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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Sixth Semester B.Tech Degree Examination June 2022 (2019 Scheme)

Course Code: MET302

Course Name: Heat and Mass Transfer

(Use of heat and mass transfer data book permitted)

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

PART A

Answer all questions, each carry 3 marks. Marks

1	What is critical radius of insulation? Explain its importance.	(3)
2	Explain Lumped system analysis.	(3)
3	Explain the physical significance of Prandtl No. and Nusselt No.in convection.	(3)
4	What is Grashof number? Explain its significance.	(3)
5	Why drop-wise condensation is better than film wise condensation? What are the methods to achieve drop wise condensation?	(3)
6	What is fouling factor? How fouling factor is accounted in heat exchanger analysis?	(3)
7	What is view factor? State summation rule of view factor.	(3)
8	Explain perfect black body concept.	(3)
9	What are the three modes of mass transfer?	(3)
10	What is the difference between mass concentration and molar concentration?	(3)

PART B

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

Module I

11	a)	Derive general conduction equation in Cartesian coordinate with necessary sketch. Reduce the equation for steady state one dimensional heat conduction across a plane wall without internal heat generation	(7)
	b)	A rectangular aluminum fin of cross section 8 x 3 cm^2 and 1 m long is protrudes out from a wall of thermal conductivity 250 W/mK. The fin base is maintained at a temperature of 400°C and the ambient temperature is 30°C with heat transfer coefficient 10W/m^2K. The tip of the fin is insulated. Calculate the heat transfer from the fin.	(7)

OR

12 a) An electric cable of 10 mm diameter is to be insulated by a rubber (k=0.14W/mK). Assume cable surface temperature is 70°C. The surrounding air temperature is 30°C and convective heat transfer coefficient is 10 W/m^2K in both bare and insulated cases. Find critical thickness of the insulation and compare the heat transfer for with and without insulation. (7)

b) The interior temperature of a refrigerator is maintained at 5°C. The walls are constructed with two mild steel sheets 3 mm thick with 5 cm of glass wool insulation between them. The heat transfer coefficients on inner and outer surface of refrigerator are 10 $W/m^2{}^\circ C$ and 12.5 $W/m^2\,{}^\circ C$ respectively. The temperature in kitchen room is 35°C.Take k (mild steel) =40 W/m-°C and k (glass wool) = 0.04 W/m-°C. Sketch the electric analog of the system. Find the rate of heat leaked to the refrigerator in watts per unit area when it is kept in a kitchen room. Also find interface wall temperatures. (7)

Module II

13 a) Air at pressure of 1 atm and temperature 70°C flows over a flat plate which maintains a surface temperature of 90°C. The plate has a length of 0.2m (in the flow direction) and width of 0.1m. The Reynolds number based on the plate length is 40000. What is the rate of heat transfer from plate to air? (9)

If the free stream velocity of air is doubled and the pressure is increased to 3 atm, what is the rate of heat transfer?

b) Explain hydrodynamic and thermal boundary layer for flow through tubes with the help of neat sketches. (5)

OR

14 a) A hot square plate 40 cm x 40 cm at 90°C is exposed to atmospheric air at 30°C. Make calculations for the heat loss from both surfaces of the plate, if (a) the plate is kept vertical (b) the plate is kept horizontal. The following empirical correlations have been suggested: (8)

$Nu = 0.125\,(Gr\,Pr)^{0.33}$ for vertical position of plate, and

$Nu = 0.72\,(Gr\,Pr)^{0.25}$ for upper surface (horizontal position)

$= 0.35\,(Gr\,Pr)^{0.25}$ for lower surface (horizontal position)

where the air properties are evaluated at the mean temperature.

b) An incandescent bulb can be considered as a sphere of 0.06 m dia. The bulb surface is at 130°C. Air at 30°C flows over it with a velocity of 0.6 m/s. Determine the heat loss from the bulb surface. (6)

Module III

15 a) Explain boiling (pool boiling) curve for water with the help of a neat sketch. (7)

b) In an open-heart surgery under hypothermic conditions, the patient's blood is cooled before the surgery and re-warmed 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 60° C and 0.1 kg/s is used to heat blood entering the exchanger at 18°C and 0.05 kg/s, what is the temperature of the blood leaving the exchanger and the heat flow rate. Take U_0 = 500 W/m^2 K, c_p of blood = 3.5 kJ/kg K and c_p of water = 4.183 kJ/kg K. (7)

OR

16 a) Derive an expression for effectiveness of parallel flow heat exchanger using NTU method. (10)

b) What are compact heat exchangers? Explain with suitable examples. (4)

Module IV

17 a) Derive an expression for the net radiation exchange between two black bodies. (7)

b) What is Wien's Displacement Law? Explain with the help of Planks distribution. (7)

OR

18 a) Calculate the radiation exchange per unit area between two parallel plates of temperature 500^{0}C and 50^{0}C. Emissivity of hot and cold plates are 0.9 and 0.7 respectively. Find the percentage reduction in heat transfer, if a radiation shield of emissivity 0.25 on both surface is placed in between the plates. (7)

b) State and prove Kirchhoff's law of radiation. (7)

Module V

19 a) State and explain Fick's law of molecular diffusion. Write its analogy with Fourier law. (7)

b) Dry air at 30°C and 1 atm flows over a wet flat plate 700 mm long at a velocity of 60 m/s. Calculate the mass transfer co-efficient of water vapour in air at the end of the plate. Take the diffusion co-efficient of water vapour in air, D = 0.26 x 10^{-4} m^2/s (7)

OR

20 a) Air at 20° C, 40% RH, flows over a water surface at a velocity of 1.2 m/s, the length parallel to flow is 200 mm and width is 300mm. If average surface temperature is 16°C, calculate the amount of water evaporated in kg/sec from the surface? (7)

Assume the following properties:

Partial pressure of water vapor at 20° and 40% RH, P_{wa} = 0.011 bar,

The saturated vapor pressure at 16°C, P_{ws} = 0.017 bar,

Kinematic Viscosity of air, $\upsilon = 16.38 \times 10\ m^2/s$,

Density of air $\rho = 1.22\ kg/m^3$,

Diffusion coefficient; $D = 0.256 \times 10^{-4}\ m^2/s$,

Gas constant of water=461.9 J/kg K

b) What is equimolar counter diffusion? Obtain an expression for molar diffusion rate in terms of partial pressures (7)

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