Roll No:	**Name:**

Date: 07-Nov-2023 (Tuesday 2PM) **Time: 1.5 hours**

CH39023 Process Equipment Design I - Test **FM: 100**

Important instructions: Please mark clearly the correct option in multiple choice questions (underline or circle the correct answer statement). There may be more than one correct option. Marks will be given only when all the correct options are chosen without selecting any incorrect option (no partial marking for questions with options).

1. Why are baffles used in a shell and tube heat exchanger? **[4]**
   a. Increases the Pressure drop
   b. Supports the tube bundles
   c. Increases the shell heat transfer coefficient
   d. Increases the tube side heat transfer coefficient.

2. A 1-1 shell and tube heat exchanger is used for cooling DI water at 65°C using tap water at 30°C. The flow rates of the DI and supply water are 15 m^3/s and 21m^3/s respectively. Select the best option for the fluid flow arrangement in the heat exchanger.
   a. Parallel flow with DI water in tube and tap water in the shell side
   b. Counter flow with tap water in tube and DI water in the shell side
   c. Parallel flow with tap water in tube and DI water in the shell side
   d. Counter flow with DI water in tube and tap water in shell side **[2]**

3. The minimum value of the F_T Correction Factor for LMTD should be chosen as:
   a. $0.5 \leq F_T \leq 0.8$
   b. $1 \leq F_T \leq 2$
   c. $0.8 \leq F_T \leq 1$
   d. $0.05 \leq F_T \leq 1$ **[2]**

4. A heat exchanger is to be designed to condense an organic vapor at a rate of 500kg/min which is available at its saturation temperature 355K. Cooling water at 286K is available at a flow rate of 60kg/s. The overall heat transfer coefficient is 475 W/m^2 °C. Latent heat of condensation of the organic vapor is 600kJ/kg. Calculate the **number of tubes required**, if 25m outer diameter, 2mm thick and 4.87m long tubes are available and also estimate **number of tube passes**, if the cooling water velocity should not exceed 2m/s. **[15+5]**

5. If U_D = Overall Design Heat Transfer coefficient and U_c = Overall Clean Heat Transfer coefficient, then which of the following relation is correct? **[2]**

   a. $U_D \geq U_c$
   b. $U_D > U_c$
   c. $U_D \leq U_c$
   d. $U_D < U_c$
   e. $U_D = U_c$

6. Identify a suitable tube layout when severe fouling is expected on the shell side **[2]**

   a. Triangular pattern
   b. Rotated square pattern
   c. Square pattern
   d. Rotated triangular pattern

7. During heating of a liquid by a hot flue gas the best arrangement in a finned tube heat exchanger is **[2]**

   a. Steam in the inner tube and the fins on the inner surface of the inner tube
   b. Steam on annular side and fins on the outer surface of the inner tube.
   c. Steam on the annular side and fins on the inner surface of the inner tube
   d. Steam on the annular side and fins on the inner surface of the outer tube.

8. In a composite (T-H) curve, the pinch point signifies **[2]**

   a. The point where the cold and hot curves intersect
   b. The point where the temperature difference between the hot and cold composite curves is minimum
   c. The point where utility requirement is minimum
   d. The point where no heat transfer occurs from cold to hot side

9. In a multiple effect evaporator, the heat transfer area of each effect _____, while the pressure _____ in consecutive effects **[4]**

   a. remains same, decreases
   b. remains same, increases
   c. increases, remains same
   d. decreases, remains same

10. A double pipe heat exchanger with the inner copper tube of 19mm OD and 16mm ID and the outer stainless tube of 30mm OD and 26mm ID is used to cool oil from 65°C to 50°C using cooling water which is available at 32°C. The oil flow rate is 0.4kg/s. Neglecting the thermal resistance offered by the copper tube wall, estimate the length of the heat exchanger tube required for this cooling duty. **[15]**

    Data given:

    $Nu=0.023\ (Re)^{0.8}\ (Pr)^{0.4}$ [tube side] and Nu = 3.65 [annulus side]

Fouling factor, water side = 0.0005 m^2K/W

Fouling factor, oil side =0.0008 m^2K/W

Water and oil properties:

Property	oil	Water
ρ (kg/m^3)	850	995
c_p (kJ/kg K)	1.89	4.187
k (W/m K)	0.138	0.615
ν (m^2/s)	7.44×10^{-6}	4.18×10^{-7}

11. In a 1-4 shell and tube heat exchanger, draw the pass partition plate layout on the tube sheet of both sides of the exchanger. **[4+4=8]**

    Tube inlet/exit side?

