SV-84

Seat No.	

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T.E. (Mechanical) (Part-III) (Semester - V) (Revised) Examination, April - 2018
HEAT AND MASS TRANSFER
Sub. Code : 66243

Day and Date : Thursday, 26 - 04 - 2018 **Total Marks : 100**
Time : 10.00 a.m. to 1.00 p.m.

Instructions :
1) **All questions are compulsory.**
2) **Figures to the right indicate full marks.**
3) **Assume Suitable Data wherever necessary and state it Clearly.**
4) **Use of scientific non programmable calculator is permitted.**

Q1) Solve any three:

a) Define critical radius of insulation. Also derive the equation for critical radius of insulation for hollow cylinder. **[6]**

b) What are the modes of mass transfer? Explain Fick's law of diffusion. **[6]**

c) Air at 90°C flows in a copper tube (k = 384 W/mK) of 4 cm inner diameter and with 0.6 cm thick walls which are heated from the outside by water at 125°C. A scale of 0.3 cm thick is deposited on outer surface of the tube whose thermal conductivity is 1.75 W/mK. The air and water side heat transfer coefficients are 221 and 3605 W/m^2K, respectively. Find overall heat transfer coefficient on the outside area basis. **[6]**

d) A steam pipe is covered with two layers of insulation. The inner layer (k = 0.17 W/mK) is 30 mm thick and the outer layer (k = 0.093 W/mK) is 50 mm thick. The pipe is made of steel (k = 58 W/mK) and has inner diameter and outer diameter of 160 and 170 mm, respectively. The temperature of saturated steam is 300°C and The ambient air is at 50°C. If the inside and outside heat transfer coefficients are 30 and 5.8 W/m^2K, respectively, calculate the rate of heat loss per unit length of pipe. **[6]**

Q2) Solve any two:

a) Steel ball bearings (k = 50 W/mK, $\alpha = 1.3 \times 10^{-5}$ m^2/s) having a diameter of 40 mm are heated to a temperature of 650°C and then quenched in a tank of oil at 55°C. If the heat transfer coefficient between ball bearings and oil is 300 W/m^2K. Determine the duration of time the bearing must remain in an oil to reach a temperature of 200°C. **[8]**

P.T.O.

b) A plate 2 cm thick and 2 cm wide is used to heat a fluid at 30°C. The heat generation rate inside the plate is 7×10^6 W/m^3. Determine heat transfer coefficient to maintain the temperature of the plate below 180°C. Take k for plate 26 W/mK. Neglect heat losses from the edge of plate. [8]

c) Derive the equation for temperature distribution & heat transfer through a plane wall with uniform heat generation; also convert this equation in terms of ambient temperature & the heat transfer coefficient. [8]

Q3) Solve any two:

a) Explain the error estimation of temperature measurement in thermo-well. [8]

b) Derive the expression for temperature distribution for a short fin with convective tip. [8]

c) An aluminum alloy fin (k = 200 W/mK), 3.5 mm thick and 2.5 cm long protrudes from the wall. The base is at 420°C and ambient air temperature is 30°C. The heat transfer coefficient may be taken as 11 W/m^{2}K. Find the heat loss and fin efficiency, if the heat loss from the fin tip is negligible. [8]

Q4) Solve any two of the following:

a) Give the physical significance of [8]
   i) Nusselt Number
   ii) Grashoff's Number
   iii) Reynolds Number
   iv) Prandtl Number

b) Assuming a man as a cylinder of 40 cm diameter and 1.72 m height with surface temperature of 37°C. Calculate the heat loss from his body while standing in wind flowing at 20 km/hr at 17°C. Use following correlation; [8]

$Nu = 0.027\ Re^{0.805}\ Pr^{1/3}$

The properties of fluid at mean film temperature are $\rho = 1.1614$ kg/m^3, $\upsilon = 184.6\times10^{-7}$ Ns/m^2, Pr = 0.707, k = 0.0263 W/mK.

c) Estimate the heat transfer rate from 100 watt incandescent bulb at 140°C to an ambient air at 24°C. Approximate the bulb as 60 cm diameter sphere and calculate percentage loss by natural convection. Use following correlation; [8]

$Nu = 0.60\ [Gr.Pr]^{1/4}$

The properties of air at 82°C are kinematic viscosity(γ) = 21.46×10^{-6} m^2/s, K = 30.38×10^{-3} W/mK, Pr = 0.699.

Q5) Solve any two of the following:

a) Write short Note on: **[8]**

i) Radiation shape factor

ii) State and prove Kirchhoff's Law

b) Write Plank's law and derive Stefan Boltzmann law from Plank's law. **[8]**

c) Calculate the following for an industrial furnace in the form of black body and emitting radiations at 2500°C. **[8]**

i) Monochromatic emissive power at wavelength 1.2 υm

ii) Wavelength at which emission is maximum

iii) Maximum emissive power

iv) Total emissive power

Q6) a) Write short notes on: **[12]**

i) Define Fouling factor and explain causes of fouling

ii) Types of Condensation and boiling

b) Hot oil with capacity rate ($m \times C_p$) of 2500 W/K flows through a double pipe heat exchanger. It enters at 360°C and leaves at 300°C. Cold fluid enters at 30°C and leaves at 200°C. If overall heat transfer coefficient (U) is 800 W/m^2K, determine the heat exchanger area required for parallel and counter flow. **[6]**