Lesson Summary

This lesson has three activities. Using the analogy of a board game, students will be introduced to the concept of reaction pathways. The teacher will introduce a CCC simulation to demonstrate how to create a graph using concentrations taken before, during, and after a reaction. Students will discover how to use the slope of the line to determine the rate of the reaction. Students will then work independently in small groups with a CCC simulation to produce a graph of concentrations and determine slope for a new reaction.

SWBAT (Student will be able to)

- Define what the reaction pathway is
- Identify the stages of the reaction pathway
- Use concentration values to identify the rate of the reaction from calculating the slope
- Indicate what a positive or negative slope indicates about a reaction

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in **bold**. Additional words that will expand your scientific vocabulary are in *italics.*
CCC Reminder

- Students and teachers from many different schools helped to design CCC so that the lessons are more helpful and meaningful for all classroom participants.

- Concentration in this unit refers to the molarity (M) of a substance. Brackets (e.g., [NaCl]) around a substance means the lesson requires the concentration of the substance.

- If you have forgotten how to calculate molarity, make sure to look back for your notes in the solutions unit or get help from your teacher.

- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.

- Draw a key when you are sketching. Keys can help you and others decode your sketches at a later time.

- There is a periodic table and list of common elements used in the back of this book. You will need to refer to the periodic table often.

Notes

Homework

Upcoming Quizzes/Tests
Activity 1: Connecting

While playing a board game, players must engage in a series of steps and meet certain conditions to win. Some actions can slow a player down, while other actions can help the player win faster. In some ways, chemical reactions are similar to a board game. A chemical reaction requires a specific series of steps or conditions for reactants to become products. The time a reaction takes to reach completion varies and depends on the steps involved and the conditions of the system.

A reaction pathway is the sequence of steps a reaction undergoes as a reactant transforms into products. The reaction pathway can be shown using a potential energy diagram that is shown below. The ‘Reaction Pathway’ axis refers to the sequence of steps a reaction takes and does not directly represent time. Recall that the time it takes for a reaction to proceed along the chemical pathway from reactions to products is called the reaction rate and is measured as the change in reactant concentration over time. Reaction rates vary widely. Some reactions, such as lighting a match, take less than a microsecond to complete. Other reactions, such as the conversion of dead plants and animals into fossil fuels, take thousands of years to complete.

On the macroscopic level, chemical reactions may be seen as observable changes in the reactants. For instance, we might see a fast explosion from a firecracker, a formation of bubbles from an acid and a base mixture, or a few spots of rust developing on a piece of iron. At the macroscopic level, we observe substances as they transform into new substances.

On the submicroscopic level, these transformations result from collisions between the reactant molecules. These collisions may break chemical bonds or form new chemical bonds to generate products. However, not all collisions produce reactions. Sometimes reactants collide and just bounce off each other without reacting because there is not enough kinetic energy to break or form bonds. A minimum amount of kinetic energy is needed for reactants to collide and produce a reaction. This minimum
energy is called **activation energy**. With this minimum energy, the reactants enter a temporary **transition state** and continue to reform into new products. When reactants do collide with sufficient energy, **chemical potential energy** in the reactants is converted into usable and unusable kinetic energy. Although sufficient energy may be available to place reactants into the transition state, the reaction will only occur under the correct conditions.

1. If the correct conditions are not met or if no activation energy is available, what do you think happens to a chemical reaction?

2. At the completion of a reaction pathway for a specific reaction, the concentration of reactants **increases** or **decreases** (circle one) and the concentration of products **increases** or **decreases** (circle one). Support your claims with evidence.

3. While the reaction pathway and rates may vary in a chemical reaction, the total mass of matter before and after the reaction does not change. **True** or **False** (circle one). Support your claims with evidence.
Activity 2: Demonstration of Chemical Kinetics

Simulation

Use Simulation 1, Set 1

Using the simulation, your teacher will demonstrate the reaction pathway of a given reaction. Create an initial sketch of the reaction showing the reactants. Record data from the monitors and write down your observations.

- Your teacher will run the simulation for 15 seconds and then pause. Record data from the monitors and write down your observations.
- Your teacher will restart the simulation and run the simulation for another 15 seconds.
- Create a final sketch of the products. Record data from the monitors and write down your observations.

Use the data to create a graph of concentration [M] vs. time (s). Create a key to distinguish between different substances. Include all appropriate labels. Additional graph paper can be found on pages 66-67 if needed.
### Submicroscopic Sketch

#### Observations

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#### Key

#### Graph
The rate of change in the concentrations of the reactants and products can be used to determine the reaction rate. Similar to the graphs you constructed, the reaction rate corresponds to the slope of any function plotted on a concentration versus time graph. For help and examples on calculating slopes see Appendix (page 68).

4. Is the slope the same for each substance that you plotted? *Support your claim with evidence.*

5. What is the sign of the slope for each of the reactants? Why?

6. What is the sign of the slope for the product? Why?

7. Steeper slopes correspond to slower or faster *(circle one)* reactions. *Support your claim with evidence.*
8. If the slope line of the line representing the change of products over time is not steep, this would indicate that the reaction is slower or faster (circle one) Support your claim with evidence.

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9. Based on your sketches, how do you know if the reaction has completely reacted?
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10. Based on sketches, from the simulation which reactant is being used up more quickly? Support your claim with evidence.
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Activity 3: Simulating the Reaction Pathway

Simulation

Use Simulation 1, Set 2

- Using the simulation, create an initial sketch of the system showing the reactants, record data from monitors, and write down your observations.
- Run the simulation for 15 seconds and then pause.
- Record data from the monitors and write down your observations.
- Restart the simulation and run it for another 15 seconds and then pause.
- Create a final sketch of the products.
- Record data from monitors and write down your observations.
- Use the data to create a graph of time vs. concentration [M] (Y). Additional graph paper can be found on pages 66-67 if needed.
- Create a key for the graph to distinguish between different substances. Include all other appropriate labels.

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**Key**

**Graph**
11. Is the slope the same for all of the products and reactants?

12. Describe how the sign of the slope of the line is related to whether the substance is a reactant or product.

13. Is this decomposition reaction faster or slower than the reaction demonstration? Explain your answer using evidence from the simulation. How would this be represented graphically?

Lesson Reflection Question

14. Consider the following scenario: During a specific chemical reaction, the concentration of reactant is found to decrease as the concentration of product is found to increase over a 5 minute period. After five minutes the concentration of both the reactant and product remain constant. Three students discuss what this data means. Student A says that the reaction has stopped and that is why the concentration has not changed. Student B says that the reaction has stopped because of a limiting reactant. Student C says that the reaction did not stop but that the products are turning back into reactants at the same rate as the reactants are turning into products. Explain which student’s description you agree with the most and provide evidence for your answer.