Enrollment No: _____ Exam Seat No:_____

C.U.SHAH UNIVERSITY

Summer Examination-2019

Subject Name: Heat and Mass Transfer
Subject Code: 4TE06HMT1 **Branch: B.Tech (Mechanical)**
Semester: 6 **Date: 20/04/2019** **Time: 10:30 To 01:30** **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) What is pool boiling? **01**

b) A person who sits in front of a fireplace feels warm. Through what process or processes of heat transfer does he receive heat? **01**

c) The expression hl / k fives the Biot number as well as the Nusselt number. What is the difference between the two? **01**

d) Define: Radiosity **01**

e) Four identical pieces of copper painted with different colour white, silver, black and grey were heated to the same temperature and then left in the environment to cool. Which of the piece of colour will give fast cooling? Why? **01**

f) How are Fourier's law and Ohm's law similar? **01**

g) Write different application of extended surface. **01**

h) Why does a cavity with a small hole behave as a black body? **01**

i) Define: Effectiveness of Heat Exchanger **01**

j) What happens to the radiant energy when it is incident upon a surface? **01**

k) Write down the units of mass diffusion coefficient. **01**

l) What do you mean by Number of Transfer Unit (NTU)? **01**

m) Write the name of different modes of mass transfer. **01**

n) The design of a water cooled steam condenser has been made by presuming that the overall heat transfer coefficient U = 5000 W/m^2 K. While deciding this value, the engineer presumed that the flowing water is very clean and accordingly he neglects the fouling resistance. Later, it is discovered that the cooling water is not clean at all and that it has a fouling resistance of the order of 0.0006 to 0.002 m^2 K/W. Should the design calculation be remade? Comment. **01**

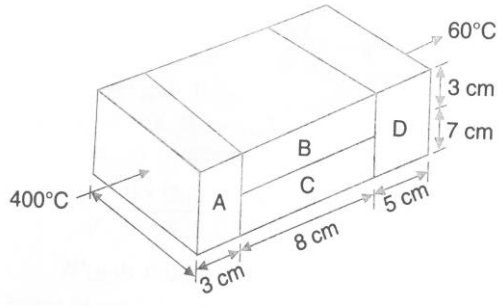
Attempt any four questions from Q-2 to Q-8

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

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 conduction equation for steady state heat transfer in one direction through isotropic material and without internal **08**

heat generation.

b) Find the heat flow rate through the composite wall as shown in Fig. A. Assume one dimensional flow rate and take **06**



k_a = 150 W/m-deg k_b = 30 W/m-deg
k_c = 65 W/m-deg k_d = 50 W/m-deg

Fig. A

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

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 spherical heater of 20 cm diameter and at 60 °C is immersed in a tank of water at 20 °C. Determine the value of convective heat transfer coefficient. **07**

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

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**

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

a) State and prove Kirchoff's law of radiation. What restrictive conditions are inherent in the derivation of Kirchoff's law? **07**

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

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

a) Set up expression for logarithmic mean temperature difference in the case of a **07**

(i) Parallel flow heat exchanger and

(ii) Counter flow heat exchanger

b) In an open heart surgery under hypothermic conditions, the patient blood is cooled before the surgery and rewarmed afterwards. The task is accomplished by a concentric tube counter-flow heat exchanger of length 500 mm with a thin walled inner tube of 60 mm diameter. The blood entering the heat exchanger at 20 °C and 0.05 kg/s is warmed by water at 60 °C and 0.12 kg/s. Determine the temperature of blood at exit from the heat exchanger and the heat flow rate. Assuming the following data: **07**

C_p of blood = 3500 J/kgK and
C_p of water = 4186 J/kgK
U (overall heat transfer coefficient) = 475 W/m^2 K

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

a) State Fick's Law of diffusion. Define the various symbols used and give their units. Show the similarity of this law to Fourier equation for conduction and Newtons' equation for shear stress. Express Fick's law in terms of partial pressure for diffusion of component A into component B and of component B into component A. **08**

b) Estimate the diffusion coefficient for ammonia in air at 25 °C temperature and one atmospheric pressure. **06**

For ammonia :

Molecular weight = 17

and Molecular volume = 25.81 cm^3/gm mole

For air :

Molecular weight = 29

and Molecular volume = 29.89 cm^3/gm mole

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

a) Derive momentum equation for hydrodynamic boundary layer over a flat plate. **07**

b) A steel plate is placed on a non-conducting opaque surface normal to incident solar radiation of 750 W/m^2. Neglecting convection effects, workout the equilibrium temperature of the plate when it is **04**

(a) Oxidized with emissivity $\varepsilon = 0.80$ and

(b) Polished with emissivity $\varepsilon = 0.07$

Assumption may be made of the gray body behavior.

Take $\sigma_b = 5.67 \times 10^{-8}$ W/m^2 K^4

c) Explain film wise and drop wise condensation in detail with neat sketch. **03**