Requests for today?

- 4.3 (see also Example 5 Module 4 Lecture II)
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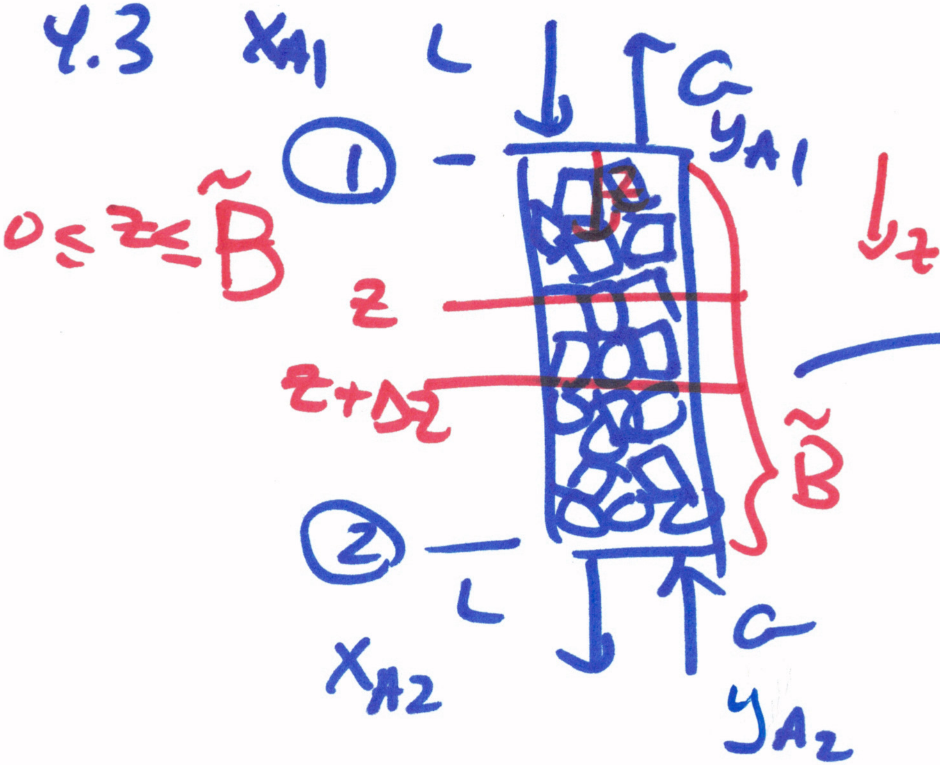
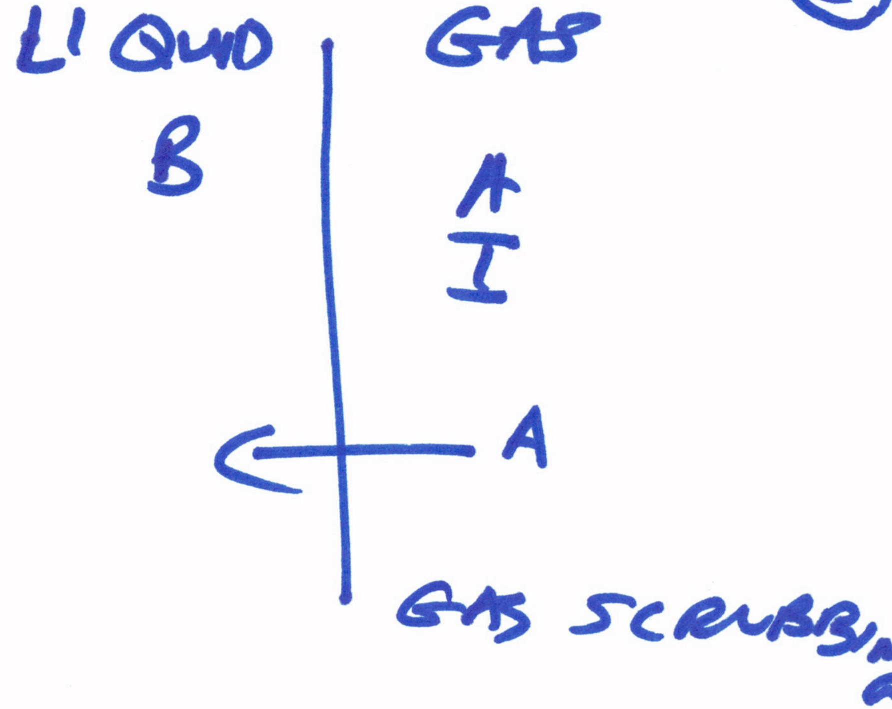
4.3





