Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V (NEW) EXAMINATION – WINTER 2023

Subject Code:3151909 Date:07-12-2023

Subject Name:Heat 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.**
4. **Simple and non-programmable scientific calculators are allowed.**

Q.1	**(a)**	Explain critical radius of insulation and its importance in electrical and thermal systems heat transfer problems.	**03**
	(b)	With appropriate diagram explain the temperature variation in parallel flow heat exchanger, counter flow heat exchanger, temperature distribution for evaporator and condenser.	**04**
	(c)	A thermopane window consist of two 5 mm thick glass (k=0.78 W/m-K) sheets separated by 10 mm stagnant air gap (k=0.025 W/m-K). The convection heat transfer coefficient for inner and outer air are 10 W/m^2-K and 50 W/m^2-K, respectively. (a) Determine the rate of heat loss per m^2 of the glass surface for a temperature difference of 60 Celsius between the inside and outside air (b) compare the result with the heat loss, if the window had only a single sheet of glass of thickness 5 mm instead of thermopane (c) compare the result with the heat loss, if window has no stagnant air (i.e., a sheet of glass, 10 mm thick.	**07**
Q.2	**(a)**	What is lumped system analysis? Under what conditions it is applicable?	**03**
	(b)	What are the fundamental dimensions? Express thermal resistance, thermal diffusivity and convective heat transfer coefficient in fundamental dimensions.	**04**
	(c)	Find out the amount of heat transferred through an iron fin of length 50 mm, width 100 mm and thickness 5 mm. Assume k = 58.33 W/m-K and h = 11.66 W/m^2-K for the material of the fin and temperature at the base of the fin as 80 Celsius. Also determine the temperature at tip of the fin, if the atmospheric temperature is 20 Celsius.	**07**
		OR	
	(c)	Derive general heat conduction equation in cylindrical coordinate system. $\frac{\partial^2 t}{\partial r^2}+\frac{1}{r}\frac{\partial t}{\partial r}+\frac{1}{r^2}\frac{\partial^2 t}{\partial \emptyset^2}+\frac{\partial^2 t}{\partial z^2}+\frac{q_g}{k}=\frac{1}{\alpha}\frac{\partial t}{\partial \tau}$	**07**
Q.3	**(a)**	Define Absorptivity, reflectivity and transmissivity with proper example.	**03**
	(b)	What is the efficiency and effectiveness of fin?	**04**
	(c)	Dry saturated steam at 10 bar enters a counter flow heat exchanger at the rate of 15 kg/s and leaves at 300 Degree Celsius. The entry of gas at 600 Degree Celsius is with mass flow rate of 25 kg/s. If the condenser tubes are 30 mm diameter and 3 m long, make calculations for the heating surface area and the number of tubes required. Neglect the resistance offered by the metallic tubes. Take the following properties for steam and gas: For steam: t_{sat}=180 ^{o}C (at 10 bar), C_{ps}=2.7 kJ/kgK, h_s=600 W/m^{2}K for Gas: C_{pg}=1 kJ/kgK, h_g=250 W/m^{2}K	**07**
		OR	

Q.3 **(a)** Define thermal diffusivity and explain its physical significance. **03**

(b) What is meant by transient heat transfer? Mention some of the situations where transient conduction occurs. **04**

(c) Derive the equation of effectiveness for the parallel flow heat exchanger **07**

$$\in = \frac{1-exp[-NTU(1+C)]}{(1+C)}$$

Q.4 **(a)** State and prove Kirchoff's law of radiation. **03**

(b) Differentiate between mechanism of heat transfer by free and forced convection. Mention some of the areas where these mechanisms are predominant. **04**

(c) Following data are obtained from a metallic cylinder of 15 mm diameter and 100 mm in length heated internally by an electric heater and subjected to cross flow of air in a low-speed wind tunnel: velocity of free stream air = 15 m/s, temperature of free stream air = 25 ^{o}C, average temperature of cylinder surface = 130 ^{o}C, power dissipation by heater is 63 W. Calculate the experimental convective heat transfer coefficient for such a system. Compare this value with that obtained from the correlation suitable for this arrangement. **07**

$$Nu = 0.26\, Re^{0.6}\, Pr^{0.36}\left({Pr}/{Ps}\right)^{0.25}$$

Thermophysical properties of air at the mean bilk temperature at 25 Celsius are: k =2.6325 x 10^{-2} W/m^{2}K, υ = 15.53 x 10^{-6} m^2/s, Pr = 0.702, Prs = 0.685

OR

Q.4 **(a)** What do you mean by geometrical or shape factor in case of radiation exchange between two surfaces? **03**

(b) The expression ${h\,l}/{k}$ gives the Biot number as well as the Nusselt number. What is the difference between the two? **04**

(c) Explain the essential features of Blasius method of solving laminar boundary layer equations for flat plate. Derive expressions for boundary layer thickness and local skin friction coefficient from this solution. **07**

Q.5 **(a)** Explain the physical mechanism of boiling. **03**

(b) Explain construction and working of heat-pipe. **04**

(c) Two concentric spheres 25 cm and 35 cm in diameter with the space between them evacuated are used to store liquid air (-150 ^{o}C) in a room at 20 ^{o}C. The surfaces of the spheres are flushed with aluminum ($\epsilon = 0.04$). Calculate the rate of evaporation of liquid air if the latent heat of vaporization of liquid air is 218 kJ/kg. Assume that other modes of heat transfer are absent. **07**

OR

Q.5 **(a)** List the applications of boiling heat transfer. **03**

(b) How does film wise condensation differ from drop wise condensation? Which type has a higher heat transfer film coefficient and point out the reason thereof. **04**

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

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