INTERNATIONAL CENTRE FOR APPLIED SCIENCES
MAHE, MANIPAL
B.Sc. (Applied Sciences) in Engg.
End – Semester Theory Examinations – Nov./ Dec. 2020
IV SEMESTER - HEAT TRANSFER OPERATION (ICHM 242)
(Branch: Chemical)

Time: 3 Hours **Date: 05 December 2020** **Max. Marks: 100**

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

1.A	Derive an expression for the rate of heat flow through a compound cylindrical wall made of several resistances in series, stating the necessary assumptions.	**10**
1.B	An ice-ball of initial diameter 0.06m is suspended in a room at 30°C. The ice melts by absorbing heat from the ambient, the surface heat transfer coefficient being 11.4 W/m^2 °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.	**10**
2.A	Briefly discus the advantage of shell and tube heat exchanger over a double pipe heat exchanger.	**10**
2.B	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°C and the average heat transfer coefficient at the surface of the wire is 100 W/m^2 °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 °C.	**10**
3.A	Derive an expression for unsteady state heat conduction. State its assumptions.	**10**
3.B	The wall of cold storage consists of three layers- an outer layer of ordinary bricks 25cm thick, a middle layer of cork 10cm thick and an inner layer of cement 6cm thick, the thermal conductivities of the materials are brick: 0.7 cork: 0.043 and cement : 0.72 W/m °C. The temperature of the outer surface of the wall is 30°C, and the inner is -15°C. Calculate a) the steady state rate of heat gain per unit area of the wall b) the temperature at the interfaces of the composite wall and c) the percentage of the total heat transfer resistance offered by the individual layers, what additional thickness of cork should be provided to make the rate of heat transfer 30% less than the present value ?.	**10**
4.A	Derive an expression for the heat flow through a rectangular fin and efficiency of rectangular fin stating all the necessary assumptions.	**12**
4.B	Determine the coefficient of water flowing in a tube of 16mm diameter (1m length) at a velocity of 3 m/s. the temperature of the tube is 297K and water enters at 353K and leaves at 309K.Use (i) Dittus- Boelter equation and (ii) Sieder-Tate equation. Data : Properties of water at 331K i.e at the arithmetic mean bulk temperature are Density – 984.1 Kg/m^3, Specific heat – 4187 J/(kg.k), Viscosity - 485x10^{-6} Pa.s, Thermal conductivity – 0.657 W/(m.K), Viscosity of water at 297 K – 920 x 10^{-6} Pa.s.	**08**

5.A Determine the individual thermal resistance to calculate overall heat transfer coefficient in a plane wall. **10**

5.B For forced convection, the heat transfer coefficient 'h' is observed to depend upon the following variables. **10**
Velocity of the fluid V. Viscosity of the fluid μ. Specific heat of the fluid Cp. Thermal conductivity of the fluid K. Density of the fluid ρ . Diameter of the pipe d. Using the dimensional analysis obtain the following relationship Nu=f(Re, Pr).

6.A 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 = 4.18KJ/kg.k). **10**

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.

6.B A steam pipe of 97mm inner diameter and 114mm outer diameter (4 inch schedule 80) is required to carry high saturate steam pressure at 30bar absolute pressure (234^{o}C), it is covered by a layer of mineral wool in order to reduce heat loss through an extra thick layer of insulation saves a lot of heat , it is expensive at the same time as a standard practice a design engineer usually allows the temperature at the outer surface of the insulation (also called the skin temperature) to remain at 15 – 20^{o}C, above room temperature, in order to calculate the thickness of insulation of the above steam pipe, assume a skin temperature of 55^{o}C, the ambient temperature is 30^{o}C, thermal conductivity of mineral wool may be taken as 0.1 W/m ^{o}C and that of pipe material (carbon steel) as 43 W/m ^{o}C, the external air-film co-efficient for heat loss to the ambient is 8 W/m^{2} ^{o}C. Calculate the thickness of insulation and the rate of heat loss per meter length of the pipe. **10**

7.A Derive an expression for the net radiant energy transfer between two infinitely long parallel planes having different emissivity. **10**

7.B Find out the heat transfer rate per unit area due to radiation between two infinitely long parallel planes. The first plane has an emissivity of 0.4 and is maintained at 473K. The emissivity of second plane is 0.2 and is maintained at 300K , if a radiation shield having e= 0.5 is introduced between the given planes, find the percentage reduction in heat transfer rate and the steady state temperature attained by the shield. **10**

8.A Explain i) Critical thickness of insulation ii) Optimum thickness of insulation iii) Overall heat transfer coefficient iv) Dirt Factor. **08**

8.B Describe boiling point curve and different types of boiling. **12**

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