112 (Pages : 2) Name.....

Reg. No.....

FIFTH SEMESTER B.Tech. (ENGINEERING) DEGREE EXAMINATION DECEMBER 2006

ME 04 502—HEAT AND MASS TRANSFER

(2004 admissions)

Time : Three Hours **Maximum : 100 Marks**

Answer **all** *questions.*

Use of Heat and Mass Transfer Data books and charts are permitted.

Any standard data can be suitably assumed, if necessary.

1. (a) How does thermal conductivity for solids, liquids and gases depend on temperature ?

(b) Differentiate between steady and transient heat conduction.

(c) Which dimensionless parameter basically determines the character of a transient conduction solution ? How does it classify transient conduction problems ? Explain in brief.

(d) Explain the terms bulk fluid and bulk temperature.

(e) Under what condition does the thermal boundary layer remain within the hydrodynamic boundary layer ?

(f) Explain on what is the basis the convection problems are classified as free convection, forced convection and combined free and forced convection.

(g) How does radiation enhance film boiling ?

(h) What do you mean by a black body ? Why is it so called ? Why does a cavity with a small hole behave as a black body ?

(8 × 5 = 40 marks)

Part B

2. (a) Discuss the property of a material which determines the heat that it can conduct under steady state conditions.

(5 marks)

(b) An annealing chamber has a composite wall made of a 17 cm thick fire brick layer (k = 1.11 W/m°C) and a 13 cm thick ordinary brick layer (k = 0.71 W/m°C). The inside and outside surface temperatures of the wall are 400°C and 45°C respectively. Calculate the heat loss from 25 m^2 of furnace wall. Also determine the temperature between the ordinary brick and the fire brick layers.

(10 marks)

Or

(c) Pipe lines for municipal water supply in cold countries are laid deep in the ground so that water does not freeze in the winter. At a certain place, the average temperature during the winter is estimated to be 3°C and the minimum temperature goes down to -15°C and continues for about a month. Calculate the depth at which the pipe should be laid in order to prevent freezing of water. For soil, density 2000.1 kg/m^3, specific heat 2.1 kJ/kg K, thermal conductivity 0.58 W/m K.

(15 marks)

Turn over

3. (a) Warm water is required at the rate of 500 kg/h for washing a filter cake, and it is decided to use a 25 mm steam heated tube for the purpose. The tube wall is maintained at 130° by condensing steam on the outside surface. Calculate the length of the tube required to heat the water from 30°C to 50°C at the required rate. Use the Dittus-Boelter equation to calculate the heat transfer coefficient. The i.d. of the tube is 21.21 mm. Take the properties of water as, Viscosity 6.82×10^{-4} kg/m s, Thermal conductivity is 0.63 W/m K, specific heat is 4.174 kJ/kg K. Neglect the tube wall resistance.

(15 marks)

Or

(b) A 25.1 mm diameter heating element having a surface temperature 300°C is immersed in water in a vessel. The ambient pressure is atmospheric. Calculate the film boiling heat flux.

(7 marks)

(c) A laboratory water bath has an immersed horizontal heating element, 2.541 cm in diameter and 30 cm in length, with a power input of 500 W. If the bulk water temperature is 38°C and heat transfer occurs by free convection only, calculate the surface temperature of the heater.

(8 marks)

4. (a) A black body is at a temperature of 1000°C. Calculate :

(i) the wavelength at which the body has maximum monochromatic emissive power, and the corresponding emissive power ;

(ii) the total emissive power of the black body.

(iii) the fraction of the total radiant energy emission between the wavelengths 2.0 and 4.5 μm.

(iv) the hemispherical emissive power.

(v) The percentage reduction in the total emissive power when the temperature of the body falls down to 900°C.

(15 marks)

Or

(b) Two large parallel surfaces at temperatures 500°C and 200°C, and of emissivities 0.8 and 0.5 respectively, are separated by a polished metal plate of emissivity 0.11. Calculate the rate of heat exchange between the surfaces and also the temperature of the separating metal plate.

(15 marks)

5. (a) Saturated steam at 120°C is condensing on the outer tube surface of a single pass heat exchanger. If the overall heat transfer coefficient is 1800 W/m^2 K. Determine the surface area of heat exchanger capable of heating 200 kg/h of water from 20°C to 90°C. Also determine the condensation rate of steam if latent heat of condensation of steam is 2202 kJ/kg.

(15 marks)

Or

(b) Write short note on Compact heat exchangers. (5 marks)

(c) Describe the various mechanism of mass transfer. (4 marks)

(d) Define mass transfer. How does it relate to molecular theory ? (6 marks)