Friday
23 APRIL 2021 MODULE 4 F. MORRISON
CM3120

Michigan Tech

①

Requests for today?

2Ap21 • 4.3 (see also Example 5
16 Ap21 • 4.A Module 4
• 4.8 Lecture II)
• 4.11 devise Heisler chart
• 4.12
21 Ap 2021 • 4.16

Today! 23 April21 • 4.4
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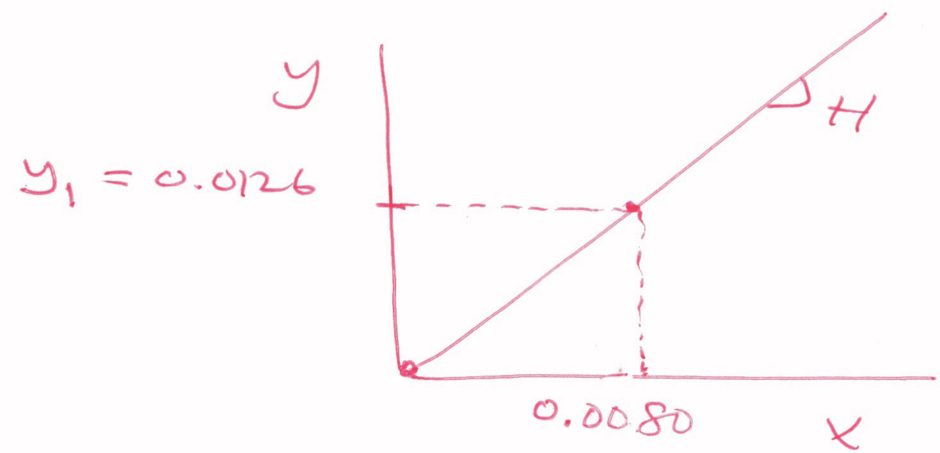
Final EXAM
CM3120 Monday
7:AM – 11:59 PM
3h 30 min max time.

4.16. A packed tower uses an organic amine to absorb carbon dioxide. The entering gas, which contains 1.26 mol% carbon dioxide, is to leave with only 0.04 mol% carbon dioxide. The amine enters pure, without CO_2. If the amine left in equilibrium with the entering gas (which it does not), it would contain 0.80 mole% CO_2. The gas flow is 2.3 mol/s, the liquid flow is 4.8 mol/s, the tower's diameter is $4.0 \times 10^1 cm$, and the overall mass transfer coefficient times the area per volume $K_y a$ is $5.0 \times 10^{-5} \frac{mol}{cm^3\,s}$. Determine the height of the tower, the NTU and the HTU.

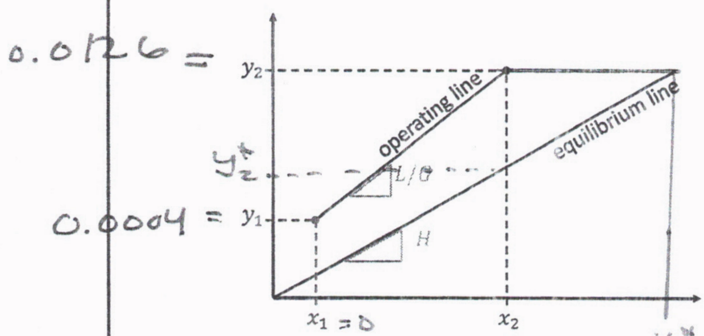


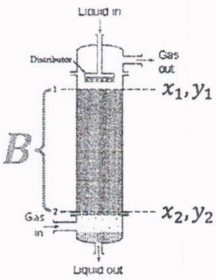
2 points on Equilibrium line

$$\text{Slope} = \frac{0.0126}{0.0080} = \boxed{1.575 = H}$$

(Cussler)

Unsteady Macroscopic Species A Mass Balance—Absorption



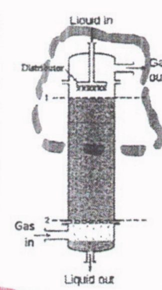


Unsteady Macroscopic Species A Mass Balance—Gas Absorption

Example 6—concluded

Example 6 Solution:

