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BIME-034

B.Tech. – VIEP – MECHANICAL ENGINEERING (BTMEVI)

Term-End Examination

00023

December, 2018

BIME-034 : HEAT AND MASS TRANSFER

Time : 3 hours *Maximum Marks : 70*

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

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

(b) A furnace wall is made up of three layers, one of brick, one of insulating brick and one of red brick. The inner and outer surfaces are at 870°C and 40°C respectively. The respective thermal conductivities of the layers are 1·17 W/mK, 0·139 W/mK and 0·875 W/mK respectively and thicknesses are 22 cm, 7·5 cm and 11 cm. Assuming close bonding of the layers at their interfaces, find the rate of heat loss per square metre per hour and interface temperatures. *5+5*

2. (a) Derive an expression for temperature distribution in a slab of thickness 'b' when its two faces are at temperatures t_1 and t_2, the thermal conductivity varies linearly with temperature according to $K = K_0(1 + \alpha t)$, where 'α' is a constant. Assume one-dimensional steady state heat conduction with no heat generation.

(b) A furnace has a small observation hole of 2·5 cm diameter. If the furnace temperature is 600°C, find

(i) the rate of energy loss from the hole due to radiation, and

(ii) the wavelength at which emission is maximum. *5+5*

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

(b) Prove that the shape factor of a cylindrical cavity of diameter D and height H with respect to itself is

$$F_{1 \to 1} = \frac{4H}{4H + D}.$$ *5+5*

4. (a) Distinguish between hydrodynamic and thermal boundary layers. What is the significance of these boundary layers in heat transfer ?

(b) Use the principle of dimensional analysis to establish a relationship between Nusselt number, Grashof number and Prandtl number. *5+5*

5. (a) Define the diffusion coefficient for a binary mixture. Is this coefficient dependent upon temperature, pressure and composition of the mixture ?

(b) Explain the phenomenon of equimolar counter diffusion. *5+5*

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

(b) Show by dimensional analysis that mass transfer by forced convection can be expressed by

$$Sh = f(Re, Sc),$$

where Sh = Sherwood number,

Re = Reynolds number, and

Sc = Schmidt number. *5+5*

7. (a) Show that the resistance offered by a hollow sphere of radii r_1, r_2 and constant thermal conductivity K, is given by

$$R_{sph} = \frac{r_2 - r_1}{4\pi r_1 r_2 K}.$$

(b) Consider a plane wall 20 cm thick. The inner surface is kept at 400°C, and the outer surface is exposed to an environment at 800°C with a heat transfer coefficient of 12 W/(m^2K). If the temperature of the outer surface is 685°C, calculate the thermal conductivity of the wall. *5+5*

8. (a) What is mass diffusivity ? What are its dimensions ? Explain each dimension in brief.

(b) Estimate the diffusion rate of water from the bottom of the test tube 1·5 cm in diameter and 15 cm long into dry atmosphere air at 25°C. Take diffusion coefficient of $25{\cdot}6 \times 10^{-6}$ m^2/sec.
(Give P_s = 3·169 kPa, Saturation pressure at 25°C) *5+5*