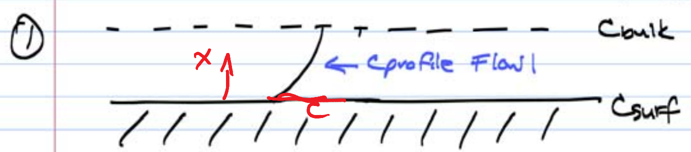
Wednesday, November 05, 2014
8:26 AM

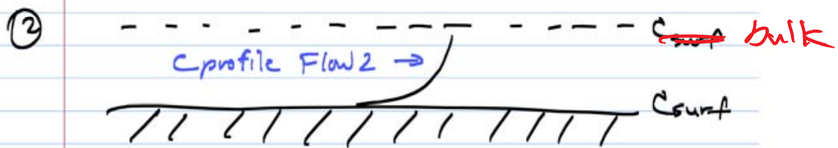
$$\text{Flux} = \frac{\text{moles}}{\text{area time}}$$

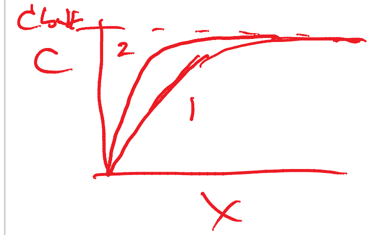
$= \text{mass transfer coefficient} \times \text{driving force}$

(1)



(2)





Difference reflected in mass transfer coefficient

~~For no net flow in "film"~~

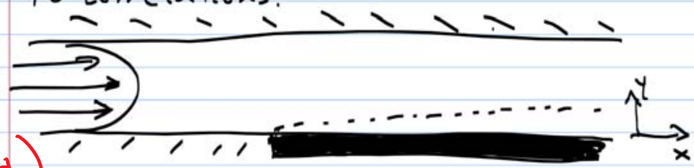
~~What does this mean?~~

$\boxed{\text{Dilute or Equimolar Transfer}}$

$$N_A = J_A = k_c\,(c_{A,2} - c_{A,1})$$
$$= k_x\,(x_{A,2} - x_{A,1})$$
$$= k_y\,(y_{A,2} - y_{A,1})$$
$$= k_p\,(p_{A,2} - p_{A,1})$$

Transfer direction: $2 \rightarrow 1$ (Units?)

Connection of mass transfer coefficients to correlations.



$$\frac{dc}{dy} = \frac{dc^*}{dy}(c_\infty - c_s)$$

Dilute or Equimolar transfer

$$N_{surf} = -D \left.\frac{\partial c}{\partial y}\right|_s$$

Let $c^* = \dfrac{c - c_s}{c_\infty - c_s}$, $Y^* = \dfrac{y}{L}$

$$dy = L\, dY^*$$

$$\therefore N_{surf} = -\frac{D}{L}(c_\infty - c_s)\left.\frac{\partial c^*}{\partial Y^*}\right|_s$$

$$\text{Dimensionless Flux} = \left.\frac{\partial c^*}{\partial Y^*}\right|_s = -\frac{L\, N_{surf}}{D(c_\infty - c_s)}$$

But, $k_c(c_s - c_\infty) = N_{surf}$

$$\left.\frac{\partial c^*}{\partial Y^*}\right|_s = \frac{-L\, k_c(c_s - c_\infty)}{D\,(c_\infty - c_s)} = \frac{k_c L}{D}$$

Hence Sh = dimensionless flux at the surface

$$\boxed{Sh = \frac{\partial c^*}{\partial Y^*} = \frac{k_c L}{D}}$$

What would it be a function of?

Sh can be determined analytically or experimentally or both, depending on the system!

Note Title

Interphase Mass Transport

11/2/2013

Separation processes involve transport between phases.

What experience do you have describing interphase transfer?

Mass Transfer Coefficients

Please answer the following T/F questions:

1. Mass transfer coefficients are used to describe interphase transport
2. Mass transfer coefficients assume that the concentration varies linearly through a film at the surface.
3. Mass transfer coefficients are typically determined experimentally.
4. Mass transfer coefficients can be determined theoretically under some conditions.
5. The correlations you used in Heat/Mass transfer are all empirical.
6. Mass transfer coefficients vary with flow conditions and fluid properties because of the impact of these variables on the concentration profile

Interphase Mass Transfer

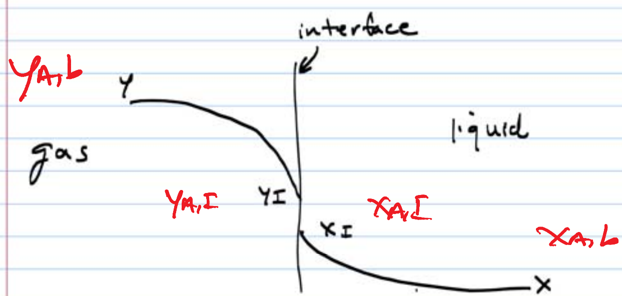
Objective: Describe mass transfer between two phases in terms of the appropriate mass transfer coefficients

Why do we want to do this?
Which phases are of interest?