"rate" equation (gas-side, species A mass balance)	$\frac{dy}{dz} = \frac{K_y a}{G}(y - Hx)$
"operating line" equation (overall, species A mass balance)	$y = \frac{L}{G}(x - x_1) + y_1$
"equilibrium line" equation (thermodynamic equilibrium, dilute mixtures)	$y^* = Hx^*$
Column height, B (result)	$B = \frac{G}{K_y a}\left(\frac{1}{1 - \frac{G}{L}H}\right)\ln\left(\frac{y_2 - y_2^*}{y_1 - y_1^*}\right)$



$y_2^* = y^*(x_2)$
$y_1^* = y^*(x_1)$

See Handnotes HW 4.16

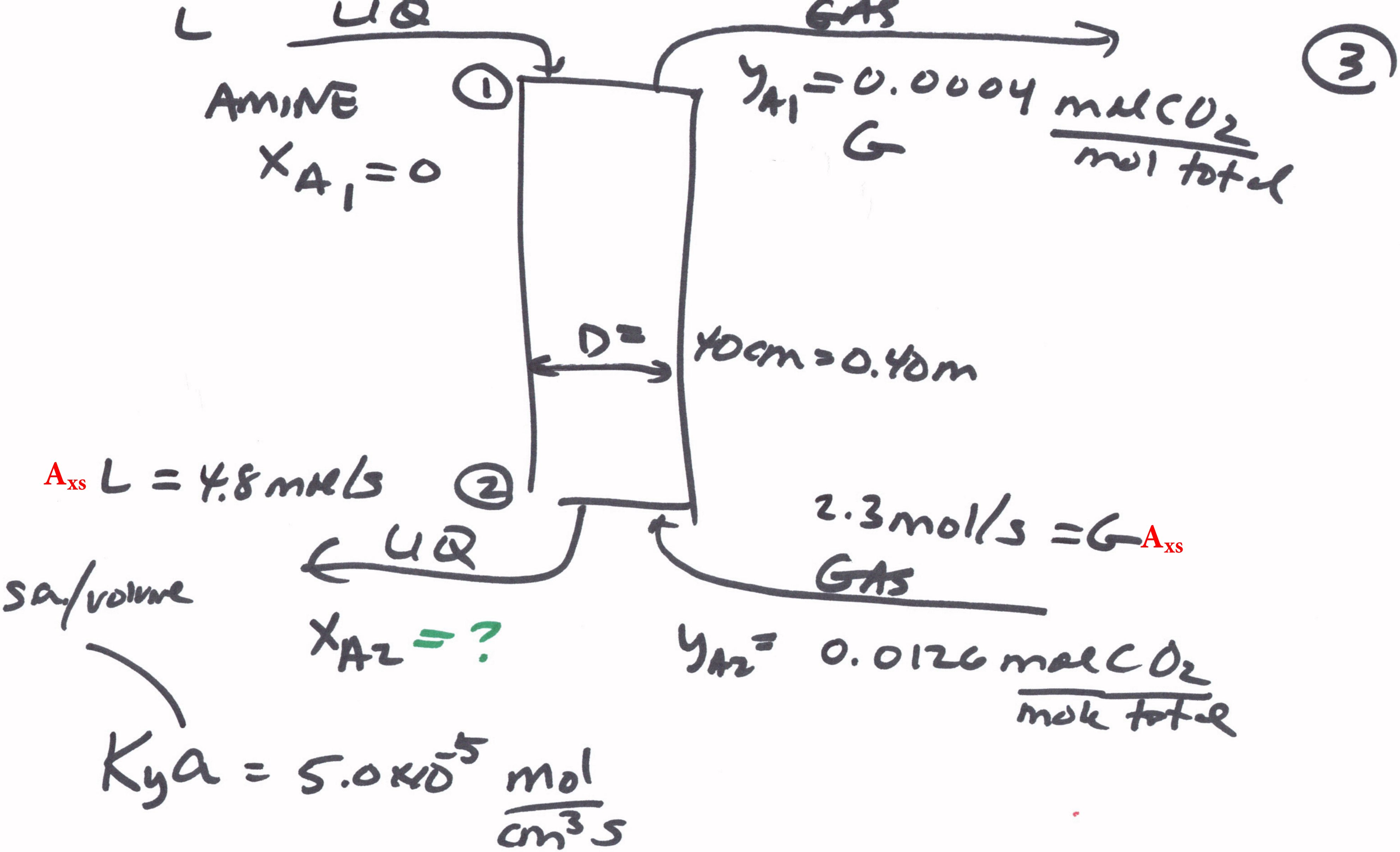
MAT'L Property

height of column

need A, y_1^*, y_2^*

Note: G is on a per m^2 basis; thus flow in mol/s is GA_{xs}

N-1



L
LIQ
AMINE
$x_{A_1} = 0$
①
GAS
$y_{A1} = 0.0004$ mol CO_2 / mol total
G
③
D = 40cm = 0.40m
A_{xs} L = 4.8 mol/s
②
LIQ
x_{A2} = ?
2.3 mol/s = G A_{xs}
GAS
$y_{A2} = 0.0126$ mol CO_2 / mole total
