Seat No.: ________ Enrolment No.______________

GUJARAT TECHNOLOGICAL UNIVERSITY

B. E. - SEMESTER – VI • EXAMINATION – WINTER 2012

Subject code: 161906 **Date: 08/01/2013**

Subject Name: Heat and Mass Transfer

Time: 02.30 pm - 05.00 pm **Total Marks: 70**

Instructions:

1. **Attempt any five questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Derive general conduction equation in Cartesian coordinate and reduce the same for one dimensional heat conduction. **07**

(b) State the general equation for the rate of heat transfer by convection and hence define the coefficient of heat transfer. What are the various factors on which the value of this coefficient depends? **03**

(c) Explain the concept of hydrodynamic and thermal boundary layers with reference to flow over a flat heated plate **04**

Q.2 **(a)** A heater of 150 mm × 150 mm size and 800 W rating is placed between two slabs A and B. Slab A is 18 mm thick with k = 55 W/m K. slab B is 10 mm thick with k = 0.2 W/m K. Convective heat transfer coefficients on outside surface of slab A and B are 200 W/m^2 K and 45 W/m^2 K respectively. If ambient temperature is 27°C, calculate maximum temperature of the system and outside surface temperature of both slabs. **07**

(b) (i) Derive a general relation for the radiation shape factor in case of radiation between two surfaces. **07**

(ii) Explain Wein's displacement law of radiation.

OR

(b) (i) Explain emissivity and absorptivity of a surface. Also differentiate between black body and grey body. **07**

(ii) Explain Kirchoff's law of radiation.

Q.3 **(a)** Define intensity of radiation and prove that the intensity of normal radiation is $1/\pi$ times the total emissive power. Also explain Planck's law radiation heat transfer. **07**

(b) A hot plate of 400 mm × 400 mm at 100°C is exposed to air at 20°C. Calculate heat loss from both the surfaces of the plate if (a) the plate is kept vertical (b) plate is kept horizontal. **07**

Air properties at mean temperature are $\rho = 1.06$ kg/m^3, k = 0.028 W/m K,

$c_p = 1.008$ kJ/kg K, and $\nu = 18.97 \times 10^{-6}$ m^2/s

Use following correlations.

$Nu = 0.125\,(Gr\,Pr)^{0.33}$ for vertical plate

$Nu = 0.72\,(Gr\,Pr)^{0.25}$ for upper surface

$Nu = 0.35\,(Gr\,Pr)^{0.25}$ for lower surfaces

OR

Q.3 **(a)** Explain the significance of Reynolds numbers, Grashof number, Prandtl number, Nusselt number and Stanton number. Explain convection heat transfer coefficient variation along the flow direction for the horizontal flow over a thin parallel isothermal plate. **07**

(b) Determine net radiation heat transfer per m^2 for two infinite parallel plates **07**

held at temperature of 800 K and 500 K respectively. Emissivities of hot and cold plates are 0.6 and 0.4 respectively.
Now it is intended to reduce the heat transfer to 40% of original value by placing a radiation shied between the plates. Calculate the emissivity of the shield and its equilibrium temperature.

Q.4 **(a)** Derive the governing differential equation for temperature distribution of constant cross-sectional area fin. Hence derive expression for temperature distribution and total steady state heat transfer for the fin with insulated tip. **07**

(b) A heat exchanger is used to cool hot water from 80°C to 60°C by transferring heat to other stream of cold water which enters the heat exchanger at 20°C and leave at 40°C. Should this heat exchanger operate under parallel flow or counter flow conditions? Also determine the exit temperatures if the flow rates of the fluids are doubled. **07**

OR

Q.4 **(a)** Show that logarithmic mean temperature difference is given by $LMTD = \dfrac{\theta_1 - \theta_2}{\ln(\theta_1/\theta_2)}$. What will be the value of LMTD if $\theta_1 = \theta_2$? **07**

(b) (i) What is the significance of Biot number in Lumped parameter analysis? **07**
(ii) During a heat treatment process, spherical balls of 12 mm diameter are initially heated to 800°C. Then they are cooled to 100°C by immersing them in an oil bath of 35°C with convection coefficient 20 W/m^2 K. Determine time required for cooling process. What should be the convection coefficient if it is intended to complete the cooling process in 10 minutes?
Thermo-physical properties of the balls are ρ = 7750 kg/m^3, c_p = 520 J/kg K, k = 50 W/m K.

Q.5 **(a)** Discuss in details the various regimes in boiling and explain (i) the condition for the growth of bubbles and (ii) effect of bubble size on boiling. **07**

(b) Explain Fick's law of mass diffusion. Also derive the equation $N_b = -D_b \dfrac{M_b}{R_o T} \dfrac{dp_b}{dx}$ of the same. Notation has usual meaning. What is mass convection process? **07**

OR

Q.5 **(a)** What is condensation? When does it occur? Differentiate between film wise and drop wise condensation. Which type has better heat transfer coefficient? In condenser design which type of condensation is usually selected and why? **06**

(b) Estimate the diffusion coefficient of carbon monoxide through air in which mole fraction of each constituents are: O_2 = 0.18, N_2 = 0.72, CO = 0.1. The gas mixture is at 300 K and 2 bar total pressure. Take diffusivity of carbon monoxide in oxygen is 18.5 × 10^{-6} m^2/s at 273 K and 1 bar and diffusivity of carbon monoxide in nitrogen is 19.2 × 10^{-6} m^2/s at 288 K and 1 bar. **05**

(c) Explain the terms fin efficiency and fin effectiveness. **03**

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