Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

PDDC - SEMESTER–VI EXAMINATION – WINTER 2015

Subject Code:X61903 **Date:05/12/2015**

Subject Name: Heat and Mass Transfer

Time: 02:30pm to 05:00pm **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 three dimensional general conduction equation in Cartesian coordinates for a homogenous material. Deduce the equation for one dimensional, steady flow without internal heat generation from the same. **07**

(b) A wall is constructed of several layers. The first layer of 25 cm thick wall consists of brick (thermal conductivity k = 0.66 W/mK), the second layer 2.5 cm thick mortar (k = 0.7 W/mK), the third layer 10 cm thick limestone (k = 0.66 W /mK) and outer layer of 1.25 cm thick plaster (k = 0.7 W/mK). The heat transfer coefficients on interior and exterior of the wall fluid layers are 5.8 W/m^2K and 11.6 W/m^2K respectively. Find: (i) Overall heat transfer coefficient and (ii) Overall thermal resistance per m^2. **07**

Q.2 **(a)** What is meant by critical thickness of insulation? Derive an expression for critical radius of insulation for cylinder. **07**

(b) Derive the energy equation for thermal boundary layer and state the assumptions made. **07**

OR

(b) A furnace wall, 32 cm thick, is made up of an inner layer of brick (k = 0.84 W/m-K) covered with layer of insulation (k = 0.12 W/m-K). The furnace operates at 1325^0 C and ambient temperature is 25^0 C. **07**

(1) Determine the thickness of brick and insulation which gives minimum heat loss,

(2) Calculate the heat loss presuming that the insulating material has maximum temperature of 1200^0 C.

Q.3 **(a)** Explain natural or free convection. Using dimensional analysis show that for a natural convection. **07**

$$N_u = C.\ (P_r)^n.\ (G_r)^n$$

(b) Air at 2 bar pressure and 200^0 C temperature gets heated as it flows through 2.5 cm diameter tube with a velocity of 10 m/s. A constant heat flux condition is maintained at the wall and wall temperature is 20^0 C above the air temperature all along the length of tube. Make calculations for the heat transfer per unit length of the tube. The correlation is **07**

$$Nu = 0.023\ (Re)^{0.8}\ (Pr)^{0.4} \quad \& \quad \text{Air properties are:}$$

$\mu = 2.57 \times 10^{-5}$ Ns/m^2 , k = 0.0385 W/m-deg and Cp = 1025 J/kgK

OR

Q.3	**(a)**	From general form of energy equation for one dimensional heat dissipation from an extended surface, derive an expression for heat transfer for a fin having infinite length.	**07**
	(b)	A steel rod (k= 30 W/m-deg) 1 cm in diameter and 5 cm long protrudes from a wall which is maintained at 100^0 C. The rod is insulated at its tip and is exposed to an environment with h = 50 W/m^2-deg and t_a = 30^0 C. Calculate the fin efficiency, temperature at the tip of fin and the rate of heat dissipation.	**07**
Q.4	**(a)**	Derive an equation of LMTD for counter flow heat exchanger.	**07**
	(b)	A thermos flask has a double walled bottle and the space between the walls is evacuated so as to reduce the heat flow. The bottle surfaces are silver plated and the emissivity of each surface is 0.025. If the contents of the bottles are at 102° C, find the rate of heat loss from the thermos bottle to the ambient air at 27° C. What thickness of cork (k=0.03 W/m-K) would be required if the same insulating effect is to be achieved by use of cork?	**07**
		OR	
Q.4	**(a)**	Show that for a unit surface the intensity of normal radiation is 1/π times the emissive power.	**07**
	(b)	Which is it better to arrange in a heat exchanger, parallel flow or counter flow? Why? In a counter flow heat exchanger, oil (Cp = 3 kJ/kg K) at the rate of 1400 kg/hr is cooled from 100^0 C to 30^0 C by water that enters the exchanger at 20^0 C at the rate of 1300 kg/hr. Determine the heat exchanger area for an overall heat transfer coefficient of 3975 kJ/m^2-hr-K.	**07**
Q.5	**(a)**	Explain in brief: Planck's law and Wein's displacement law	**07**
	(b)	Calculate for a hot body at 800K having an area of 0.12 m^2, (a) total rate of energy emitted and (b) intensity of normal radiation.	**07**
		OR	
Q.5	**(a)**	Differentiate between heat transfer and mass transfer. State and explain Fick's law of diffusion.	**07**
	(b)	What is boiling? Explain different regimes of boiling.	**07**

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