Q. Code: 914116

Reg. No. | | | | | | | | | |

B.E. / B.TECH. DEGREE EXAMINATIONS, DEC 2019

Fifth Semester

ME16502 – HEAT AND MASS TRANSFER

(Mechanical Engineering)

(Regulation 2016)

Time: Three Hours **Maximum : 100 Marks**

Answer **ALL** questions

PART A - (10 X 2 = 20 Marks)

		CO	RBT
1.	What are the factors affecting thermal conductivity of material?	1	R
2.	Explain lumped parameter analysis.	1	R
3.	What are the differences between Forced and natural convection.	2	R
4.	In a process, water at 30°C flows over a flat plate maintained at 10°C with a free stream velocity of 0.3 m/s. Determine the thermal boundary layer.	2	U
5.	Explain fouling factor.	3	R
6.	How does film boiling differ from nucleate boiling?	3	R
7.	What is black body? Give examples of some surfaces which do not appear black, but have high values of absorptivities.	4	U
8.	State and explain the reciprocity theorem.	4	R
9.	Define the following. (i) Mass Concentration (ii) Molar Concentration	5	R
10.	Give examples of diffusion and convective mass transfer.	5	R

PART B - (5 X16 = 80 Marks)

11.	(a)	(i)	Consider a 1 m high and 2.2 m wide double plane window consisting of two 5 mm thick layers of glass (K = 0.78W/m K) separated by a 10mm wide stagnant air space (K = 0.026 W/m K). Determine the heat transfer through this double plane window and temperature of the inner surface, which the room is maintained at 20°C while the temperature of the outdoors is -10^{0}C. Take the convective heat transfer coefficient inner and outer surfaces of the window to be h_1 = 12 W/m^2 K and h_2 = 42 W/m^2 K.	(8)	1	AP
		(ii)	The body of an electric motor is 360 mm in diameter and 240 mm long. it dissipates 360 W of heat and its surface temperature should not exceed 55°C. Longitudinal fins of 15 mm thickness and 40 mm height are proposed. The heat	(8)	1	AP

transfer coefficient is 40 W/m^2C when the ambient air is 30°C. determine the heat transfer per fin and number of fins.

(OR)

	(b)	(i)	A long 20 cm diameter cylindrical shaft made of stainless steel-304 comes out of a oven at a uniform temperature of 600°C. The shaft is then allowed to cool slowly in an environment chamber at 200°C with an average heat transfer coefficient of h = 80 W/m^2 K. Determine the temperature at the centre of the shaft 45 min after the start of the cooling process.	**(8)**	**1**	**AP**
		(ii)	A thermocouple, the junction of which can be approximated as a 1 mm diameter sphere is used to measure temperature of a gas stream. The properties of the junction are ρ = 8500 $kg/m^{3,}$ c =320 J/kg K, and K = 35 W/m k. The heat transfer coefficient between the the junction and the gas is 210 W/m^2K . Determine how long it will take for the thermocouple to read 99% of the initial temperature difference.	**(8)**	**1**	**AP**
12.	(a)	(i)	Air at 1 atm, 27°C flows across a sphere of 0.015 m diameter at a velocity of 5 m/s. A heater inside the sphere maintains the surface temperature at 77°C. Determine the heat transfer rate.	**(7)**	**2**	**AP**
		(ii)	Water flows at a velocity of 12 m/s in a straight tube of 60 mm diameter. The tube surface temperature is maintained at 70°C and the flowing water is heated from the inlet temperature of 15°C to an outlet temperature of 45°C, calculate the (i)the heat transfer coefficient from the tube surface to the water,(ii) heat transferred and (iii)the length of the tube.	**(9)**	**2**	**AP**

(OR)

	(b)	Consider a 0.6 m x 0.6 m thin square plate in a room at 30°C. One side of the plate is maintained at a temperature of 90°C, while the other side is insulated. Determine the rate of heat transfer from the plate by natural convection if the plate is (a) vertical (b) horizontal with the hot surfaces facing up. (c) horizontal with the hot surface is facing down.	**(16)**	**2**	**AP**
13.	(a)	(i) Explain various regimes of pool boiling curve.	**(6)**	**3**	**U**
		(ii) Ammonia vapour is condensed at 35°C is to be condensed on the outside of the horizontal tubes of outer diameter 2.5 cm with a surface temperature of 25°C. A square array of 100 tubes of 1.2 m length are used. Determine the rate of condensation of Ammonia. Take the latent heat of vaporization as =1123.46 kJ/kg	**(10)**	**3**	**AP**

(OR)