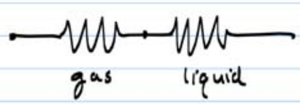
For a gas/liquid system:

$$N_{A,z,gas} = N_{A,gas} = k_y \left(y_{A,b} - y_{A,I} \right)$$

$$N_{A,liquid} = k_x \left(x_{A,I} - x_{A,b} \right)$$



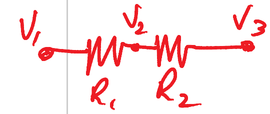
Two resistances in series



Why resistance?

Driving Force (Gas) = $y_{A,b} - y_{A,I}$

Driving Force (Liquid) = $x_{A,I} - x_{A,b}$



Flux (N_A) is analogous to current (I)
Driving Force is analogous to voltage (V)

Ohm's Law $\quad V = IR$ or $I = \frac{V}{R}$

$$N_A = \frac{\text{Driving Force}}{\text{Resistance}}$$

$$I = \frac{V_1 - V_2}{R_1} = \frac{V_2 - V_3}{R_2}$$

$$IR_1 = V_1 - \cancel{V_2}$$

$$IR_2 = \cancel{V_2} - V_3$$

$$I(R_1 + R_2) = V_1 - V_3$$

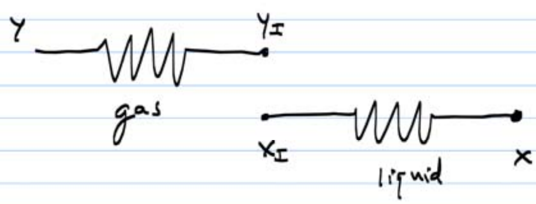
Resistance

Gas: $\quad \frac{1}{k_y}$

Liquid: $\quad \frac{1}{k_x}$

If we know the two resistances, then we should be able to determine the transfer rate.

Problem - we don't know the interfacial values! Also, driving forces different.



If the driving forces were in the same "units", then we could simply add the two resistances to get a total resistance and express the flux in terms of a total resistance and overall driving force

The interfacial concentrations $y_{A,I}$ and $x_{A,I}$ are in equilibrium

At equilibrium:

$$y_A = m x_A + b$$

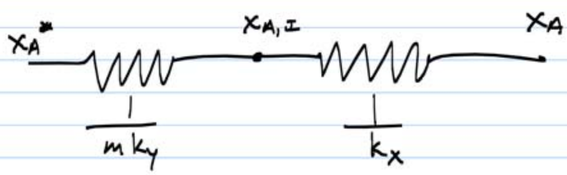
$$m x_{A,I} + b$$

$$N_{A,gas} = k_y (y_{A,b} - y_{A,I})$$

Let $x_A^* = x_A$ value in equilibrium with $y_{A,b}$

$$N_{A,gas} = k_y (m x_A^* - m x_{A,I}) = k_y (y_{A,b} - y_{A,I})$$

$$N_{A,gas} = m k_y (x_A^* - x_{A,I})$$



Total Resistance

$$\frac{1}{K_x} = \frac{1}{m k_y} + \frac{1}{k_x}$$

Total Driving Force: $x_A^* - x_A$

$$N_A = \frac{x_A^* - x_A}{\frac{1}{mk_y} + \frac{1}{k_x}}$$

$$= \frac{x_A^* - x_A}{\frac{1}{K_x}}$$

$$N_A = K_x (x_A^* - x_A)$$

What assumptions did we make?

Generalize:

$$y_A - y_{A,I} = \Delta y_A = \frac{\partial y_A}{\partial x_A} \Delta x_A$$

$$= m \, \Delta x_A$$

$$= m (x_A^* - x_{A,I})$$

Just need local slope of equilibrium curve.

Summary:

1) Mass transfer coefficients
2) Relationships for liquid and gas phases
3) Correlation connection
4) Interphase transport and overall K