21. Varying Reaction Rates

How Fast Will it Fizz?

Driving Question

How do different temperatures affect the rate of a chemical reaction?

Materials and Equipment

For each student or group:

- ☐ Data collection system
- ☐ Temperature sensor, fast response
- ☐ Graduated cylinder, 100-mL
- ☐ Alka-Seltzer® tablets
- ☐ Stopwatch
- ☐ Clear plastic cups or beakers (3), 300-mL (10 oz)
- ☐ Spoon or stirring stick
- ☐ Warm water
- ☐ Ice water

Safety

Add these important safety precautions to your normal laboratory procedures:

- Handle glassware carefully.
- Do not use water hotter than 40 °C.

Thinking about the Question

If you have ever helped your family to prepare a meal or if you have ever baked, then you are familiar with changes in the rates of chemical reactions. There are many examples of changes in *reaction rates* in our daily lives, and some of the most easily observed changes happen in cooking. An egg cooks faster in a hotter pan. Bread dough rises more quickly in a warm place than in a cool one.

If you have had a glow-in-the-dark light stick before, such as the kind worn at concerts, you might have heard that putting the used light sticks in the freezer will help make them last longer. Such light sticks work by producing light through a chemical reaction. Placing a light stick into hot water makes it glow more intensely, showing that the reaction runs faster at a higher temperature. Placing it in the freezer slows down the rate of reaction.

The rate of a chemical reaction is the time required for a given quantity of *reactants* to be changed to *products*.

Can you think of other chemical reactions in which rates are affected by changes in temperature? Discuss with the members of your group a general rule that relates temperature to reaction rate.

Sequencing Challenge

☐ **The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.**

○	○	○	○	○
Make sure each lab group member is aware of safety rules and procedures for this lab.	Gather the necessary equipment and materials, or check to see that they have been provided to your group.	Fill a cup or beaker with 200 mL of warm tap water.	Drop the Alka-Seltzer tablet into the cup or beaker of water.	Begin recording the first run of temperature data.

Investigating the Question

☐ **Note:** When you see the symbol "**[2]**" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Part 1 – Making predictions

1. ☐ Predict what the reaction rate will be for a chemical reaction that occurs at room temperature.

2. ☐ Predict what the reaction rate will be for the same type of chemical reaction that occurs at a temperature close to freezing (ice-cold water).

Part 2 – What is the effect of warm temperature on reaction rate?

Trial 1

3. ☐ Start a new experiment on the data collection system. ◆(1.2)

4. ☐ Fill a clear plastic cup or beaker with 200 mL of room temperature water.

5. ☐ Connect the temperature sensor to the data collection system. ◆(2.1)

6. ☐ Place the temperature sensor in the plastic cup or beaker.

7. ☐ Start recording the first run of temperature data. ◆(6.2)

8. ☐ Display Temperature on the y-axis of a graph with Time on the x-axis. ◆(7.1.1)

9. ☐ Drop the Alka-Seltzer tablet into the water at the same time that you start the stopwatch. If you are not using a stopwatch, note on your graph the exact time that you dropped the Alka-Seltzer tablet in the water.

10. ☐ Continue collecting data until the Alka-Seltzer tablet has completely finished fizzing. Immediately stop the stopwatch or note the exact time on your graph, and then stop recording the first run of data. ◆(6.2)

11. ☐ Why do you think it is important to note the time as exactly as possible?

_____

_____

12. ☐ Record the time it took for the Alka-Seltzer tablet to completely finish fizzing.

    Trial 1 _____ seconds

13. ☐ Pour out the water and dissolved Alka-Seltzer tablet, according to your teacher's instructions.

14. ☐ Rinse and refill the clear plastic cup or beaker with 200 mL of room temperature water.

Trial 2

15. ☐ Start recording a second run of temperature data. ◆(7.1.3)

16. ☐ Drop the Alka-Seltzer tablet into the water at the same time that you start the stopwatch. If you are not using a stopwatch, note on the graph the exact time that you dropped the Alka-Seltzer tablet in the water.

17. ☐ Continue collecting data until the Alka-Seltzer tablet is completely finished fizzing. Immediately stop the stopwatch or note the exact time on your graph of data, and then stop recording the second run of data. ◆(6.2)

18. ☐ Record the time it took for the Alka-Seltzer tablet to completely finish fizzing.

Trial 2 _____ seconds

19. ☐ What is the reason for repeating this trial and averaging the time? Why is this considered good experimental design?

_____

_____

_____

Part 3 – What is the effect of ice-cold temperature on reaction rate?

Trial 1

20. ☐ Fill a clear plastic cup or beaker with 200 mL of water. Add five ice cubes to the cup, stir to mix, and wait one minute. Measure exactly 200 mL of the chilled water into another cup or beaker.

21. ☐ Place the temperature sensor in the plastic cup or beaker.

