CHEMISTRY 12

FACTORS THAT AFFECT REACTION RATES

INTRODUCTION

The purpose of this experiment is to investigate how different factors affect the rate of a chemical reaction.

There are six parts to this study: examining the effect of temperature changes, concentration changes, and changes in surface area.

PROCEDURE

Part I: The Effect of Temperature Changes

The reaction being studied is $2\ HCl(aq) + Na_2S_2O_3(aq) \longrightarrow S(s) + SO_2(g) + 2\ NaCl(aq) + H_2O(l)$.

1. Use a graduated cylinder to measure out 5.0 mL of 0.100 M $Na_2S_2O_3$ into each of four test tubes (18-x150 mm). Thoroughly rinse the graduated cylinder and use it to measure 5.0 mL of 0.100 M HCl into a different set of four test tubes (18 x 150 mm).
2. Juggle the following four tasks so that you can carry out the reaction quickly at four different temperatures, one after another. **IMPORTANT:** You may have to readjust the temperature from time to time if you don't use the baths right away.
   (a) Use ice chips to cool a 400 mL beaker $^{2}/_{3}$ full of tap water to a temperature of 10" 2^{o}C.
   (b) Use hot and cold water from the tap to get a 400 mL beaker $^{2}/_{3}$ full of tap water at 30" 2^{o}C.
   (c) Use hot and cold water from the tap to get a 400 mL beaker $^{2}/_{3}$ full of tap water at 50" 2^{o}C.
   (d) Use a bunsen burner to heat a 400 mL beaker $^{2}/_{3}$ full of water to 70" 2^{o}C.
3. Place one $Na_2S_2O_3$ tube and one HCl tube into each of the 10^{o}C, 30^{o}C, 50^{o}C and 70^{o}C bath for 5-minutes, to establish thermal equilibrium.
4. In each of the four reactions below, use a stop watch to measure the time passing between the instant a tube of $Na_2S_2O_3$ and a tube of HCl are mixed and the instant the mixed solution turns cloudy due to the production of solid sulphur.
   (a) One partner should quickly mix the HCl and $Na_2S_2O_3$ solutions in the 10^{o}C bath, immediately stopper the solution and shake for a few seconds before putting the solution back into its ice bath. The other partner should start the stop watch at the instant the two solutions touch each other and stop timing when the solution turns cloudy. As soon as the reaction is finished, take the temperature of the test tube contents; this temperature is the reaction temperature.
   (b) Similarly, react and time the HCl and $Na_2S_2O_3$ solutions in the 30^{o}C, 50^{o}C and 70^{o}C baths. (Don't forget to put the mixture back in its bath while you are timing the reaction.)

Part II: The Effect of Concentration Changes

The reaction being studied is $2\ HCl(aq) + Mg(s) \longrightarrow H_2(g) + MgCl_2(aq)$.

1. Into 4 separate, labelled, test tubes measure 10 mL of each of 1.00 M, 2.00 M, 3.00 M and 6.00 M HCl. Weigh one piece of 10cm long Mg ribbon. Next, cut the strip into 4 strips of 25 mm long Mg ribbon to two decimal places, using the electronic balance. It is important that each piece is exactly the same length so that the amount of magnesium does not change in each of the reactions. (If you divide the mass of the 10cm strip by 4, it should be the same as the mass of one of the 25mm pieces).. **Record this value in your table 1**.

2. Add one of the weighed strips of Mg ribbon to the most dilute acid and immediately start timing the reaction, while constantly swirling the test tube. Stop the timing when the last trace of Mg disappears. Similarly, time the reaction of the other Mg strips with the other acid concentrations. **Record these values on your data table.**

3. **Calculate** the average reaction rate by determining the grams of magnesium used per second. Record these values in your data table.

