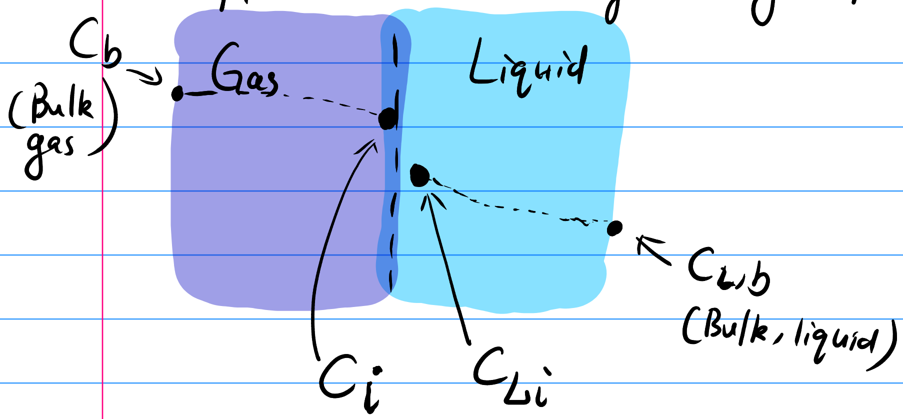
CHE 318 L14
Feb-04 2026

Mass Transfer coefficients

Recap: we need to know concentration accross bondary between phases

Assume we study gas / liquid interface



Assume molecules acrossing interface has no resistance

$\Rightarrow$ Equilibrium constant $K = \dfrac{[\text{conc in gas}]}{[\text{conc in liquid}]}$ → Interface concentration

$= \dfrac{C_i}{C_{Li}}$

K : dimensionless

Similarly, we have ① Henry's law $H = \dfrac{P_{gas}}{C_{Li}}$ $\quad P_g = C_g RT$

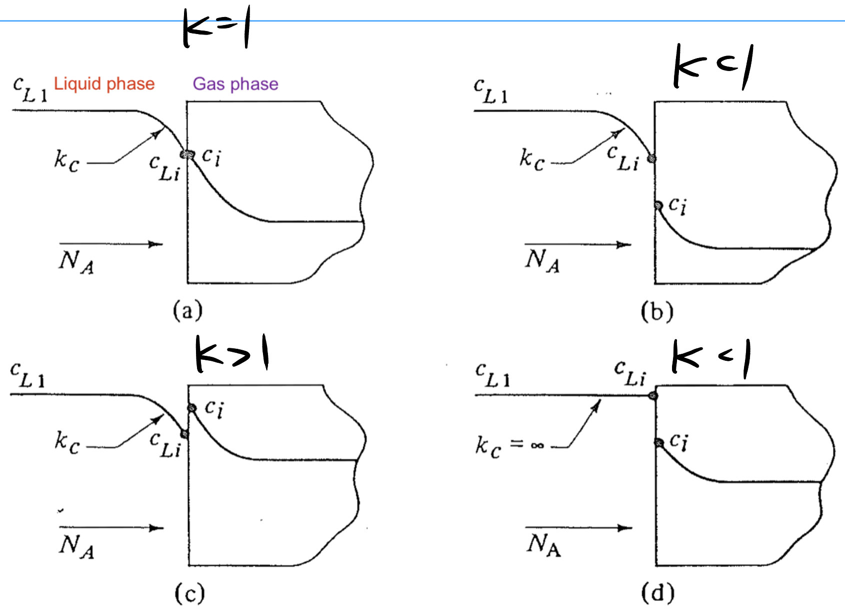
② Solubility $C_A = \dfrac{S \cdot P_A}{22.414}$

$K \to 0 \equiv$ Gas phase vapor pressure ≈ 0 (A = protein)

$K = 1 \equiv$ same concentration (A: liquid at boiling point)

$K = \infty \equiv$ Liquid phase conc $= 0$ (insoluble gas)

Interfacial concentration profile may look very di



Geankoplis 7.1.3

What eles controls the profile ?

M.B across interface

$N_A|_{left}$ → $N_A|_{right}$ →

$$N_A|_L = N_A|_R$$

We can use $N_A = J^*_{AZ} + C_A \cdot v_m$ in each phase, but the actual form of J^*_{AZ} depends on local gradient (harder to model)

Instead, without losing generality

$$[\text{Flux}] = \frac{[\text{Driving Force}]}{[\text{Resistance}]}$$

① We can have conc. diff. between $\begin{cases} C_b \ \& \ C_i \\ C_{Lb} \ \& \ C_{Li} \end{cases}$

② Driving force ? Just use a coefficient $\frac{1}{k}$

In general $N_A = k_c' \cdot (C_{L,b} - C_{L,i})$

Meaning: k_c' $\Rightarrow$ EMCD-like
$\Rightarrow$ concentration diff as driving force

Unit of k_c' ?