(b) (i) Steam in the condenser of a power plant is to be condensed at a temperature of 30ºC with cooling water nearby lake, which enters the tubes of the condenser at 14ºC and leaves at 22ºC. The surface area of the tubes is $45m^2$ and the overall heat transfer coefficient is 2100 W/m^2 K. determine the mass flow rate of the cooling water needed and the rate of condensation of the steam in the condenser. Take the heat of vaporization of water as 2431 = kJ/kg and specific heat of water as 4.2 kJ/kg K. **(8) 3 AP**

(ii) In an open heart surgery under hypothermic conditions, the patient's blood is cooled before the surgery and rewarmed afterwards. It is proposed that a concentric tube counter flow heat exchanger of length 0.5 m is to be used for this purpose, with a thin walled inner tube having a diameter of 55 mm. If water at 60ºC and 0.1 kg/s is used to heat blood entering the exchanger at 18ºC and 0.05 kg/s. Find the effectiveness and the temperature of the blood leaving the exchanger. Take U= 500 W/m^2 K, C_p of blood = 3.5 kJ/kg K and c_p of water = 4.183 kJ/kg K. **(8) 3 AN**

14. (a) (i) Determine the shape factor between the surfaces 1-4 and 4-1 as shown in Figure 1. Also determine the heat flow if ε_1 = 0.4, ε_2 = 0.6 and T_1= 1000 K and T_4 =500 K. **(12) 4 AP**

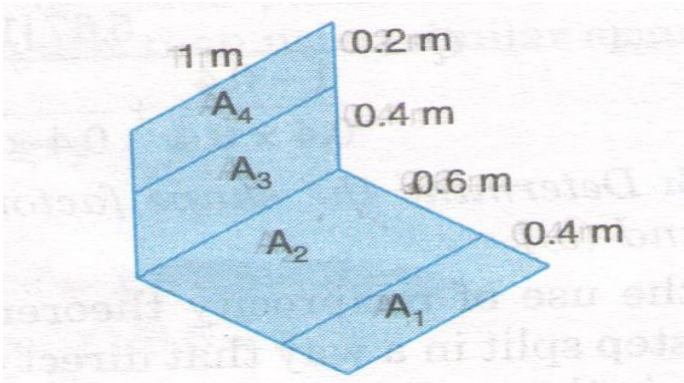

Figure 1

(ii) Assuming the sun to be a black body having a surface temperature of 5800 K. (a) calculate the total emissive power (b) the percentage of total energy emitted that lies in the visible rang of 0.3 μ to 0.76 μ. **(4) 4 AP**

(OR)

(b) (i) A spherical container with 0.9 m diameter stores cryogenic fluid at - 178ºC. The surface emissivity is 0.03, It is enclosed by another concentric sphere of 1 m diameter with a surface emissivity of 0.04.The interface is evacuated.The outside **(8) 4 AP**

			surface is at 10°C. Calculate the rate of heat leakage and rate of evaporation of cryogenic fluid.Take the rate of vaporization as 220 kJ/kg.			
		(ii)	Two very large plate parallel planes with emissivity 0.3 and 0.8 exchange radiative energy. Determine the percentage reduction in radiative energy transfer when a polished aluminium shield of emissivity 0.04 is placed between them.	**(8)**	**4**	**AP**
15.	(a)	(i)	Hydrogen gas is maintained at 5 bar and 1 bar on opposite sides of a plastic membrane which is 0.3 mm thick. The temperature is 25°C and the binary diffusion coefficient of hydrogen in the plastic is 8.7 x 10^{-8} m^2/s. The solubility of hydrogen in the membrane is 1.5 x 10^{-3} kg mol/m^3 bar. What is the mass flux of hydrogen by diffusion through the membrane?	**(8)**	**5**	**U**
		(ii)	CO_2 and air experience equimolar counter diffusion in a circular tube whose length and diameter 1 m and 50 mm respectively. The system is at a total pressure 1 atm and temperature 25°C. The ends of the tube are connected to large chamber in which the species concentration are maintained at fixed value. The partial pressure of CO_2 at one end is 190 mm of Hg while the other end is 95 mm of Hg. Estimate the mass transfer rate of CO_2 and air through the tube, Take the R = 8.205 x10^{-2} m^3 atm / kmol K.	**(8)**	**5**	**AP**
			(OR)			
	(b)	(i)	Describe the analogy between heat and Mass transfer.	**(8)**	**5**	**U**
		(ii)	Air at 1 atm, 25°C, containing small quantities of iodine flows with a velocity of 5.18 m/s inside a 3.048 cm diameter tube. Determine the mass transfer coefficient for iodine transfer from the gas stream to the wall. Take diffusion coefficient of Iodine = 0.82 x 10^{-5} m^2/s.	**(8)**	**5**	**AP**