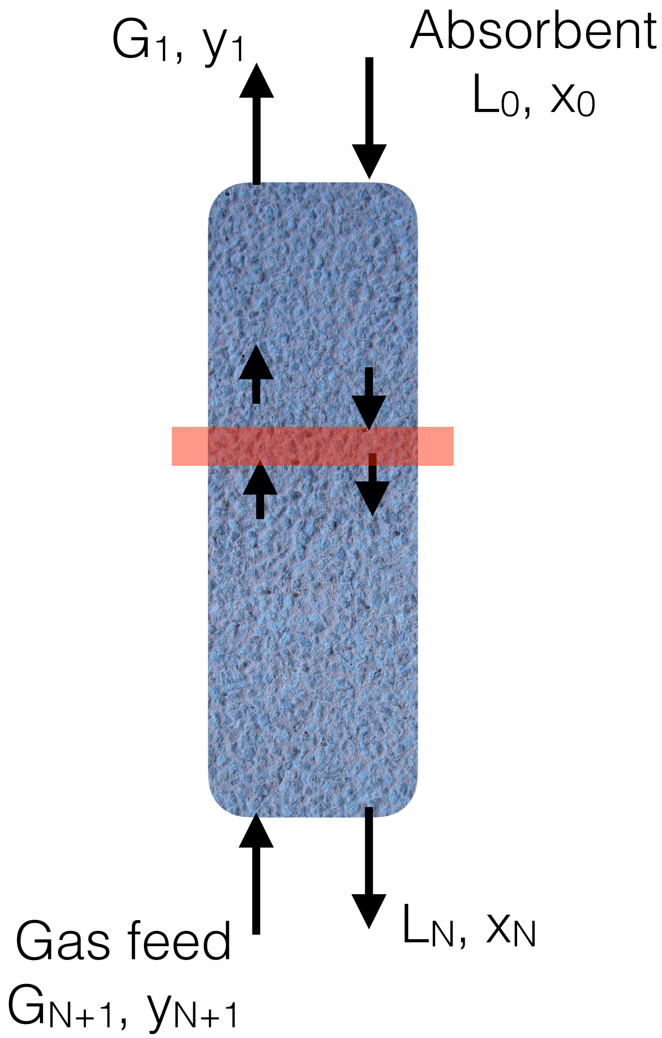
Review quiz

Consider the following case of mass balance on an absorption column where a gas is being absorbed. The gas is concentrated. Which of the following statements is correct.



A. The gas flow rate is constant.

B. The absorbent flow rate is constant.

C. Mass transfer takes place from liquid to gas.

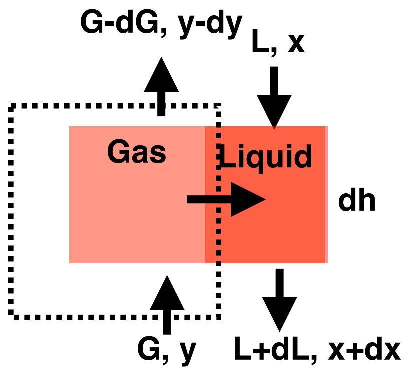
D. Equilibrium line is no longer in Henry's regime.

