Tuesday, May 21, 2019 02:30 pm - 05:30 pm 1T00525 - T.E.(CHEMICAL)(Sem V) (Choice Based) / 31703 - Heat Transfer Operations (HTO) 59451

(3 hours) **Maximum Marks: 80**

N.B

1. **Question No. 1** is compulsory.
2. Attempt any **three** out of remaining **four** questions.
3. Refer steam table if necessary and indicate it clearly.
4. Figures to the right indicate marks.
5. Illustrate answers with sketches wherever required.

1. Attempt any **four.**

a) An ice box of inner dimensions 1m x 0.7 m x 0.6 m has a 6.5 cm thick layer of thermocol on it as insulation. It contains 12 kg of ice. If the outer surface temperature of the box is 20 ^{0}C, calculate the time required for the ice to melt. Latent heat of ice to water is 3350 KJ/kg ice. The thermal conductivity of the insulation layer is 0.0355 W/m ^{0}C. Assume that this layer virtually offers all the heat transfer resistance. State any other assumption you make. **5**

b) Explain significance of Biot Number and Fourier Number. **5**

c) Explain the regimes of pool boiling. **5**

d) What is fin efficiency and what is fin effectiveness. **5**

e) A person is found dead at 5 pm in a room whose temperature is 20 ^{0}C. The temperature of the body is measured to be 25 ^{0}C when found, and the heat transfer coefficient is estimated to be 8 W/m^2 K. Modelling the body as a 30 cm diameter, 1.7 m long cylinder, estimate the time of death of that person. k = 0.617 W/m ^{0}C, ρ = 996kg/m^3, Cp = 4178J/kg ^{0}C. Solve using lumped parameter system. **5**

2. (a) A steel pipe 25 mm internal diameter and 33 mm outer diameter and insulated with rock wool carries steam at 451 K. If surrounding air temperature is 294 K, calculate the rate of heat loss from one metre length of pipe. The thickness of insulation is 38 mm. Thermal conductivities of steel and rock wool are 44.97 W/(m.K) and 0.175 W/(m.K) respectively. The inside and outside heat transfer coefficients are 5678 W/ (m^2.K) and 11.36 W/ (m^2.K) respectively. Contact resistance between the pipe and insulation may be neglected. **10**

(b) A solid steel ball 50 mm in diameter and initially at a temperature of 723 K is quenched in the controlled environment whose temperature is maintained at a steady value of 363 K. Determine the time taken by the centre of the ball to reach a temperature of 423 K if internal temperature gradient is neglected. **10**

Data: h = 115 W/ (m^2.K), ρ = 8000 kg/m^3, C_p = 0.42 kJ/ (kg.K)

3. (a) Air at 101.325 kPa pressure and 333 K flows parallel to and on both sides of a flat plate (20 cm square) with a velocity of 15 m/s. If the plate is maintained at 293 K, calculate the rate of heat transfer to the plate. Also, calculate and **10**

compare the rate of heat transfer if leading edge is roughened and the boundary layer is entirely turbulent.

Data: The properties of air at the mean film temperature of 313 K are:

$\nu = 16.96 \times 10^{-6}$ m^2/s, $\rho = 1.128$ kg/m^3, $N_{Pr} = 0.699$, k = 0.0276 W/(m.K)

(b) A 20 mm φ horizontal heater is maintained at a surface temperature of 313 K and submerged in water at 298 K. Estimate the heat loss/ unit length of heater by natural convection.

Data:- Properties of water at mean temperature of 32.5 ^{0}C are
K = 0.63 w/m K, $\beta = 3.04*10^{-4}$ K^{-1}, $\rho = 1000$ kg/m^3, $\mu = 8*10^{-4}$ kg/m-s, $c_p = 4.187$ kJ/kg ^{0}C.
Use Nu = 0.53 (Gr. Pr)$^{1/4}$ **10**

4. (a) Two long planes A and B are maintained at 600 K and 300 K and their surface emissivities are 0.8 and 0.5 respectively. Two thin radiation shields C and D having emissivities 0.5 and 0.4 are introduced between two planes the given planes. The given planes are in the order A, C, D and B. Assuming all the planes to be infinitely long, find the rate of heat exchange per unit area and steady- state temperatures attained by the planes C and D. **10**

(b) In 1-4 pass STHE, if the tubes are arranged on a 25.4 mm-600 triangular pitch, tube outer diameter is 19 mm. 25% cut segmental baffles are used with 0.15 m baffle spacing. Shell diameter is 10 inch. If shell side mass flow rate is 2083kg/h, estimate shell side Reynold's number (μ = 3.3 * 10-4 Kg/m-S). **5**

(c) Write short note on Heat Transfer in Agitated Vessels **5**

5. (a) Derive for Counter Flow heat exchanger $\varepsilon = \dfrac{1+e^{-NTU(1-C)}}{1-C.e^{-NTU(1-C)}}$ **10**

(b) Water at 298 K entering a single pass counter flow heat exchanger, at a rate of 0.167 kg/s is to be used to cool oil flowing outside of tubes at a rate double of that of water. Inlet oil temperature is 398 K and sp. heat of oil is 2.1 kJ/kg.K. The tubes specification is 20 mm I.D., 25 mm O.D. and 2.5 m long. Determine the number of tubes required. **10**

Data:
h on oil side = 200 W/(m^2.K)
h on water side = 1500 W/(m^2.K)
C_P of water = 4.2 kJ/(kg.K)
Effectiveness of heat exchanger = 80 %
k for tube material = 46 W/(m.K)

6. (a) Pin fins are provided to increase the heat transfer rate from the hot surface. Two arrangements are available (i) 6 fins of 100 mm length (ii) 10 fins of 60 mm length. By calculation show that, which arrangement is more effective. **10**

Data:
K for fin material = 300 W/m.K
h = 20 W/(m^2.K)
Cross sectional area of fin = 2 cm^2
Perimeter of fin = 5 cm
Temperature of hot surface to which fins are attached = 503 K
The surrounding air temperature = 303 K
Assume that, ends of fins to be insulated.

(b) Write note on various feed arrangements in multiple effect evaporators. **5**

(c) Explain Wilson's Plot. **5**

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