B.TECH SEM – V (2007 COURSE) (MECHANICAL ENGG.) :
SUMMER - 2018
SUBJECT: HEAT TRANSFER

Day: **Wednesday**
Date: **23/05/2018**

S-2018-2681

Time: **10.00 AM TO 01.00 PM**
Max. Marks: 80

N.B.:

1) **Q. 1** and **Q. 5** are **COMPULSORY** and attempt **ANY TWO** questions from the remaining questions in both the sections.
2) Answer to both sections should be written in **SEPARATE** answer books.
3) Figures to the right indicate **FULL** marks.
4) Assume suitable data wherever **necessary**.
5) Use non –programmable **CALCULATOR** is allowed.

SECTION - I

Q.1 a) What is Stefan Boltzmann Law? **(04)**

b) Discuss the effect of following parameters on thermal conductivity of solids: **(05)**
- i. Chemical composition
- ii. Mechanical forming
- **iii.** Temperature rise

c) State physical significance of Biot and Fourier number. **(05)**

Q.2 a) A steel pipe with 50 mm OD is covered with a 6.4 mm asbestos insulation (k = 0.166 W/m°C) followed by a 25 mm layer of fiber-glass insulation (k = 0.0485 W/m°C). The pipe wall temperature is 393 K and the outside insulation temperature is 311 K. Calculate the interface temperature between the asbestos and fiber-glass. **(08)**

b) Explain the concept of thermal resistance and conductance in case of a composite slab. **(05)**

Q.3 a) The rate of heat generation per unit volume in a long cylinder of radius R is given by $\dot{q}_g = a + br^2$ where a and b are constants and r is any radius. The cylinder is undergoing heat transfer with the medium which is at temperature T_a and surface heat transfer coefficient is h. Find the steady state temperature distribution in the solid. **(08)**

b) Explain the concept of critical thickness of insulation. **(05)**

Q.4 a) Derive an expression for heat transfer through an infinitely long rectangular fin with constant cross-sectional area. **(08)**

b) An aluminum alloy plate of 400 mm × 400 mm × 4 mm size at 200 °C is suddenly quenched into liquid oxygen at -183 °C. Determine the time required for the plate to reach a temperature of -70 °C. **(05)**
Assume following data:
h = 20000 kJ/m²h°C, C_p = 0.8 kJ/kg°C, ρ = 3000 kg/m³

P.T.O.

SECTION - II

Q.5 **a)** Define Nusselt number and state its physical significance. **(05)**

b) Define irradiation and radiosity. **(05)**

c) How will you classify heat exchangers? **(04)**

Q.6 A horizontal high pressure steam pipe of 10 cm outside diameter passes through a large room whose walls and air are at 23 °C. The pipe outside surface temperature is 165 °C and its emissivity is 0.85. Estimate the heat loss from the pipe per unit length. Use the following correlation for the calculation of film coefficient: **(13)**

$$\overline{Nu} = \left(0.6 + \frac{0.387 Ra^{1/6}}{\left(1+\left(\frac{0.559}{Pr}\right)^{9/16}\right)^{8/27}} \right)^2$$

Where *Ra* is known as Rayleigh number and is given by

$$Ra = Gr \times Pr = \frac{g\beta\Delta T L_c^3}{\vartheta\alpha}$$

Take following properties of air:

$k = 0.0313$ W/m°C, $\nu = 22.8 \times 10^{-6}$ m^2/s, $\alpha = 32.8 \times 10^{-6}$ m^2/s, $Pr = 0.697$, $\beta = 2.725 \times 10^{-3}$ K^{-1}

Consider both convective and radiative heat loss.

Q.7 **a)** State and explain Kirchhoff's law. **(06)**

b) Determine heat lost by radiation per meter length of 80 mm diameter pipe at 300 °C if, **(07)**

i. Located in large room with red brick walls at a temperature of 27 °C
ii. Enclosed in a 160 mm diameter red brick conduit at a temperature of 27°C

Take $\varepsilon_{pipe} = 0.79$ and $\varepsilon_{brick\ conduit} = 0.93$.

Q.8 **a)** Explain the concept of film condensation and drop-wise condensation. **(05)**

b) The amount of refrigerant (F_{12}) used in compression refrigeration system is 4 tonnes/hour. The brine flowing at 850 kg/min with inlet temperature of 120 °C, is cooled in the evaporator. Assuming F_{12} entering and leaving the evaporator as saturated liquid and saturated vapor respectively, determine the area of evaporator required. **(08)**

Take the following properties for F_{12}:

Saturation temperature: -23 °C, $C_p = 1.17$ kJ/kg°C, $h_{fg} = 167.4$ kJ/kg,

$C_{p,\,brine} = 6.3$ kJ/kg, $U = 8368$ kJ/m^{2}h°C

* * *