Review quiz

In the following statement, what is y*

Accumulation = in - out

$$0 = Gy - (G-dG)(y-dy) - K_y(y-y^*)aAdh$$



A. $y^* = y_i$ where y_i is interfacial gas concentration.

B. $y^* = mx$ where x is dissolved gas concentration in the bulk liquid.

C. $y^* = mx_i$ where x_i is dissolved gas concentration in the at the liquid-gas interface.

D. y^* is hypothetical concentration which depends on mass transfer but not on thermodynamics.

EPFL

Review quiz

Which is the expected order for heat of adsorption

A. F < Cl < Br < I

B. F > Cl > Br > I

C. F = Cl = Br = I

D. F< Cl = Br = I

Review quiz

What will happen if pressure is low in the case of Langmuir isotherm

$$\theta = \frac{KP}{1+KP}$$

A. $\theta = 1$

B. $\theta = 0$

C. θ will follow Henry regime

D. Langmuir isotherm is not valid at low pressure

Review quiz

Which of the following is true

A. Physisorbents refer to gases whereas chemisorbents refer to all chemicals.

B. Physisorbents have low binding energy, chemisorbents have high binding energy.

C. Physisorbents are not reversible but chemisorbents are reversible.

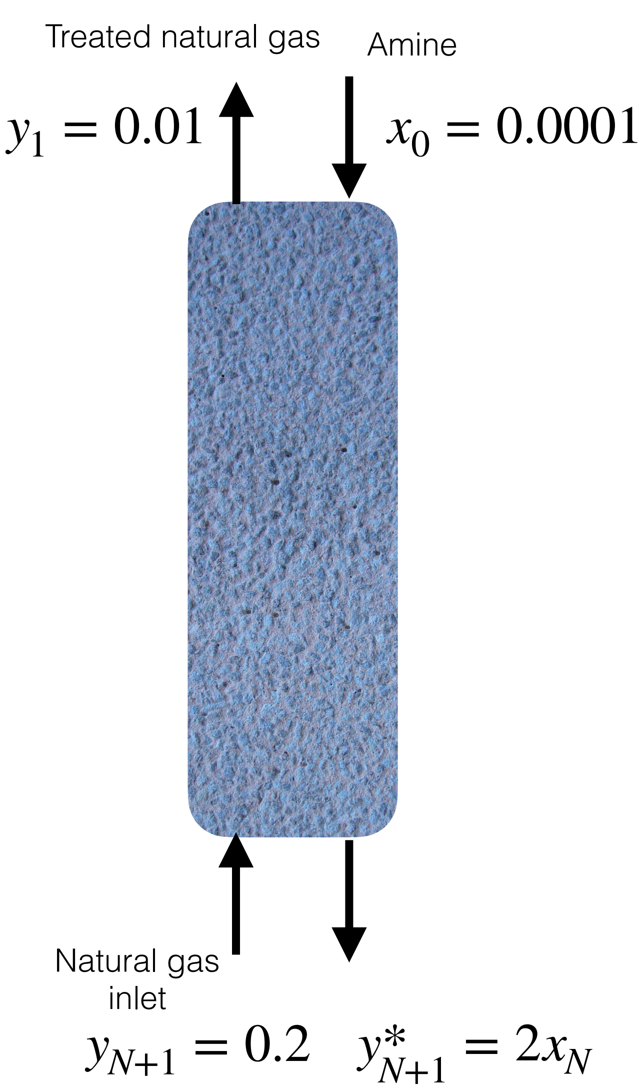
D. Both rely on extremely strong affinity with the solutes.

EPFL

A natural gas from a well in offshore Norway has CO_2 concentration of 20% (molar basis). CO_2 needs to be captured and sequestrated to curb global warming. Therefore, the gas needs to be treated to reduce CO_2 concentration to 1%. For this, you decided to create a pilot plant test using a packed bed absorption column contacting with liquid amine at 25 °C in a countercurrent fashion. The height of column is 1.0 meter and its cross-sectional area is 0.1 m^2. An amine is available as an absorbent with 0.01% of CO_2. You decided to use 100 mole/s of amine and 10 mole/s of natural gas. You have designed the system to perfection and equilibrium is established at the contact between the gas phase and the liquid phase. Assuming the case of concentrated absorption:

1. Calculate the concentration of CO_2 in the outlet stream of the amine.
2. Calculate HTU and NTU using approximate method with height formula shown below. $y_1^* = 10x_0;\ y_{N+1}^* = 2x_N$
3. Calculate the gas phase overall mass transfer coefficient, Kya.

$$y_1^* = 10x_0$$



$$h = \left(\frac{G_C}{K_y aA}\right) \frac{y_{N+1} - y_1}{(y-y^*)_{N+1} - (y-y^*)_1} \ln\left[\frac{(y-y^*)_{N+1}}{(y-y^*)_1}\right]$$

