Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A Constituent Institution of MAHE, Manipal)

IV SEMESTER B.TECH. (CHEMICAL ENGINEERING)

END SEMESTER EXAMINATIONS, APRIL 2018

SUBJECT: HEAT TRANSFER OPERATION [CHE 2202]

REVISED CREDIT SYSTEM
(25/04/18)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A.	Derive an expression for the rate of heat flow through a composite cylindrical wall made of several resistances in series by 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.	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.	**4**
2B.	Derive the expression for temperature profile in the rectangular fin with its ends insulated. State all the assumptions made.	**6**
3.	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.	**10**

	c) do you think that the tube wall has 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. **Thermo physical properties.** **i) 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 **ii) Water at average temperature (35^{o}C)** Viscosity – 0.8CP, Thermal conductivity – 0.623 W/m.k, Specific heat – 4.183 KJ/kg.^{o}C Density – 1000 kg/m^3.	
4A.	Explain the importance of super-saturation in crystallization process and explain working principle of vacuum crystallizer with neat sketch.	**5**
4B.	A single effect evaporator is to be designed to concentrate 8000 kg/hr of a chemical solution from 10% to 20% by weight, feed enters at 25oC, saturated steam at 110^{o}C (latent heat 532 Kcal /kg) is available, condensate leaves at saturation temperature, the solution boils at 45^{o}C (latent heat is 570 Kcal/kg), specific heat of all the solution may be taken as 1 Kcal/kg and overall heat transfer co-efficient is 1800 Kcal/hr.m^2.^{o}C . Find (a) Steam economy (b) Heat transfer area.	**5**
5A.	A Swenson-walker crystallizer is used to produce 1000 kg/hr of copperas ($FeSO_4.7H_2O$) crystals by the cooling of a saturated solution which enters the crystallizer at 50^{o}C and slurry is leaving at 26.6^{o}C, cooling water enters the crystallizer jacket at 15^{o}C and leaves at 25^{o}C. a) Estimate heat removed b) cooling water and total heat transfer area required. Assume: U for crystallizer = 6.61 w/m^2.k X_L' at 50^{o}C= 140 kg of copperas / 100kg of excess water X_L' at 26.6^{o}C = 74 kg of copperas / 100kg of excess water. Average specific heat of solution and water is 2.93 and 4.187 KJ/kg.K respectively. Latent heat of crystallization is (26.5^{o}C) is 66.291 KJ/kg.	**6**
5B.	Explain in detail the effect of liquid head and boiling point elevation in multiple effect evaporators.	**4**