13/11/2024 CHEMICAL SEM-V C SCHEME HTO QP. CODE: 10066582

[Time:3 Hours] **[Total Marks : 80]**

N. B.: (1) Question No. 1 is Compulsory.
(2) Attempt any Three questions out of the remaining Five questions.
(3) Figures to the right indicate full marks.
(4) Make suitable assumptions wherever necessary.

Q.1 Answer the following sub-questions (**Any Five**) **(20)**

(a) Write a short note on Multiple effect evaporators. **(04)**

(b) Explain Thermal and Hydrodynamic Boundary Layer in brief. **(04)**

(c) Explain Kerns Method for design of heat exchanger. **(04)**

(d) Explain Pool Boiling Curve **(04)**

(e) 1.2 kg of liquid water, initially at 15°C Is to be heated to 95°C in a teapot equipped with 1200 W electricheating element inside. The Tea-pot is 0.5 kg and has an average Specific heat of 0.7 kJ/kg ^{O}C, taking the specific heat of water to be 4.18 kJ/kg ^{O}C and disregarding any heat loss from the Teapot. Determine how long it will take water to be heated. **(04)**

(f) Derive an expression for the Radiation shield **(04)**

Q.2

(a) Derive the expression for heat transfer through furnace wall made of three different materials in series. Assume K_1, K_2, K_3, be the thermal conductivities of materials and X_1, X_2, X_3, be the respective thickness. h_i, and h_o be the convective heat transfer coefficients for inside hot gas and ambient air respectively? **(10)**

(b) A hot pipe of 325°C flows through a metal pipe of outer diameter 3mm thick. It is insulated with mineral wool for reducing heat loss in such a way that the insulation surface should not exceed 50°C Determine the thickness of insulation required. Taking the following data: h_1 = 25 W/m^{2}K, h_2 = 10 W/m^{2}K Surrounding air temperature = 25°C, k_1 (metal pipe) = 40 W/mK, k_2 (mineral wool) = 0.045 W/(m.K) Also calculate the loss of heat per unit length of pipe after putting the insulation. **(10)**

Q.3

(a) Show that Nusselt Number is a function of Grashoff Number and Prandtl Number in Natural Convection. **(10)**

(b) Air at 20°C flows over a plate of 60cm x 30cm with a velocity of 29 m/s. The critical Reynolds number is 5x10^5.Calculate the heat flow per hour from the surface of the plate assuming the flow is parallel to the 60 cm side. Temperature of the plate is 100°C. Properties of air at mean temperature: ρ = 1.06 kg/m^3, Cp = 0.24 kcal/kg°C, υ = 18.97x10$_{-6}$ m^2/hr, K = 0.025 kcal/m-hr°C. **(10)**

Q.4

(a) Steam enters a counter flow heat exchanger, dry saturated at 10 bar and leaves at 350°C. The mass flow rate of the steam is 720 kg/min. The hot gas enters the exchanger at 650°C with mass flow rate of 1320 kg/min. If the tubes are 30 mm in diameter and 3 m long, determine the number of tubes required. Neglect the resistance offered by metallic tubes. Use following data: **(10)**

For steam, T_{sat} = 180°C (at 10 bar),

C_p, s = 2.71 kJ/kg.K,

h_i = 600 W/m2.K

For gas, C_p, g = 1 kJ/kg.K,

h_o = 250 W/m²K

(b) Two long planes A and B are maintained at 600 K and 300 K and their surface emissivities are 0.8 and 0.5. Two thin radiation shields C and D having emissivity's 0.5 and 0.4 are introduced between the given planes. The given planes are in 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. (Use $\sigma = 5.67\text{x}10^{-8}$ $W/m^2.K^4$) **(10)**

Q.5

(a) A condenser is designed to condense 500 kg/h of dry and saturated steam at 0.1 bar. A square array of 400 tubes, 6 mm in diameter is used. The tube surface is maintained at 24°C by flowing water. Calculate the heat transfer coefficient and length of each tube. **(10)**

Properties of fluid: At pressure of 0.1 bar; T_{sat} = 45.74°C, h_{fg} = 2393 kJ/kg, T_f = 35°C

Properties of saturated water at 35°C

ρ = 993.95 kg/m^3, $\mu = 728.15\text{x}10^{-6}$ kg/m.s, k_f = 0.625 W/m.K.

(b) Derive an expression of LMTD for Co Current Flow. Clearly state the assumption made. **(10)**

Q.6 **(10)**

(a) Explain the methods used in feeding a multiple evaporation system in detail

(b) For Parallel flow heat exchanger Show that **(10)**

$$\varepsilon = \frac{e^{-NTU(1+C)}}{1+C}$$

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