$N_A \Rightarrow \frac{mol}{m^2 \cdot s}$ $\quad \Delta C \Rightarrow \frac{mol}{m^3}$ $\quad$ So: k_c' unit m/s
(velocity !)

k_c' from multiple scenarios

EMCD $\quad N_A = \underbrace{\frac{D_{AB}}{z_2 - z_1}}_{k_c'} (C_{A1} - C_{A2})$

Stagnant B $\quad N_A = \underbrace{\underbrace{\frac{D_{AB}}{z_2 - z_1}}_{k_c'} \cdot \frac{1}{x_{BM}}}_{k_c \text{ (with } x_{BM} \text{ contribution)}} (C_{A1} - C_{A2})$

Solve concentration at boundaries

2 equations : $N_A|_L = N_A|_R$

$k_{c,L}'(C_{L,b} - \underset{\text{var 1}}{C_{L,i}}) = k_{c,g}'(\underset{\text{var 2}}{C_{g,i}} - C_{g,b})$

$K = \frac{C_{g,i}}{C_{L,i}}$

That explains the different shape

$k_{c,L}' \to \infty \Rightarrow$ concentration profile liquid $\equiv$ flat !

> Idea of K & k_c' will be discussed in absorption process

k_c' makes calculating N_A convenient

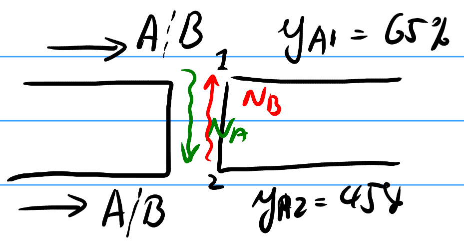
We can write $N_A = k_c'(C_{A1} - C_{A2})$
$= k_G'(p_{A1} - p_{A2})$
$= k_y'(y_{A1} - y_{A2})$
$=$ etc...

Convention
gas fraction y_A
liquid frac x_A

$k_c' =$ EMCD-like
$k_c =$ Stagnant B (x_{BM} pare)

Unit? k_c' k_c $\Rightarrow$ m/s
k_y' k_y k_x' k_x $\Rightarrow$ kg mol/(m^2·s)
k_G' k_G $\Rightarrow$ kg mol/(m^2·s·Pa)
kg mol/(m^2·s·atm)
choose your preference

Solution to Q1



1 → 2
$N_A = k_y' \cdot (y_{A1} - y_{A2})$
$= 1.5\times10^{-4} \times (0.65 - 0.45)$
$= 3.0\times10^{-5}$ kg mol/(m^2·s)
$N_B = -N_A$ 2 → 1

We realize k_y' is dependent on total pressure!

$k_y' \rightarrow k_c'$ $k_y' = k_c' \cdot C_T = k_G' \cdot P_T$

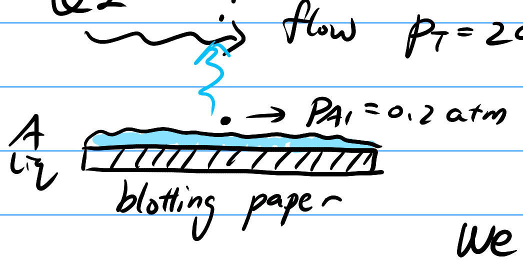
$$k_G' = \frac{k_y'}{P_T} = \frac{1.5\times10^{-4}}{2000\ kPa} = 2.14\times10^{-7}\ \text{kg mol/(m}^2\cdot\text{s}\cdot\text{kPa)}$$

$$k_c' = \frac{k_y'}{C_T} = \frac{k_y'}{P_T}\cdot RT = k_G'\cdot RT = 6.65\times10^{-4}\ \text{m/s}$$

superficial vel

Q2 $\quad p_{A2} = 0$

flow $\quad p_T = 2\,atm$



$k_y' = 6.78 \times 10^{-5} \dfrac{kg\,mol}{m^2 \cdot s}$

We don't care direction of N_A in fluid

All mass transfer coefficient $\Rightarrow$ lumped

$$N_A = k_y' \cdot \frac{1}{y_{Bm}} \cdot (y_{A1} - y_{A2})$$

$\Leftarrow$ stagnant B

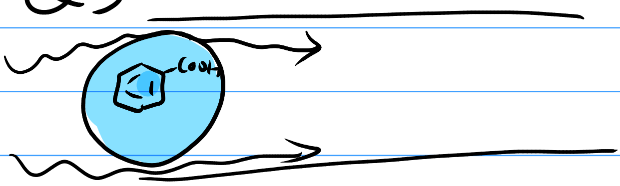
$$y_{Bm} \approx \frac{y_{B1} + y_{B2}}{2} = 0.95 \qquad y_{A1} = 0.1 \qquad y_{A2} = 0$$

$$N_A = 6.78 \times 10^{-5} \cdot \frac{1}{0.95} \cdot 0.1 = 7.14 \times 10^{-6}\ kg\,mol/(m^2 \cdot s$$

$$k_y = k_y' / y_{Bm} = 7.14 \times 10^{-5}\ kg\,mol/(m^2 \cdot s)$$

$$k_G = k_y / p_T = 3.57 \times 10^{-5}\ kg\,mol/(m^2 \cdot s \cdot atm)$$

Q3



$$\overline{Flux} = \frac{[\text{weight}]}{[\text{molar mass}][\text{time}]}$$

$$N_A \cdot 4\pi r_0 = \frac{m_1 - m_2}{M_A \cdot \Delta t} = k_L (C_{As} - 0)$$

$$k_L = \frac{1}{4\pi r_0^2} \cdot \frac{m_1 - m_2}{C_{As} \cdot M_A \cdot \Delta t}$$

← Get from solubility