**Hot, hot, fizz, fizz:**

**How are reaction rate and volume of gas produced affected by temperature?**

**Example Student Paper (Put your name)**

**Put your grade**

**2013-2014**

**Abstract**

This experiment investigated what the effect of temperature of water was on the rate of the chemical reaction of Alka-Seltzer tablets and water. The relationship between the reaction rate and the volume of gas product produced was also examined. Water temperatures of 10°C, 25°C, 40°C and 55°C were studied. The end of the reaction was considered when there were no more bubbles formed. The carbon dioxide gas was collected over water in a plastic bottle to determine the volume. The results showed that as the water temperature increases, there is a consistent decrease in the reaction time. This decrease in reaction time corresponds to a faster reaction rate. The volume of gas produced with the different temperatures did not change very much throughout the experiment. This suggests that the amount of gas produced is not affected by the temperature of the water or the reaction rate. Therefore, the results support the idea that if reactions are left to finish, the slower reactions will still make the same amount of gas product as the faster reactions. Further investigations with other types of chemical reactions and other factors that can increase the rate of a chemical reaction would be needed to support this with more evidence.

* The abstract is the last part of the project report to be written. It is written after the project is completed.
* It is a short (150-250 word) summary of your project that informs the reader what the project covered, and what has been accomplished.
* Making every word count is very important when you are completing an abstract.
* **An abstract should include:**
* A statement of purpose or a hypothesis.
* The experimental design, descriptive outline of the procedures or methods.
* A summary of results.
* Your conclusion.
* Application of the research project, if you have space, and your ideas for future studies.

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**(You will want to separate your sections onto different pages – I put them together to decrease the number of pages to print.)**

**Purpose**

 Chemical reactions occur at different rates depending on conditions. The purpose of this experiment is to determine if temperature has an effect on the reaction rate of a chemical reaction. If a chemical reaction that produces a gas is faster under certain conditions, will more gas be produced when the reaction rate is faster? How does the temperature of the water affect the rate of the reaction of Alka-Seltzer and water and the volume of the carbon dioxide produced? I decided to investigate this because… **(Then you can include your rationale and reasons behind choosing your topic and designing your experiment.)**

**Variables**

**Independent variable**

The independent variable is the temperature of the distilled water.

**Dependent variables**

The dependent variables are the reaction time and the volume of carbon dioxide produced.

**Controlled variables (constants)**

The factors kept constant in this experiment are the volume of water, the type of distilled water, the size of the bottles, the type of bottle, the age of the Alka-Seltzer tablet, the type of Alka-Seltzer tablet.

**Hypothesis**

 If Alka-Seltzer tablets are reacted with different temperatures of water, then the hottest water temperature will result in the fastest reaction. The faster reaction will also result in the largest volume of carbon dioxide released. Since the molecules need to come into contact in order to react, the higher temperature should allow the substances in the Alka-Seltzer to react faster.

**Background**

**Chemical reactions**

 A chemical reaction occurs when two or more substances come in contact and something happens. This thing that happens may be a temperature change, a color change, a state change or other observable differences between the starting and ending materials (Andrew Rader Studios, 2011). Many different chemical reactions occur every day. Examples are things like a silver spoon tarnishing, an iron bar rusting, a fuel burning or an antacid neutralizing stomach acid (Chemtutor, 2011).

 The overall reaction of Alka-Seltzer and water is well-known and has been explained well with its early jingle “Plop, plop, fizz, fizz” (Bayer Healthcare, 2011). However, what is the chemical reaction that occurs as the tablet fizzes in the water? Alka-Seltzer tablets contain sodium bicarbonate and citric acid as a solid. Sodium bicarbonate is a weak base and citric acid is a weak acid. The reaction below occurs as the two solids are dissolved in water (Senese, F., 2010).

Sodium bicarbonate + citric acid 🡪 sodium citrate + carbon dioxide + water

The gas that is observed coming off of the reaction is carbon dioxide. This creates the fizz (Bayer Healthcare, 2011). This reaction of an acid and a base is called a neutralization reaction (Andrew Rader Studios, 2011).

***(This is a shortened background section. Yours should be 2 or more pages. Remember, you want to cover the background scientific information that is the basis of your project. You also would want to include what is already known about your topic. You can see example topics for this example project in the Table of Contents.)***

**Materials**

* Distilled water
* Alka seltzer tablets (20)
* Rubber stopper with hole drilled through it
* Rigid plastic tubing (about 10 cm long) that fits snugly in rubber stopper
* Flexible plastic tubing that fits snugly over rigid tubing
* 500mL plastic water bottle
* Thermometer (measures -20 to 110 °C)
* 2 L plastic soda bottle
* Bucket
* Stop watch
* Graduated cylinder

**Procedure**

1. Safety precautions:
* Adult supervision is required since the contents of the bottle are under pressure and hot water is used.
* Wear goggles since using chemicals and contents are under pressure.
* Be careful with heated water and use hot mitts if necessary.
1. Procedure:
2. Wash plastic bottles thoroughly and rinse them with distilled water.
3. Fill the bucket half way with tap water.
4. Fill the 2 liter soda bottle to the top with tap water.
5. Put hand over the opening to the bottle and invert into the water in the bucket. There should be no bubbles. If bubbles are in the bottle, repeat until the 2 liter bottle is inverted and has only water in it.
6. Measure 120mL of distilled, room temperature, water into a clean 500mL water bottle.
7. Take the temperature of the water. Adjust the temperature with warm and cold water so that it reads 25°C.
8. Put the rigid plastic tubing through the rubber stopper and attach the flexible tubing as shown in Figure 1.



