Lab: Plop, Fizz: How to Affect the Rate of a Chemical Reaction

FOR THE TEACHER

Summary
In this lab, students will react Alka-Seltzer tablets with water. By varying the temperature of the water, particle size of the Alka-Seltzer, and concentration of the Alka-Seltzer they can see the effect on the rate and strength of the chemical reaction.

Grade Level
Middle/High school

Objectives
By the end of this lab, students should be able to
- understand how changes in temperature, surface area, and concentration can affect the reaction rate.
- make predictions based on the data collected during the experiment.

Chemistry Topics
- Chemical Reactions
- Reaction Rates

Time
Teacher Preparation: 30 minutes
Lesson: One 60 minutes class period (a second period could be used if doing the extension activities)

Materials
For the class:
- A large container of room temperature water
- A large container of hot water
- A large container of cold (ice) water

For each lab group:
- One 400 mL beaker
- One mortar and pestle
- 8 Alka-Seltzer tablets
- One thermometer
- One stopwatch or timer
- One cell phone/iPad/computer camera (optional)

Safety
- Always wear safety goggles when using chemicals in the lab.
- The final solutions may be discarded into the sink.
- When students complete the lab, instruct them how to clean up their materials.
- Students should wash their hands thoroughly before leaving the lab.
Teacher Notes

- This lab is designed for the students to work in pairs or groups of three.
- The teacher may need to demonstrate how to properly use a mortar and pestle.
- The teacher should demonstrate or show pictures/video of reactions in order to prepare students for how to determine the rating of the strength of a chemical reaction. This could be done with a quick demonstration using vinegar and baking soda.
- During the lab, the students could take a picture or video of the reactions to help them compare and rate the strengths of the various reactions.
- Generic brand antacid effervescent tablets can be substituted for Alka-Seltzer tablets.
- This activity connects well with the Reaction Rate activity in the AACT library.

Extension:

1. Using the three reaction rate variables, design a way to create the fastest and most vigorous reaction. Describe your method.
2. Using the three reaction rate variables, design a way to create the slowest and least vigorous reaction. Describe your method.
3. Using the three reaction rate variables, design a way to create a relatively slow and moderately vigorous reaction. Describe your method.

Try each of your ideas and share your results with the class.

FOR THE STUDENT

Plop, Fizz: How to Affect the Rate of a Chemical Reaction

Background
A chemical reaction is a process where one or more substances (reactants) are chemically changed into one or more new substances (products). In industry, companies try to control the rate of chemical reactions to make them useful and safe. There are several ways to affect how quickly the reaction occurs. We will investigate three of these factors: temperature, particle size (surface area), and the amount of the reactants (concentration).

Problem
How do temperature, surface area, and concentration affect the rate of a chemical reaction?

Prelab Questions

1. What affect do you think increasing the temperature of one of the reactants will have on the rate of the chemical reaction? Why do you think this?

2. What affect do you think increasing the surface area (decreasing the particle size) of one of the reactants will have on the rate of the chemical reaction? Why do you think this?
3. What affect do you think increasing the concentration (how much) of one of the reactants will have on the rate of the chemical reaction? Why do you think this?

Materials
- Room temperature water
- Hot water
- Cold (ice) water
- One 400 mL beaker
- One mortar and pestle
- 8 Alka-Seltzer tablets
- One thermometer
- One stopwatch or timer
- Cell phone camera (optional)

Safety
- Always wear safety goggles when using chemicals in the lab.
- The final solutions may be discarded into the sink.
- Follow teacher instructions for how to clean up your materials.
- Wash your hands thoroughly before leaving the lab.

Procedure
The Effect of Temperature:
1. Pour 300mL of room temperature water into the 400mL beaker. This will be your control.
2. Place the thermometer into the center of the water.
3. Once the temperature reading stabilizes, record the temperature in the data table below.
4. Get ready to start the stopwatch/timer.
5. Start the timer as you drop one Alka-Seltzer tablet into the water.
6. Time how long it takes the tablet to finish visibly reacting with the water.
7. Record the time (in seconds) in the data table below.
8. Also rate the strength of the reaction on a scale of 0 – 5, with 0 being no reaction and 5 being a reaction that would overflow the beaker. You may use a camera to photograph or record a video of the reaction to help in your decision.
9. Record the strength of the reaction in the data table below.
10. Rinse out the beaker thoroughly with water.
11. Repeat steps 1 – 10 with the cold water.
12. Repeat steps 1 – 10 with the hot water.

