Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

PDDC-Semester –VI (May-2012) Examination

Subject code: X61903

Subject Name: Heat and Mass Transfer

Date:10/05/2012

Time: 10.30 am – 01.00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Use of properties tables permitted.**

Q.1 **(a)** Write the assumptions to be made as a base of Fourier's law of heat conduction. Also derive the equation for thermal conductivity of the body with the help of Fourier's law. **06**

(b) Define the following laws. **08**
i). Newton's law of cooling ii). Kirchhoff's law iii). Stefan-Boltzmann law
iv). Fick's law of diffusion

Q.2 **(a)** Derive generalized heat conduction equation for non-homogeneous material without internal heat generation in Cartesian coordinates. **07**

(b) A spherical container of negligible thickness holding hot fluid at 140^0 C and having an outer diameter of 0.4 m is insulated with three layers of each 50 mm thick insulation of conductivity of 0.02, 0.06 and 0.16 W/mK from inner to outer layers respectively. The outside surface temperature is 30^0 C. Calculate the heat loss and interface temperatures of insulating layers. **07**

OR

(b) A spherical vessel of 0.05 m outside diameter is insulated with 0.2 m thickness of low temperature insulation of thermal conductivity 0.04 W/mK. The surface temperature of vessel is -195^0 C and outside air is at 10^0 C. Determine heat flow, heat flow per m^2 based on inside and outside areas and temperature gradients at the inner and outer surfaces. **07**

Q.3 **(a)** State the purpose of thermal insulation. Also derive the equation for critical thickness of insulation for the sphere. **07**

(b) Calculate the rate at which heat is being lost to the surrounding per unit length of an insulated steam pipe having the following dimensions and specifications. **07**
D_i = 3 cm, D_0 = 3.4 cm for pipe, thickness of insulation= 1 cm, h_i = 10 W/m^2K and h_0 = 10 W/m^2K, $k_{(pipe)}$=15 W/mK and $k_{(insulation)}$=0.5 W/mK, $t_{(steam)}=100^0$ C and $t_{atm}=25^0$ C.

OR

Q.3 **(a)** Sketch the different fin configurations. Also write the assumptions are to be made for the analysis of heat flow through the fins. **07**

(b) A longitudinal copper fin (k = 380 W/mK) 600 mm long and 5 mm diameter and insulated at tip is exposed to air stream at 20^0 C. The convective heat transfer **07**

coefficient is 20 W/m^{2}K. If the fin base temperature is 150^0 C, determine the heat transferred and the efficiency of the fin.

Q.4 **(a)** Define the following terms **07**
i). Boundary layer thickness ii). Nusselt number iii). Prandtl number

(b) Explain with figure the various regimes of saturated pool boiling. **07**

OR

Q.4 **(a)** Differentiate between the mechanism of filmwise and dropwise condensation. **07**

(b) A vertical cylinder 1.5 m high and 180 mm in diameter is maintained at 100^0 C in an atmosphere environment of 20^0 C. Calculate heat loss by free convection from the surface of the cylinder. Assume properties of air at mean temperature as ρ=1.06 kg/m^3, ν= 18.97×10^{-6} m^2/s, C_p=1.004 kJ/kgK and k = 0.1042 kJ/mhK. **07**

Q.5 **(a)** Derive expression for logarithmic mean temperature difference for parallel heat exchanger. **07**

(b) The overall temperature rise of the cold fluid in a cross flow heat exchanger is 20^0 C and overall temperature drop of hot fluid is 30^0 C. The effectiveness of heat exchanger is 0.60. The heat exchanger area is 1 m^2 and overall heat transfer co-efficient is 60 W/m^{2}K. Find out the rate of heat transfer. Assume both fluids are unmixed. **07**

OR

Q.5 **(a)** Derive the equation $\frac{m_A}{A} = \frac{D}{L}(C_{A1} - C_{A2})$ of mass flux through the membrane with usual annotations. **07**

(b) Determine the rate of heat loss by radiation from a steel tube of outside diameter 70 mm and 3 m long at a temperature of 227^0 C. if the tube is located within a square brick conduit of 0.3 m side and at 27^0 C. Take emissivity of steel and brick are 0.79 and 0.93 respectively. **07**

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