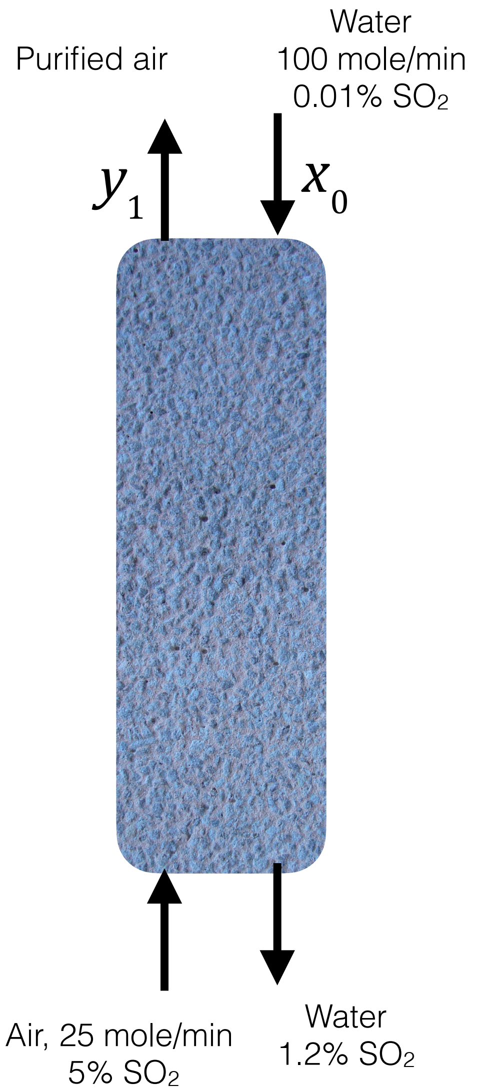
Exercise problem 1: Calculate NTU, and K_ya for the case of concentrated absorption.

SO_2 is absorbed from air with water at 20.0°C in a 0.7 meter tall packed column absorber with a cross-sectional area of 1 m^2. The inlet water contains 0.01% SO_2. The outlet water contains 1.2 mol% SO_2. The concentration of SO_2 in inlet air is 5%. The total liquid inlet flow rate is 100 mole/minute. The total gas inlet flow rate is 25 mole/minute. Equilibrium relationship is given below. Calculate the concentration of SO_2 in the exit air stream, NTU, and K_ya.

$$y^*_{N+1} = 3x_N \qquad y^*_1 = 10x_0$$

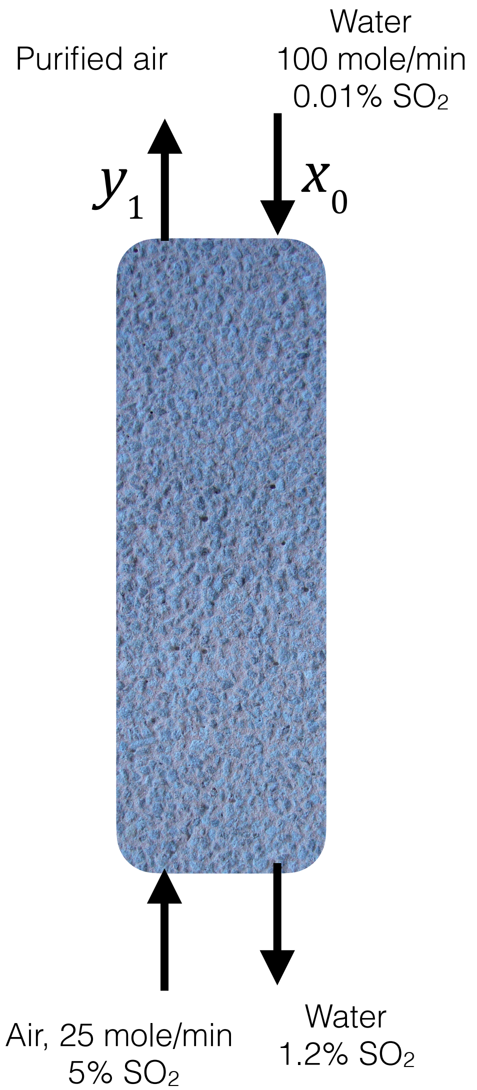
$$h = \left(\frac{G_C}{K_y aA}\right) \frac{y_{N+1} - y_1}{(y - y^*)_{N+1} - (y - y^*)_1} \ln\left[\frac{(y - y^*)_{N+1}}{(y - y^*)_1}\right]$$



Exercise problem 1: Calculate NTU, and $K_y a$ for the case of concentrated absorption.

SO_2 is absorbed from air with water at 20.0°C in a 0.7 meter tall packed column absorber with a cross-sectional area of 1 m^2. The inlet water contains 0.01% SO_2. The outlet water contains 1.2 mol% SO_2. The concentration of SO_2 in inlet air is 5%. The total liquid inlet flow rate is 100 mole/minute. The total gas inlet flow rate is 25 mole/minute. Equilibrium relationship is given below. Calculate the concentration of SO_2 in the exit air stream, NTU, and $K_y a$.

