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

Please check whether you have got the right question paper.

N.B:
1. Q. No. 1 is **compulsory**.
2. Attempt any Three out of remaining questions.
3. Assume suitable data if necessary and state it clearly.
4. Draw neat sketches wherever required.
5. Answer to the sub questions of individual question should be grouped & written together i.e one below the other.
6. Steam Tables would be provided.

1. a) 12 kg of liquid water initially at 15^0C is to be heated to 95^0C in a teapot equipped with a 1200-W electric heating element inside. The teapot is 0.5 kg & has an avg. sp. Heat of 0.7 kJ/kg K. Taking the specific heat of water to be 4.18 kJ/kg K, and disregarding any heat loss from the pot, determine how long it will take for the water to be heated. **05**

   b) Consider a person standing in a room that is maintained at 22^0C at all times. The inner surfaces of the floor, walls and ceiling of the house, are observed to be at an average temperature of 10^0C in the winter and 25^0C in summer. Determine the rate of heat transfer by radiation between the person and surrounding surfaces. Inner surface area of room is approximately 1.4 m^2 and average body temperature of person is 35^0C. 6 = 5.67 x 10^{-8} & view factor = 0.9. **05**

   c) State the assumption made in Nusselt's theory of condensation. **05**

   d) Write a note on shell & Tube heat exchanger. **05**

2. a) A certain quantity of steam in a closed vessel of fixed volume of 0.14m^3 exerts a pressure of 10 bar at 250^0C. If the vessel is cooled so that the pressure falls to 3.6 bar, determine (a) the final quality of steam (b) The final temperature (c) The change in internal energy and (d) The heat transferred during the process. Take C_p for superheated steam as 2.1 kJ/kg K **10**

   b) A 3mm diameter & 5 m long electric wire is tightly wrapped with a 2 mm thick plastic cover whose thermal conductivity is 0.15 W/m K. Electric measurements indicate that a current of 10 A passes through the wire & there is a voltage drop of 8V along the wire. It the insulated wire is exposed to the medium at T_∞ = 30^0C with a heat transfer coefficient of h =12 W/m^2 ^{0}C, determine the temperature at the interface of the wire and the plastic cover in steady operation. Also determine whether doubling the thickness of the plastic will increase or decrease this interface temperature. Thermal conductivity of plastic is 0.15 W/m K. **10**

3. a) A 20 mm ϕ horizontal heater is maintained at a surface temperature of 313 K & submerged in water at 298 K. Estimate the heat loss/unit length of heater by natural convection. Properties of water at mean temperature of 32.5^0C are K = 0.63 W/m K, β = 3.04 x 10^{-4} K^{-1}, ρ = 1000 kg/m^3 μ = 8x10^{-4} kg/m-s, C_p= 4.187 kJ/kg K. Use Nu = 0.53 (Gr. Pr)$^{1/4}$ **10**

   b) Show by dimensional analysis that Nusselt Number is a function of Reynold's Number & Prandtl number for the case of heat transfer by forced convection. **10**

4. a) Explain significance of Biot Number and Fourier Number. **05**
   b) Explain the different regimes in pool boiling. **05**
   c) Saturated steam at t_{sat} = 90^{0}C (P = 70.14 kPa) condenses on the out surface of 1.5 m long 2.5m OD vertical tube maintained at a uniform temperature of 70^{0}C. Assuming film condensation, calculate the local heat transfer coefficient at the bottom of the tube. Data :- Properties of water at 80^{0}C ρ_L = 974 kg/m^3, λ = 2309 kJ/Kg , k_w= 0.666 W/m K μ = 335 x 10^{-6} kg/m-s . Neglect the vapor density. **10**

5. a) Pin fins are provided to increase the heat transfer rate from the hot surface. Two arrangements are available (i) 6 fins of 100 mm length (ii) 10 fins of 60 mm length. By calculations show that which arrangement is more effective. k for fin material = 300 W/m K, h = 20 W/m^2 K. cross-sectional area of fin = 2cm^2 Temperature of hot surface to which fins are attached is 503 K, surrounding air temperature is 303 K. **10**
   b) Explain the method of wall temperature estimation, in case of DPHE. **05**
   c) One ton mass of reactants (C_p= 3800 J/kgK) is heated from 290 K to 360 K by a submerged steam coil (coil area 1m^2) in batch reactor. The time taken to heat the material is $2\frac{1}{4}$ hours. **05**

   The temperature of steam is 390 K. Assume no heat loss to the surrounding calculate overall heat transfer coefficient. Neglect the internal convective resistance.

6. Calculate the total length of DPHE required to cool 5500 kg/hr of ethylene glycol from 358 K to 314 K using toluene as a cooling medium which flows in counter current fashion. Toluene enters at 303 K and leaves at 335 K. **20**

   Data :- OD of outer pipe = 70mm
   OD of inner pipe = 43 mm
   Wall thickness of both pipes = 3mm.

   Physical properties of two fluids at mean temperature are as given below:-

Property	EG	Toluene
C_p(kJ/kg K)	2.68	1.8
ρ (kg/m^3)	1080	840
k(W/mK)	0.248	0.146
μ (Pa.sce)	3.4x10^{-3}	4.4x10^{-4}

   K of pipe wall = 46.52 W/mK & EG flows through inner pipe
