Con. 8512-13. **LJ-11410**

(3 Hours) **[Total Marks : 100**

N.B. : (1) Question No. **1** is **compulsory**.
(2) Answer any **four** from the **remaining**.
(3) Assume suitable **data** if **necessary**.

Q-1. Answer any 4 questions: [20]

a) Find the heat flux across acomposite slab of width 0.25m and 0.15 m of conductivity 388 W/m-K and 250 W/ m-K respectively when its one surface is at 150°C and the other surface is at 40°C. Also find the temperature at the joint of two materials of the slab.

b) Air flows over a heated plate of length 15m at a velocity of 50m/sec. Calculate the Reynolds Number, Pradtl Number and Stanton number. The properties of the flow are as given below. (i) density of air, ρ = 0.88kg/m^3 (ii) viscosity, μ=2.286x10^{-6}Kg/m-s (iii) C_p =1.001KJ/Kg-K (iv) conductivity, k = 0.035 W/m-K (v) Heat transfer coefficient , h =110W/m^2 K.

c) Draw a neat Boiling curve for water and show the different boiling Regimes.

d) Calculate the following for an industrial furnace in the form of a black body and emitting radiation at 2500 °C.(Stefan Boltzmann Constant = 5.67 x 10^{-8}).
   (i) Monochromatic emissive power at 1.2 μm.
   (ii) Wave length at which the emission is maximum.
   (iii) Total emissive power of the furnace if it is assumed as areal surface with emissivity equal to 0.8.

e) Explain the critical thickness of insulation with its significance.

Q-2. a) A thermocouple junction is in the form of 8 mm diameter sphere. Properties of materials are C_p = 420 J/kg°C, ρ = 8000Kg/m^3, k = 40 W/m°C and h = 40W/ m^2-°C. This junction is initially at 40 °C and inserted in a stream of hot air at 300 °C. Find (i) Time constant of the thermocouple.(ii) The thermocouple is taken out from the hot air after 10 seconds and kept in still air at 30°C. Assuming the heat transfer coefficient in air 10 W/m^2-°C, find the temperature attained by the junction 20 seconds after removing from hot air. [10]

b) Derive the relationship between the effectiveness and the number of Transfer Units for a parallel flow heat exchanger [10]

Q-3. a) Define **"shape factor"** and explain its properties [4]

b) A cylindrical enclosure is formed by 3 surfaces and the details of their shape factors, the emissivity and the temperatures are as given below. [8]

Surface	Shape	Emissivity	Temperature (°C)
1	Curved Surface	0.8	500
2	Top end closing Disc	0.85	400
3	Other end closing Disc	0.85	400

Diameters of two closing flat surfaces and the interspacing between them are 25mm and 100 mm respectively. Shape factor between two identical flat surfaces is 0.05. Calculate net rate of radiant heat transfer leaving from curved surface and reaching the closing flat circular surfaces.

c) One end of a copper rod 15cm long and 0.6 cm in diameter is connected to a wall maintained at 300°C and the other end protrudes into a room whose air temperature is 20°C. If tip of the rod is insulated, estimate heat loss by the rod. Take h= 28W/m^2-K, k =370W/m-K. Also find the efficiency of heat transfer. [8]

Q-4. a) A hollow cylinder 60mm ID, 90mm OD has a heat generation rate of $5x10^6 W/m^3$. Inner surface is maintained at 450°C and outer surface at 350°C. K of the material is 3W/m-K. [10]

(i) Determine location and value of maximum temperature
(ii) What is the temperature at mid thickness of the cylindrical shell?
(iii) Determine the fraction of heat generated going to the inner surface.

b) The inner and outer radii of a hollow cylinder are 50mm and 100mm respectively. The inside surface is maintained at 300°C and the outer surface at 100°C. The thermal conductivity varies with the temperature over this temperature range as k(T) =0.5 +$0.5x10^{-3}$T, where T is in °C and k(T) is in W/m°C. Determine [10]

(i) heat flow rate per meter length of cylinder
(ii) temperature at mid thickness of the shell

Q-5. a) A flat plate 1m wide and 1.5 m long is to be maintained at 90°C in air with a free stream temperature of 10°C. Determine the velocity with which the air must flow over flat plate along the 1.5 m side so that the rate of energy dissipation from the plate is 3.75KW. Use the correlation (i) $\overline{Nu} = 0.664 Re_L^{1/2} Pr^{1/3}$(for Laminar flow) (ii) $\overline{Nu} = (0.036\ Re_L^{0.8} - 836)\ Pr^{1/3}$ (for turbulent flow). Properties of air at mean temperature (50°C) are ρ = 1.09Kg/m^3, k = 0.028W/m°C, C_p=1.007KJ/Kg°C, μ=$2.03x10^{-5}$Kg/m-s, Pr = 0.7. [10]

b) Using dimensional analysis, derive an expression for heat transfer coefficient in forced convection in terms of Nusselt number, Reynolds number and Prandtl number. [10]

Q-6. a) The effectiveness of aheat exchanger is 0.7 and the heat transferarea is 1.5m^2. Find the rate of hear transfer if The overall temperature rise of the cold fluid in a **counter flow** heat exchanger is 30°C and overall temperature drop of hot fluid is 40°C.Assume both fluids are unmixed and use analytical method. Also find the LMTD of the heat exchanger if the overall heat transfer coefficient is 50W/m^2 °C. [10]

b) A horizontal steam pipe of 100mm OD runs through a room where the ambient air is at 20°C. If the outside surface of the pipe is at 180°C and the emissivity of the surface is 0.9, find out total heat loss per meter length of pipe. Properties of air at film temperature are ρ = 0.946Kg/m^3, v = 23.02 $x10^{-6}$, k= 0.03127W/m°C, C_p=1011.3J/Kg°C, Pr =0.704 and the correlation for the free convective heat loss is Nu=0.48 $Ra^{(1/4)}$. [10]

Q-7. a) A 30mm deep pan is filled with water to a level of 15mm and is exposed to dry air at 40°C. Assuming the mass diffusivity as 0.25 x $10^{-4}m^2$/s calculate time required for all the water to evaporate. Take partial pressure of water = 0.07384 bar and Atmospheric pressure = 1.0132 bar. [8]

b) Define effectiveness and efficiency of fins [4]

c) Explain significance of (i) Reynolds Number (ii) Grashoff Number [4]

d) State and explain Kirchoff's law [4]