1. The flexible tubing should be in the open mouth of the 2L bottle. The whole assembly should look like in Figure 2.



1. Place the alka seltzer into the mouth of the 500mL bottle being careful not to let it fall into the water.
2. Push the stopper into the bottle securely.
3. Have an assistant ready to start and stop the stop watch when the reaction starts and ends.
4. Straighten bottle and allow alka seltzer to react.
5. Record the time from the alka seltzer going into the water until there are no more bubbles formed.
6. Once the reaction has stopped, carefully mark a line on the 2L bottle showing the level of the gas produced.
7. Using the graduated cylinder, find the volume of water that fits into the bottom of the 2 liter bottle. Record the volume.
8. Repeat steps 1-15 for 4 more trials at 25°C.
9. Then repeat the experiment for 3 other temperatures (10°C, 40°C, 55°C).

**Data, Analysis and Discussion**

**Table 1: Mean Reaction times**

|  |  |
| --- | --- |
| **Temperature** | **Mean** |
| **10°C** | **231 s** |
| **25°C** | **129 s** |
| **40°C** | **74 s** |
| **55°C** | **47 s** |

**Table 2: Mean Volume of carbon dioxide produced**

|  |  |
| --- | --- |
| **Temperature** | **Mean** |
| **10°C** | **255mL** |
| **25°C** | **265 mL** |
| **40°C** | **267 mL** |
| **55°C** | **253 mL** |

**Graph 1: The effect of temperature on reaction time**

**Graph 2: The effect of temperature on the volume of carbon dioxide produced.**

****

**Discussion**

 When the mean reaction times are graphed against the temperature of the water, there is a definite trend showing that the reaction time decreases as the temperature increases. Since short reaction times correspond to faster reaction rates, this means that as the temperature increases, the reaction rate increases as well.

 When the mean volumes are graphed against the temperature of the water, a dramatic difference does not appear among the different temperatures. The individual values from the data table also show a similar overall spread of values with the lowest value being 240mL and the highest value being 280mL.

***(You would continue your discussion in this way. You may also have calculations that need to be explained. The mean is just one way to describe averages, it may be more appropriate for you to look at other trends in your data. I’m here to help with this – so please let me know if you have questions!)***

**Conclusion**

 The data collected during this experiment supported the hypothesis that stated that the rate of the reaction would increase with increasing temperature. However, the data did not support the hypothesis that stated that the volume of gas produced in the reaction would be more with a faster reaction. The range of results was small among the different trials and the experiment was able to test each hypothesis.

 Since molecules move faster when they are heated, it makes sense that the reaction rate is faster with the higher temperature. Even though the different temperatures had different reaction rates, they ended up producing about the same amount of gas in the end. It appears that the time it takes the reaction to go does not affect the amount of product formed. Further research could be conducted to test other types of chemical reactions and other factors besides temperature that can speed up a chemical reaction.

***(You would continue your conclusion in this way. Use the questions below to help you think of things to discuss. These questions should not limit you, they are just some ideas.)***

*Here are some questions to think about when forming the conclusion. These may not all apply to your project, but may get you thinking in the right direction.*

* Did you collect enough data? Do you need to collect more data?
* Were your variables and control properly designated?
* Which variables are important?
* How do your results compare with other studies? (Refer to your background information)
* Do your results seem reasonable?
* Are there any trends in your data?
* What might explain these trends?
* How might the results of your work be relevant to society or to other scientists working in your field?
* Do you need to do more experimentation?
* Do your results support your hypothesis? If not, why not? Has your experiment tested your hypothesis?
* What recommendations would you give for someone doing a similar experiment?
* Are there changes that should be made to the procedure?
* What further studies could be conducted that are related to this one?

**Acknowledgements**

 I would like to thank both of my parents for helping me to get all of the materials I needed for my experiment and for their support with each stage of my project. I’d also like to thank my little brother Jason for acting as my lab assistant through all of the trials.

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**Appendix A**

Experimental data

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Temperature** | **Trial 1** | **Trial 2** | **Trial 3** | **Trial 4** |
| **10°C** | 245 s | 260 s | 220 s | 200 s |
| **25°C** | 120 s | 125 s | 137 s | 133 s |
| **40°C** | 70 s | 74 s | 78 s | 73 s |
| **55°C** | 46 s | 50 s | 53 s | 40 s |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Temperature** | **Trial 1** | **Trial 2** | **Trial 3** | **Trial 4** |
| **10°C** | 255 mL | 270 mL | 245 mL | 250 mL |
| **25°C** | 270 mL | 260 mL | 280 mL | 250 mL |
| **40°C** | 260 mL | 255 mL | 280 mL | 276 mL |
| **55°C** | 240 mL | 250 mL | 280 mL | 245 mL |