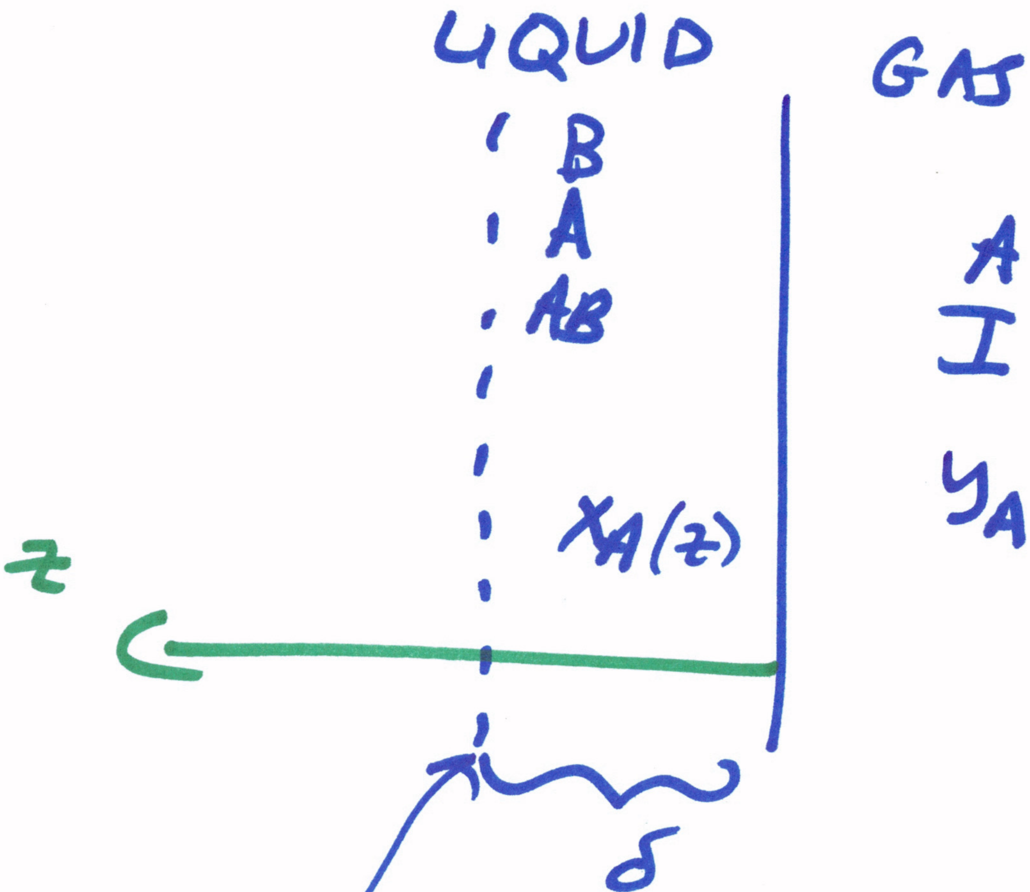
Goal: scrub A out of the gas

Tactic: create a lot of liq-gas interface in a column

$$a = \frac{\text{contact surface area}}{\text{volume}} \Rightarrow A_{xs}\,\Delta z$$

A_{xs}

$a\,A_{xs}\,\Delta z$ = contact surface area



Use a penetration model to think about this

A w/ homogeneous rxn:

$A + B \rightarrow AB$

Domain:

$0 \leq z \leq \delta$

$z = \delta \quad x_A = 0$ (all A in liquid reacts to form AB)

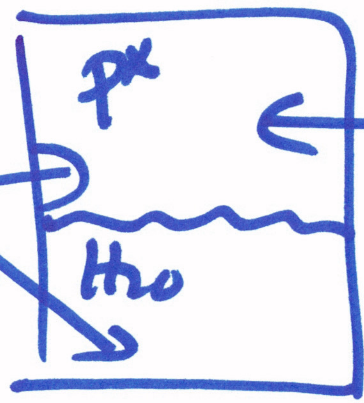
$z = 0 \quad x_A = x_{A_i}^*(y_{A_i}^*)$ } more on this later...

