Exercise problem 1
Scrubbing problem

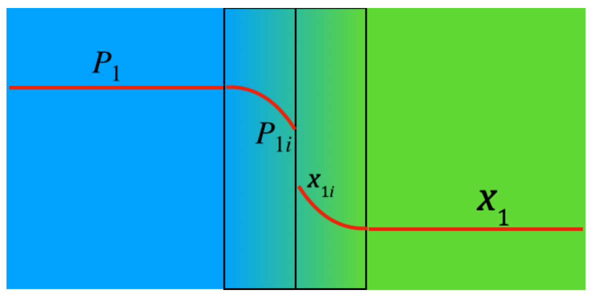
Ammonia in a carrier gas (air) is being scrubbed from the gas phase to a solvent in a packed tower. The interaction (absorption) of NH_3 with the solvent is extremely strong and irreversible. Calculate the concentration of ammonia as a function of column height.

$$x_{1i} = \bar{H} P_{1i}$$

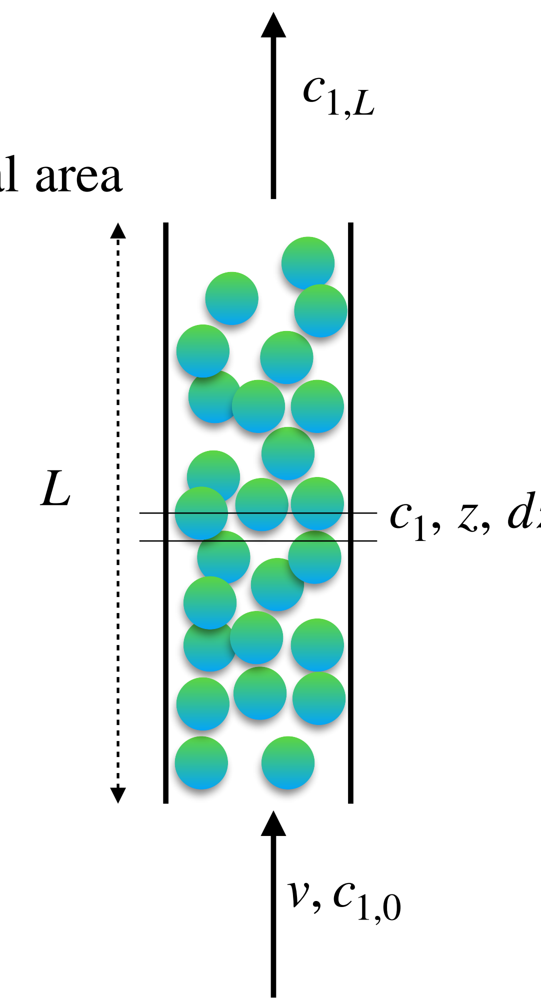
$$\Rightarrow \bar{H} \to \infty$$

$$\Rightarrow P_{1i} \to 0$$

$$\Rightarrow c_{1i} \to 0 \text{ (in gas phase)}$$



$$\text{A} = \text{cross} - \text{sectional area}$$



Analysis on gas phase at height z

$$\text{Accumulation in gas phase} = (\text{flow in} - \text{flow out}) - (\text{mass lost to absorption})$$

Steady-state, accumulation = 0

$$0 = (c_1 v) * A_1 |_z - (c_1 v) * A_1 |_{z+dz} - k A_2 (c_1 - c_{1,i})$$

$$A_1 = A$$

$$\Rightarrow (c_1 v) * A |_z - (c_1 v) * A |_{z+dz} - k a A dz (c_1 - 0)$$

$$A_2 = a A dz$$

$$\Rightarrow \frac{dc_1}{dz} = -\frac{k a c_1}{v}$$

Ammonia in a carrier gas (air) is being scrubbed from the gas phase to a solvent in a packed tower. The interaction (absorption) of NH_3 with the solvent is extremely strong and irreversible. Calculate the concentration of ammonia as a function of column height.

