Absorption/Stripping 1

Task- Use a tray tower to clean up a gas stream containing a dilute concentration of a contaminant. Need picture!

What do we know?

1. Gas flow (contaminated)
2. Gas conc. in
3. Gas conc. out (target value – environmental?)

We are free to choose a solvent that we absorb the contaminant. Upon which criteria would we base this decision?

1) Does not dissolve carrier gas – just contaminant
2) Non-volatile
3) Cost?
4) Recycle

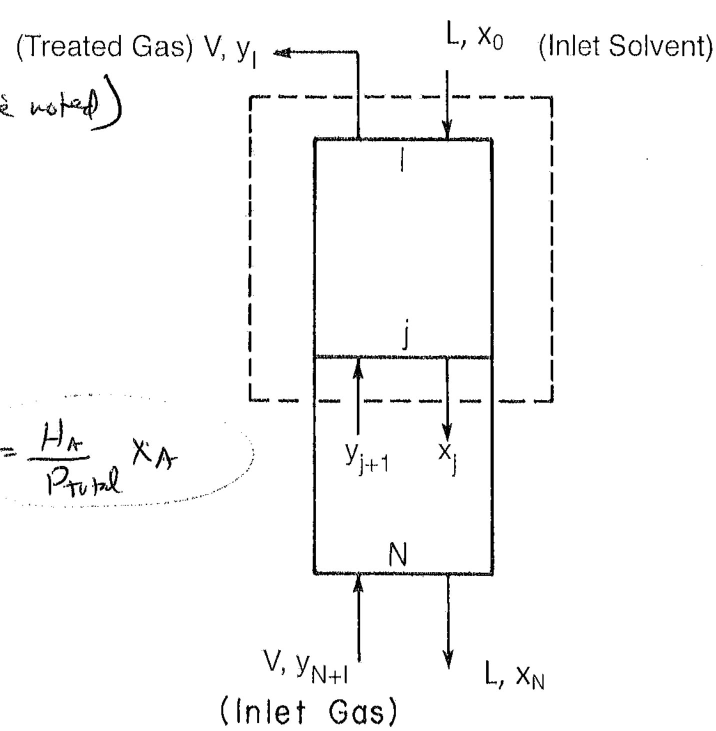
What are we trying to determine?

1. Flow rate of solvent required
2. Number of equilibrium trays required (where does equilibrium come in?)

– Gas up
– Liquid down

Physical Situation

1. Streams and variables (V, L, $y_{1\,(out)}$, $y_{N+1\,(in)}$, x_0)
2. Dilute assumption (~1% unless otherwise noted)
3. Location in column and tray numbering
4. T and P const.



Equilibrium

1. Solubility in liquid
2. Dilute solutions (Is it possible for the equilibrium mole fraction in the liquid to be less than that of the gas? How does this impact separation?)
3. Henry's Law $p_A = H x_A$ $\quad y_A = \frac{H_A}{P_{Total}} x_A$
4. How is this similar and/or different than the equilibrium situations that we have examined? Straight line!

Discuss

Material Balance- operating line equation

1. Diagram of column
2. Balance around the top
3. Derive expression for y_{j+1} as a function of x_j

$V = \text{const.}$
$L = \text{const.}$

$$y_{j+1} V + L x_0 = y_1 V + x_j L \quad \text{(Number from top)}$$

$$y_{j+1} = \frac{L}{V} x_j + \left[y_1 - \frac{L}{V} x_0 \right] \quad \underline{\underline{OL}}$$

Equilibrium – goes through zero
– also mol units work
– pick point ⇒ calculate x
plot 2 points

Example (12-1 from your text)

$= V$ $\quad y_{N+1}$ $\quad x_0 = 0$

1000 kmol/h of air containing 100 ppm (mol) of chloroform at 25C and 2 atm is to be processed. We will absorb the chloroform into pure water to reduce the amount in the gas to 10ppm. Operation should be at 1.4 times the minimum L/V. The Henry's Law constant is 211.19 atm/mol. frac. $\to y_1$

Draw a diagram of the column and label the streams.
Plot the point on the operating line that represents the top of the column
Identify the horizontal line that represents the inlet concentration in the gas (known)
What is the minimum L/V that will intersect with the inlet concentration? Where does it intersect?
Note that it is straightforward to calculate the intersection point from the equilibrium curve.
How would you step off trays? (try stepping both ways)

$$\left(\frac{L}{V}\right)_{min} = \frac{(100-10)}{.947-0} = 95$$

$$L/V = (1.4)(95) = 133$$

$$L = (133)(1000) = 133{,}000 \ \frac{kmol}{h}$$

$$\frac{L}{V} = \frac{y_{N+1} - y_1}{x_N - x_0} = \frac{90}{x_N}$$

$$x_N = \frac{90}{133} = 0.677$$