    Opposite side?

12. Estimate the rate of evaporation from a feed at 30 kg/hr at 25°C using a constant supply of steam at 10 kg/hr? Latent heat of vaporization of water =2,260 kJ/kg

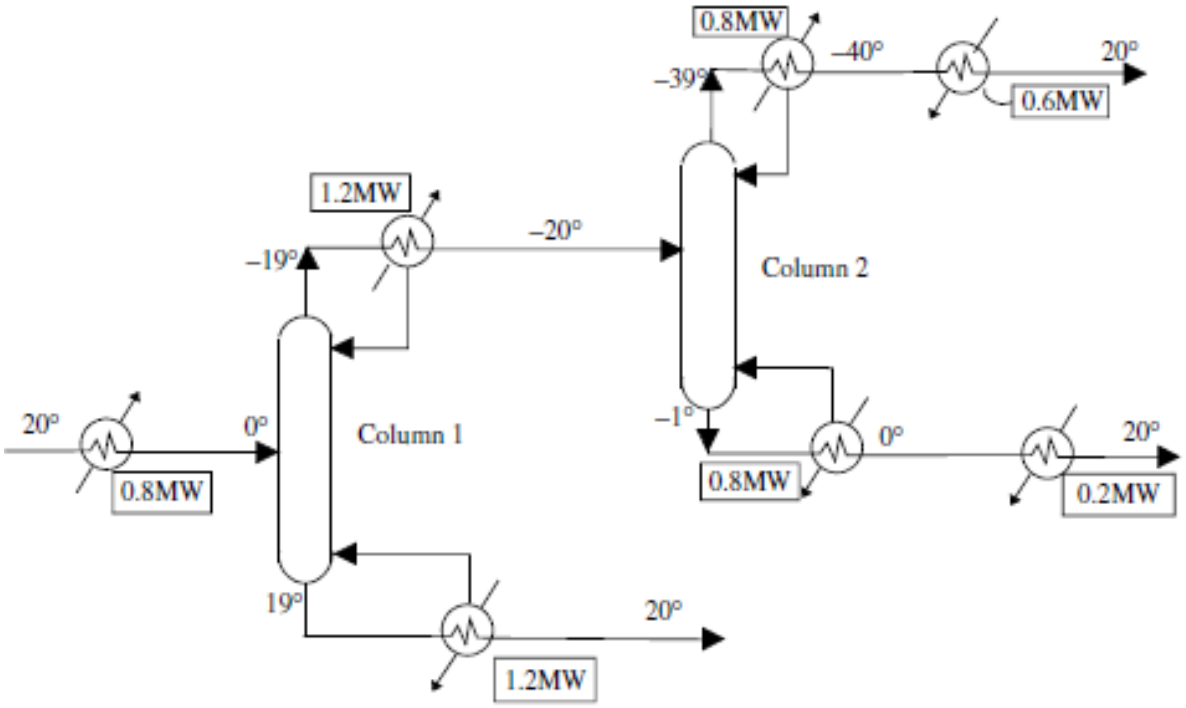
[4]

13. The flow sheet for a cryogenic distillation process is shown in the figure. Construct a stream table from the figure. Assuming $\Delta T_{min} = 5$℃, and a pinch temperature of -21.5°C, Find

    a. Pinch temperature at hot and cold side

    b. Minimum hot and cold utility required

    c. Construct the hot and cold composite curves for the problem. **[2+5+8=15]**



14. Estimate the steam economy of the first effect of feed forward triple effect evaporator for a total evaporation rate of 30 kg/hr from a saturated feed of flow rate of 50kg/hr. The steam

flow rate is 25kg/hr and the product is concentrated from 0.3w/w to 0.55w/w in the first effect. **[4]**

Given latent heat of vaporization of water = 2260kJ/kg

Specific heat capacity = 6kJ/kg K

15. In a triple effect evaporator, the number of pumps needed is _____ for a feed forward arrangement and _____ in a backward feed arrangement. **[6]**
16. A double effect evaporator is used to concentrate the solution that has no appreciable boiling point elevation. The temperature of steam to the first effect is 380K and the boiling point of the solution the second effect is 325K. The overall heat transfer coefficients in the first, second are 2700, 2100 W/m^2 K respectively. Estimate the temperatures in the first effects. Assuming all the effects to have equal area. [**8]**