Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE – SEMESTER – VI (OLD).EXAMINATION – WINTER 2016

Subject Code: 161906 **Date: 25/10/2016**

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)** Write the general heat conduction equation on spherical coordinate. Using this equation, show that the resistance offered by a hollow sphere of radii r_1 and r_2 and constant thermal conductivity is given by **07**

$$R_{sph} = \frac{r_2 - r_1}{4\pi k r_1 r_2}$$

(b) A wall is constructed of several layers. The 25 mm thick first layer consists of brick (k = 0.66 W/mK), the second layer 2.5 cm mortar (k = 0.7 W/mK), the third layer 10 cm thick lime stone (k = 0.66 W/mK) and outer layer of 1.25 cm thick plaster (k = 0.7 W/mK). The heat transfer coefficient on interior and exterior of the wall are 5.8 W/m^{2}K and 11.6 W/m^{2}K respectively. Find the rate of heat transfer per m^2, if the interior of the room is at 26°C and outer air is at -7°C. **07**

Q.2 **(a)** If a thin and long fin, insulated at its tip is used, show that the heat transfer from the fin is given by **07**

$$Q_{fin} = \sqrt{hPkA_c}\,(T_0 - T_\infty)\tanh mL$$

(b) A steel fin (k = 54 W/mK) with a cross section of an equilateral triangle, 5mm in side is 80 mm long. It is attached to a plane wall maintained at 400°C. The ambient air temperature is 50°C and unit surface conductance is 90 W/m^{2}K. Calculate heat dissipation rate by the rod. **07**

OR

(b) Prove that the temperature distribution in a body at time t during a Newtonian heating or cooling is given by **07**

$$\frac{T - T_\infty}{T_i - T_\infty} = e^{-Bi*Fo}$$

Q.3 **(a)** Explain Reynold Colburn analogy for laminar flow over a flat plate. **07**

(b) Atmospheric air at 275 K and free stream velocity of 20 m/s flows over a 1.5 m long flat plate maintained at 325 K temperature. Calculate the average heat transfer coefficient over the region of laminar boundary layer. **07**

Use following properties and correlation.

$$k_f = 0.026 \text{ W/mK},\ \ \Pr = 0.708,\ \ \nu = 16.8\times10^{-6}\text{m}^2/\text{s},\ \ \mu = 1.98\times10^{-5}\text{kg/ms}$$

$$\text{Re}_{cr} = 2\times10^5$$

$$Nu_x = 0.664\,\text{Re}_{cr}^{1/2}\,\Pr^{1/3}$$

OR

Q.3 **(a)** In a constant surface temperature tube, the fluid enters at temperature T_i and leaves the tube at temperature T_o. Prove that **07**

$$\frac{T_s - T_o}{T_s - T_i} = \exp\left(-\frac{hA_s}{\dot{m}C_p}\right)$$

(b) Water entering at 10°C is heated to 40°C in the tube of 0.02 m internal diameter at mass flow rate of 0.01 kg/s. The outside of the tube is covered with an insulated electric heating element that produces a uniform heat flux of 15000 W/m^2 over the surface. Neglecting any entrance effect, determine heat transfer coefficient and the length of pipe needed for a 30°C increases in average temperature. **07**

Use following properties,

$\rho = 997$ kg/m^3, $k_f = 0.608$ W/mK, $C_p = 4180$ J/kgK, $\mu = 910\times10^{-6}$ Ns/m^2

Q.4 **(a)** Explain the film boiling. Why is it avoided in practice? **03**

(b) Distinguish between **04**

(a) Sub cooled and saturated boiling

(b) Nucleate and film boiling

(c) Saturated steam at 90°C and 70 kPa is condensed on outer surface of a 1.5 m long, 2.5 m diameter vertical tube maintained at a uniform temperature of 70°C. Assuming film wise condensation, calculate the heat transfer rate on the tube surface. Use the following properties of water, **07**

$\rho = 974$ kg/m^3, $k_f = 0.668$ W/mK, $h_{fg} = 2309$ kJ/kg, $\mu = 0.355\times10^{-3}$ kg/ms

OR

Q.4 **(a)** Prove that the effectiveness of a parallel flow heat exchanger is given by **07**

$$\varepsilon_{parallel\ flow} = \frac{1-\exp\{-NTU(1+C)\}}{1+C}$$

(b) Water enters the tubes of a single pass heat exchanger at 20°C and leaves at 40°C. On the shell side, 25 kg/min of steam condenses at 60°C. Calculate the overall heat transfer coefficient and the required flow rate of water if the area of the heat exchanger is 12 m^2. The latent heat h_{fg} is 2358.7 kJ/kg at 60°C and specific heat of water 4174 J/kgK **07**

Q.5 **(a)** Define the following terms **07**

(i) Total emissivity (ii) Gray body (iii) Total emissive power (iv) Radiosity

(v) Solid angle (vi) Kirchhoff's law (vii) Lambert cosine law

(b) Calculate the view factor between two opposite sides of a hollow cube, if view factor between two adjacent sides of it is 0.2. **07**

OR

Q.5 **(a)** Define the following in relation with mass transfer **03**

(i) Schmidt number (ii) Lewis number (iii) Sherwood number

(b) Explain Fick's law of diffusion. **04**

(c) An open pan 20 cm in diameter 20 mm deep is filled with water to a level of 10 mm and is exposed to air at 25°C. Assuming mass diffusivity of 0.25×10^{-4} m^2/s, calculate the time required for all the water to evaporate. Take the partial pressure of water vapor, corresponding to saturation temperature of 298 K **07**

$p_s = 3.169$ kPa

$p_\infty = 0$ at the top of the pan, dry air

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