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BME-027

B.Tech. MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING)

Term-End Examination

00353

December, 2016

BME-027 : HEAT AND MASS TRANSFER

Time : 3 hours *Maximum Marks : 70*

Note : *Answer any **seven** questions. All questions carry equal marks. Use of scientific calculator is permitted. Assume missing data, if any.*

1. (a) Differentiate between thermal conductivity and thermal diffusivity.

(b) Two concentric spheres of 210 mm and 300 mm diameters with the space between them evacuated are to be used to store liquid air (−153°C) in a room at 27°C. The surfaces of the spheres are flushed with aluminium (ε = 0·03) and the latent heat of vaporization of the liquid air is 209·35 kJ/kg. Calculate the rate of evaporation of the liquid air. *5+5*

2. (a) What is critical thickness of insulation on a small diameter wire or pipe ? Explain its physical significance.

(b) A thick walled tube of stainless steel with 20 mm inner diameter and 40 mm outer diameter is covered with a 30 mm layer of asbestos insulation (K = 0·2 W/m °C). If the inside wall temperature of the pipe is maintained at 600°C and the outside insulation at 1000°C, calculate the heat loss per metre of length. *5+5*

3. (a) Distinguish between natural and forced convection heat transfer.

(b) A furnace wall is made up of three layers of thickness 250 mm, 100 mm and 150 mm with thermal conductivities of 1·65, K and 9·2 W/m °C respectively. The inside is exposed to gases at 1250°C with a convection coefficient of 25 W/m^2 °C and the inside surface is at 1100°C, the outside surface is exposed air at 25°C with convection coefficient of 12 W/m^2 °C.

Determine :

(i) The unknown thermal conductivity 'K'

(ii) The overall heat transfer coefficient

(iii) All surface temperatures *5+5*

4. (a) Distinguish between laminar and turbulent flow.

(b) An exterior wall of a house may be approximated by a 0·1 m layer of common brick (K = 0·7 W/m °C) followed by a 0·04 m layer of gypsum plaster (K = 0·48 W/m °C). What thickness of loosely packed rock wool insulation (K = 0·065 W/m °C) should be added to reduce the heat loss (or gain) through the wall by 80 percent ? *5+5*

5. (a) Define absorptivity, reflectivity and transmissivity.

(b) A large window glass, 0·5 cm thick (K = 0·78 W/m K), is exposed to warm air at 25°C, over its inner surface, with convection coefficient of 15 W/m^2 K. The outside air is at −15°C with convection coefficient of 50 W/m^2 K. Determine the heat transfer rate and temperature at the inner and outer surfaces of the glass. *5+5*

6. (a) What is convective mass transfer coefficient and what are its units ?

(b) Water flows at 20°C at 8 kg/sec. through a diffuser having 3 cm diameter at the entrance and 7·0 cm diameter at its exit. Calculate the fluid velocity and Reynolds number at the inlet and exit of the diffuser. *5+5*

7. (a) Define the Schmidt number, Sherwood number and Lewis number. What is the physical significance of each ?

(b) An electric wire of 1·5 mm diameter and 20 cm length is laid horizontally and submerged in water at atmospheric pressure. The current flowing through the wire is 40 A, while voltage drop is 16 V. Calculate the heat flux, heat transfer coefficient and excess temperature. *5+5*

8. (a) Explain Fick's law of diffusion. What is mass diffusivity ? What is its dimension ?

(b) The hydrogen gas diffuses through a steel wall of 2 mm thickness. The molar concentration of hydrogen at the interface is 1·5 kg mol/m^3 and it is zero on the outer face. Calculate the diffusion rate of hydrogen, if its diffusivity coefficient is $0{\cdot}3 \times 10^{-12}$ m^2/sec. *5+5*

9. (a) Explain equimolar counter diffusion.

(b) At the bottom of a well, 2·5 m in diameter, water is 5 m deep. Calculate the diffusion rate into dry atmospheric air at 25°C and 1·032 bar. Take diffusion coefficient $D_{AB} = 0{\cdot}0925$ m^2/h. *5+5*

10. (a) What is a black body ? What are its properties ? Why does a cavity with a small hole behave as a black body ?

(b) Air with a velocity of 3 m/sec. is flowing over a tray full of water. Assuming the temperature of air 20°C and the temperature of water on the surface 15°C, determine the amount of water evaporated per hour. Length of the tray along the air flow direction is 30 cm and its width is 50 cm. Take total pressure of water as 1·00 bar and partial pressure of water vapour in it as 0·0078 bar.

Properties of air are :

$\rho = 1{\cdot}205\ kg/m^3$, $C_p = 1{\cdot}00\ kJ/kg\ K$,

$\kappa = 0{\cdot}025\ W/m\ K$, $\nu = 15 \times 10^{-6}\ m^2/sec.$

$D = 0{\cdot}15\ m^2/hr$ *5+5*