Lesson plan for *Reactions and Rates* 3*:* **Equilibrium** Introduction

(Macroscopic Description, Q, Temperature, and Reaction Coordinate)

Time for activity: 90 minutes of class and some homework

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. *(Amounts of chemicals, temperature which also effects K)*
- Predict how the shape of the reaction coordinate will affect the equilibrium amounts of reactants and products.

Background:

Reactions and Rates activity 1 was done in September, #2 was done in December, 3 and 4 will be done in the same unit in March.

I used Amy Jordan's activity http://phet.colorado.edu/en/contributions/view/3055 in 2009 and decided to make some changes based on my students' comments. One thing that my students said are that they wished they had more time to explore with the water exchange equilibrium and that they felt that they could do the PhET part for homework, so I put the water experiments first. This version is a combination of Amy's lab and my changes to the PhET directions.

Amy Jordan wrote to me after she used her activity: "*I think it was successful in working through the students' misconceptions about equilibrium, and how temperature affects equilibrium position. For one thing, almost all students predicted that when temperature was raised to above the activation energy bump, there would be all product and no reactants left---then they learned that temperature does affect equilibrium position, but not in the way they thought!"*

Reactions and Rates **Introduction:** My students had used the simulation and did not need help figuring out how to use the third panel. They commented that the PhET part could be done outside of class. The simulation is meant for qualitative concept development. There is much variation in values because of the small number of particles. I experimented with just using different amounts of reactants only and only 2 temperatures (the default and a value that would be just above the activation energy). The results give qualitative data that supports literature expectations. If you want to get quantitative values for the equilibrium constant, K, use the simulation called *Salts and Solubility*; the data for K_{sp} are easily verified in solubility tables.

Lesson:

There is an experiment that precedes the use of the simulation. After Part A Step 4, I think it would be helpful to talk to students about whether they think this situation represents a new type of reaction or just new initial conditions. I think that some students thought that the new conditions represented a new reaction coordinate partly because they used the sim before they did the lab. I have not decided how to best address question 8, but I think we should at least have a class discussion about that there could be a way to optimize the initial conditions.

For Part B, question 2, I will assign groups different reactions (one reaction per group) and we will share our results on another day. I hope to arrange for this to happen in class if I can get the computer lab.

Post-Lesson: There are some clicker questions.