Total No. of printed pages = 5

19/5th Sem/UFET504

2021

FUNDAMENTALS OF HEAT AND MASS TRANSFER

Full Marks – 100

Time – Three hours

The figures in the margin indicate full marks for the questions.

Answer any *five* questions.

1. (a) What are the modes of heat transfer in a tray dryer ? 2

(b) A long aluminium fin of 15 mm diameter is made up of brass with a thermal conductivity of 108 W/mK. It is attached to a surface at 110°C. The surrounding medium is at 30°C and has 'h' of 13.4 W/m^2K.

(i) Determine slope 'm'

(ii) Determine temperature at x = 5 cm

(iii) Heat transfer rate from each fin

(iv) Number of fins

(v) Calculate effectiveness and say whether it is economical or costly.

3+5+3+2+5=18

[Turn over

2. (a) What are the two types of convection and what are their respective driving forces ? 3

(b) Define Prandtl number and write the equation. 3

(c) Define Nusselt number and with the equation. 3

(d) Air at atmospheric pressure and 250°C flows at a velocity of 4.5 m/s. The plate is 10 mm wide and is maintained at a temperature of 180°C. Assume the flow is on one side of the plate, density is 1.225 kg/m^3, viscosity is 24.5×10^{-6} Ns/m^2, Pr is 0.7 and thermal conductivity of 0.0364 W/mK.

(i) Calculate the thickness of hydrodynamic layer

(ii) Thickness of thermal boundary layer

(iii) Local heat transfer coefficient at a distance of 0.25m from the leading edge

4+3+4 =11

3. (a) What is the absorptivity and emissivity for a black body ? What will be the emissivity for a gray body ? 4

(b) Define view factor F_{i-j}. Consider radiation exchange between two concentric spheres. Mention all the possible view factors and how they can be determined using different rules. 6

(c) A thermos is made of two coaxial glass cylinders. Emissivity of glass surface is 0.095. The diameter of inner and outer cylinder are 0.15m and 0.17m respectively. The length of cylinder is 0.28m. the surface temperature of inner and outer cylinder are 88°C and 28°C respectively. Calculate the rate of heat loss by radiation from inner to outer cylinder. 5

(d) Calculate the emissivity of the pipe surface if overall heat transfer is taking due to convection and radiation for steam maintained at 240°C running in a room at 30°C. Heat transfer coefficient due to convection and radiation are 7.25 W/m²K and 12.24 W/m²K respectively. 5

4. (a) Why mass, heat and momentum are transferred ? 6

(b) Write Fick's first law. 4

(c) A molecule is being transported by diffusion through a fluid at steady state. At a given point 1, concentration is 1.37×10^{-2} g/m^3 and 0.72×10^{-2} g/m^3 at point 2. The distance in between is 0.4m. Diffusivity 0.013 m^2/s and cross sectional area is constant.

Calculate flux.

Derive the equation for concentration as a function of distance.

Calculate concentration at the middle point of 1 and 2. 10

5. (a) Write Fick's second law. 4

(b) A mixture of He and N_2 gas is contained in a pipe at 298K and 1 atm total pressure which is constant throughout. At one end of the pipe at point 1 partial pressure P_{A1} of He is 0.6 atm and at other end 0.2m apart, P_{A2} = 0.2 atm. Calculate the flux of He at steady state if D_{AB} of He-N_2 mixture is 0.687×10^{-4} m^2/s. 5

(c) Prove that diffusion through a varying cross sectional area, Flux X Area = Constant. 5

(d) How diffusivity varies with temperature, pressure, molecular weight, molecular size ? Mention diffusivity range of solute in gas and liquid phase at ambient temperature. 6

6. (a) Derive convective mass transfer coefficient. What is eddy diffusivity ? Write SI Unit of Flux, diffusion coefficient, mass transfer coefficient, volumetric oxygen transfer coefficient. 4+2+4=10

(b) Briefly write about interphase mass transfer. 10

7. (a) Write solute transfer for the following unit operation : 8

(i) Absorption

(ii) Adsorption

(iii) Liquid-liquid extraction

(iv) Leaching.

(b) Write about steady state counter current process in liquid-liquid extraction. 12