Reg No.:_______________ Name:_______________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S6 (S, FE) / S4 (PT) (S,FE) Examination December 2024 (2019 Scheme)

Course Code: MET302

Course Name: HEAT & MASS TRANSFER

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

PART A

Answer all questions, each carries 3 marks. Marks

1	What do you mean by critical radius of insulation over a cylindrical surface?	(3)
2	Define Biot number. Give its formula and explain the terms. What is its relevance?	(3)
3	What is the physical significance of Prandtl number?	(3)
4	Give a briefing on the mechanism of natural convection with reference to the forces that come into play in it, with special reference to the non dimensional numbers that is involved in the determination of natural convection heat transfer coefficient.	(3)
5	Why does a cavity with a small hole behave as a black body?	(3)
6	Explain Kirchoff's law.	(3)
7	Compare parallel flow & counter flow heat exchanger.	(3)
8	Define effectiveness of a heat exchanger.	(3)
9	Explain Fick's law of diffusion.	(3)
10	Explain the physical significance of Schmidt number.	(3)

PART B

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

Module I

11	a)	A large plane wall of thickness $L = 0.2$ m, thermal conductivity $k = 1.2$ W/m °C, and surface area $A = 15$ m^2. The two sides of the wall are maintained at constant temperatures of $T_1 = 120$°C and $T_2 = 50$°C, respectively. Determine (*a*) the variation of temperature within the wall and the value of temperature at $x = 0.1$ m and (*b*) the rate of heat conduction through the wall under steady conditions.	(10)
	b)	What is the criterion for treating a heat transfer problem as a lumped heat system?	(4)

OR

12	a)	An aluminium alloy fin (k= 200 W/m.K) with an insulated tip is 2 mm thick, 20mm wide and 10 cm long protrudes from a wall. The base is at 240 °C and ambient temperature is 30 °C. The heat transfer coefficient may be taken as 11 W/m^2K. Find the heat loss and fin efficiency.	(10)
	b)	Differentiate between effectiveness and efficiency of a fin.	(4)

Module II

13	a)	Air at 30 °C and 1 atm flows over a heated plate with a velocity of 2 m/s. The plate is at a uniform temperature of 90 °C. Calculate the heat transfer rate per unit width from the first 0.4 m of the plate. Also calculate the critical length, assuming a critical Reynolds Number of 5,00,000.	(10)
	b)	Draw the pool boiling curve of water at 1 atm and mark the major regimes.	(4)

OR

14	a)	Water at 20 °C enters a 2 cm 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.	(10)
	b)	How does the heat transfer coefficient differ from thermal conductivity?	(4)

Module III

15	a)	Steam in a condenser of a steam power plant is to be condensed at a temperature of 30 °C with cooling water from nearby lake, which enters the tubes of condenser at 14 °C and leaves at 22 °C. The surface area of tubes is 45 m^2 and overall heat transfer coefficient is 2100 W/m^2K. Calculate the mass flow rate of water needed and rate of steam condensation in the condenser. Assume condenser as counter flow heat exchanger.	(10)
	b)	What do you mean by fouling factor? State the causes of fouling.	(4)

OR

16	a)	A counter flow heat exchanger is used to heat air entering at 400°C with a flow rate of 6 kg/s by exhaust gas entering at 800 °C with a flow rate of 4 kg/s. The overall heat transfer coefficient is 100 W/m^2 K and the outlet temperature of the air is 55.5 °C. The specific heat at constant pressure for both air and exhaust gas can be taken as 1100 J/kg K. Calculate (a) heat transfer area needed (b) Number of transfer units.	(10)
	b)	Explain LMTD method and its limitations in analysing heat exchangers.	(4)

Module IV

17 a) One side of a metallic plate is insulated, while the other side absorbs a radiant heat flux of 900 W/m^2. The convective heat transfer coefficient between the plate and the ambient air is 10 W/m^2 K. The surface emissivity of the plate is 0.8. The surrounding ambient air temperature are at 27 °C. Determine the temperature of the plate at steady state condition. (8)

b) Differentiate between an opaque body, grey body and black body in terms of absorptivity, reflectivity and transmissivity. (6)

OR

18 a) Two parallel, infinite gray surfaces are maintained at a temperature of 127 °C and 227 °C respectively. If the temperature of the hot surface is increased to 327 °C by what factor will the net radiation exchange per unit area be increased? Assume the emissivities of colder and hotter surfaces to be 0.9 and 0.7 respectively. (8)

b) Explain these view factor relations. (a) Reciprocity rule (b) Summation rule (6)

Module V

19 a) The hydrogen gas diffuses through a steel wall of 2 mm thickness. The molar concentration of hydrogen at the interface is 1.5 kg-mol/m^3 and it is zero on the outer surface. Calculate the diffusion rate of hydrogen if its diffusivity coefficient in steel is 0.3×10^{-12} m^2/s. (7)

b) Explain the overall mass transfer coefficient. (7)

OR

20 a) Explain the phenomenon of equimolar counter diffusion. Derive an expression for equimolar counter diffusion between two gases or liquids. (10)

b) Explain different modes of mass transfer with examples. (4)

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