Lesson plan for *Reactions and Rates* 2: Introduction to Reaction Kinetics with Single Collisions Revised for College Chemistry

Background: I teach a dual credit chemistry course using Chemistry 6th Edition Zumdahl Houghton Mifflin, NY, 2003. The students in my class are taking their first high school chemistry course and receive credit for the first semester of college chemistry and credit for the corresponding lab. I used this lesson as part of introduction to spontaneity. Originally, this was 2 lessons, but I discovered that the students learned more from the first activity than I expected, so I took out some steps. I have written another activity (still called # 4) using the *Reactions and Rates* simulation to be used in the Kinetics unit second semester along with two *Soluble Salt* activities (3 and 4 in the series of 5).

Learning Goals for activity 2 Introduction to reaction kinetics with Single collisions**:** Students will be able to:

- Describe how the **reaction coordinate** can be used to predict whether a reaction will proceed including how the potential energy of the system changes.
- Describe what affects the potential energy of the particles and how that relates to the energy graph. *Answer: distance and type of particle*
- Describe how the reaction coordinate can be used to predict whether a reaction will proceed **slowly, quickly or not at all**.
- Use the potential energy diagram to determine:
    - The *approximate* activation energy for the forward and reverse reactions.
    - The *sign* difference in energy between reactants and products.
- Draw a potential energy diagram from the energies of reactants and products and activation energy.

***Reactions and Rates* Introduction:** I did have to remind many students to select "view" to display the graphs on the right side which they need to fully meet the goals.

Lesson for Activity 2:
Demonstration**:** Mix solutions of iron (III) nitrate and sodium thiocyanide. This is nice because it forms a complex instead of a precipitate

My students work in pairs and use the lab sheet for guidance. I predict that it will be important to check that the students discover that the shooter can be used to get low energy and they may have trouble understanding the difference between potential and total energy. The activity took most of my college chemistry students one 50 minute period, but some had to finish outside of classtime.

First panel, Single Collision

1. Students will describe on a microscopic level, what contributes to a successful reaction. (Include illustrations)

    - Make sure your students pull the shooter a variety of distances and change the angle
    - Reactions are the result of collisions between molecules. Whether a collision leads to products or not is determined by both the speed (energy) and angle of the collision. It may be difficult for the students to see the effect of the angle, but if you have the

shooter on an angle and pull it out so that the Total energy is above the activation energy, the collisions produce a reactant only if the angle is appropriate.
- Reactions are reversible and they can experiment forward and reverse by selecting a different species to shoot.
- Students may describe things they discover about the reaction coordinate here too. See the note in #3

2. Describe how the reaction coordinate can be used to predict whether a reaction will proceed including how the potential energy of the system changes.

- Based on the reaction coordinate and the energy of the reactants, students should be able to predict if a collision with a given energy will lead to products.
- For reactants that do not have enough energy to react, students should be able to propose how they could make the reaction happen through changes in temperature or use of a catalyst. They can't add anything that looks like a catalyst, but they can change the activation energy by selecting Design your Own. Alternately, in order to stop a reaction from happening, they could propose how they could slow down or stop the reaction through changes in temperature or use of a catalyst.
- Reactions can proceed at lower temperatures if the activation energy is lowered. In a real reaction, this is done with catalyst.
- For the reaction to occur, reactant molecules must have sufficient energy to overcome the activation energy. Heating and cooling molecules will change their energy, and as a result will change the probability of successful collisions.

3. Students will use the potential energy diagram to determine
    1. The activation energy for the forward and reverse reactions,
    2. The difference in energy between reactants and products.
    3. The relative potential energies of the molecules at different positions on a reaction coordinate
- Number 1 and 2 are traditionally in texts and there are usually practice problems. For number 3, students can observe how the distance between the molecules relates to the reaction coordinate. As the particles get close together, the energy increases. This is usually illustrated in texts as well.

5. Students will draw a potential energy diagram from the energies of reactants and products and activation energy.

- The reaction coordinate shows how potential energy changes with the separation of reactants and products.
- The reaction coordinate shows the relative potential energies of the reactants, products, and the transition state.
- Different chemical reactions will have different reaction coordinates.