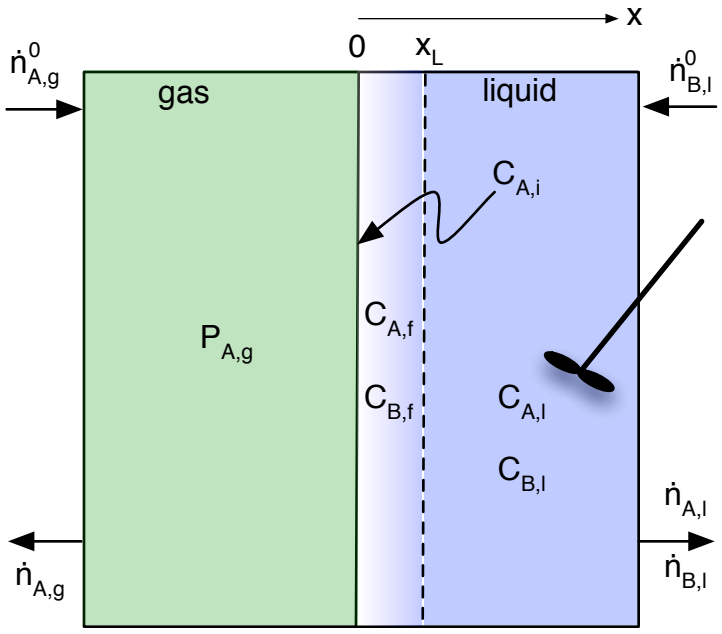
A First Course on Kinetics and Reaction Engineering

Activity 39.1

Pure gas phase A and a liquid solution containing B at a feed concentration of 2.5 mol L^{-1} react isothermally at 35 ºC in a steady state CSTR according to reaction (1). At that temperature, the rate coefficient in equation (2) is equal to 5.1 x 10^8 cm^3 mol^{-1} min^{-1}. None of the solution components are volatile, and the reactor has been designed so that the liquid phase is perfectly mixed, the interfacial area is constant and equal to 3 cm^2 per cm^3 of liquid, and the gas pressure is constant and equal to 5 atm. The liquid volume may be assumed to be constant and equal to 250 cm^3 over the course of the reaction. The Henry's law constant for A is equal to 40 L atm mol^{-1}, its diffusion coefficient in the liquid is equal to 1.7 x 10^{-5} cm^2 s^{-1}, the liquid mass transfer coefficient for A is 6.7 x 10^{-2} cm s^{-1} and the diffusion coefficient of B in the liquid is 8 x 10^{-6} cm^2 s^{-1}. At what liquid flow rate will 99% of the B be converted? What fraction of that conversion will take place in the liquid film? What will the liquid phase concentration of A equal? You may assume a planar interface between the gas and the liquid.

$$A + B \rightarrow Z \qquad (1)$$

$$r = k[A][B] \qquad (2)$$



Problem Solution

Read through the problem statement and each time you encounter a quantity, assign it to the appropriate variable. Show how to calculate any other necessary constants.

Write bulk liquid phase mole balances for A and B. Let N_A and N_B represent the fluxes of A and B into the bulk liquid from the liquid film. Assume that the liquid film volume is negligible compared to the bulk liquid film volume (i. e. the bulk liquid volume is equal to V_l above)

Identify the type of equations just written and the unknowns in those equations

Write the mole balances on the liquid film, neglecting curvature of the interface, along with the boundary conditions needed to solve them.

What unknown quantities are needed in order to solve the liquid film mole balances?

How are the fluxes calculated once the liquid film mole balances have been solved?