sa/volume
$K_y a = 5.0 \times 10^{-5}$ mol / cm^3 s

need to calc x_{A2} :

Macroscopic species mole Bal (overall):

$$\underbrace{x_1 L + y_2 G}_{\text{in}} = \underbrace{x_2 L + y_1 G}_{\text{out}}$$

(per unit column cross section)

$$x_2 = 0.0058458$$

Last items:

on Equil line

$$\begin{cases} y_2^* = H x_2 & \text{(on Equil Line)} \\ y_1^* = \underbrace{H x_1}_{\text{equil line}} = 0 \end{cases}$$

We have everything we need. (to get B)

... B ~ 320 cm

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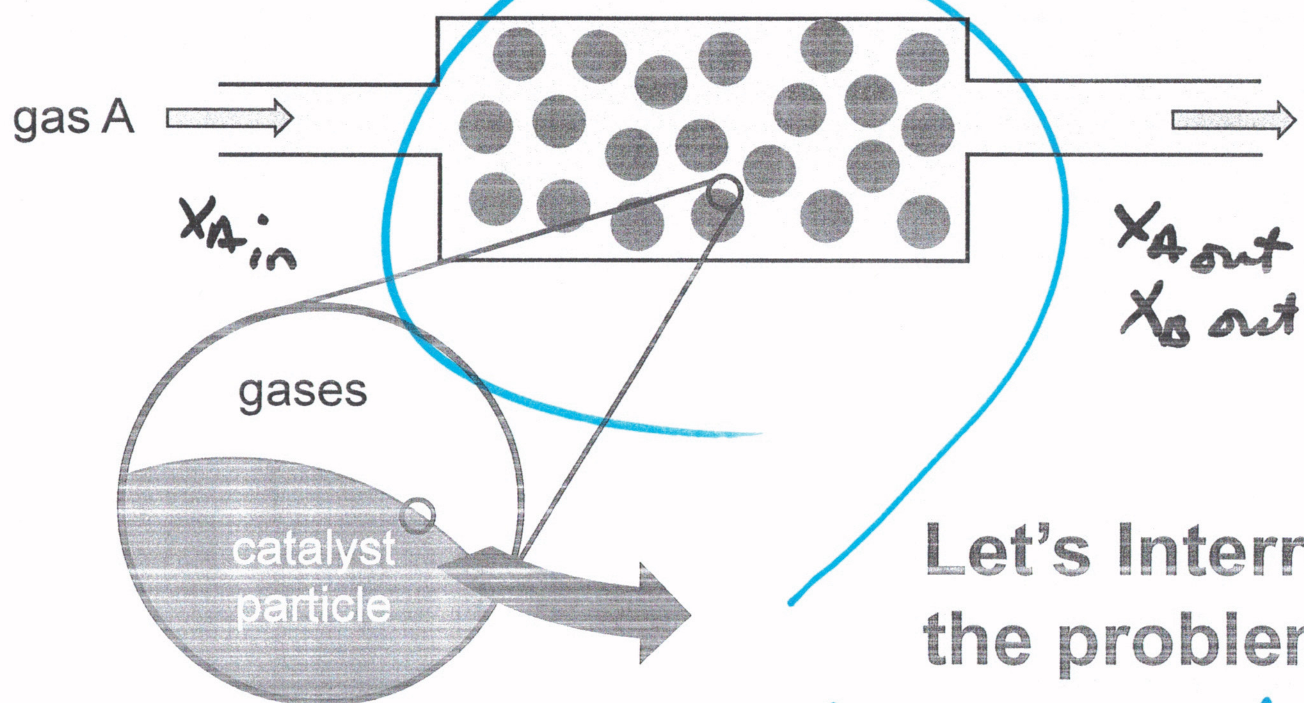
4.4. An irreversible, instantaneous chemical reaction $2A \rightarrow B$) takes place at a catalyst surface in a reactor (see Example 3, lecture VI, module 3). How might mass transfer affect the observed rate of reaction? Use the solution to the example in your discussion.