Part III: The Effect of Surface Area Changes

The reaction being studied is $2\ HCl(aq) + Mg(s) \longrightarrow H_2(g) + MgCl_2(aq)$

1. Label three test tubes as A, B, and C. Place 10 mL of 1.0 M hydrochloric acid in each of the test tubes.

2. Obtain a 5 cm strip of Mg ribbon. Cut this strip into 3 pieces, each 1.5cm in length.

3. Take one of the 1.5 cm pieces of Mg ribbon and use the scissors to cut the strip into as many slivers as possible. Be careful not to lose any of the slivers as this will affect the results. Place the slivers in test tube A. **Record the time it takes for all of the magnesium to react in table 2.**

4. Take the second piece of Mg ribbon and fold /bend the piece so that it is coiled up as tightly as possible. Place the rolled Mg into test tube B. **Record the time it takes for the Mg to react in your data table.**

5. The third piece will be left as is. Add this piece to test tube C. **Record the time it takes for all the Mg to react in your data table.**

Observations

Part II: Effect of Concentration on Reaction Rate

Mass of 10 cm strip of Mg ______________
Mass of 25 mm piece of Mg ____________

Table 1

Concentration of Acid	Reaction Time in Seconds	Reaction Rate (gMg/s)
6.0 M		
3.0 M		
2.0 M		
1.0 M		

Part III: Effect of Surface Area on Reaction Rate

Table 2

Shape of Mg Strip	Reaction Time in Seconds	Reaction Rate (gMg/s)
Test tube A - slivers		
Test tube B - rolled		
Test tube C- flat		

ANALYSIS

1. (a) Calculate the moles of HCl used in each of the four HCl solutions in part II, using the formula:

$$\text{Molarity (c)} = \frac{\text{moles(n)}}{\text{volume (V)}}$$, where V is expressed in **litres.**

   (b) Using the mass of Mg found in step 1 OF PART II and the molar mass of Mg, calculate the moles of Mg used in each reaction in part II, step 1 and 2.

   (c) Calculate the value of the ratio (moles HCl/moles Mg) for each of the 4 reactions; this ratio allows you to make allowance for slightly differing masses of Mg reacting and tells you how many times more HCl there was than Mg.

   (d) Construct a graph of time of reaction versus (moles HCl/moles Mg), with time on the vertical axis, using the data collected in steps 1 and 2 of Part II.

   (e) Use the data you took in steps 1 and 2 of Part II to complete the following statement: "When the concentration of a reactant increases, the reaction rate ..... and the time of reaction ....".

   (f) i) Calculate the average mass of Mg used in Part II.

   ii) Calculate the moles of Mg corresponding to the above average mass.

   iii) Calculate the moles of HCl present in 10.0 mL of 3.0 M HCl.

   iv) Calculate the value of the ratio $\frac{\text{moles of HCl in 10.0 mL of 3.0 M HCl}}{\text{average moles of Mg}}$.

   v) Use your graph to estimate the time required for the reaction when 3.0 M HCl reacts with a strip of Mg having a mass equal to the average mass of Mg used in step 6. Indicate on your graph how you arrived at the time for 3.0 M HCl.

2. What happens to the concentration of the REACTANTS as a reaction proceeds? Therefore, what should happen to the rate of a reaction as the reaction proceeds?

3. Using the data collected in Part III, state how the surface area of the reactants affects the rate of a reactant. How do you use the effect of surface area on the reaction rate when starting a campfire?

4. When $Fe(NO_3)_3$ is added to water, the following dissociation reaction occurs:

$$Fe(NO_3)_3 \longrightarrow Fe^{3+} + 3\ NO_3^-.$$

The Fe^{3+} is able to move freely through the H_2O_2 solution and catalyze the decomposition reaction. Similarly, when Na_3PO_4 is added to water the following dissociation reaction occurs:

$$Na_3PO_4 \longrightarrow 3\ Na^+ + PO_4^{3-}.$$

When Fe^{3+} is combined with PO_4^{3-}, an insoluble precipitate of $FePO_4(s)$ forms:

$$Fe^{3+} + PO_4^{3-} \longrightarrow FePO_4(s).$$

Why is Na_3PO_4 expected to act as an inhibitor for the catalyzed decomposition of H_2O_2 by Fe^{3+}?