Seat No.: _____ *Enrolment No._____*

GUJARAT TECHNOLOGICAL UNIVERSITY

B E Sem-VI Examination May 2011

Subject code: 161906 **Subject Name: Heat & Mass Transfer**

Date:24/05/2011 **Time: 10.30 am – 01.00 pm**

Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Derive general heat conduction equation in Cartesian co-ordinates. Also deduce the equation for **07**

(i) Steady state conduction
(ii) No heat sources
(iii) No heat source and steady state condition
(iv) One dimensional heat conduction equation without heat generation under steady state

(b) A wall 30 mm thick of size 5m X 3m made of red bricks (k=0.35 W/mK). It is covered on both sides by the layers of plaster 2cm thick (k=0.6 W/mK). The wall has a window of size 1m X 2m. The 12 mm thick window glass is having thermal conductivity of 1.2 W/mK. Estimate the rate of heat flow through the wall. The temperatures of inner and outer face are 10^oC and 40^oC respectively. **07**

Q.2 **(a)** (i) Define the effectiveness of fin? How to increase the effectiveness of fin? **07**

What happens if $\varepsilon_{fin} = 1$, $\varepsilon_{fin} < 1$ and $\varepsilon_{fin} > 1$

(b) Two rods A and B of equal diameter and equal length, but of different materials are used as fins. The both rods are attached to a plain wall maintained at 160^oC, while they are exposed to air at 30^oC. The end temperature of rod A is 100^oC while that of the rod B is $80\ ^oC$. If thermal conductivity of rod A is 380 W/mK, calculate the thermal conductivity of rod B. These fins can be assumed as short with end insulated. **07**

OR

(b) A 240 mm dia. steam pipe, 200 meter long is covered with 50mm of high temperature insulation of thermal conductivity 0.092 W/m^0C and 50mm of low temperature insulation of thermal conductivity 0.062 W/m^0C. The inner and outer surface temperatures are maintained at 340^0C and 35^0C respectively. Calculate: **07**

(i) The total heat loss per hour
(ii) The heat loss per m^2 of pipe surface
(iii) The heat loss per m^2 of outer surface
(iv) The temperature between interfaces of two layers of insulation.
Neglect heat conduction through pipe material.

Q.3 **(a)** Define effectiveness of heat exchanger. Derive equation for effectiveness of a parallel flow heat exchanger. **07**

(b) A counter flow heat exchanger is employed to cool oil of specific heat C_p=2.45 KJ/Kg^0C with mass flow rate of 0.55 Kg/sec from 115^0C to 40^0C by water. The inlet and outlet temperature of cooling water are 15^0C and 75^0C respectively. The overall heat transfer co-efficient is $1450W/m^{2.0}C$. Using NTU method, calculate: **07**

(i) The mass flow rate of water
(ii) The effectiveness of heat exchanger
(iii) The surface area required.

OR

Q.3 **(a)** Define: (i) Emissivity, (ii) Radiosity, (iii) Monochromatic emissive power, (iv) Irradiation, (v) Absorptivity, (vi) Total emissive power, (vii) Solid angle. **07**

(b) Two large parallel plates with emissivity (ε) = 0.5 each, are maintained at different temperatures and are exchanging heat only by radiation. Two equally large radiation shields with surface emissivity 0.05 are introduced in parallel to the plates. Find percentage reduction in net radiative heat transfer. **07**

Q.4 **(a)** For natural convection heat transfer, show that Nu =f(Gr, Pr). **07**

(b) A large fireplace has a glass fire screen which covers a vertical opening in the fireplace. The opening is 1.2m high and *2.50* m wide. Its surface temperature is 230^0C and the ambient air temperature is 24°C. Determine the convective rate of heat transfer from the fireplace to the room. The air properties at mean film temperature are : **07**

k = 0.033 65 W/m.K, v = 25.90 X 10^{-6} m2/s Pr = 0.689

Use correlation for given condition

$$\overline{Nu} = \left\{ 0.825 + \frac{0.387(Gr.\Pr)^{1/6}}{\left[1+(0.492/\Pr)^{9/16}\right]^{8/27}} \right\}^2$$

OR

Q.4 **(a)** Show physical significance of Following non-dimensional numbers: **07**

Nu (Nusselt Number), Gr (Grashof Number) and Pr (Prandtl Number), Re (Reynold Number).

(b) Air at 20^0C and 1 atmosphere pressure is forced through a 25 mm diameter tube 400 mm long, at an average velocity of 0.33 m/sec. calculate the rate of heat transfer if the tube wall is maintained at 180^0C. The air properties at mean film temperature are : **07**

k = 3.208 W/m.^{0}C, v = 23.13 X 10^{-6} m2/s Pr = 0.688

Use correlation for given condition

$$\overline{\mathrm{Nu}} = 1.671\left[\mathrm{Re.Pr}\left(\frac{\mathrm{D}}{\mathrm{L}}\right) + 0.012\left(\mathrm{Re.Pr}\left(\frac{\mathrm{D}}{\mathrm{L}}\right)(\mathrm{Gr})^{1/3}\right)^{4/3}\right]^{1/3}$$

Q.5 **(a)** Discuss various regimes of pool boiling. **08**

(b) Write note on influence of non condensable gases on condensation. **06**

OR

Q.5 **(a)** State the modes of mass transfer with suitable examples. Explain Fick's law of diffusion mass transfer. **07**

(b) A spherical element of 40 mm diameter is initially at temperature of 27^0C. It is placed in boiling water for 4 minutes. After 4 minutes, at what temperature, the spherical element will reach? If the same spherical element is initially at 0^0C, find out by lump theory that how much time will be taken by the element to reach at that temperature? **07**

Take properties of the given spherical element as:

k = 10 W/m^{0}C, ρ=1200kg/m^3 , c = 2KJ/kg^{0}C and heat transfer coefficient h= 100W/m^{20}C

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