what does this mean?

QUICK START

(5½)

Example 3: Heterogeneous catalysis



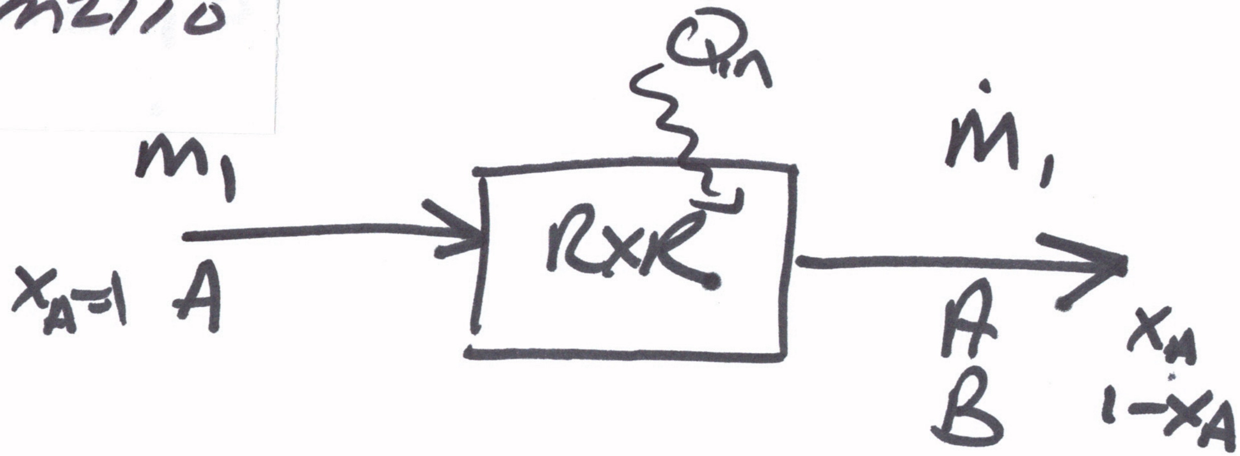
Let's Interrogate the problem.

"observed rate of reaction" means conversion across the reactor

An irreversible, instantaneous chemical reaction ($2A \rightarrow B$) takes place at a catalyst surface in a reactor as shown. How might mass transfer affect the observed rate of reaction?

