Q. P. Code: 39558

[3 Hours] **[Total Marks: 80**

N. B : (1) Question no.1 is **Compulsory**.
(2) Attempt any **THREE** from question no.2 to 6.
(3) Use illustrative diagrams wherever possible.
(4) Assume suitable data if necessary and mention it clearly.
(5) Use of steam table is permitted.

Q.1 Answer any **Four** questions : 20

a) What is the mode of heat transfer in vacuum? Define absorptivity, reflectivity and transmissivity and establish the relation among them.

b) Differentiate between the mechanism of filmwise and dropwise condensation.

c) What are the various types of fins? Discuss some of the important applications of fins

d) What is Heat exchanger? Draw Temperature profile for Parallel flow and Counter flow heat exchanger, Condenser, Evaporator.

e) A large window glass 0.5 cm thick (k = 0.78W/m.K) of heat transfer area of $1m^2$ is exposed to warm air at 25^0C ,over its inner surface, with convection coefficient of 15 $W/m^2.K$.The outer air is at -15^0C with convection coefficient of 50 $W/m^2.K$. Determine the heat flow rate through the glass.

Q.2 a) A steam pipe of length 1m and 5cm inside diameter and 6.5 cm outside diameter is insulated with a 2.75 cm radial thickness of high temperature insulation (k= 1.1 W/m.K). The surface heat transfer coefficient for inside and outside surfaces are 4650 $W/m^2.K$ and 11.5 $W/m^2.K$, respectively. The thermal conductivity of pipe material is 45 W/m.K. If the steam temperature is 200^0C and ambient air temperature is 25^0C,determine ;i) Heat lost per metre length of pipe ii) Temperature at the interface iii) Overall heat transfer coefficient based on inner and outer radius 12

b) Write short note on- 8
i) Lump system analysis
ii) Heisler charts

Q.3 a) Air at 27°C is flowing across a tube with a velocity of 25 m/s. The tube could be either a square of 5 cm side or a circular cylinder of 5 cm diameter. Compare 10
the rate of heat transfer in each case, if the tube surface is at 127°C.
Use $Nu = C (Re)^n (Pr)^{1/3}$
Where, C =0.027, n =0.805 for cylinder
C =0.102, n =0.675 for square tube.
Properties of air at 77°C,
ρ =0.955 kg/m^3, k_f =0.03 W/mK, v =20.92 $X10^{-6}$ m^2/s, Pr=0.7,
Cp =1.009 kJ/kgK.

b) Prove that the total emissive power (E) of a diffuse surface is equal to π times its intensity of radiation (I). 10

Q.4 a) Steam in a condenser of a steam power plant is to be condensed at a temperature of 30^0C with a cooling water from nearby lake, which enters the tube of condenser at 14^0C and leaves at 22^0C. The surface area of the tubes is 45 m^2 and an overall heat transfer coefficient is 2100W/m^2K.Calculate the mass flow rate of cooling water needed and rate of steam condensation in the condenser. Treat the condenser as counter flow heat exchanger. Cp of water at 18^0C is 4.18kJ/kg.K and latent heat of vaporization at 30^0C is h_{fg} =2430.5kJ/kg — 10

b) State and explain the following laws- — 6

i) Plank's law

ii) Stefan Boltzman law

c) Explain time constant of a thermocouple. — 4

Q.5 a) An enclosure measures 1.5 m x 1.75 m with a height of 2 m. Under steady state equilibrium conditions, the wall and ceiling are maintained at 525 K and floor at 400 K. Determine the net radiation to floor. ε_1(emissivity of ceiling and wall) =0.85 ε_2 (emissivity of floor) =0.75 take σ (Stefan-Boltzman constant)=5.67 x 10^{-8} W/m^2 K^4 — 6

b) The inside temperature of furnace wall, 200 mm thick, is1350^0C.The mean thermal conductivity of wall material is 1.35W/m^0C.The heat transfer coefficient of the outside surface is a function of temperature difference and is given by $h=7.85+0.08\Delta t$ where Δt is the temperature difference between outside wall surface and surroundings .Determine the rate of heat transfer per unit area if the surrounding temperature is 40^0C . — 6

c) Derive an expression for the effectiveness of a parallel flow heat exchanger in terms of the number of transfer units (NTU) and the capacity ratio[C_{min}/C_{max}]. — 8

Q.6 a) Explain physical significance of i) Reynold's number ii) Nusselt's number — 4

b) In a quenching process a copper plate of 3 mm thick is heated up to 350^0C and then suddenly ,it is dropped into a water bath at 25^0C. Calculate the time required for the plate to reach the temperature of 50^0C.The heat transfer coefficient on the surface of the plate is 28 W/m^2.K. The plate dimensions may be taken as length 40 cm and width 30 cm. Take the properties of copper as C=380J/kg.K, ρ =8800 kg/m^3,k=385W/m.K — 8

c) Explain shape factor and its properties. Find the shape factor of a cylindrical cavity(enclosed on its surface with a flat surface) of diameter d and depth h with respect to itself. — 8