Student Directions for *Reactions and Rates* 3*:* Introduction to **Equilibrium**

Learning Goals: Students will be able to:

- Use a physical experiment to model chemical equilibrium
- Sketch how the number of reactants and products will change as a reaction proceeds
- Predict how changing the initial conditions will affect the equilibrium amounts of reactants and products.
- Predict how the shape of the reaction coordinate will affect the equilibrium amounts of reactants and products.

PART 1: Done in pairs in class

Materials: 4 beakers: 100 mL and 50 mL and **two** 1000 mL beakers,

Directions: **Read a-e, make an appropriate data table, and then begin.**

a) Label the 1000 ml beakers A and B
b) Put about 700 ml water in the large beaker “A”. Leave the other beaker “B” empty.
c) Record the volume of water in the beakers in your table.
d) Transfer water between the large beakers using the following “rules”
   - Use the 100 mL beaker to transfer water from A to B;
   - Use the 50 mL beaker transfer water from B to A.
   - Fill the small beakers as full as possible **without tipping the large beakers** in any way.
   - One cycle consists of one A → B transfer and one B → A transfer.
   - **For each cycle**, record the volume of water in beakers A and B.
e) Continue cycles and recording the volumes, until the level of water in beakers A and B are unchanging.

Analysis:

1. Graph the volumes of water in beakers A and B per cycle.

2. Describe in your own words how this experiment relates to chemical reaction equilibrium.

3. What is the ratio of the volume in Beaker B to Beaker A at equilibrium? _____When we work with chemical experiments, what do we calculate that is similar?

4. What do you think would be different and same if the water transfers were repeated with the beaker A initially half full?

5. Repeat the directions to test your ideas. Use a table, graph, and ratio of B to A to show your results. Explain how your ideas were supported or need to be corrected.

6. Sketch what you think the graph will look like if you repeated the directions starting with beaker A empty and beaker B with 700ml? ***Remember that a "cycle" is using the 100ml beaker to take from A and the 50ml beaker to take from B.***

7. Repeat the directions to test your ideas. Use a table, graph, and ratio of B to A to show your results. Explain how your ideas were supported or need to be corrected.

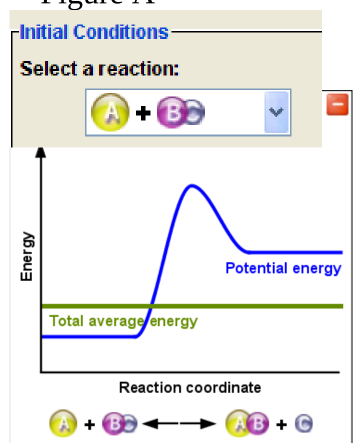
8. If you wanted to optimize the final ratio of B volume to A volume, without changing the cycle definition "***using the 100ml beaker to take from A and the 50ml beaker to take from B"*** how might you change the experimental design?

PART B: Done for homework; may be done with your partner from PART A

1. Open **Reaction and Rates,** using the Rate Experiments tab, design experiments and provide evidence to answer the following. Use the default reaction as shown in Figure A.

   a. With the water exchange experiment, Beaker A water represented reactants and Beaker B represented the products; how does this chemical reaction sim compare?
   b. How do you know when equilibrium has been reached?
   c. How does changing the initial amounts of the reactants affect the amount of product?
   d. How does changing the initial temperature of the reactants affect the amount of product?

Figure A



2. Each team will be assigned one of the other reactions to test. Be prepared to share your results with the class.