Factors Affecting Reaction Rates

Introduction:
The quick boom and flashes of fireworks and the slow rusting of iron and corrosion of copper are all chemical reactions. The study of chemical kinetics centers on the reason for the different rates at which chemical reactions occur. The primary theory behind chemical kinetics is the collision theory. According to this theory, reactant molecules must collide with enough force to achieve activation energy before a reaction can occur. Activation energy is the minimum amount of energy needed to break the chemical bonds of reactant molecules such that they form new products. While molecules collide continuously (according to the kinetic molecular theory), only those that meet or exceed their activation energy and collide in a favorable orientation will form new products with new bonds.

Objective:
The rate of chemical reactions can be influenced by different factors. The purpose of this lab is to investigate and learn what factors affect reaction rates.

PreLab Questions:
1) What is activation energy?
2) As described in the above introduction, what are the TWO requirements for a reaction to take place?
3) What are some examples of reactions that people may wish to speed up or slow down?
4) In each of the following three examples, make drawings (and label drawings) to explain how the molecules differ in the two items described:
   a. Water at 70°C and water at 40°C
   b. 5 M glucose and 6 M glucose
   c. a 64 cm³ cube of sugar and a 2 x 8 x 4 cm prism of sugar

Materials:
0.05 M potassium iodide        24-well micro plates        50 mL beakers
0.10 M hydrochloric acid       1 mL syringe             150 mL beakers
0.01 M sodium thiosulfate      Stop watch (stop watch app)    Scoopulas
0.001 M copper (II) sulfate    Labeled pipettes         Balance (±0.001g)
1% starch                      Hot plate                  Test tube tongs
3% hydrogen peroxide           Ice                       Test tubes (13x100)
Potassium iodide solid         Thermometer             10 mL graduates
Weigh boats/weigh paper         Mortar and pestle       DI or distilled water
Test Tube rack

Calibration Procedure:
1) Orient well plate so that there are 4 wells across and 6 down.
2) In the to left well, place 8 drops of KI
3) Add 2 drops of HCl to the same well
4) Add 4 drops of Na₂S₂O₃ to the same well.
5) Add 4 drops of starch to the solution in the well.
6) Swirl to mix
7) With the syringe draw up 0.4mL of the hydrogen peroxide.
8) As the hydrogen peroxide is added to the well, begin timing.
9) Swirl the plate and monitor the color.
10) Record the amount of time it takes for the entire solution to turn a dark blue-black color.
11) If the solution took more than approximates 20 seconds to turn, repeat above but this time with only 3 drops of Na₂S₂O₃ rather than 4. Continue trials reducing the Na₂S₂O₃ by 1 drop each time until it takes 20 seconds to turn.
12) If the solution took less than approximates 20 seconds to turn, repeat above but this time with only 6 drops of Na₂S₂O₃ rather than 6. Continue trials increasing the Na₂S₂O₃ by 2 drop each time until it takes 20 seconds to turn.
13) Once you hit approximately 20 seconds, no more trials are necessary
14) Record the number of drops of used to achieve the time. This number will be used in all subsequent experiments.

**Calibration Data Table:**

<table>
<thead>
<tr>
<th>Drops of Na$_2$S$_2$O$_3$ required in Calibration</th>
</tr>
</thead>
</table>

**Activity 1 Procedure:**

1) In the leftmost well of you plate, place 8 drops of KI.
2) Add 2 drops of HCl to the same well
3) Add the number of drops of Na$_2$S$_2$O$_3$ determined in the calibration.
4) Add 4 drops of starch.
5) Swirl the solution by moving the plate in small circles on the table.
6) With the syringe draw up 0.4mL of hydrogen peroxide
7) As the hydrogen peroxide is added to the solution in the well plate, begin timing.
8) Keep swirling and monitor color.
9) Record the amount of time it takes for the entire solution to turn a dark blue-black color.
10) Repeat steps 1-9 for trials 2-4 (one trial at a time) using amounts found in the data table below:

**Data Table 1:**

<table>
<thead>
<tr>
<th>KI drops</th>
<th>Distilled H$_2$O drops</th>
<th>HCl</th>
<th>Na$_2$S$_2$O$_3$ drops</th>
<th>Starch</th>
<th>H$_2$O$_2$</th>
<th>Time to turn color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>8</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>0.4 mL</td>
<td>**</td>
</tr>
<tr>
<td>Trial 2</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>0.4 mL</td>
<td>**</td>
</tr>
<tr>
<td>Trial 3</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>0.4 mL</td>
<td>**</td>
</tr>
<tr>
<td>Trial 4</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>0.4 mL</td>
<td>**</td>
</tr>
</tbody>
</table>