$$y^*_{N+1} = 3x_N \qquad y^*_1 = 10x_0$$



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

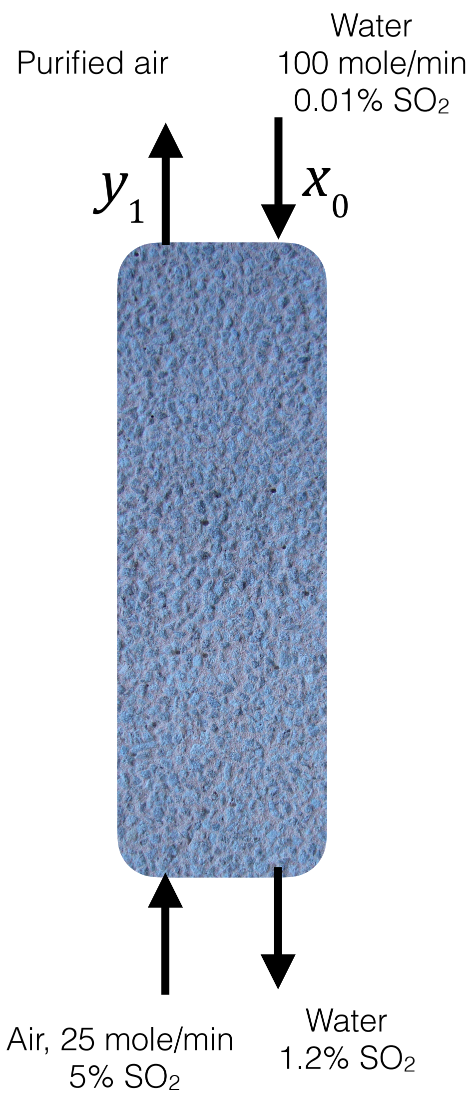
$$h = 0.7 \qquad y_{N+1} = 0.05 \qquad x_0 = 0.0001 \qquad x_N = 0.012$$

$$y^*_1 = 0.001 \qquad y^*_{N+1} = 0.036$$

$$G = \frac{G_C}{1 - y_{N+1}} \qquad G_C = G(1 - y_{N+1}) = 25*(0.95) = 23.75$$

$$L = \frac{L_A}{1 - x_0} \qquad L_A = L(1 - x_0) = 100(0.9999) = 99.99$$

Overall balance to calculate y_1



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

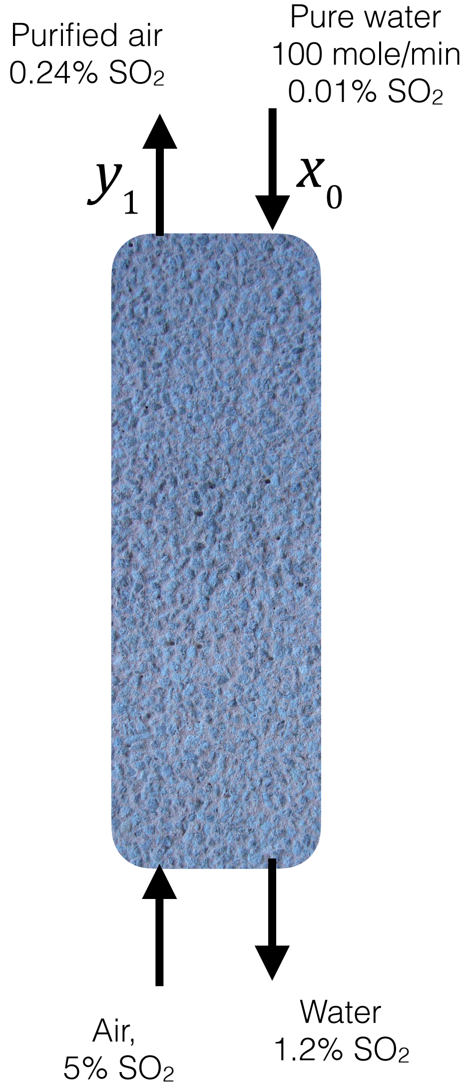
$$\frac{L_A}{1-x_N} x_N - \frac{L_A}{1-x_0} x_0 = \frac{G_C}{1-y_{N+1}} y_{N+1} - \frac{G_C}{1-y_1} y_1$$

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

$$\frac{23.75}{1-y_1} y_1 = \frac{23.75}{1-0.05} * 0.05 - \frac{99.99}{1-0.012} * 0.012 + \frac{99.99}{1-0.0001} * 0.0001$$

$$y_1 = 0.0019$$

$$NTU = \frac{0.05-0.0019}{(0.05-0.036)-(0.0019-0.001)} \ln\left[\frac{(0.05-0.036)}{(0.0019-0.001)}\right] = 10.07$$



$$HTU = \frac{h}{NTU} = \frac{0.7}{10.07} = 0.069\ m$$

$$HTU = \frac{G_C}{K_y aA}$$

$$K_y a = \frac{G_C}{A * HTU} = \frac{23.75}{1*0.069} = 341.89\ mole\ m^{-3}\ s^{-1}$$

Exercise problem 2

For the separation of 10% CO_2 from N_2, will you use physisorbent or chemisorbent.

Solution to Exercise problem 2

Both physisorption and chemisorption can be used for CO_2 while physisorption is preferable. This is mainly because CO_2 concentration is much higher (10 wt%), and we will need to regenerate the absorbent to make the process economically attractive.

Exercise problem 3

For the separation of 10 ppm toxic chemical (e.g. phosgene) in air, will you use physisorbent or chemisorbent.

Solution to Exercise problem 3

Chemisorption must be used for phosgene. For toxic gases, the key consideration is that the outlet stream should have as low concentration as possible. Physisorption is based on equilibrium behavior and at 10 ppm concentration of phosgene, physisorption will be weak ($\theta = kP$), and may not be able to effectively remove phosgene. In comparison, strong chemisorption can ensure close to complete removal of phosgene.