Ref. No: Ex/ChE/T/414A/2019

B.E CHEMICAL ENGINEERING FOURTH YEAR FIRST SEMESTER – 2019

Advanced Heat Transfer

Time: three hour **Full marks: 100**

Answer any four questions.

All questions carry equal marks
Assume any missing data
Symbols have usual meaning

1. **Consider a semi-infinite phase change material, initially at its melting temperature T_m. The domain is placed in a rectangular co-ordinate system. The left surface temperature at x=0 is raised to a temperature T_s where, T_s greater than T_m. Schematically show the progression of melting surface with time as per Neumann problem. Write required 1-D differential equation and relevant initial and boundary conditions for temperature distribution in the domain.**

   A solution to the problem may be given by the following equation for temperature distribution in liquid phase.

   $$T(x,t) = A + B\left[erfc\left(\frac{x}{2\sqrt{\alpha t}}\right)\right]$$

   Using the initial and boundary conditions find the expression of A and B. Also find the location of the melting front.

   5+10+5+5

2. **A wall of thickness 2L is initially at Ti. Its both surfaces are suddenly raised to a temperature Ts. Find unsteady state temperature distribution in the slab. Assume thermo-physical properties (k, α, ρ, C_p) of material are independent of temperature.** **25**

3. **Water flows through a 30 cm tube whose inner and outer diameter are 5 cm and 7 cm. the tube is uniformly heated from its outer surface. Inlet and outlet temperatures of water are 300K and 500K respectively. Mass flow rate of water is 700 kg/h. Calculate inner surface temperature at the tube outlet.**
   Data:
   $\rho = 992.1$ kg/m^3
   $c_p = 4179$ J/kg K
   $k_f = 0.631$ W/m K
   Pr = 4.32
   $\nu = 0.658 \times 10^{-6}$ m^2/s
   25

4. **Explain gray body radiation and radiation view factor. Consider Assume N number of radiation shields are placed between two parallel gray bodies of different emissivity. Draw the radiation network of electrical analog, and derive relation between radiation exchange for, with and without radiation shield.**

   5+5+5+10

5. **Design the four stream heat exchanger network using temperature interval method as per following data.**

Stream No.	Condition	FCP	T in C	T out C	Q (kW) Available
1	Hot (H1)	1000	250	120	130 X 10^3
2	Hot (H2)	4000	200	100	400 X 10^3
3	Cold (C1)	3000	90	150	-180 X 10^3
4	Cold (C2)	6000	130	190	-360 X 10^3

   Find number of coolers and heaters required for minimum utility consumption. Find average Pinch temperature. Assume temperature of approach = 10 C. **20+5**

[Turn over

6. **Explain void fraction and static quality in two phase gas-liquid flow. Derive relationship between static quality and void fraction. Draw schematics of different flow patterns in vertical gas liquid flow. Explain the phenomena of bubbly flow , churn flow and annular dispersed flow in vertical heated tube. Draw and explain flow regime map for vertical two-phase flow and mention its utility.**

5+10+5+5

7. **What is Loss of coolant accident. Draw a schematic of a typical Nuclear PHWR circulating loop. Write Mathematical model equations for sub-cooled liquid in PHWR loop . Write numerical algorithmic steps to show how pressure of any cell in segment type component may be related to the boundary Header pressures.**

5+5+5+10