**Activity 2 Procedure:**

1) Prepare three water baths as follows (share baths with the group across from you)
   a. Room-temperature water bath – put water that has been sitting out into a 150 mL beaker. Directly before using it record the temperature of the bath into your data table.
   b. Hot water bath – heat water so that it is at least 20°C over room temperature. Directly before using it, record the temperature of the water into your data table.
   c. Cold water bath – half fill a beaker with ice then add tap so water that it is at least 20°C below room temperature. Directly before using it, record the temperature of the water into your data table.
2) Add 8 drops of KI to each of 3 test tubes
3) Add 2 drops of HCl to the test tubes
4) Add the number of drops of Na$_2$S$_2$O$_3$ determined in the calibration to each tube.
5) Add 4 drops of starch to each tube.
6) Swirl to mix well and place in test tube rack
7) Get three new tubes! With the syringe put 0.4 mL hydrogen peroxide in each of the new three tubes.
8) Mark each of the tubes containing hydrogen peroxide
9) Place in each of the three prepared water baths one test tube containing the mixture of solutions and one test tube containing the hydrogen peroxide. All baths should contain a pair of your test tubes.
10) Allow the solutions to remain for at least 5 minutes in the baths (you can start preparing Activity 3 while you wait)
11) Remove the tests tubes from the room temp bath. Pour the hydrogen peroxide into the tube containing the mixture and begin timing.
12) Swirl and monitor the color.
13) Record the time it takes to turn blue-black
14) Repeat the process for the pairs of tubes in both the hot and the cold baths as well. (Use test tube tongs as needed)

Activity 2 Data Table:

<table>
<thead>
<tr>
<th>Water Bath</th>
<th>Temperature (°C)</th>
<th>Time to react (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room temp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Activity 3 Procedure:

1) Add 4 drops of HCl to each of two test tubes
2) Add 3 mL of Na₂S₂O₃ to each tube
3) Add 5 drops of starch to each tube
4) Add 0.8 mL of hydrogen peroxide to each tube
5) Swirl each tube well to mix and place in test tube rack
6) Using a mortar and pestle, grind approximately 0.5 g of KI into powder (there might be still some left in the mortar from a previous class so check there first)
7) Weigh out 0.02 g of the smashed powdered crystals into an empty test tube
8) Weigh out 0.02 g of the KI original crystals from the bottle into an empty test tube
9) Pour one of the mixtures into the tube with the crystals and DO NOT SWIRL. Start the timer.
10) Record the time it takes for the solution to turn black.
11) Repeat steps 9 and 10 with the powdered crystals.

Data Table 3:

<table>
<thead>
<tr>
<th>0.02g of KI</th>
<th>Time to react</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powdered KI</td>
<td></td>
</tr>
<tr>
<td>Original KI crystals</td>
<td></td>
</tr>
</tbody>
</table>

Activity 4 Procedure:

1) In the well plate place 8 drops of KI in the leftmost well of an empty row.
2) Add 2 drops of HCl to the same well
3) Add the number of drops of Na₂S₂O₃ determined in the calibration.
4) Add 4 drops of starch
5) Add 2 drops DI water
6) Swirl the solution to mix it by moving the plate in circles on the table.
7) With the syringe draw up 0.4 mL hydrogen peroxide.
8) As the hydrogen peroxide is added, begin timing.
9) Swirl and monitor the color
10) Record the amount of time it takes for the entire solution to turn dark blue-black.
11) Repeat 1-10 using 2 drops of copper sulfate instead of water (see table below for clarification)
Data Table 4:

<table>
<thead>
<tr>
<th></th>
<th>KI drops</th>
<th>HCl drops</th>
<th>Na₂S₂O₃</th>
<th>Starch drops</th>
<th>Water drops</th>
<th>Copper (II) sulfate drops</th>
<th>Hydrogen peroxide</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>8</td>
<td>2</td>
<td># Drops determined in calibration</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0.4 mL</td>
<td></td>
</tr>
<tr>
<td>Trial 2</td>
<td>8</td>
<td>2</td>
<td># Drops determined in calibration</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>0.4 mL</td>
<td></td>
</tr>
</tbody>
</table>

Post Lab Questions:
1) What was changed about the experiment from trial to trial in Activity 1?
2) Make a general concluding statement regarding how the “factor” changed in activity 1 will affect any reaction rate. (i.e. When you increase ____________, rates of reactions ____________)
3) What was changed about the experiment from trial to trial in Activity 2?
4) Make a general concluding statement regarding how the “factor” changed in activity 2 will affect any reaction rate.
5) What was changed about the experiment from trial to trial in Activity 3?
6) Make a general concluding statement regarding how the “factor” changed in activity 3 will affect any reaction rate.
7) How did the addition of the copper (II) sulfate affect the reaction rate in activity 4?
8) What is the most probably role of the copper (II) sulfate?
9) Make a general concluding statement regarding how the “factor” added in activity 4 will affect any reaction rate.
10) Many fast acting medications are sold as powders, sometimes in soluble capsules. Why?
11) Recap! What are the 4 factors that can affect reaction rate?

Lab Write Up Instructions

Pre Lab
Name, Date, Title, Purpose
PreLab Questions 1-4
Copy the following in THIS ORDER in your book:
• Calibration Procedure
• Calibration Data Table
• Procedure for Activity 1
• Data Table for Activity 1
• Procedure for Activity 2
• Data Table for Activity 2
• Procedure for Activity 3
• Data Table for Activity 3
• Procedure for Activity 4
• Data Table for Activity 4

Post Lab
Answer Post lab questions 1-12