(Set-T_1)

B.Tech-5th (Chem)

Heat Transfer

Full Marks : 70

Time : 3 hours

Answer **six** questions including **Q. No. 1** which is compulsory

The figures in the right-hand margin indicate marks

Steam table is allowed in the examination hall

1. Answer *all* questions : 2 × 10

   (*a*) What do you mean by 25% baffle cut ?

   (*b*) Why fins are attached on the heat transfer surface area ?

   (*c*) The heat flux (from outside to inside) across an insulating wall with thermal conductivity $K = 0{\cdot}04$ W/m.k and thickness 0·16 m is 10 W/m^2. What will be the outside wall temp of the temperature of the inside wall is $-5\,^{\circ}C$?

(*d*) What is the need of shell expansion joint in the shell and tube heat exchanger ?

(*e*) Write the unit of heat transfer coefficient based on the dirt factor.

(*f*) State Wien's Displacement law.

(*g*) Differentiate between approach and range.

(*h*) For a turbulent flow in a tube by how much factor will the heat transfer coefficient change, if the tube diameter is halved and the flowrate is double ?

(*i*) Write the significance of Prandtl number.

(*j*) Define Leinden frost point.

2. (*a*) Derive the expression for steady-state heat conduction through a cylinder of variable area by taking suitable assumption. 5

(*b*) A 30 cm outside diameter pipe is covered with two layers of insulation $\left(K_1 = 0{\cdot}09 \text{ and } K_2 = 0{\cdot}06 \frac{\text{kcal}}{\text{hr.m.k}}\right)$. The better insulating material is on the outside and

is 4 cm thick. The other insulating material is of 5 cm thickness. The inner and outer surface temperature of the insulation are 350 °C and 50 °C. Calculate, 5

(*i*) Heat loss per meter per hour.

(*ii*) Heat loss per square meter of outer insulation surface.

3. (*a*) Why critical insulation radius is required in case of a cylinder and sphere ? Derive the critical insulation radius for a cylinder of radius '*r*' and length '*L*'. Assume all other necessary conditions. 5

(*b*) The outside surface temperature of a pipe (radius = 0·1 meter) is at 300 K. The pipe is losing heat to the atmosphere, which is at 200 K. The film heat transfer coefficient is $15\frac{W}{m^2 \cdot K}$. To reduce the rate of heat loss, the pipe is insulated by a 50 mm thick layer of asbestos $\left(K = 0{\cdot}5\frac{W}{m \cdot K}\right)$. Calculate the percentage reduction in the rate of heat loss. 5

4. (*a*) What are the different boiling regimes ? Define critical heat flux. 5

(*b*) In a 1-1 counter flow shell and tube heat exchanger, a process stream ($C_p = 4{\cdot}2$ kJ/kgt) is cooled from 450 K to 350 K using water $\left(C_p = 4{\cdot}2 \frac{\text{kJ}}{\text{kg.K}}\right)$ at 300 K. The process stream flows on the shell side at a rate of 1 kg/sec and water on the tubeside at a rate of 5 kg/sec. If the heat transfer coefficients on the shell and tubes are 1000 $\frac{\text{W}}{\text{m}^2.\text{K}}$ and 1500 $\frac{\text{W}}{\text{m}^2.\text{K}}$ respectively, Determine.

(*i*) The required heat transfer area.

(*ii*) By what factor will the required area change of the flow is cocurrent.

Neglect the tube wall resistance and fouling resistance. 5

5. (*a*) Define convection. Describe in detail the different modes of convection and regimes of heat transfer in fluids. 5

(*b*) Derive the Reynold's analogy equation for a fluid flowing in turbulent motion through a pipe of length '*L*' and radius '*R*'. 5

6. (*a*) Classify the multiple effect evaporator system based on the modes of feeding will the help of neat labelled diagram. 5

(*b*) An aquous solution of a solute is concentrated from 5% to 20% (mass basis) in a single effect evaporator. The feed enters the evaporator at a rate of 10 kg/s and at a temperature of 300 K. Steam is available at a saturation pressure of 1·3 bar. The pressure in the vapour space of the evaporator in the vapour space of the evaporator is 0·13 bar and the corresponding saturation temp of steam is 320 K. If the overall heat transfer coefficient is 5000 $\frac{W}{m^2.K}$, calculate 5

(*i*) Steam economy

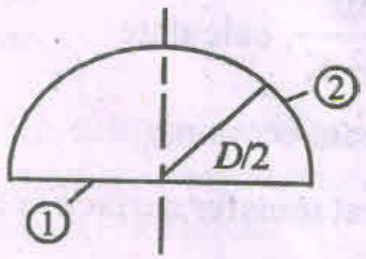
(*ii*) Heat transfer surface area.

Given :

Boiling point elevation = 5 K.

	Enthalpy (kJ/kg)	Heat of vaporization (kJ/kg)
Saturated steam (1.3 bar, 380 K)	–	2000
Saturated steam (0.13 bar, 320 K)	2200	–
Feed (5%, 300 K)	80	
Concentrated liquour 20%, 325 K	400	

7. (*a*) Consider an enclosure consisting of a hemisphere of diameter '*D*' and a flat surface of the same diameter as shown in the figure. Determine the relevant view factor. 5



(*b*) Determine the net radiant interchange between two parallel oxidised iron plates, placed at a distance of 25 mm having sides of 3 m × 3 m. The surface temperatures of the two plates are 100 °C and 40 °C respectively. Emissivities of the plates are equal.

Given, $\epsilon_1 = \epsilon_2 = 0{\cdot}736$ 5

8. Write short notes on (any *two*) : 5 × 2

(*i*) BPR

(*ii*) Basic laws of heat transfer

(*iii*) Thermal boundary layer

(*iv*) Dropwise condensation.