$$y_1^* = 10x_0 = 10 * 0.0001 = 0.001$$

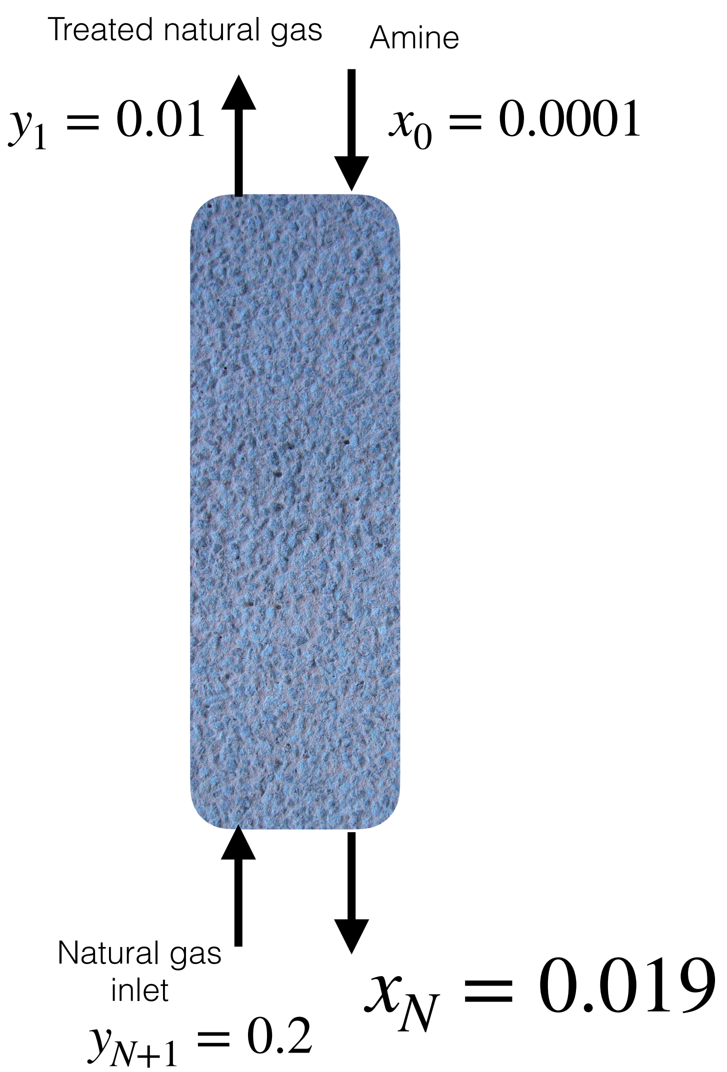
$$h = 1$$

$$G = \frac{G_C}{1 - y_{N+1}} \qquad G_c = G(1 - y_{N+1}) = 10 * (1 - 0.2) = 8 \text{ mole/s}$$

$$L = \frac{L_A}{1 - x_0} \qquad L_A = L(1 - x_0) = 100 * (1 - 0.0001) \approx 100 \text{ mole/s}$$

EPFL

Overall balance to calculate x_N



$$(L)_N x_N - (L)_0 x_0 = (G)_{N+1} y_{N+1} - (G)_1 y_1$$

$$\frac{L_A}{1-x_N} x_N - \frac{L_A}{1-x_0} x_0 = \frac{G_C}{1-y_{N+1}} y_{N+1} - \frac{G_C}{1-y_1} y_1$$

$$x_N = 0.019$$

$$h = \left(\frac{G_C}{K_y a A}\right) \frac{y_{N+1} - y_1}{(y-y^*)_{N+1} - (y-y^*)_1} \ln\left[\frac{(y-y^*)_{N+1}}{(y-y^*)_1}\right]$$

$$NTU = 3.6$$

$$HTU = \frac{G_C}{K_y a A} = h/NTU = 0.28$$

$$\Rightarrow K_y a = 285.7$$

EPFL

In-class exercise problem

Calculate and compare θ for benzene in activated carbon at 0.1 bar and 10 bars using the following isotherms

1. Henry's $q = HP, \; q_{max} = 0.1 \frac{mol \; solute}{mol \; adsorbent}$ $\quad H = 0.0016 \; bar^{-1}$
2. Langmuir $\theta = \frac{q}{q_{max}} = \frac{KP}{1+KP}$ $\quad K = 0.01 \; bar^{-1}$
3. Freundlich

$$\theta = KP^{\frac{1}{n}} \qquad K = 0.002 \; bar^{n} \qquad n = 3$$

θ

	P = 0.1 bar	P = 10 bar
Henry's	1.60E-03	1.6E-01
Langmuir	9.99E-04	9.09E-02
Freundlich	9.28E-04	4.31E-03

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