Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Sixth Semester B.Tech Degree Regular and Supplementary Examination July 2021

Course Code: ME302
Course Name: HEAT AND MASS TRANSFER

Use of heat and mass transfer data book permitted

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any three full questions, each carries 10 marks. Marks

1 a) Derive the general heat conduction equation in rectangular coordinates. (6)

b) Define critical thickness of insulation. What is its significance? (4)

2 a) A plane wall of thickness L is having uniform thermal conductivity k. Heat is being uniformly generated in the wall at a rate of q_g per unit volume. Assuming one dimensional heat conduction through the wall with wall surfaces having same temperature t_w, derive an expression for maximum temperature in the wall. (6)

b) A 25 mm thick metal plate (k = 1 W/m°C) has a uniform volumetric heat generation of 100 kW/m^3. The surrounding temperature is 30°C and the surface heat transfer coefficient of 20 W/m^2K. Determine the temperature at the mid-plane. (4)

3 a) What are Nusselt number and Prandtl number? Explain their significance (4)

b) Using neat sketches, show the hydrodynamic and thermal boundary layer formation over a flat plate (no explanation required). Mention the terms used in the sketches. (6)

4 Atmospheric air at 20^{o}C flows over a flat plate with a velocity of 3 m/s. The plate has a length of 500 mm (in the flow direction) and a width of 300 mm. If the plate is maintained at 80^{o}C, calculate the following quantities at the trailing edge: (10)

i) Hydrodynamic boundary layer thickness

ii) Thermal boundary layer thickness

iii) Local skin friction coefficient

iv) Local convective heat transfer coefficient

v) Rate of heat transfer by convection from the plate

PART B

Answer any three full questions, each carries 10 marks.

5	a)	What is lumped system analysis? Derive an expression for temperature distribution in a lumped system in terms of initial temperature and ambient temperature.	(6)
	b)	A metallic sphere of 25 mm diameter (k = 40 W/m°C, ρ = 7900 kg/m^3, c = 480 J/kg°C) is cooled by exposing air at 25°C with a convective heat transfer coefficient of 125 W/m^2 °C. Find the time required to cool the sphere from 650°C to 150°C.	(4)
6		Derive the governing differential equation for a rectangular fin of constant area of cross-section. Find the expression for temperature distribution for an infinitely long case.	(10)
7	a)	Mention the important classifications in heat exchangers with examples for each one.	(4)
	b)	With the aid of a temperature distribution curve, derive the expression for the logarithmic mean temperature difference of a parallel flow heat exchanger.	(6)
8		In a shell and tube type counter flow heat exchanger, water flows through a copper tube 20 mm I.D. and 22 mm O.D., while oil flows through the shell. Water enters at 20°C and comes out at 30°C, while oil enters at 80°C and comes out at 60°C. The water and oil side film coefficients are 4400 and 1250 W/m^2°C respectively. The thermal conductivity of the tube wall is 350W/m°C. If the length of the tube is 2.5 m, calculate the overall heat transfer coefficient and the heat transfer rate.	(10)

PART C

Answer any four full questions, each carries 10 marks.

9	a)	What is a black body? What are its properties?	(4)
	b)	Explain Planck's Law and Wein's displacement law of radiation.	(6)
10	a)	Define shape factor. What is reciprocity theorem?	(4)
	b)	The radiation shape factor of one circular surface of a thin hollow cylinder, 10 cm diameter and 10 cm long, to the other circular surface is 0.2. What is the shape factor of the curved surface of the cylinder with respect to itself?	(6)
11		Two large parallel plates are kept at 500°C and 30°C. Calculate the net radiation exchange per unit area between the plates. The emissivities of the plates are 0.8	(10)

and 0.5 respectively. If a radiation shield of emissivity 0.3 is placed in between them, calculate the percentage reduction in heat transfer.

12 a) State the law governing mass diffusion and name it. Explain all the terms involved with units. (4)

b) Gaseous hydrogen is stored at elevated pressure in a steel container of 16 mm wall thickness. The molar concentration of hydrogen in steel at the inner surface is 1.2 kg mol/m^3, while the concentration of hydrogen in steel at the outer surface is zero. The binary diffusion coefficient for hydrogen in steel is 0.25 x 10^{-12} m^2/s. What is the mass flux of hydrogen through the steel? (6)

13 a) Define equimolar counter diffusion. In a binary diffusion process of components A and B, show that $D_{AB} = D_{BA}$ for an equimolar counter diffusion. (6)

b) Discuss Reynolds analogy for heat transfer and mass transfer. (4)

14 a) Explain Lewis number and Schmidt number. How are they related to Prandtl number? (3)

b) Air at 20^{o}C flows through a pipe of 25 mm diameter with a velocity of 5 m/s. The inner surface of the tube is constantly wetted with water so as to maintain a thin water film on the surface. The mass diffusivity of water vapour in air is 0.25 x 10^{-4} m^2/s. Calculate the mass transfer coefficient of water vapour in air. Use properties of dry air at 20°C. (7)

****