Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

IV SEMESTER B.TECH. (CHEMICAL ENGINEERING)
END SEMESTER EXAMINATIONS, APRIL/MAY 2019

SUBJECT: HEAT TRANSFER OPERATIONS

[CHE 2202]
REVISED CREDIT SYSTEM

Date : 02/05/2019 **Time: 2 – 5 PM** **MAX. MARKS: 50**

Instructions to Candidates:

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

1A.	A rectangular fin of length 5 cm, thickness of 1.25 mm extends from a plane wall having thermal conductivity as 45 W/m ºC, heat transfer coefficient as 56 W/m^2 ºC. Assuming wall temperature and ambient temperature are at 150 ºC and 28 ºC respectively find heat transfer rate per unit width of fin.	**(3 marks)**
1B.	The inside and outside surfaces of a hollow sphere $a \le r \le b$ at $r = a$ and $r = b$ are maintained at temperatures T_1 and T_2 respectively. The thermal conductivity varies with temperature as $k(T) = k\,(1 + \alpha T + \beta T^2)$.Derive an expression for total heat flow through the sphere.	**(4 marks)**
1C.	Water is passed through an annular space of 5 cm outer tube diameter and 3 cm of inner tube diameter at 0.5 m/sec velocity. Wall temperature of inner tube is maintained at 80ºC. Inlet water temperature is 20ºC. Find heat transfer coefficient between water and tube. Data : Density of water = 988 kg/m^3 Specific heat at constant pressure = 0.993 k-cal/kg ºC. Thermal conductivity of water = 0.557 k-cal/hr m ºC. Kinematic viscosity = 0.55 x 10^{-6} m^2/sec	**(3 marks)**

2A.	Stainless steel ball of diameter 3 cm is uniformly heated to a temperature of 800°C. It is to be hardened by first cooling in an oil bath to a temperature of 100°C and The heat transfer coefficient and the oil bath temperature are 700 $W/m^{2o}C$ and 40°C respectively. What is the time required for this process? If 100 balls are to be quenched per minute, determine the heat removal rate from the oil bath per minute so that its temperature remains constant at 40°C. Properties of Stainless steel are: k = 61 W/mºC, ρ= 7865 kg/m^3, C_p = 0.46 kJ/kg ºC.	**(5 marks)**
2B.	A 10 mm cable is to be laid in atmosphere of 20ºC with outside heat transfer coefficient 8.5 $W/m^{2o}C$.The surface temperature of cable is likely to be 65 ºC due to heat generation within. Will the rubber insulation (k = 0.155 W/ mºC) be effective. If yes how much?	**(3 marks)**
2C.	Explain enthalpy balance in a single effect evaporator	**(2 marks)**
3A.	A large plate of 6 m high and 1.2 m wide is maintained at a constant temperature of 57ºC and exposed to atmospheric air at 4ºC. Calculate the heat loss by free convection by the plate. Properties of air at an average temperature of 30.5 ºC: Density = 1.16 kg/m^3 ; C_p =1.007 KJ/kg ºC ; Kinematic viscosity = 15.89 x 10^{-6} m^2/sec; K = 26.3 x 10^{-2} W/m ºC	**(3 marks)**
3B.	Explain Colburn Analogy.	**(3 marks)**
3C.	A thin aluminium sheet with an emissivity of 0.1 on both sides is placed between two very large parallel plates that are maintained at uniform temperatures T_1 = 800 K and T_2 = 500 K and have emissivities ε_1= 0.2 and ε_2= 0.2, respectively. Determine the net rate of radiation heat transfer between the two plates per unit surface area of the plates and compare the result to that without the shield.	**(4 marks)**
4A.	A single effect evaporator is used to concentrate 9070 kg/hr of 20% caustic soda solution to 50% solids. The gauge pressure of steam is 1.37atm. The absolute pressure in the vapor space is 100 mm Hg. There is a BPE of 22.78 °C. The overall heat transfer coefficient is estimated to be 1400 W/m2 °C and the feed temperature is 37.8 °C. Calculate (a) Amount of steam consumed (b) Economy (c) Heating surface required. Data: Enthalpy of feed at 37.8 °C = 127.9245 kJ/kg Enthalpy of thick liquor = 514.0239 kJ/kg Enthalpy of vapour = 2672.46 kJ/kg Heat of vaporization of	

	steam at 1.37 atm = 2184.0201 KJ/ Kg Condensation temperature of steam = 126.11°C	**(5 marks)**
4B.	Explain mechanism of crystallization process. Briefly explain Swensor Walker and Oslo crystallizer with a neat sketch.	**(5 marks)**
5A.	Cold water leading to a shower enters a thin walled double pipe counter flow heat exchanger at 0.25 kg/s at 15°C and is heated to 45°C by hot water that enters at 100°C and 3 kg/s. If the overall heat transfer coefficient is 950 W/m^2°C, determine the heat transfer rate and the area of the heat exchanger by $\varepsilon - NTU$ method. Assume specific heat of water to be 4180 J/kg°C.	**(4 marks)**
5B.	Write short notes on the following: (i) Pool boiling (ii) Nucleation (iii) Dropwise condensation (iv) Kirchoff's law of radiation (v) Mier's Supersaturation theory (vi) Natural circulation evaporator	**(6 marks)**