

**GUJARAT TECHNOLOGICAL UNIVERSITY****PDDC - SEMESTER-VI • EXAMINATION – WINTER • 2014****Subject Code: X61903****Date: 04-12-2014****Subject Name: Heat and Mass Transfer****Time: 02:30 pm - 05:00 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 an expression for LMTD in case of parallel flow heat exchanger. State the limitations of LMTD method. **07**

**(b)** In a surface condenser steam at 100°C is entering with  $h_{fg} = 2160$  kJ/kg, there is no sub-cooling in the condenser. The cooling water enters at 15°C and leaves at 75°C with flow rate of 200 kg/h. Determine length of tube and steam condensation rate assuming tube diameter of 25 mm. Use NTU method only. Take  $C_{p_{water}} = 4$  kJ/kg K,  $U = 860$  W/m<sup>2</sup>K. **07**

**Q.2 (a)** Derive an expression for temperature distribution and heat dissipation in a straight fin of rectangular profile for infinitely long fin. **07**

**(b)** Both ends of a 6 mm diameter 'U' shaped copper rod are rigidly fixed to vertical wall. The wall is maintained at 100°C. The developed length of the rod is 50 cm and conductivity is 300 W/mK. It is exposed to air at 30°C. The convective heat transfer coefficient is 30 W/m<sup>2</sup>K. Calculate (i) Temperature at the centre of the rod. (ii) Heat transferred by the rod. **07**

**OR**

**(b)** State the significance of Biot number and Fourier number. **07**  
A sphere of mass 6 kg is being maintained at a temperature of 400°C in a furnace. Suddenly it is immersed in a fluid at 40°C. Estimate the time required to cool the sphere up to the temperature 160°C. Assume,  $h = 60$  W/m<sup>2</sup>K,  $\rho = 3000$  kg/m<sup>3</sup>,  $c = 600$  J/kg K and  $k = 200$  W/mK.

**Q.3 (a)** (i) Heat diffuses through gases at approximately the same rate as it does through metals-Explain. **03**

(ii) The thermal conductivity of pure metals tends to decrease with increasing temperature-Explain. **03**

(iii) State the factors on which convective heat transfer coefficient depends. **01**

**(b)** A cold storage room has walls made of 0.23m of brick on the outside, 0.08m of plastic foam, and finally 1.5 cm of wood on the inside. The outside and inside air temperatures are 22°C and -2°C respectively. If the inside and outside heat transfer coefficients are respectively 29 and 12 W/m<sup>2</sup>K, and the thermal conductivities of brick, foam and wood are 0.98, 0.02 and 0.17 W/mK respectively. Determine (i) the rate of heat removed by refrigeration if the total wall area is 90 m<sup>2</sup> and (ii) the temperature of the inside surface of the brick. **07**

**OR**

**Q.3 (a)** Derive an expression for critical thickness of insulation for a cylindrical body. Explain the effect of total thermal resistance on heat transfer rate. **07**

- (b) A standard C.I. pipe (id= 50 mm, od=55 mm) is insulated with magnesium insulation ( $k=0.02 \text{ W/m}^\circ\text{C}$ ). Temperature at the interface between the pipe and insulation is  $300^\circ\text{C}$ . The allowable heat loss through the pipe is  $600 \text{ W/m}$  length of pipe and for the safety, the temperature of the outside surface of insulation must not exceed  $100^\circ\text{C}$ . Determine (i) minimum thickness of insulation required and (ii) the temperature of inside surface of the pipe assuming its thermal conductivity as  $20 \text{ W/m}^\circ\text{C}$ . **07**
- Q.4** (a) Using dimensional analysis show that heat transfer by force convection is given by  $Nu=f(Re,Pr)$ . **07**
- (b) Determine (i) the distance  $x$  in terms of  $L$  from the leading edge where the total heat transfer of the plate is divided into two equal parts. (ii) the percentage increase in the heat transfer rate from the plate if its length is doubled. Assume the plate and free stream fluid at constant temperature. **07**
- The forced convective heat transfer for the above case can be expressed by:  
 $Nu_x=0.332 (Re_x)^{1/2} \cdot (Pr)^{1/3}$
- OR**
- Q.4** (a) Explain: irradiation, grey body, emissive power, radiosity, emissivity **07**
- (b) Consider two concentric spheres A and B of diameters 300 mm and 400 mm respectively. Space between these two spheres is evacuated. Liquid gas at  $-183^\circ\text{C}$  is stored inside the sphere A. The surfaces of the spheres A and B facing each other are coated with aluminium of emissivity 0.03. Latent heat of vaporization of the liquid gas is  $210 \text{ kJ/kg}$ . If the system is kept in space vehicle having  $40^\circ\text{C}$ , calculate the rate of evaporation of liquid gas. **07**
- Q.5** (a) (i) Explain with sketches different regimes of forced convection boiling. **04**
- (ii) Explain pool boiling and critical heat flux. **03**
- (b) Explain the physical significance of the following dimensionless numbers: **07**
- Nusselt number, Prandtl number, Stanton number
- OR**
- Q.5** (a) Derive an expression for reduction in heat transfer by radiation when a radiation shield is inserted between two large parallel plates. **07**
- (b) A 40 mm deep cylindrical vessel is filled with water up to a level of 20 mm. It is exposed to dry air having pressure of 1 bar and temperature of  $35^\circ\text{C}$ . The mass diffusivity of water is  $0.25 \times 10^{-4} \text{ m}^2/\text{s}$ . Calculate the time required for all the water to evaporate. **07**

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