Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE – SEMESTER – VI EXAMINATION – WINTER 2015

Subject Code:161906 **Date:11 /12/ 2015**

Subject Name: Heat and mass transfer

Time:2:30pm to 5:00pm **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 a general heat conduction equation in Cartesian coordinates using standard notations. **07**

(b) With the help of a neat sketch explain the various boiling regimes in the case of a pool boiling operation **07**

Q.2 **(a)** Define critical radius of insulation and hence explain outer diameter versus heat transfer curve . also comment on the outer radius in the case of a current carrying conductor. **07**

(b) Consider a 2m high and 0.7 m wide metal plate is thickness is 0.1 m . One side of the plate is maintained at a constant temperature of 600 K, while the other side is maintained at 400k. The thermal conductivity of the metal can be assumed to vary linearly in this temperature range as in the equation $k(T) = k_0\,(1 + \beta T)$, K_0 = 38w/m K and β = 9.21 X 10^{-4} K^{-1}. Neglecting the edge effect and assuming a steady one dimensional heat transfer determine the rate of heat conduction through the plate. **07**

OR

(b) A metal plate of 5 mm thickness and a surface area of 300 cm^2 is heater from one of the faces by heater. The thermal conductivity of the plate is 15 W/m ^{O}C. A heat input of 1200 W is supplied to one of the surface by electric heaters and the other surface loses heat to the surrounding at 20° C by convection at the rate of 80 W/ m^2 ^{O}C. Derive an equation for the temperature distribution across the thickness of the plate and hence the temperatures on the two surfaces of the plate. Neglect losses due to radiation. **07**

Q.3 **(a)** Derive the basic differential equation for a extended surface or fins using the principle of energy balance and hence derive the expression for steady state heat transferred by a infinity long fin using the relevant boundary conditions. **07**

(b) The Maximum allowable surface temperature of an electrically heated plate 15 cm high and 10cm wide is 140° C. Estimate the maximum rate of heat dissipated from both sides of the plate to the atmosphere at 20° C. The heat transferred by radiation can be approximated to 8.72 W/m^2 K . The convective heat transfer under natural convection can be Estimated as Nu = 0.59 $(Ra)^{0.25}$. where Ra is the Rayleigh number. For air take kinematic viscosity as 21.09 x10^{-6} m^2/s, Pr = 0.692 and thermal conductivity is equal to 0.03w/m K. **07**

OR

Q.3 **(a)** The temperature of a gas stream is to be measured by a thermocouple whose junction can be approximated as sphere of 1 mm diameter. The properties of the junction are k = 35 W/m^{O} C, ρ =8500 kg/m^3. Cp = 320 J/kg ^{O}C and convection heat transfer coefficient between the junction and the gas is 210 W/m^2 ^{O}C. determine how long will it take for the thermocouple to read 99 percent of the initial temperature difference. Take initial temperature as 300 K and gas stream is at a temperature of 373 K **07**

(b) Define the Newton's law of cooling under convection ? Therefore state what is local heat transfer coefficient and hence derive an equation for average heat transfer **07**

coefficient also state the factors affecting it.

Q.4	**(a)**	Water flows through a straight tube of diameter 60mm with a velocity of 12m/s. The tube surface temperature is maintained at 70° C and flowing water is heated from 15° c to 45° C. Taking physical properties at mean bulk temperature of 30° C as density = 995.7 kg/m3, specific heat as 4.174kJ/kg K, thermal conductivity as 61.78 W/m K, kinematic viscosity as 0.805 x 10-6 m^2/s and pradtl number as 5.42 calculate i) heat transfer coefficient from the tube surface to water considering turbulent flow and Dittus-Boelter corelation (ii) The heat transferred and (iii) length of the tube	**07**
	(b)	Define view factor and hence derive an expression for view factor between two parallel infinite grey plates	**07**
		OR	
Q.4	**(a)**	Discuss the classification of heat exchangers based on various aspects	**07**
	(b)	Define: Emissivity, Radiosity, Monochromatic emissive power	**07**
Q.5	**(a)**	A 4 kg/s product stream from a distillation column is to be cooled by a3 kg/s water stream in a counter flow heat exchanger. The hot and the cold stream inlet temperatures are 400 K and 300 K respectively. The area of the heat transfer surface is $30m^2$. The overall heat transfer coefficient is $820W/m^2$ K. calculate the effectiveness of the heat exchanger and hence calculate the product stream and the coolant outlet temperature. Take specific heat of product stream as 2500J/kg k and for water as 4180 J/kg K.	**07**
	(b)	Discuss flick's law of molecular diffusion and hence show the analogy between heat conduction ,molecular diffusion and momentum transfer.	**07**
		OR	
Q.5	**(a)**	Derive an expression for LMTD for a counter flow recuperative heat exchanger	**07**
	(b)	Liquid air is stored at its boiling point 120 K in a spherical container of diameter 320 mm. The container is surrounded by another spherical shell of diameter 360 mm and is at 300 K. Vacuum is created in the space between the two containers to prevent heat in leak. If the surfaces of the containers are coated with aluminum of emissivity 0.03. Considering the latent heat of liquid air as 210kj/kg. Determine the rate of evaporation. Neglect heat in leak due to conduction and convection.	**07**

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