6. (a) A gray surface has an emissivity ε = 0.35 at a temperature of 550 K source. If the surface is opaque, calculate its reflectivity for black body radiation coming from a 550 K source. 7½

(b) A pipe with surface temperature of 480 K is kept within a large enclosure whose walls are at 380 K. Presuming the pipe surface to be black, calculate the coefficient of radiant heat transfer. If the heat transfer coefficient including the effect of radiation and convection is 34.9 $W/m^2$-deg, find the convective heat transfer coefficient. 7½

## Section D

7. (a) Define the term overall heat transfer coefficient. 7½

(b) What is meant by fouling factor ? How does it affect the performance of a heat exchanger ? 7½

8. (a) Sketch a shell and tube type heat exchanger. 7½

(b) A cold liquid (sp.heat 2.95 kJ/kg K) at 10 kg/min to be heated from 25ºC to 55ºC in a heat exchanger. The task is accomplished by



**Roll No. ........................** **Total Pages : 05**

# J-21-0021

## B. Tech. EXAMINATION, 2021

Semester V(CBCS)

HEAT TRANSFER (ME, AE)

ME-503

*Time :* 2 *Hours* *Maximum Marks :* 60

*The candidates shall limit their answers precisely within 20 pages only (A4 size sheets/assignment sheets), no extra sheet allowed. The candidates should write only on one side of the page and the back side of the page should remain blank. Only blue ball pen is admissible.*

**Note** : Attempt *Four* questions in all, selecting *one* question from any of the Sections A, B, C and D. Q. No. **9** is compulsory.

## Section A

1. (a) Write the Fourier rate equation for heat transfer by conduction. Give the physical significance of each term. 7½

(b) A plane slab of thickness $\delta = 60$ cm is made of a material of thermal conductivity $k = 17.5$ W/m-deg. The left side of the slab absorbs a net amount of radiant energy from a radiant source at the rate $q = 530$ watt/m$^2$. If the right-hand face of the slab is at a constant temperature $t_2 = 38$ºC, set up an expression for temperature distribution within the slab as a function of relevant space co-ordinates. Therefrom work out the temperature at the mid-plane of the slab and the maximum temperature within the slab. It may be presumed that the temperature distribution is steady and there is no heat generation. **7½**

**2.** A container with outside surface area 0.36 m$^2$ and outside temperature of 0ºC contains ice at 0ºC. The container is placed in ambient air at 24ºC and the surface coefficient of heat transfer between the container surface and the surrounding air is estimated to be 6.25 W/m$^2$-deg. Calculate the rate at which ice would be changed into liquid water. Take latent of fusion of ice as 340 J/g. **15**



## Section B

**3.** Prove that the temperature of a body at any time $\tau$ during Newtonian heating or cooling is given by the relation $\frac{t - t_a}{t_i - t_a} = \exp[-B_i F_0]$, where $B_i$ and $F_0$ are the Biot and Fourier modulus respectively; $t_a$ is the ambient temperature and $t_i$ is the initial temperature of the body. **15**

**4.** Glass spheres of 2 mm radius and at 500ºC are to be cooled by exposing them to an air stream at 25ºC. Make calculation for the maximum value of convection coefficient that is permissible, and the minimum time required for cooling to a temperature of 60ºC.

Assume the following property values :

density 2250 kg/m$^3$; sp. Heat 850 J/kgK and conductivity 1.5 W/m-deg. **15**

## Section C

**5.** When a small body of emissivity $\varepsilon$ at temperature T is placed in a large enclosure at temperature $T_0$, the net radiation heat loss is $\varepsilon\sigma_b(T^4 - T_0^4)$. Express this result in the form of Newton-Rikhman law and obtain the value of radiative heat transfer coefficient. **15**

extracting heat from hot water (sp. heat 4.186 kJ/kg K) available at mass flow rate 5 kg/min and inlet temperature 85ºC. Should the thermal engineer make design calculation based on parallel flow or counter flow configuration ? State the reason thereof. **7½**

**(Compulsory Question)**

**9.** Attempt all the following : **5×3=15**

(a) Write short notes on thermal conductivity and change with temperature for matters.

(b) Write short notes on Wein's displacement law, Stefen Boltzmann's law and Planck's law.

(c) Derive expressions for view factor of black bodies.

(d) Derive expressions for temperature profile for transient heat transfer.

(e) Discuss the importance of heat exchanger for industrial use.