Name: **Honors Chemistry**

Section: Modeling Equilibrium

Many chemical processes are reversible—that is, they can go in both the forward and the reverse directions. Eventually, the process will come to a balance point, called *equilibrium*, where the rate of the forward process equals the rate of the reverse process. Equilibrium is a state of balance between two opposite reactions, physical or chemical, which are taking place at the same rate. Equilibrium describes the overall characteristics of the system, rather than describing the activities of individual particles. When equilibrium is achieved, both the forward and reverse reactions are going on, although no net change in the system will be seen. In this lab, we will model the equilibrium process by using different size pipettes to transfer liquid between two graduated cylinders to model a reversible reaction.

Problem
If the rate of the forward reaction is somewhat faster than the reverse reaction, will the system ever reach equilibrium?

Hypothesis
State a hypothesis on whether or not the system will achieve equilibrium if the forward and reverse processes occur at different rates.

Objectives
- Model the equilibrium process using transfer of liquids between containers.
- Extend this model of equilibrium to chemical processes as balanced opposing reaction.

Possible Materials
2 100 mL graduated cylinders
large transfer pipette
small transfer pipette
water

Roles
Project Manager
Materials Manager
Quality Control Manager

Procedure
1. As a group, agree upon and write out a hypothesis statement.
2. Read through the entire procedure before continuing.
3. Fill one of the graduated cylinders so that it is nearly full (75-80 mL of water). Record the volume of water used. Label this cylinder Cylinder A.
4. Fill the second graduated cylinder so that it is nearly empty (10-15 mL of water). Record the volume of water used. Label this cylinder Cylinder B.
5. One pipette is to be used only for Cylinder A → B transfers; the other pipette is to be used only for Cylinder B → A transfers. Label the pipettes.
6. The model reaction consists of transferring liquid from one cylinder to another.
7. Create an appropriate data table in your notebook for recording your data.
8. Begin transfers. Record the volumes in each cylinder after every three transfers.
9. Call your instructor over to your group when you believe that your group has achieved equilibrium.

Analyze and Apply Questions

Answer these questions in complete sentences in your lab report.

1. Explain how this experiment models a chemical process at equilibrium. Be as detailed as possible in your explanation.
2. How did you recognize that your system had achieved equilibrium?
3. Graph your volume vs. transfer data. What happens to the volumes of A and B when you reach equilibrium?
4. Write the general form of the equilibrium constant expression for the following reaction:
   $eA + fB \leftrightarrow gC + hD$, in which A, B, C, and D are all gases.
5. Assume that Volume A corresponds to reactant and Volume B corresponds to product. Calculate the value of the equilibrium constant for your system at equilibrium. Which is favored—reactants or products?
6. Explain how the reaction quotient can be used to determine whether or not a reaction is at equilibrium and, if not, in what direction it will proceed.
7. Consider what would have happened in this experiment if you had started with 40 mL of water in Cylinder A and 20 mL of water in cylinder B. How would your results have been different from today's results? How would they have been similar?

Include the following in your MINILAB:

- Hypothesis
- Group Members and Roles
- Data Table
- Analyze and Apply Questions (attach graph)
- Conclusion