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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fourth Semester B.Tech Degree Examination July 2021 (2019 Scheme)

Course Code: CHT204

Course Name: HEAT TRANSFER OPERATIONS

Max. Marks: 100 Duration: 3 Hours

PART A

(Answer all questions; each question carries 3 marks) Marks

1	Consider an insulated pipe exposed to the atmosphere. Will the critical radius of insulation be greater on calm days or on windy days? Why?	3
2	State and write Fourier's law of heat conduction	3
3	Draw the thermal boundary layer and temperature profile for fluid flowing a flat plate. (Surface temperature of flat plate is higher than free stream fluid temperature)	3
4	Heat transfer to the ambient air is primarily by natural convection. In which of the above cases, is the heat transfer coefficient higher and why? A hot horizontal plate is exposed to air by keeping, (i) the hot surface facing (ii) the hot surface facing down	3
5	Explain Leidenfrost point.	3
6	For film condensation on a vertical plate, Will the heat flux be higher at the top or at the bottom of the plate? Why?	3
7	What is role of baffles in heat exchangers	3
8	Define efficiency and capacity ratio of heat exchanger	3
9	What kind of feeding method is advised if the product is viscous and why?	3
10	Why steam trap used in evaporators?	3

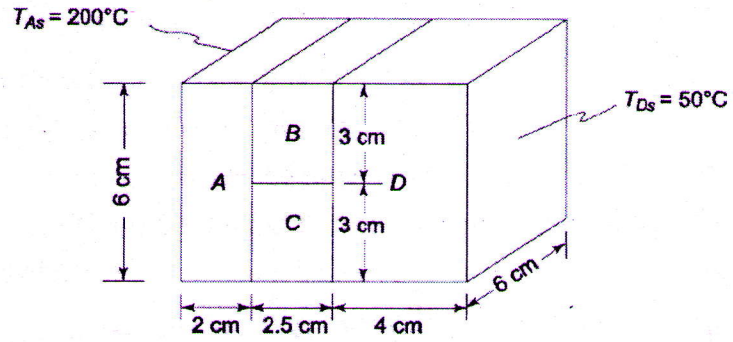
PART B

(Answer one full question from each module, each question carries 14 marks)

Module -1

11	A composite wall (shown below) has uniform temperatures. If the thermal conductivities of the wall materials are: k_A = 70 W/m.K, k_B = 60 W/m.K, k_C = 40 W/m. K, and k_D = 20 W/m.K, determine the rate of heat transfer through this section of the wall and the temperatures at the interfaces. (Surfaces normal to	14

heat transfer direction are isothermal).



12 A steam pipe of 10 cm ID and 11 cm OD is covered with an insulating substance k = 1 W/mK. The steam temperature is 200^0C and ambient temperature is 20^0C. If the convective heat transfer coefficient between insulating surface and air is 8 W/m^{2}K, find the critical radius of insulation for this value of rc. Calculate the heat loss per m of pipe and the outer surface temperature. Neglect the resistance of the pipe material. 14

Module -2

13 a) Define thermal boundary layer. Draw and explain hydrodynamic and thermal boundary layers when Pr=1, Pr<1 and Pr>1. (Pr=Prandtl number) for flow over a flat plate. 8

b) What is use of analogical expressions? Explain Reynolds Analogy stating all assumptions used in derivation. 6

14 a) When 0.6 kg of water per minute is passed through a tube of 2 cm diameter, it is found to be heated from 20°C to 60°C. the heating is achieved by condensing steam on the surface of the tube and subsequently the surface temperature of the tube is maintained at 90°C. Determine the length of the tube required for fully developed flow. 10

Data: At bulk mean temperature

Density= 995 kg/m^3

Viscosity= 0.657x10^{-6} m^2/s

Pr = 4.340

k = 0.628 W/mK

Cp = 4178 J/kgK

b) Differentiate Biot number and Nusselt number in heat transfer 4

Module -3

15 Derive Nusselt's equation for condensation on a vertical plate stating all the assumptions. 14

16 The sun emits maximum radiation at $\lambda = 0.52\ \mu$. Assuming the sun to be a black body, calculate the surface temperature of the sun. Also calculate the monochromatic emissive power of the sun's surface. 14

Given:

$\lambda_{max} = 0.52\ \mu = 0.52 \times 10^{-6}$ m

To find:

(i) Surface temperature, T.

(ii) Monochromatic emissive power, $E_{b\lambda}$

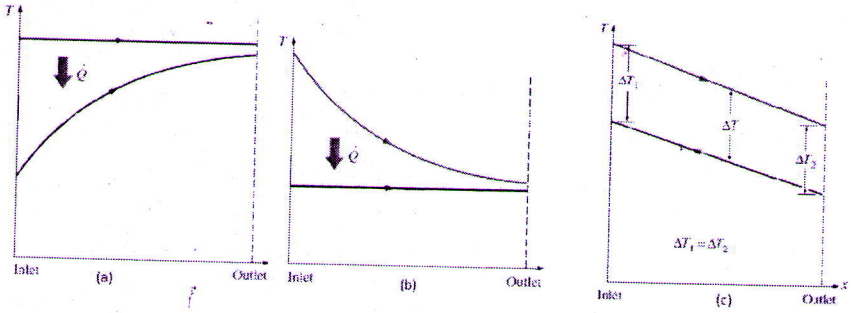
(iii) Total emissive power, E

(iv) Maximum emissive power, E_{max}

Module -4

17 a) Draw a 1-2 shell and tube heat exchanger and mark the parts of heat exchanger 8

b) Heat exchanger temperature profiles of three different purposes are given below. Comment on the heat transfer mechanism in each case. Comment whether to use correction factor (FT) in each case. 6



18 Hot chemical products (Cph = 2.5 kJ/kg K) at 600° C and at a flow rate of 30 kg/s are used to heat cold chemical products (Cp = 4.2 kJ/kg K) at 200° C and at a flow rate 20 kg/s in a parallel flow heat exchanger. The total heat transfer is 50 m2 and the overall heat transfer coefficient may be taken as 1500 W/m^2 K. calculate the outlet temperatures of the hot and cold chemical products. 14

Module -5

19 A single effect evaporator is used to concentrate 9070 kg/hr of 20% caustic soda solution to 50% solids. The gauge pressure of steam is 1.37 atm. The 14

absolute pressure in the vapor space is 100 mm Hg. There is a BPE of 22.78 °C. The overall heat transfer coefficient is estimated to be 1400 W/m^2 °C and the feed temperature is 37.8 °C. Calculate the (a) Amount of steam consumed (b) Economy (c) Heating surface required. Data: Enthalpy of feed at 37.8 °C = 127.9245 kJ/kg Enthalpy of thick liquor = 514.0239 kJ/kg Enthalpy of vapour = 2672.46 kJ/kg Heat of vaporization of steam at 1.37 atm = 2184.0201 KJ/ Kg Condensation temperature of steam = 126.11°C

20 a) Write the material and energy balance of a backward feed triple effect evaporator with a neat sketch 8

b) With a neat sketch explain the working of agitated thin film evaporators 6

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