Chemical Reaction Engineering
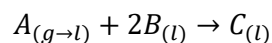
Practical Session 7

21 December 2018

Gas/Liquid reactors

1. **Overall rate of change through the 2-film theory**

   Air with gaseous species A bubbles through a vertical tower containing aqueous species B at uniform, constant temperature of 303 K. Reaction occurs as follows:

   $$A_{(g \to l)} + 2B_{(l)} \to C_{(l)}$$

   The reaction rate is given by: $r = kC_A C_B^2$, with a kinetic constant $k = 10^8 \frac{m^6}{mol^2 h}$.

   The diffusion coefficients of species A and B are $\Gamma_A = 10^{-6} \frac{m^2}{h}$ and $\Gamma_B = 10^{-6} \frac{m^2}{h}$. The liquid volume fraction is $f_L = 0.98$ and the gas/liquid interface area per unit of volume is $a = 20 \frac{m^2}{m^3}$. The Henry's constant at the given temperature is equal to $H_A = 10^5 \frac{Pa\, m^3}{mol}$ and the liquid and gas mass transfer coefficients equal to $K_L a = 2 \frac{1}{h}$ and $K_G a = 0.01 \frac{mol}{h\, m^3 Pa}$.

   Estimate the overall rate of change according to the 2-film theory if the partial pressure of A is $5000\ Pa$ and the concentration of B is $1\ mol/m^3$.

2. **Simulation of a co-current bubble tower**

   The reaction described in Exercise 1 is carried out in a co-current bubble tower with internal circular section having diameter of $30\ cm$ and height of $5\ m$. The air stream (containing species A, with partial pressure of $5000\ Pa$) is fed at total pressure of $1\ atm$ and volumetric flow rate of $0.8\ l/s$. The liquid stream, containing only species B and water with concentrations equal to $1\ mol/m^3$ and $300\ mol/m^3$, respectively, is fed with volumetric flow rate of $20\ l/s$.

   Calculate the profiles of partial pressure of A and concentrations of B and C along the reactor and estimate the conversion of A at the outlet section.

3. **Simulation of a counter-current bubble tower**

   Repeat the previous exercise in case of counter-current configuration.