CHE318 L05

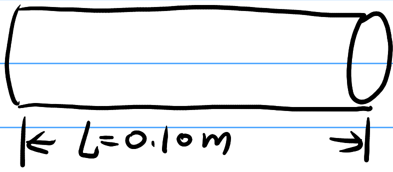
Jan - 14 2026

Problems

1. EMCD see Geankoplis 6.2-1

A ammonia

B N_2



$P_T = 1.0132 \times 10^5$ Pa

$T = 298$ K

$P_{A1} = 1.013 \times 10^4$ pa $\qquad P_{A2} = 0.507 \times 10^4$ Pa

$D_{AB} = 0.230 \times 10^{-4}$ m^2/s

① Determine which condition to use ?

EMCD

② Which equation ?

S.S. Flux

$$J_{Az}^* = \frac{D_{AB}}{RT \cdot L} \cdot (P_{A1} - P_{A2})$$

$R = 8.314$ J/(mol·K) = 8314 J/(kg mol·K)

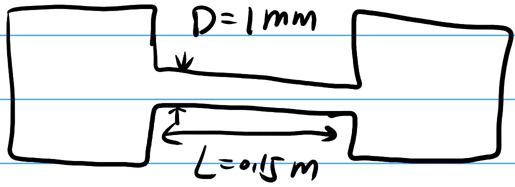
$$J_{Az}^* = \frac{0.230 \cancel{\times 10^{-4}} * (1.013 - 0.507) \cancel{\times 10^{4}}}{8314 \times 298 \times 0.10}$$

$$= 4.70 \times 10^{-7} \text{ kg mol}/m^2/s$$

$$J_{Bz}^* = -J_{Az}^* = -4.70 \times 10^{-7} \text{ kg mol}/m^2/s$$

Example 2

H_2 & N_2 counter diffusion in two-bulb



A: N_2 $\quad D_{AB} = 0.784\ cm^2/s$

B: H_2 $\quad T = 25\ °C$

$P = 1atm$

$t=0$ Left $N_2 = 100\%$ $H_2 = 0\%$ Right $N_2 = 0\%$ $H_2 = 100\%$

$t=t_1$ $N_2 = 80\%$ $N_2 = 25\%$

1) Determine N_A, N_B at $t=t_1$

Condition ⇒ EMCD

$$N_A = \frac{D_{AB}}{RT\ L} \cdot P_T \cdot (x_{A1} - x_{A2})$$

$$= \frac{7.84 \times 10^{-5}}{8314 \times 298 \times 0.15} \cdot 101325 \cdot (0.80 - 0.25)$$

$$= 1.18 \times 10^{-5}\ kg\ mol/m^2/s$$

$$S \cdot N_A = \frac{\pi D^2}{4} \cdot N_A = 9.23 \times 10^{-9}\ g\ mol/s$$

2) Find v_{Ad} (diffusive velocity)

$pv = nRT$

$p = CRT$

$$J_{Az}^* = N_A = C_A \cdot v_{Ad}$$

$$= \frac{P_A}{RT} \cdot v_{Ad}$$

$$= \frac{P_T \cdot \overline{x_A}}{RT} \cdot v_{Ad}$$

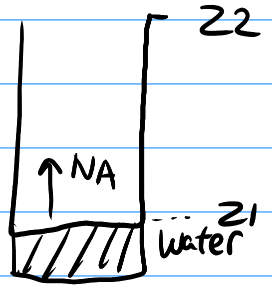
$$\overline{x_A} = \frac{x_{A1} + x_{A2}}{2} = 0.53$$

(same volume)

$$= \frac{101325 \times 0.53}{8314 \times 298} \cdot v_{Ad} = 1.18 \times 10^{-5}$$

$$v_{Ad} = 5.44 \times 10^{-4}\ m/s$$

Example 3 (6.2-3) Diffusion with change path length



Water evaporates → level decrease

time of level drop from z_0 to z_F (t_F)

① Draw scheme

② which condition? Stagnant B

③ Which assumption?

