05/06/2025 TE CHEMICAL SEM-V C-SCHEME HTO QP CODE: 10081881

(Time: 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. Assume suitable data if necessary and state it clearly.
5. Figures to the right indicate marks.
6. Illustrate answers with sketches wherever required.

Q1. (a) Calculate the heat loss by radiation by unlagged horizontal steam pipe, 50 mm O.D. at 377 K to air at 283 K. Use emissivity, e = 0.9. **05**

(b) For one plane wall (slab) of uniform thickness prove that, **05**

$$Q = \frac{\Delta T}{R}$$

(c) Write a short note on flow arrangements in heat exchanger. **05**

(d) State the assumptions made in Nusselt's theory of condensation. **05**

Q2. (a) A steel pipe 25 mm internal diameter and 33 mm outer diameter and insulated with rockwool 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 rockwool 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. Data**:** h = 115 W/(m^2.K), ρ = 8000 kg/m^3, C_p = 0.42 kJ/(kg.K). **10**

Q3. (a) Air at a temperature of 523K flows over a flat plate 0.3 m wide, 1m long, at a velocity 8m/s. If the plate temperature is 315K, find the rate of heat transfer to the plate. Data at mean temperature : k=0.0364 W/m K. N_{pr} = 0.69. kinematic viscocity = 0.0004m^2/s. **10**

(b) A 20 mm φ horizontal heater is maintained at a surface of 313K and submerged in water at 298K. estimate the heat loss/ unit length of heater by natural convection. **10**

Data:- Properties of water at mean temperature of 32.5 ^{0}C

k = 0.63W/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 $Nu = 0.53(Gr.Pr)^{1/4}$

Q4. (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 and0.4 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) Describe the various methods of feeding in Multiple Effect Evaporator. **05**

(c) Derive equation for Reynold – Colburn Analogy. **05**

Q5. (a) Saturated steam at 80 ^{0}C condenses at outside of a horizontal tube of 100 mm O.D. and length L. The tube wall is maintained at 70 ^{0}C. When the tube was kept vertical, it was observed that the rate of condensation was the same as before. Find the tube length L and the rate of condensation per hour. **10**

Data: The properties of condensate of film temperature of 75 ^{0}C are:

k = 0.871W/(m.K), $\rho = 975\ kg/m^3$, $\mu = 380.5*10^{-6}$ N.s/m^2,

Latent heat of condensation of steam = 2300kJ/kg

(b) Show by dimensional analysis that Nusselt number is a function of Reynold's number & Prandtl number for the case of heat transfer by forced convection. **10**

Q6. (a) Derive the expression for log mean temperature difference for countercurrent flow. Also state the correction in LMTD for 1-2 heat exchanger. **10**

(b) It is desired to heat 230 kg/h of water from a temperature of 308 K to 366 K with a oil having initial temperature of 448 K . The mass flow rate of oil is the same as that of water. Use counter current flow. The following two double – pipe heat exchangers are available: **10**

HE-1 :	U = 570 W/(m^2.K)	A = 0.47 m^2
HE-2 :	U = 370 W/(m^2.K)	A = 0.94 m^2

Which heat exchanger should be used?