Ex 3

CM2110



How did we handle reactors in CM2110?

$$A \rightarrow B \qquad f = \frac{\text{moles A reacted}}{\text{moles A fed}}$$

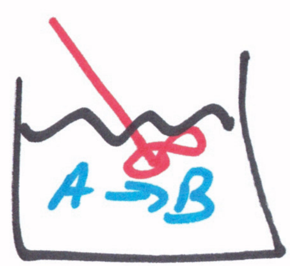
} observed conversion

CM3510

$$\frac{\text{A consumed}}{\text{volume}} = r_A = k\, C_A^{\alpha}$$

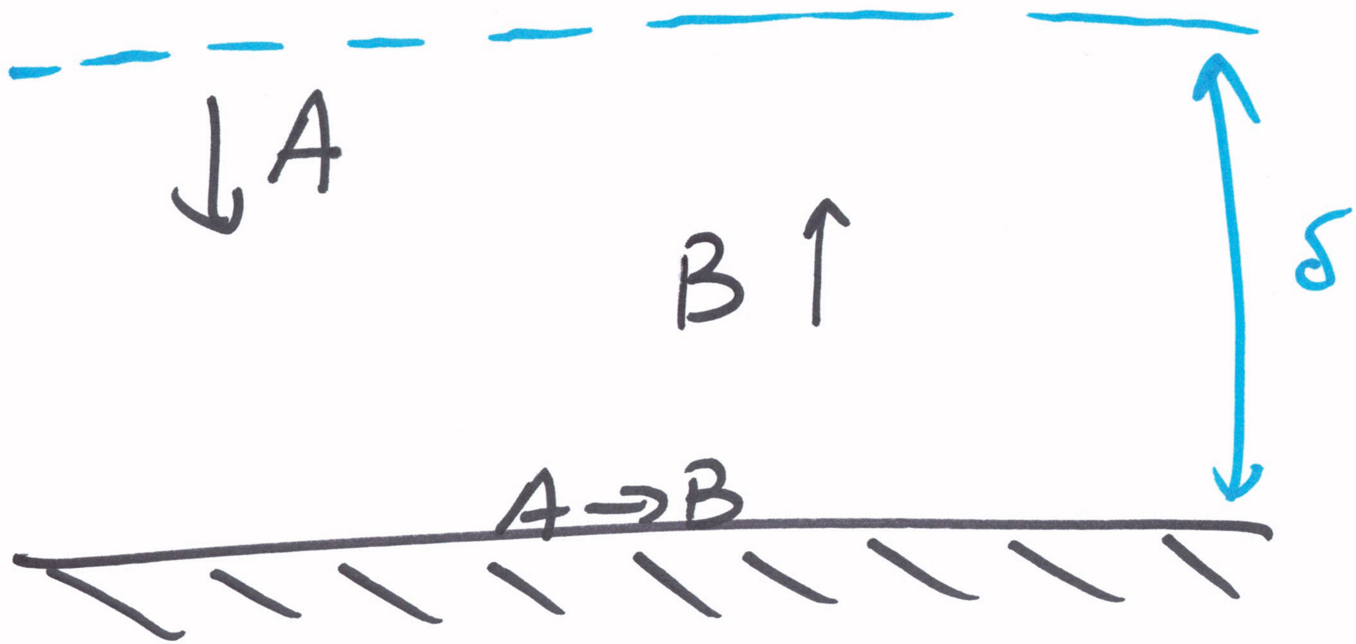
How about CM3510?

good mixing (no mass xfer limitations)



k ↑ rate constant (mat'l property)

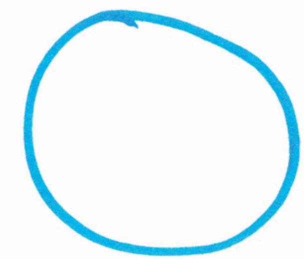
Answer the question:



1. diffusion of A thru stagnant B ~~is~~ may be rate limiting
2. B desorbing from surface may be rate limiting

