Enrollment No: _____ Exam Seat No:_____

C.U.SHAH UNIVERSITY

Summer Examination-2017

Subject Name: Heat and Mass Transfer

Subject Code: 4TE06HMT1 Branch: B.Tech. (Mechanical)

Semester: 6 Date: 13/04/2017 Time: 02:30 To 05:30 Marks: 70

Instructions:

(1) Use of Programmable calculator & any other electronic instrument is prohibited.
(2) Instructions written on main answer book are strictly to be obeyed.
(3) Draw neat diagrams and figures (if necessary) at right places.
(4) Assume suitable data if needed.

Q-1 Attempt the following questions: (14)

a) Thermal conductivity of metals with addition of alloying elements **(1)**
(a) Increases (b) Decreases (c) Remains constant (d) None

b) Temperature distribution during conduction in a cylindrical body is **(1)**
(a) Linear (b) Hyperbolic (c) Logarithmic (d) None

c) Internal resistance in heat transfer means **(1)**
(a) Radiation resistance (b) Convective resistance
(c) Conductive resistance (d) None

d) External resistance in heat transfer means **(1)**
(a) Radiation resistance (b) Convective resistance
(c) Conductive resistance (d) None

e) Critical radius of insulation is applicable for heat transfer across **(1)**
(a) A plain wall (b) A composite wall (c) A wire (d) None

f) Which dimensionless numbers is used in unsteady state of heat conduction **(1)**
(a) Reynolds and Prandtl Number (b) Reynolds and Grashoff's Number
(c) Reynolds and Nusselt number (d) None

g) 40% of incident radiant energy on the surface of a thermally transparent body is reflected back. If the transmissivity of the body be 0.15, then the emissivity of surface is **(1)**
(a) 0.45 (b) 0.55 (c) 0.40 (d) 0.75

h) Why conduction and convection are not affecting heat transfer into the space? **(1)**

i) Give the name which mechanisms are use for heat transfer by conduction. **(1)**

j) Give the industrial applications of convective heat transfer. **(1)**

k) Write a state of Buckingham's π- Theorem. **(1)**

l) What is Radiosity? **(1)**

m) What is Heat capacity ratio? **(1)**

n) Give the example of pool boiling. **(1)**

Attempt any four questions from Q-2 to Q-8

Q-2 **Attempt all questions** **(14)**

(a) A furnace wall is made up of three layer of thickness 250 mm, 100 mm and 150 mm having coefficient of thermal conductivities of 1.65 W/mK, 9.2 W/mK and K3(W/mk) respectively. The inside surface is exposed to hot gases of furnace at 1250 °C with convective coefficient of heat transfer of 25 W/m^2K and inside surface temperature is 1100 °C. The outside surface of composite wall is exposed to air at 25 °C having coefficient of convective heat transfer of 25 W/m^2K. Determine following: **(7)**

1) Heat transfer rate per unit surface area.
2) Thermal conductivity of third layer K_3
3) Overall Heat transfer coefficient U
4) Intermediate surface temperatures.

(b) What is Fourier's law of heat conduction and provide its electrical analogy? Derive the expression for critical thickness of insulation for sphere. **(7)**

Q-3 **Attempt all questions** **(14)**

(a) Derive the governing differential equation for temperature distribution of constant cross sectional area fin. Hence derive expression for temperature distribution for long fin stating the assumption made. **(7)**

(b) A steel pipe line has inner diameter of 100 mm and outer diameter of 110 mm. Its thermal conductivity is 50 W/mK. It is covered with two layers of insulation each 50 mm thick. The thermal conductivity of inner insulation is 0.06 W/mK and that of outer insulation is 0.12 W/mK. Calculate the loss of heat per meter length of pipe and the interface temperature between the two layers of insulation if the temperature of the inside surface of tube is 250 °C and that of outside surface of insulation is 50 °C. If the outer insulation is made as inner insulation and inner insulation is made as outer insulation, estimate the percentage increase or decrease in heat loss per meter length. **(7)**

Q-4 **Attempt all questions** **(14)**

(a) A steel rod (k=30 W/m ^oC), 12 mm in diameter and 60 mm long, with an insulated end is to be used as spine. It is exposed to surrounding with a temperature of 60 ^oC and heat transfer coefficient of 55 W/m^2 ^oC. The temperature at the base is 100 ^oC. Determine : (i) The fin effectiveness (ii) The fin efficiency (iii) The temperature at the edge of the spine (iv) The heat dissipation **(7)**

(b) Derive the continuity Equation for fluid flow in Cartesian coordinates based on the law of conservation of mass with usual notations. **(7)**

Q-5 **Attempt all questions** **(14)**

(a) Derive the equation for dimensional analysis of Forced convection with usual notations. **(7)**

(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. **(7)**

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

Q-6 **Attempt all questions** **(14)**

(a) A counter flow heat exchanger is employed to cool oil of specific heat Cp =2.45 KJ/Kg ^oC with mass flow rate of 0.55 K/sec from 115 ^oC to 40 ^oC by water. The inlet and outlet temperature of cooling water are 15 ^oC and 75 ^oC respectively. The overall heat transfer coefficient is 1450 W/m^2 ^oC. Using NTU method calculate: **(7)**

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

(b) Explain Heat Exchanger according to Geometry of construction with neat sketch. **(7)**

Q-7 **Attempt all questions** **(14)**

(a) What is shape factor? Derive a general relation for the radiation shape factor in case of radiation between two surfaces with usual notations. **(7)**

(b) Define intensity of radiation and prove that intensity of normal radiation is $1/\pi$ times the total emissive power. Also explain Kirchhoff's law radiation heat transfer. **(7)**

Q-8 **Attempt all questions** **(14)**

(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? **(7)**

(b) Define mass transfer and explain Modes of Mass Transfer. **(7)**