$$\Rightarrow \frac{dc_1}{dz} = -\frac{kac_1}{v}$$

$$\Rightarrow \ln c_1 = -\frac{kaz}{v} + \text{constant}$$

$$c_1 = c_{1,0} \text{ when } z = 0,$$

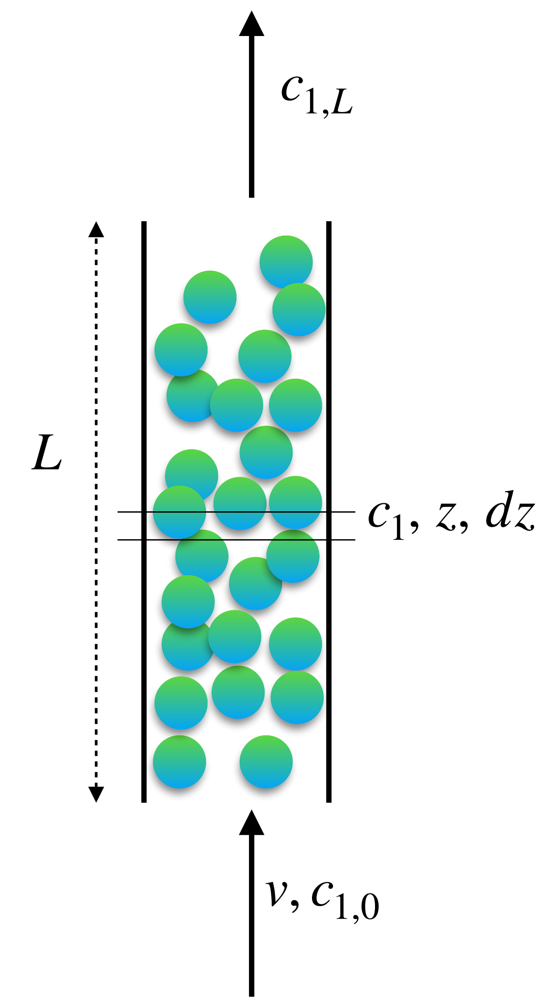
$$\Rightarrow \text{constant} = \ln c_{1,0}$$

$$\Rightarrow \ln\left(\frac{c_1}{c_{1,0}}\right) = -\frac{kaz}{v}$$

$$\Rightarrow ka = -\frac{v}{z}\ln\left(\frac{c_1}{c_{10}}\right)$$

$$\Rightarrow c_1 = c_{1,0}\exp\left(-\frac{kaz}{v}\right)$$

$$\Rightarrow ka = -\frac{v}{L}\ln\left(\frac{c_{1L}}{c_{10}}\right)$$



Exercise problem 2
Overall mass transfer coefficient

A distillation column tray is contacting liquid benzene with its vapor. Bulk liquid and vapor mole fractions are 0.2 and 0.7, respectively. The equilibrium relationship, liquid-side and vapor-side mass transfer coefficients are given below.

Calculate the flux and interfacial mole fraction.

At interface, $y_{1i} = m x_{1i}$ $\quad m = 2 \quad k_x = 1\ \frac{\text{mole}}{\text{m}^2\text{s}} \quad k_y = 1\ \frac{\text{mole}}{\text{m}^2\text{s}}$

$$\frac{1}{K_y} = \frac{1}{k_y} + \frac{m}{k_x} = 3 \qquad K_y = 0.33 \text{ mole m}^{-2}\text{ s}^{-1}$$

$$\mathbf{N_1 = K_y(y_1 - mx_1)} = 0.33(0.7 - 2 * 0.2) = 0.099 \text{ mole m}^{-2}\text{ s}^{-1}$$

$$N_1 = k_y(y_1 - y_{1i}) \qquad \Rightarrow y_{1i} = y_1 - \frac{N_1}{k_y} = 0.7 - \frac{0.099}{1} = 0.601 \qquad \Rightarrow x_{1i} = y_{1i}/m = 0.3$$

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