Reg No.:_______________ Name:_______________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Sixth Semester B.Tech Degree Supplementary Examination May 2023 (2019 Scheme)

Course Code: MET302

Course Name: HEAT &MASS TRANSFER

Max. Marks: 100 **Duration: 3 Hours**

(Use of Heat and Mass Transfer Data Book permitted)

PART A

Answer all questions, each carries 3 marks. Marks

1	Define thermal diffusivity and explain its physical significance	(3)
2	Discuss the effect of contact resistance on heat transfer and temperature distribution.	(3)
3	Explain the significance of Nusselt number and Prandtl number in convection	(3)
4	Explain why the heat transfer coefficient for natural convection is much less than that for forced convection?	(3)
5	List and explain any three classification of heat exchangers.	(3)
6	Discuss the advantage of NTU method over the LMTD method.	(3)
7	Distinguish between absorptivity and emissivity of a surface	(3)
8	State and Explain Kirchhoff's law	(3)
9	Explain diffusion mass transfer and convective mass transfer by giving example	(3)
10	Define diffusion resistance in mass transfer	(3)

PART B

Answer any one full question from each module, each carries 14 marks.

Module I

11	a)	Derive an equation for steady state temperature distribution across a plane wall with internal heat generation. Both the surfaces have equal temperatures and subjected to convection heat transfer. The surface heat transfer coefficient is h and fluid temperature is T_∞	(7)
	b)	A steam pipe of 5 cm inside diameter and 6.5 cm outside diameter is covered with a 2.75 cm radial thickness of high temperature insulation (k = 1.1 W/m.K). The surface heat transfer coefficient for inside and outside surfaces are 4650 W/m^2.K and 11.5 W/m^2.K, respectively. The thermal conductivity of the pipe material is	(7)

45 W/m.K. If the steam temperature is 200°C and ambient air temperature is 25°C, determine:

(i) Heat loss per metre length of pipe.

(ii) Overall heat transfer coefficient based on outer radius

OR

12 a) Derive three-dimensional unsteady state heat conduction equation with heat generation, in Cartesian co-ordinate system for anisotropic material. (7)

b) A furnace wall is made of three layers. First layer is of insulation (k = 0.6 W/m.K), 12 cm thick. Its face is exposed to gases at 870°C with convection coefficient of 110 W/m^2.K. It is covered with (backed with), a 10 cm thick layer of fire brick (k = 0.8 W/m.K) with a contact resistance of 2.6×10^{-4} m^2.K/W between first and second layer. The third layer is a plate of 10 cm thickness (k = 4 W/m.K) with a contact resistance between second and third layer of 1.5×10^{-4} m^2.K/W. The plate is exposed to air at 30°C with convection coefficient of 15 W/m^2.K. Determine the heat flow rate and overall heat transfer coefficient. (7)

Module II

13 a) Water at 20°C enters a 20mm diameter tube with a velocity of 1.5 m/s. The tube is maintained at 100°C. Find the tube length required to heat the water to a temperature of 60°C (7)

b) Estimate the heat transfer rate from a 100 W incandescent bulb at 140°C to an ambient at 24°C. Approximate the bulb as 60 cm diameter sphere. Calculate the percentage of power lost by natural convection. (7)

OR

14 a) Explain with neat sketches the evolution of hydrodynamic and thermal boundary layer when a heated fluid flows over a flat plate (7)

b) A motor cycle travels at 100 km/hr. On the engine head a fin of 0.16 m length and 0.04 m width is exposed to convection on both sides. The fin surface is at 300°C and air is at 20°C. Determine the rate of heat removal from the fin assuming turbulent flow prevails all through. (7)

Module III

15 a) Derive an expression for Log Mean Temperature Difference in the case of a counter flow heat exchanger. (7)

b) A counter flow heat exchanger consists of two concentric flow passages is used for heating 1110 kg/hr of oil (sp. heat = 2.1 kJ/kg.K) from a temperature of 27°C to 49°C. The oil flows through the inner pipe made of copper (Outside Diameter = 2.86 cm, Inside Diameter = 2.54 cm) and the surface heat transfer coefficient on the oil side is 635 W/m^2.K. The oil is heated by hot water supplied at the rate of 390 kg/hr and at an inlet temperature of 93°C. The water side heat transfer coefficient is 1270 W/m^2.K. If the thermal conductivity of copper is 350 W/m.K and the fouling factors on the oil and water sides to be 0.0001 and 0.0004m^2.K/W, calculate the length of the heat exchanger (7)

OR

16 a) Derive an equation for the effectiveness (ε) of a concentric tube parallel flow heat exchanger in terms of NTU and Capacity Ratio (C) (7)

b) In an open-heart surgery, under hypothermic conditions, the patient 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 be used for this purpose with the thin-walled inner tube having a diameter of 55 mm. If the water at 60°C and 0.10 kg/s is used to heat the blood entering the exchanger at 18°C and 0.05 kg/s, what is the temperature of blood leaving the exchanger? The overall heat transfer coefficient is 500 W/m^2.K and specific heat of the blood is 3500 J/kg.K. (7)

Module IV

17 a) Define Intensity of radiation. Show that the emissive power of a black body is π-times the intensity of emitted radiation (7)

b) A black body emits radiation at 1727 ^{0}C. Calculate (i) the monochromatic emissive power at 1μm wavelength, (ii) wavelength at which the emission is maximum, and (iii) the maximum emissive power. (7)

OR

18 a) Explain the "surface resistance" and "space resistance". Construct a radiation network for two grey surfaces exchanging radiant energy. (7)

b) A room 4 m × 4 m × 4 m is heated through the ceiling by maintaining it at uniform temperature of 77 ^{0}C, while walls and the floor are at 27 ^{0}C. If all surfaces have an emissivity of 0.8, determine the rate of heat loss from ceiling by radiation. (7)

Module V

19 a) Explain the significance of Reynolds number, Schmidt number, Sherwood number and Lewis number. (7)

b) A tank contains a mixture of CO_2 and N_2 in the mole proportions of 0.2 and 0.8 at 1 bar and 17^0C. It is connected by a duct of sectional area 0.1 m^2 and 0.5 m long, to another tank containing a mixture of CO_2 and N_2 in the molar proportion of 0.8 and 0.2 respectively. Determine the diffusion of rates CO_2 and N_2. Assume Diffusion coefficient, $D = 0.16 \times 10^{-4}$ m^2/s. (7)

OR

20 a) Discuss the following (7)

(i) Analogy between heat and mass transfer.

(ii) Equimolar counter diffusion

b) The water in a 5 m × 15 m outdoor swimming pool is maintained at a temperature of 27°C. The average ambient temperature and relative humidity are 27°C and 40%, respectively. Assuming a wind speed of 2 m/s in the direction of long side of the pool, estimate the mass transfer coefficient for the evaporation of water from the pool surface (7)

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