Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VI • EXAMINATION – SUMMER 2014

Subject Code: 161906 **Date: 30-05-2014**

Subject Name: Heat and Mass Transfer

Time:10:30 am to 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.**

Q.1 (a) Derive the general heat conduction equation in 3-dimensional Cartesian coordinates for anisotropic material with internal heat generation in unsteady state condition. Using this equation, derive the heat conduction equation for steady state heat transfer in one direction through isotropic material and without internal heat generation. **07**

(b) A 8 mm thick metal plate, having thermal conductivity 98.6 W/m-K is exposed to vapor at 100^0 C on one side and cooling water at 30^0 C on another side. The heat transfer coefficients are 14200 W/m^2–K on vapor side and 2325 W/m^2–K on water side. Determine the rate of heat transfer and drop in temperature on each side of the plate. Assume area of the plate as unity. **07**

Q.2 (a) State Buckingham's π Theorem. Derive the relation between Nusselt no., Prandtl no. and Reynolds no. for forced convection using this theorem. **07**

(b) A 200 W bulb of spherical shape of 7 cm diameter is subjected to flow of air at 30^0 C. The velocity of air is 0.4 m/s. The surface temperature of the bulb is 120^0 C. Calculate the rate of heat transfer by convection from bulb surface. At mean temperature of 75^0 C the properties of air are : **07**

$\nu = 2.06 \times 10^{-6}$ m^2/s, k = 0.03 W/m-K, Pr = 0.7

Use the relation $Nu = 0.365\ Re^{0.6}\ Pr^{0.33}$

OR

(b) The air at atmospheric temperature of 30^0 C flows over one side of plate with a velocity of 1.5 m/s. The plate is heated and maintained at 100^0 C over its entire length. Calculate the following at 0.3 m from its leading edge. **07**

(1) Reynolds number
(2) thickness of velocity boundary layer
(3) thickness of thermal boundary layer
(4) mass flow rate through the boundary layer

Assume unit width of plate.

Take properties of air at 30^0 C as under :

$\rho = 1.165$ kg/m^3, $\nu = 16 \times 10^{-6}$ m^2/s, Pr = 0.701

Q.3 (a) Why fins are used ? Define effectiveness and efficiency of fin. For long fin with insulated tip, show that **07**

η of fin = tanh mL / mL with usual notations.

(b) What do you understand by critical radius of insulation ? Draw rough sketch showing variation in heat transfer with respect to radius of insulation. Derive the equation for critical radius of insulation for cylinder. **07**

OR

Q.3 **(a)** A copper rod 0.5 cm diameter and 50 cm long protrudes from a wall maintained at a temperature of 500^0 C. The surrounding temperature is 30^0 C. Convective heat transfer coefficient is 40 W/m^2 K and thermal conductivity of fin material is 300 W/m K. Show that this fin can be considered as infinitely long fin. Determine total heat transfer rate from the rod. **07**

(b) Define pool boiling. Draw pool boiling curve for water and explain various regimes of the curve. **07**

Q.4 **(a)** Derive the expression for radiant heat exchange between two non-black parallel surfaces. **07**

(b) Determine the rate of heat loss by radiation from a steel tube of outside diameter 7 cm and length 3 m 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 as 0.79 and 0.93 respectively. **07**

OR

Q.4 **(a)** Define total emissive power. Derive the relation between total emissive power and intensity of radiation for a diffuse surface. **07**

(b) Define shape factor. State salient features of the shape factor. **07**

Q.5 **(a)** Draw rough sketch of temperature distribution curve for condenser and evaporator type heat exchangers. Derive the expression for overall heat transfer coefficient for shell and tube type heat exchanger. **07**

(b) Hot air at 66^0 C is cooled upto 38^0 C by means of cold air at 15.5^0 C. Mass flow rates of hot and cold air are 1.25 kg/s and 1.6 kg/s respectively. Specific heat of hot and cold air are 1.05 kJ/kg-K, U = 80 W/m^2 K, find the area of heat exchanger for parallel flow configuration. **07**

OR

Q.5 **(a)** Hot oil enters into a counter flow heat exchanger at 150^0 C and leaves at 40^0 C. The mass flow rate of oil is 4500 kg/hr and its specific heat is 2 kJ/kg K. The oil is cooled by water which enters the heat exchanger at 20^0 C. The overall heat transfer coefficient is 1400 W/m^2 K. The exit temperature is not to exceed 80^0 C. Using effectiveness-NTU method, find **07**

(1) mass flow rate of water
(2) effectiveness of heat exchanger
(3) surface area required

(b) State and explain Fick's law of diffusion and compare it with Fourier's law of heat conduction. **07**

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