Recall:

Ex 1:

near interface
$y_A \sim y_A^*$
(assumed)

$$y_A = \frac{P^{sat}}{P}$$



saturated

in equilibrium

equilibrium is <u>dynamic</u>

Combind

4

The **Equation of Species Mass Balance in Terms of Combined Molar quantities** in Cartesian, cylindrical, and spherical coordinates for binary mixtures of A and B.

The general case, where the combined molar flux with respect to molar velocity ($\underline{N}_A$), is given on page 1.

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In terms of total molar flux, $\underline{N}_A$

Microscopic species mass balance, in terms of molar flux; Gibbs notation

$$\frac{\partial c_A}{\partial t} = -\nabla \cdot \underline{N}_A + R_A$$

WRF 25-11

Microscopic species mass balance, in terms of combined molar flux; Cartesian coordinates

STEP 1

$$\cancel{\frac{\partial c_A}{\partial t}} = -\left(\cancel{\frac{\partial N_{A,x}}{\partial x}} + \cancel{\frac{\partial N_{A,y}}{\partial y}} + \frac{\partial N_{A,z}}{\partial z}\right) + R_A$$

Microscopic species mass balance, in terms of combined molar flux; cylindrical coordinates

$$\frac{\partial c_A}{\partial t} = -\left(\frac{1}{r}\frac{\partial (r N_{A,r})}{\partial r} + \frac{1}{r}\frac{\partial N_{A,\theta}}{\partial \theta} + \frac{\partial N_{A,z}}{\partial z}\right) + R_A$$

$$\underbrace{R_A = k_1 c_A^{(1)}}_{\text{rxn kinetics}}$$

Microscopic species mass balance, in terms of combined molar flux; spherical coordinates

$$\frac{\partial c_A}{\partial t} = -\left(\frac{1}{r^2}\frac{\partial (r^2 N_{A,r})}{\partial r} + \frac{1}{r\sin\theta}\frac{\partial (N_{A,\theta}\sin\theta)}{\partial \theta} + \frac{1}{r\sin\theta}\frac{\partial N_{A,\phi}}{\partial \phi}\right) + R_A$$

Fick's law of diffusion, Gibbs notation: $\underline{N}_A = x_A(\underline{N}_A + \underline{N}_B) - cD_{AB}\nabla x_A$

$$= c_A \underline{v}^* - cD_{AB}\nabla x_A$$

WRF 2…

Step 2

Fick's law of diffusion, Cartesian coordinates:

$$\begin{pmatrix} \cancel{N_{A,x}} \\ \cancel{N_{A,y}} \\ N_{A,z} \end{pmatrix}_{xyz} = \begin{pmatrix} \cancel{x_A(N_{A,x} + N_{B,x}) - cD_{AB}\frac{\partial x_A}{\partial x}} \\ \cancel{x_A(N_{A,y} + N_{B,y}) - cD_{AB}\frac{\partial x_A}{\partial y}} \\ x_A(N_{A,z} + \cancel{N_{B,z}}) - cD_{AB}\frac{\partial x_A}{\partial z} \end{pmatrix}_{xyz}$$

Fick's law of diffusion, cylindrical coordinates:

$$\begin{pmatrix} N_{A,r} \\ N_{A,\theta} \\ N_{A,z} \end{pmatrix}_{r\theta z} = \begin{pmatrix} x_A(N_{A,r} + N_{B,r}) - cD_{AB}\frac{\partial x_A}{\partial r} \\ x_A(N_{A,\theta} + N_{B,\theta}) - \frac{cD_{AB}}{r}\frac{\partial x_A}{\partial \theta} \\ x_A(N_{A,z} + N_{B,z}) - cD_{AB}\frac{\partial x_A}{\partial z} \end{pmatrix}_{r\theta z}$$

continue as usual

Fick's law of diffusion, spherical coordinates:

$$\begin{pmatrix} N_{A,r} \\ N_{A,\theta} \\ N_{A,\phi} \end{pmatrix}_{r\theta\phi} = \begin{pmatrix} x_A(N_{A,r} + N_{B,r}) - cD_{AB}\frac{\partial x_A}{\partial r} \\ x_A(N_{A,\theta} + N_{B,\theta}) - \frac{cD_{AB}}{r}\frac{\partial x_A}{\partial \theta} \\ x_A(N_{A,\phi} + N_{B,\phi}) - \frac{cD_{AB}}{r\sin\theta}\frac{\partial x_A}{\partial \phi} \end{pmatrix}_{r\theta\phi}$$