A First Course on Kinetics and Reaction Engineering
Activity 37.1 Worksheet

A gas mixture containing CO_2 is fed to an isothermal steady state CSTR. A solution containing an amine, NH_2R, is also fed to the reactor. The agitator system for the reactor has been designed so that the gas phase may be treated as perfectly mixed. The gas is dispersed as bubbles in the liquid, which is also perfectly mixed. The inlet molar flow rates of all species are known and constant, as are the liquid volume, the gas volume and the interfacial area per volume of liquid, a_V. The inlet and outlet volumetric flow rates may be taken to be equal and known. None of the gases except CO_2 are soluble in the solution, and none of the components of the solution are volatile. When CO_2 dissolves in the solution, it reacts with the amine to form an adduct according to equation (1). The rate expression for the reaction is given in equation (2) where square brackets denote solution phase concentrations, and the rate coefficient is known. If the reaction rate is very, very slow, then the gas phase and solution phase CO_2 will be equilibrated according to Henry's Law, equation (3), where h is the known Henry's law constant. Write the mole balance design equations needed to calculate the amount of CO_2 removed from the gas phase by this reactor.

$$NH_2R + CO_2 \rightarrow CO_2{:}NH_2R \quad (1)$$

$$r = k\left[NH_2R\right]\left[CO_2\right] \quad (2)$$

$$P_{CO_2} = hC_{CO_2} \quad (3)$$

You can perform these steps on a separate piece (or pieces) of paper.

1. Determine what design equations will be needed for the gas phase, and write those equations.
2. Determine what design equations will be needed for the liquid phase, and write those equations.
3. Determine the type of the design equations and what will be needed to solve them numerically.
4. Show how to solve the design equations by providing the necessary information.
5. Show any additional calculations that will need to be performed after the design equations have been solved.