$\boxed{\text{Pseudo steady state}}$ ⟹ 1) Flux at each t follows stagnant B

2) $t \to t+\Delta t$ $z_2 - z_1$ increases

④ Governing eq (using log-mean pressure form)

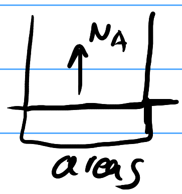
at each t $\quad N_A = \dfrac{D_{AB}}{RT(z_2 - z_1)} \cdot \dfrac{P_T}{P_{Bm}} (P_{A1} - P_{A2})$

P_{Bm}: $\dfrac{P_{B1} - P_{B2}}{\ln \frac{P_{B1}}{P_{B2}}}$ $\quad$ P_{A1}: vapor pressure $\quad$ P_{A2}: $=0$ dry air

Mass balance

$\text{In} - \text{Out} + \text{Gen} = \text{Acc}$

$0 - N_A + 0 = -\dfrac{(\text{mass loss})}{(\text{time})}$



$\int N_A \cdot dt = \dfrac{\int dz \cdot \rho_A}{M_A}$ and sur

Integrate

$$\dot{N}_A \cdot dt = \frac{dz \cdot \rho_A}{M_A}$$

$$\frac{D_{AB}\ dt}{RT\ z} \cdot \frac{P_T}{P_{Bm}} \cdot (P_{A1} - P_{A2}) = \frac{\rho_A}{M_A} dz$$

$$\int_{z_0}^{z_F} z\ dz = \int_0^{t_F} \frac{D_{AB}\ M_A}{RT\ \rho_A} \cdot \frac{P_T}{P_{Bm}} (P_{A1} - P_{A2})\ dt$$

$$\Rightarrow \frac{1}{2}(z_F^2 - z_0^2) = \frac{D_{AB}\ M_A}{RT\ \rho_A} \cdot \frac{P_T}{P_{Bm}} (P_{A1} - P_{A2})\ t_F$$

Rearrange

$$t_F = \frac{\rho_A (z_F^2 - z_0^2) \cdot RT}{2 D_{AB}\ M_A} \cdot \frac{P_{Bm}}{P_T} \cdot \frac{1}{(P_{A1} - P_{A2})}$$

Unit check

$$\frac{\frac{\cancel{kg}}{m^3} \cdot \overset{m^2}{\cancel{(m^2 - m^2)}} \cdot \frac{J}{kg\ mol \cdot \cancel{K}} \cdot \cancel{K}}{\frac{m^2}{s} \cdot \frac{\cancel{kg}}{kg\ mol}} \cdot \frac{1}{1} \cdot \frac{1}{\frac{N}{m^2} - \frac{N}{m^2}}$$

$$\frac{1}{\cancel{m}} \cdot \frac{\cancel{N \cdot m}}{\cancel{kg\ mol}} \cdot \frac{S}{\cancel{m^2}} \cdot \cancel{kg\ mol} \cdot \frac{\cancel{m^2}}{\cancel{N}}$$

Final unit S ✓

Example 4 Determine diffusivity w/ evaporation

(From Griskey 10-2)

tube $D = 0.01128\,m$

A CCl_3NO_2 (chloropicrin)

B air 1atm

$t=0$ liquid from top $= 0.0388\ m$

$t = 1\text{ day}$ ······· $= 0.0412\,m$

Vapor pressure ($P_{A1} = 3178.3\ N/m^2$)

$\rho_A = 1650\ kg/m^3$

$M_A = 164.39\ kg/kg\ mol$

Rearrange previous eq

$$\begin{cases} P_{A1} = 3178.3\ N/m^2 \\ P_{A2} = 0\ N/m^2 \\ P_{B1} = 101325 - 3178.3 \\ P_{B2} = 101325 \end{cases}$$

$$D_{AB} = \frac{\rho_A (Z_F^2 - Z_0^2)\cdot RT}{2t_F M_A} \cdot \frac{P_{Bm}}{P_T} \cdot \frac{1}{(P_{A1} - P_{A2})}$$

$P_{Bm} = 99727.4$

$$= \frac{1650\cdot(0.0412^2 - 0.0388^2)\cdot 8314\cdot 298}{2\cdot 164.39\cdot(3600\cdot 24)} \cdot \frac{99727.4}{101325} \cdot \frac{1}{3178.3}$$

$$= 8.56\times 10^{-6}\ m^2/s$$

(assuming constant N_A then $D_{AB} = 8.75\times 10^{-6}\ m^2/s$)
+2.2% error