Printed Pages—4 **EME504**

(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : 2104 **Roll No.** | | | | | | | | | | |

B. Tech.

(SEM. V) ODD SEMESTER THEORY EXAMINATION

2010-11

HEAT & MASS TRANSFER

Time : 3 Hours *Total Marks : 100*

Note : (1) Attempt **all** questions.

(2) All symbols have usual meanings.

(3) Be precise in your answer.

(4) Assume any relevant data, if missing.

1. Attempt any **two** of the following : **(10×2=20)**

(a) (i) Describe the mechanism of heat conduction in solids.

(ii) Identify the modes of heat transfer for the following cases :

Heat loss from a thermos flask and Boiling of water in a boiler.

(b) An electric cable having outside diameter as 1·2 cm, needs to be insulated with rubber. The cable is exposed to atmospheric air at 18°C. Calculate :

(i) the dissipation of heat from bare pipe per unit length.

(ii) the value of maximum heat dissipation per unit length.

(iii) the critical thickness of insulation.

Take k for rubber as 0·15 W/mK and h from outer surface to atmosphere as 8·7 W/m²K. Surface temperature of cable is 70°C.

(c) A chemical reactor consists of two co-axial cylinders having radii 1·5 cm and 1·7 cm respectively. The annular gap between the two cylinders is filled with packed bed in which the chemical reaction is taking place at constant pressure. The reaction releases heat 6,00,000 W/m^3 throughout the reactor. The entire inner wall is at a uniform temperature of 600°C and no heat transfer takes place from this surface. Calculate the temperature of outer wall. Derive the formula used. Take K for packed bed as 0·6 W/mK.

2. Attempt any **two** out of the following : **(10×2=20)**

(a) (i) Define the efficiency and effectiveness of fin.

(ii) Define Biot number and discuss its significance.

(b) A very long fin is exposed to air at 400°C. The temperature at locations 25 mm and 120 mm from the base of fin are 325°C and 375°C respectively. Find the box temperature of fin.

(c) A hot mild steel sphere (K = 43 W/mK) of diameter 10 mm is required to be cooled by an air flow at 25°C. Calculate the following considering its thermal diffusivity as 0·044 m^2/h :

(i) time required to cool the sphere from 600°C to 100°C.

(ii) instantaneous rate of heat transfer 1·5 minutes after the start of cooling.

Take h as 115 W/m^{2}K, specific heat of the spherical body as 474 J/kgK and density of sphere as 7850 kg/m^3.

3. Attempt any **two** out of the following : **(10×2=20)**

(a) For thermally fully developed internal flow of a fluid with constant properties, prove that the local heat transfer coefficient is constant (independent of axial location).

(b) A 100 W electric bulb has been approximated as 60 mm diameter sphere. Air stream at 27°C is moving at 0·3 m/s across this bulb and the bulb is at 127°C. Determine the heat transfer rate and percentage of power lost due to convection. For flow of gases over spheres, use correlation, $N_u = 0{\cdot}37\, R_e^{0{\cdot}6}$ for $25 < R_e < 1000$.

The physical properties of air at film temperature 77°C are :

$$\nu = 2{\cdot}08 \times 10^{-5}\ \text{m}^2/\text{s},\ K = 0{\cdot}03\ \text{W/mK}.$$

(c) For the case of free convection boundary layer on a heated vertical plate, show that :

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = g\beta(T - T_\infty) + v\frac{\partial^2 u}{\partial y^2}.$$

4. Attempt any **two** out of the following : **(10×2=20)**

(a) (i) Discuss various rules used in determination of radiation shape factor.

(ii) Derive an expression for surface resistance of a gray body.

(b) Two large plates maintained at 800°C and 300°C have emissivities as 0·3 and 0·5 respectively. Find the net radiant heat exchange per square metre for these plates. Value of Stefan-Boltzmann constant is $5{\cdot}669 \times 10^{-8}\ \text{W/m}^2\text{k}^4$.

(c) What is the use of radiation shield ? Prove that :

$$\frac{\text{heat transfer with n shields}}{\text{heat transfer without shields}} = \frac{1}{n+1}.$$

5. Attempt any **two** of the following : **(10×2=20)**

(a) 10000 kg/h of an oil having a specific heat of 2095 J/kgK is cooled from 80°C to 50°C by 8000 kg/h of water entering at 25°C in a double pipe counterflow heat exchanger. Determine the heat exchanger area for an overall heat transfer coefficient of 300 W/m^{2}K. Specific heat of water is 4180 J/kgK.

(b) Enlist the various applications of boiling heat transfer. Discuss the various regimes of saturated pool boiling.

(c) Define equimolar counter diffusion and derive the expression for diffusion flux rate for a binary gas mixture.