

**UNIVERSITY COLLEGE TATI (UC TATI)****FINAL EXAMINATION QUESTION BOOKLET**

COURSE CODE	: BCE 2114
COURSE	: TRANSPORT PROCESS
SEMESTER/SESSION	: 1-2023/2024
DURATION	: 3 HOURS

**Instructions:**

1. This booklet contains 4 questions. Answer **ALL** questions.
2. All answers should be written in answer booklet.
3. Write legibly and draw sketches wherever required.
4. If in doubt, raise your hands and ask the invigilator.

**DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO  
YOU ARE ALLOWED TO BRING TEXT BOOK AND APPENDIX**

**THIS BOOKLET CONTAINS 4 PRINTED PAGES INCLUDING COVER PAGE**

**QUESTION 1**

A heat exchanger with a 1–2 configuration, featuring one shell pass and two tube passes, is responsible for heating 2.52 kg/s of water. This water is heated from 21.1 to 54.4°C by utilizing pressurized hot water, which enters at 115.6°C and exits at 48.9°C. The tubes in the exchanger have an outside surface area denoted as  $A_o$ , and its value is 9.30 m<sup>2</sup>. Calculate:

- a) The mean temperature difference  $\Delta T_m$  in the exchanger. (11 marks)
- b) The overall heat-transfer coefficient  $U_o$ . (5 marks)
- c) The mean temperature difference  $\Delta T_m$  in the 2-4 exchanger using similar temperatures. (9 marks)

(Hint: Assume  $c_{pm}$  of water = 4187 J/kg.K)

**QUESTION 2**

a) Helium and nitrogen gas are contained in a conduit 5 mm in diameter and 0.1 m long at 298 K with a uniform constant pressure of 1.0 atm abs. The partial pressure of He at one end of the tube is 0.060 atm and at the other end it is 0.020 atm. The diffusivity coefficient is  $0.687 \times 10^{-4}$  m<sup>2</sup>/s. Calculate the following for steady-state equimolar counterdiffusion:

- i) Calculate flux of He in SI and cgs unit (4 marks)
- ii) Calculate Flux of N<sub>2</sub>. Justify your answer. (2 marks)
- iii) Figure 1 is a diagram for equimolar counterdiffusion in gas. Redraw the diagram and identify the values for each parameter. (5 marks)

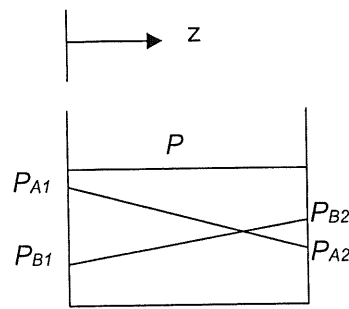


Figure 1

iv) Calculate partial pressure of He at a point 0.05 m from either end. (3 marks)

b) A naphthalene is evaporated from a sphere with a 2.0 mm radius suspended in still air at 318 K and  $1.01325 \times 10^5$  Pa (1 atm). The naphthalene surface temperature is 318 K, and its vapor pressure at this temperature is 0.555 mmHg. The diffusion coefficient of naphthalene in air at 318 K is  $6.92 \times 10^{-6}$  m<sup>2</sup>/s.

- i) Determine  $P_{A1}$ ,  $P_{A2}$ ,  $P_{B1}$ ,  $P_{B2}$  and  $P_{BM}$  in unit Pa (8 marks)
- ii) Calculate the rate of evaporation of Naphtalene from the surface (3 marks)

### QUESTION 3

a) The solute HCl (A) is diffusing through a thin film of water (B) 2.0 mm thick at 283 K. The concentration of HCl at point 1 at one boundary of the film is 12.0 wt % HCl (density  $\rho_1 = 1060.7$  kg/m<sup>3</sup>), and at the other boundary at point 2 it is 6.0 wt % HCl ( $\rho_2 = 1030.3$  kg/m<sup>3</sup>). The diffusion coefficient of HCl in water is  $2.5 \times 10^{-9}$  m<sup>2</sup>/s. (Assume: steady state and one boundary impermeable to water, 100 kg solution). Given molecular weight for HCl (A) is 36.47 and H<sub>2</sub>O (B) = 18.02.

- i) Determine  $x_{A1}$ ,  $x_{B1}$ ,  $x_{A2}$ ,  $x_{B2}$ , and  $x_{BM}$  (8 marks)
- ii) Calculate  $M_1$  and  $M_2$  in kg/kgmol solution (5 marks)
- iii) Find  $C_{AV}$  in kgmol/m<sup>3</sup> and  $N_A$  in kgmolA/s.m<sup>2</sup> (6 marks)

b) Classify three examples of:

- i) Diffusion in liquid for daily life application (3 marks)
- ii) Diffusion in liquid for chemical industry application (3 marks)

#### QUESTION 4

The transfer of mass from a naphthalene sphere to air is transfer at 45°C and 1 atm absolute pressure, with an airflow velocity of 0.305 m/s. The sphere has a diameter of 25.4 mm and the diffusivity of naphthalene in air at 45°C is  $6.92 \times 10^{-6}$  m<sup>2</sup>/s. Given the vapor pressure of solid naphthalene is 0.555 mmHg. Determine:

- a) The value of mass transfer coefficient ( $k'_G$ ) in SI and English units (15 marks)
- b) The flux ( $N_A$ ) in SI and English units (10 marks)

-----End of question-----