Seat No.: _____ Enrolment No.

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– V EXAMINATION – SUMMER 2020

Subject Code: 2151909 **Date:04/11/2020**

Subject Name: HEAT TRANSFER

Time: 02:30 PM TO 05:00 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)**	Why does metal feel colder than wood, even if both are at the room temperature?	**3**
	(b)	An exterior wall of a house may be approximated by a 10.16 cm layer of common brick (k=0.7 W/m°C) followed by a 3.8 cm layer of gypsum plaster (k=0.48 W/m°C). What thickness of loosely packed rock-wool insulation (k=0.065 W/m°C) should be added to reduce the heat loss (or gain) through the wall by 80%?	**4**
	(c)	What are the advantages of dimensional analysis? Show by dimensional analysis for forced convection, $N_u = f(R_e, P_r)$	**7**
Q.2	**(a)**	Define black body. What is the difference between surface if coated with lampblack and ice (snow) in terms of black body?	**3**
	(b)	Define the terms: (a) Emissivity (b) Total emissive power (c) Monochromatic emissive power (d) Intensity of radiation.	**4**
	(c)	The handle of a saucepan, 30 cm long and 2 cm in diameter is partially immersed in boiling water at 100°C. The average unit conductance over the handle surface is 7.35 W/m^2K in the kitchen air at 24°C. The cook is likely to grasp the last 10 cm of the handle and hence, the temperature of this portion should not exceed 32°C. What should be the material conductivity of handle? The handle may be treated as a fin of insulated tip.	**7**
		OR	
	(c)	Steam at T_i = 320°C flows in a cast iron pipe (k = 80 W/m°C) whose inner and outer diameters are D_1= 5 cm and D_2 = 5.5 cm, respectively. The pipe is covered with 3 cm thick glass wool (k=0.05 W/m°C) insulation. Heat is lost to the surroundings at T_o = 5°C by natural convection, with a heat transfer coefficient of h_o = 18 W/m^2°C. Taking the heat transfer coefficient inside the pipe to be h_i = 60 W/m^2°C, determine the rate of heat loss from the steam per unit length of the pipe. Also determine the temperature drops across the pipe shell and the insulation.	**7**
Q.3	**(a)**	Suppose a person stated that heat cannot be transferred in a vacuum. How do you respond?	**3**
	(b)	What do you mean by critical radius of insulation? Derive its expression for cylinder.	**4**
	(c)	Water at the rate of 0.8 kg/s at 90°C flows through a steel tube having 25 mm ID and 30 mm OD. The outside surface temperature of the pipe is 84°C and temperature of surrounding air is 20°C. The room pressure is 1.013 bar and pipe is 15 m long. How much heat is lost by free convection in the room? You may use correlation $N_u = 0.53 (Gr\ Pr)^{0.25}$ for $10^4 < Gr\ Pr < 10^9$ $N_u = 0.10 (Gr\ Pr)^{1/3}$ for $10^9 < Gr\ Pr < 10^{12}$ Take properties of air as ρ = 1.0877 kg/m^3, c_p= 1.0073 kJ/kg K, $\mu = 1.9606 \times 10^{-5}$ kg/ms, k_f = 0.02813 W/m K	**7**
		OR	
Q.3	**(a)**	Describe the mechanism of thermal conduction in a gas.	**3**
	(b)	A steam pipe is insulated to reduce the heat loss. However, the measurement reveals that the rate of heat loss has increased instead of decreasing. Can you elaborate the reasons?	**4**

(c) A plate of length 750 mm and width 250 mm has been placed lengthwise in a stream of crude oil which flows with a velocity of 5 m/s. If the oil has a specific gravity of 0.8 and kinematic viscosity of 1 stroke, calculate: (a) Boundary layer thickness at the middle of plate (b) Shear stress at the middle of plate and (c) Friction drag on one side of the plate **7**

Q.4 **(a)** What is critical Reynolds number? State its approximate values for flow over flat plate and through a circular tube. **3**

(b) Draw the boiling curve with the different boiling regimes. What is the difference between pool boiling and flow boiling? **4**

(c) Consider a 20 cm diameter spherical ball at 800 K suspended in air. Assuming the ball closely approximates a blackbody, determine (a) the total blackbody emissive power, (b) the total amount of radiation emitted by the ball in 5 min, and (c) the spectral blackbody emissive power at a wavelength of 3 μm. **7**

OR

Q.4 **(a)** What is the cross string method? For what kind of geometries is the crossed string method applicable? **3**

(b) Give the answer for following questions: **4**

(a) How does the presence of a non-condensable gas in a vapour influence the condensation heat transfer?

(b) Consider film condensation on the outer surfaces of long tubes. For which orientation of the tubes will the condensation heat transfer coefficient be the highest: (a) vertical and (b) horizontal?

(c) Two large parallel planes with emissivity 0.6 are at 900 K and 300 K. A radiation shield with one side polished and having emissivity of 0.05, while the emissivity of other side is 0.4 is proposed to be used. Which side of the shield to face the hotter plane, if the temperature of shield is to be kept minimum? Justify your answer. **7**

Q.5 **(a)** Explain the difference between evaporation and boiling with some suitable examples. **3**

(b) Write the advantages of effectiveness-NTU method over LMTD method. **4**

(c) A counter-flow double-pipe heat exchanger is to heat water from 20°C to 80°C at a rate of 1.2 kg/s. The heating is to be accomplished by geothermal water available at 160°C at a mass flow rate of 2 kg/s. The inner tube is thin-walled and has a diameter of 1.5 cm. If the overall heat transfer coefficient of the heat exchanger is 640 W/m^2K, determine the length of the heat exchanger required to achieve the desired heating. Take the specific heats of water and geothermal fluid to be 4.18 and 4.31 kJ/kg K, respectively. **7**

OR

Q.5 **(a)** What is the difference between film and dropwise condensation? Which is a more effective mechanism of heat transfer? **3**

(b) A concentric tube heat exchanger with an area of 50 m^2 operating under the following conditions: **4**

Fluid	Heat capacity rate, kW/K	Inlet temperature °C	Outlet temperature °C
Hot	6	70	-
Cold	3	30	60

(a) What would be the outlet temperature of hot fluid? (b) Is the heat exchanger operating in counter flow or parallel flow or cannot be determined from the available information? (c) Determine the overall heat-transfer coefficient. (d) Calculate the effectiveness of the heat exchanger. (e) What would be the effectiveness of this heat exchanger if its length were greatly increased?

(c) Define effectiveness and NTU and derive equation of effectiveness for parallel flow heat exchanger. **7**

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