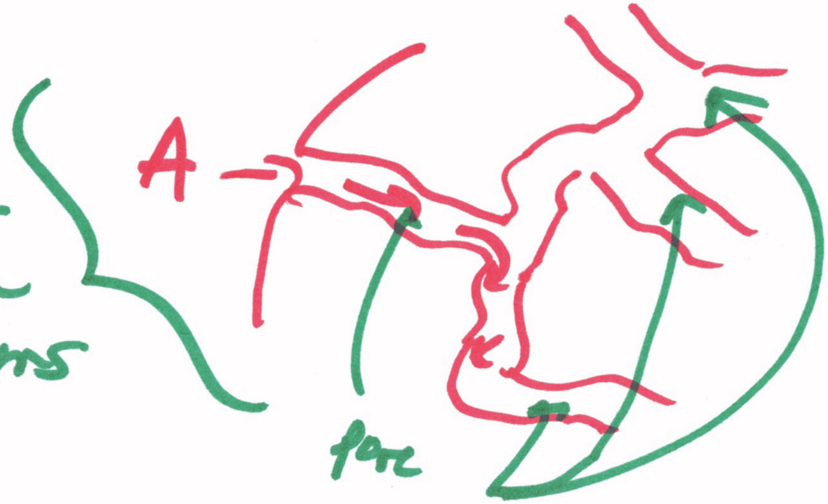
3) pore diffusion may be rate limiting

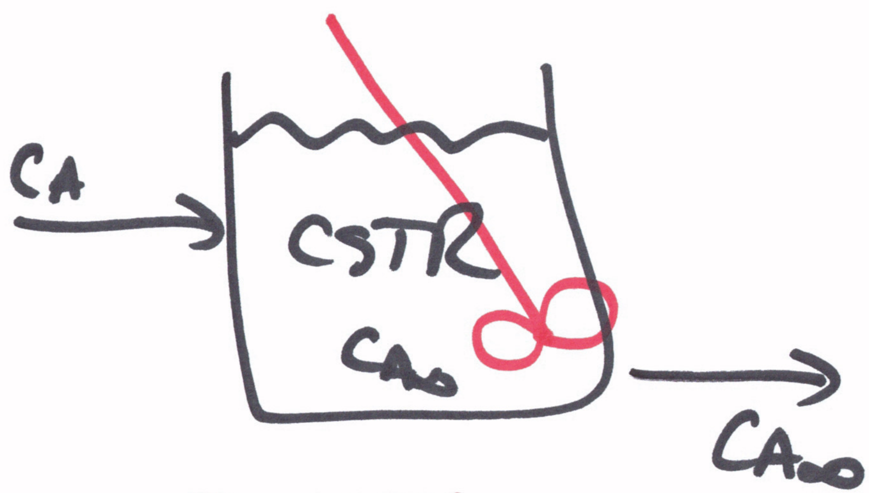
$$a = \frac{\text{surface area}}{\text{volume}}$$



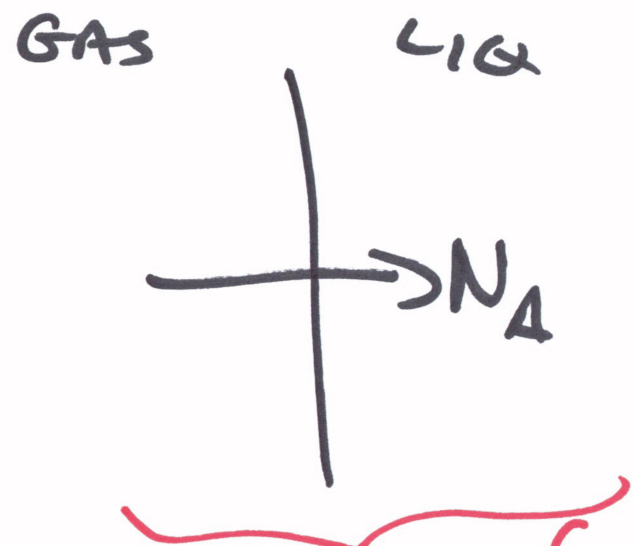
$$\frac{s.a.}{vol} = \frac{4\pi R^2}{\frac{4}{3}\pi R^3} = \frac{3}{R}$$

likely to have mass xfr limitations





no mass xfr limitations



mass xfr