22. ☐ Using the same graph as in Part 2, start recording the first run of temperature data. ◆(6.2) Note that this will be your third run of temperature data overall. You may choose to hide the previous runs of temperature data while you are conducting this part of the experiment. ◆(7.1.7)

23. ☐ Drop the Alka-Seltzer tablet into the water at the same time that you start the stopwatch, or note the exact time on the graph that you dropped the Alka-Seltzer tablet in the water.

24. ☐ Continue collecting data until the Alka-Seltzer tablet has completely finished fizzing. Immediately stop the stopwatch or note the exact time on your graph, and then stop recording data. ◆(6.2)

25. ☐ Record the time it took for the Alka-Seltzer tablet to completely finish fizzing.

Trial 1 _____ seconds

Trial 2

26. ☐ Again fill the clear plastic cup or beaker with 200 mL of water. Add five ice cubes to the cup, stir to mix, and wait one minute.

27. ☐ Rinse and refill the clear plastic cup or beaker from the reaction with 200 mL of the chilled water.

28. ☐ Start recording the second run of temperature data ◆(6.2) for the ice water. Note that this will be your fourth run of data overall.

29. ☐ Drop the Alka-Seltzer tablet into the water at the same time that you start the stopwatch, or note the exact time on the graph that you dropped the Alka-Seltzer tablet in the water.

30. ☐ Continue collecting data until the Alka-Seltzer tablet has completely finished fizzing. Immediately stop the stopwatch or note the exact time on your graph, and then stop recording the second run of data. ◆(6.2)

31. ☐ Record the time it took for the Alka-Seltzer tablet to completely finish fizzing.

Trial 2 _____ seconds

32. ☐ Save your experiment. ◆(11.1)

Answering the Question

Analysis

1. Determine the average temperature for the experiment you performed with warm water in Part 2 of the Investigating the Question section.

Average time to finish fizzing in warm water: _____ seconds

2. Determine the average temperature for the experiment you performed with ice-cold water in Part 3 of the Investigating the Question section.

Average time to finish fizzing in ice-cold water: _____ seconds

3. Review the average time needed for the Alka-Seltzer tablet to finish fizzing in each part. Using room temperature water, how many times faster is the reaction rate than with the ice-cold water?

4. How does temperature affect the rate of a chemical reaction?

_____

_____

_____

Multiple Choice

☐ **Circle the best answer or completion to each of the questions or incomplete statements below.**

1. Rate of reaction:

   A. A measure of how fast a reaction occurs
   B. An equation showing the products and reactants of a chemical reaction
   C. A chemical reaction changes reactants into new products with new properties
   D. An element or compound that enters into a chemical reaction

2. Liquid:

   A. A state of matter that has no fixed shape but that has a definite volume
   B. The process where reactants change to form products
   C. Formulas and symbols are used to show what happens during a chemical reaction
   D. One of the original substances before a chemical reaction takes place

3. Product:

   A. Matter that has a definite shape and takes up a definite amount of space
   B. A substance that undergoes a chemical reaction, often by combining with another substance.
   C. An expression in which symbols, formulas, and numbers are used to represent a chemical reaction
   D. A substance formed by a chemical reaction

4. Solid:

   A. A state or phase of matter in which a substance has no definite shape or volume
   B. A process in which one or more substances are changed into others, including color or temperature changes or bubbles being formed
   C. A state of matter that has a definite shape and a definite volume
   D. Matter with no definite shape but with a definite volume

5. Reactant:

   A. The process where substances change to form products
   B. Element or compound that enters into a chemical reaction
   C. A measure of how fast a reaction occurs
   D. An equation showing the products and reactants of a chemical reaction

6. Reaction:

   A. Matter that has a definite shape and takes up a definite amount of space
   B. A chemical process changes reactants into new products with new properties
   C. An element or compound that enters into a chemical reaction
   D. A state of matter that has no fixed shape but that has a definite volume

7. Chemical equation:

   A. A substance formed by a chemical reaction
   B. A state of matter that has no fixed shape but that has a definite volume
   C. A chemical reaction changes reactants into new products with new properties
   D. Formulas and symbols are used to show what happens during a chemical reaction

8. Gas:

   A. A state or phase of matter in which a substance has a definite volume but no definite shape
   B. A description of a chemical reaction using chemical symbols and formulas to represent reactants and products
   C. A substance that undergoes a chemical reaction, often by combining with another substance
   D. A state or phase of matter in which a substance has no definite shape or volume

Key Term Challenge

☐ **Fill in the blanks from the randomly ordered words below.**

gas	product	solid	reaction
liquid	a chemical reaction	reaction rate	reactant

1. Iron and oxygen change into iron oxide during a chemical _____.

2. The rate of _____ is the time required for a given quantity of reactants to be changed to products.

3. Matter can be a _____, a liquid, or a gas.

4. Carbon dioxide is a _____ of the chemical reaction between vinegar and baking soda.

5. The phase of matter that carbon dioxide is usually found as is a _____.

6. A _____ takes on the shape of its container.