INTERNATIONAL CENTRE FOR APPLIED SCIENCES
MAHE, MANIPAL

B.Sc. (Applied Sciences) in Engg.

End – Semester Theory Examinations – MAY 2021

IV SEMESTER - HEAT TRANSFER OPERATIONS (ICHM 242)

(BRANCH: CHEMICAL ENGINEERING)

Time: 03 Hours **Date: 17 May 2021** **Max. Marks: 50**

- ✓ **Answer ALL FIVE full Questions.**
- ✓ **Missing data, if any, may be suitably assumed**

1A Derive an expression for the rate of heat flow through a compound cylindrical wall made of several resistances in series, stating the necessary assumptions. **(5)**

1B An ice-ball of initial diameter 0.06m is suspended in a room at 30^{o}C. The ice melts by absorbing heat from the ambient, the surface heat transfer coefficient being 11.4 W/m^2 ^{o}C. The air in the room is essentially dry. If the shape of the ball remains unchanged, calculate the time required for reduction in its volume by 40%. The density of ice is 929 kg/m^3 and its latent heat of fusion is 3.35 x 10^5 J/kg. **(5)**

2A Determine the individual thermal resistance to calculate overall heat transfer coefficient in a plane wall. **(5)**

2B A double pipe parallel flow heat exchanger use oil (Cp = 1.88 KJ/kg.k) at an initial temperature of 205 ^{o}C to heat water, flowing at 225 kg/hr from 16^{o}C to 44^{o}C, the oil flow rate is 270 kg/hr (Cp water = 4.18K J/kg.k).

a. What is the heat transfer area required for an overall heat transfer co-efficient of 340W/m^2.K
b. Determine the number of transfer unit (NTU)

Calculate the effectiveness of heat exchanger. **(5)**

3A Explain (i) Critical thickness of insulation (ii) Optimum thickness of insulation (iii) Overall coefficient (iv) Dirt Factor. **(4)**

3B Explain step by step design procedure for Shell and Tube Heat Exchanger. **(6)**

4A A 1 kW electric room heater has a coil of nichrom wire of diameter 0.574 mm and electrical resistance 4.167 ohm/m. if the temperature of the room remains constant at 21^{o}C and the average heat transfer coefficient at the surface of the wire is 100 W/m^2. ^{o}C, calculate the time required for the heating coil, after it is switched on, to reach 63% of its steady state temperature rise. Assume that the wire itself offers negligible heat transfer resistance. The density of the material of the wire is 8920 kg/m^3, and its specific heat is 384 J /kg ^{o}C. **(5)**

4B Explain Log mean temperature difference and derive the equation for it. **(5)**

5 Benzene from the condenser at the top of a distillation column is cooled at a rate of 1000 kg/h from 75^{o}C to 50^{o}C in a counter current double pipe heat exchanger, the construction of heat exchanger is a hairpin type with an effective length of 15 m, the inner tube of carbon steel 25 mm outer diameter 14 BWG, the outer pipe is schedule 40, 1-1/2 inch nb (nominal bore). Benzene flows through the annulus, water which flows through the inner tube, entering at 30^{o}C and leaving at 40^{o}C is the coolant.

a) Calculate the heat duty of the exchanger and the water flow rate.

b) Calculate the individual film co-efficient and the overall co-efficient based on both inside and outside areas.

c) do you think that the tube wall have gathered scale and have been fouled ? if so estimate the fouling factor.

The following data are available

Inner tube: I.D -21mm, O.D – 25.4mm, wall thickness-2.2mm, thermal conductivity of the tube wall – 74.5 w/m.k

Outer pipe: I.D – 41mm. O.D – 48mm. **(10)**

Thermo physical properties:

a) Benzene at the average temperature (62.5^{o}C)

Specific heat – 1.88 KJ/kg ^{o}C, Viscosity – 0.37CP,

Density – 860 kg/m^3, Thermal conductivity – 0.154 W/m.k

b) Water at average temperature (35oC)

Viscosity – 0.8CP, Thermal conductivity – 0.623 W/m.k,

Specific heat – 4.183 KJ/kg.^{o}C, Density – 1000 kg/m^3.