(3 Hours) **Total Marks:80**

N.B.:

1) Question-1 is compulsory. Answer any three questions from remaining.
2) Use of Heat Exchanger databook is permitted.
3) Assume data if necessary and specify the assumptions clearly
4) Draw neat sketches wherever required
5) Answer to the sub-questions of an individual question should be grouped and written together i.e one below the other

1. (a) What is the effect of over surface area and over design in case of design of a heat exchanger? [05]
   (b) Write a note on welded plate heat exchanger [05]
   (c) What is the effect of non condensables on the rate of condensation? [05]
   (d) What are the different types of Shells in case of shell and tube heat exchanger as per TEMA standards [05]

2. (a) Enlist the different types of reboilers. Explain the working of Kettle type reboiler with neat sketch [10]
   (b) Draw the schematic of equivalent hydraulic network for shell side flow in case of stream analysis method and give the name of each stream [04]
   (c) How do you ensure negative pressure in furnace while design? [06]

3. There is a requirement to cool 20000 kg/h of condensate water from 64 °C to 46°C. Cooling water will be used for cooling, with inlet and outlet temperatures of 25 °C and 41°C. Design a gasketed-plate heat exchanger for this duty. Use stainless steel (k= 15 W/m.K) plates of 0.75mm thick. Maximum operating pressure and allowable pressure for both fluids is 3 bar and 0.7 bar respectively and maximum permissible velocity is 3m/s. [20]
   Show one iteration of design calculation including thermal and hydrodynamic and if design is not satisfactory in first iteration then comment on the calculations.
   Given data:

Property	Cooling water	Condensate
Specific heat (kJ/kg.K)	4.179	4.183
Viscosity (cP)	0.705	0.504
Density (kg/m^3)	994	985.7
Thermal conductivity (W/m.K)	0.625	0.65

4. (a) Write algorithm for Lobo-Evans method [12]

(b) Draw schematic diagram of any one type box furnace showing different sections. Also explain its operation. [08]

5. (a) It is required to sub-cool condensate from a methanol condenser from 94°C to 40°C. Flow rate of methanol is 100 x10^6gm/h. Brackish water will be used as the coolant with the temperature rise from 25°C to 40°C. [16]

Given data:

Shell side fluid: Methanol	Number of tubes = 918
Shell ID = 894mm	Bundle diameter = 826mm
Tube OD = 20mm	Pitch 1.25triangular = 25mm
Tube length = 4830mm	Baffle pitch = 356 mm

Properties of methanol at average temperature are:

Specific heat = 2.84 kJ/kg.K	Viscosity = 0.34cP
Thermal conductivity= 0.19 W/m.K	Density= 750kg/m^3

Calculate the shell side heat transfer coefficient using Bell-Delaware method

(b) List gasket materials used in plate heat exchanger with their respective applications. [04]

6. (a) Saturated steam at 351°K condenses on the outside of a horizontal tube of 200 mm O.D. and length L. The tube wall is maintained at 341°K. 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]

Physical properties of the condensate at the film temperature of 346°K are as follows:

k_L =0.871 W/m°K; ρ = 975 kg/m^3; μ_L = 0.380 x 10^{-3}N.s/m^2

Latent heat of condensation of steam= 2300 kJ/kg

(b) A hot fluid enters a 1-2 shell and tube heat exchanger at a temperature 140°C and it is to be cooled to 100°C by a cold fluid entering at 25°C & heated to 60°C. Calculate the LMTD for this process with correction factor. [05]

(c) Write a note on tube count, tube pitch and baffles. [05]

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