The Effect of Surface Area:
1. Pour 300mL of room temperature water into the 400 L beaker.
2. Take one Alka-Seltzer tablet and place it in the mortar.
3. Use the pestle to crush the tablet into a fine powder.
4. Get ready to start the stopwatch/timer.
5. Start the timer as you pour the crushed Alka-Seltzer tablet from the mortar into the water.
6. Time how long it takes the tablet to finish visibly reacting with the water.
7. Record the time (in seconds) in the data table below.
8. Also rate the strength of the reaction on a scale of 0 – 5, with 0 being no reaction and 5 being a reaction that would overflow the beaker. You may use a camera to photo or record a video of the reaction to help in your decision.
9. Record the strength of the reaction in the data table below.
10. Rinse out the beaker thoroughly with water.
11. Repeat steps 1 – 10 but use the mortar and pestle to crush the tablet into larger sized pieces.
12. Repeat steps 1 – 10 with one uncrushed tablet (this is the control).

The Effect of Concentration:
1. Pour 300mL of room temperature water into the 400mL beaker.
2. Break one Alka-Seltzer tablet in half.
3. Break one of the half tablets in half again to make it a quarter of a tablet.
4. Get ready to start the stopwatch/timer.
5. Start the timer as you drop the quarter tablet into the water.
6. Time how long it takes the tablet to finish visibly reacting with the water.
7. Record the time (in seconds) in the data table below.
8. Also rate the strength of the reaction on a scale of 0 – 5, with 0 being no reaction and 5 being a reaction that would overflow the beaker. You may use a camera to photo or record a video of the reaction to help in your decision.
9. Record the strength of the reaction in the data table below.
10. Rinse out the beaker thoroughly with water.
11. Repeat steps 1 – 10 with the half tablet.
12. Repeat steps 1 – 10 with the whole tablet (this is the control).

**Data**

The Effect of Temperature:

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Time (seconds)</th>
<th>Strength Rating (0 – 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Effect of Surface Area:

<table>
<thead>
<tr>
<th>Surface Area</th>
<th>Time (seconds)</th>
<th>Strength Rating (0 – 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Powder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Larger Pieces</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Effect of Concentration:

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Time (seconds)</th>
<th>Strength Rating (0 – 5)</th>
</tr>
</thead>
</table>
1. On graph paper, make a **line graph** of the temperature vs. time. The x-axis should be temperature while the y-axis should be time.

2. On graph paper, make a **bar graph** of the temperature vs. strength. The x-axis should be temperature while the y-axis should be strength.

3. On graph paper, make a **bar graph** of the surface area vs. time. The x-axis should be surface area while the y-axis should be time.

4. On graph paper, make a **bar graph** of the surface area vs. strength. The x-axis should be surface area while the y-axis should be strength.

5. On graph paper, make a **line graph** of the concentration vs. time. The x-axis should be concentration while the y-axis should be time.

6. On graph paper, make a **bar graph** of the concentration vs. strength. The x-axis should be temperature while the y-axis should be strength.

**Analysis**
Write an analysis for each of the variables that we investigated. Write your analysis in paragraph form using the CER format by making a **claim** (C) and supporting the claim with **evidence** (E) from your observations, data tables, and graphs, as well as **reasoning** what you know about chemical reactions (R).

**Temperature:**

**Surface Area:**

**Concentration:**

**Conclusion**
1. Using the temperature data and graph, explain how you can predict the reaction rate of a temperature that is between what you tested and the room temperature water. Use actual temperature values and times in your explanation.

2. Using the concentration data and graph, explain how you can predict the reaction rate of a concentration that is different than what was tested. Use actual concentration amounts and times in your explanation.