S5 Chemistry
SBA Experiment
Investigating the Factors affecting the Rate of Reaction

Objective

To investigate the factors affecting the rate of reaction

Introduction

The rate of a reaction is the time required for a given quantity of reactants to be turned into products. The rate is determined by a number of factors include nature of the reactants, concentration, temperature, catalyst, and pressure (if the reaction involve gases). Rate of reaction can be found by investigating the rate of change of reactants or products.

Safety

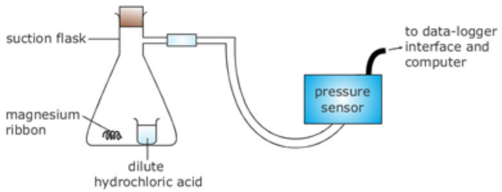
1. Handle all chemicals with care. Eye protection must be worn.
2. In case any acid gets into your eyes, report to your teacher immediately and flush your eyes under running water for at least 3 minutes. If any acid gets onto your skin, wash the affected area with plenty of water.
3. The sulphur dioxide gas produced is TOXIC. Perform the experiment in a well-ventilated laboratory. NEVER smell sulphur dioxide gas directly.

Task 1: To investigate the effect of concentration on rate of reaction

In this experiment, hydrogen gas is generated as a product thus pressure will increase if the reaction container is a closed system. By tracing the rate of change of pressure of the container with a pressure sensor connected to a data-logger, the rate of reaction can be easily found.

Apparatus and Chemicals

- Computer with data logging software
- data logger interface
- absolute pressure sensor
- 250 cm^3 suction flask with a rubber stopper
- 10 cm^3 measuring cylinder
- 100 cm^3 beaker
- plastic bottle
- forceps
- vacuum sealant
- Mg ribbons (3 cm long x 6)
- 50 cm^3 2 M HCl(aq)
- 200 cm^3 1 M HCl(aq)



Procedure

1. Connect the pressure sensor to the data logger interface which is connected to a computer. Execute data-logging software on the computer. Set the sample to 10 Hz. Open a graph display that has a plot of "Pressure (kPa) against Time (s)".
2. Pour 20 cm^3 of 1 M HCl(aq) into the plastic bottle and carefully place the plastic bottle with HCl(aq) into the suction flask.
3. Place a clean Mg ribbon (3 cm) into a dry suction flask using a pair of forceps.
4. Seal the suction flask with a rubber stopper and a little vacuum sealant.
5. Press "START" to start recording the change in pressure inside the flask.
6. Quickly shake the suction flask to make the plastic bottle fall. (Press the stopper gently at times to ensure good sealing)
7. Press "STOP" after 3 minutes.
8. Repeat *steps (2) to (7)* with different conditions as stated in next page.
9. Observe and record the results.

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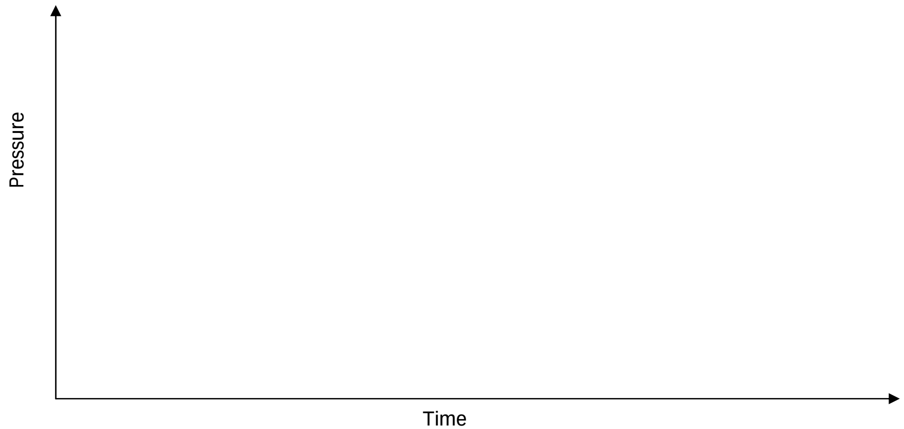
Results

Condition A: (Control)
Mg: ___3____ cm (~______ g)
HCl: ___1____ M, ___20____ cm^3
Which is the limiting reactant? Why?

Condition B:
Mg: ___3____ cm
HCl: ___2____ M, ___20____ cm^3
Comparing condition A and condition B,
(i) what has changed?
(ii) describe how the curve has changed.

Condition C:
Mg: ___2 x 3 ____ cm
HCl: ___1____ M, ___20____ cm^3
Comparing condition A and condition C,
(i) what has changed?
(ii) describe how the curve has changed.

Condition D:
Mg: ___3____ cm
HCl: ___1____ M, ___40____ cm^3
Comparing condition A and condition D,
(i) what has changed?
(ii) describe how the curve has changed.



Discussion

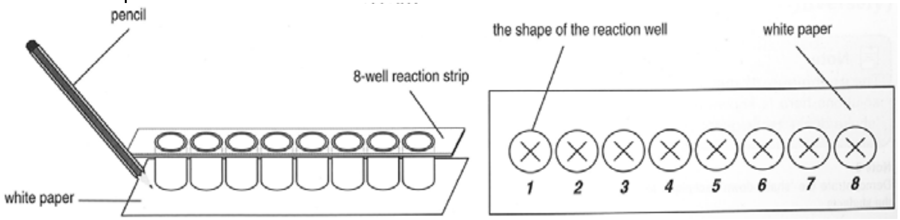
1. What kind of change(s) in the above conditions can affect the reaction rate?
   (Hint: change in the shape of curve does not necessarily mean a change of reaction rate)

2. State other factor(s) that may affect the reaction rate. Explain.

Task 2: To investigate the effect of concentration on rate of reaction using a microscale experiment

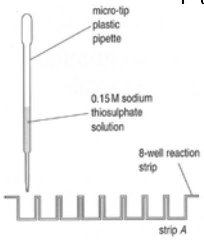
Apparatus and Chemicals

- 8-well reaction strips x 2
- Micro-tip plastic pipettes x 2
- Stopwatch
- Sodium thiosulphate solution (0.15 M, 60 cm^3)
- Sulphuric acid (1.0 M, 10 cm^3)
- Deionized water



Procedure

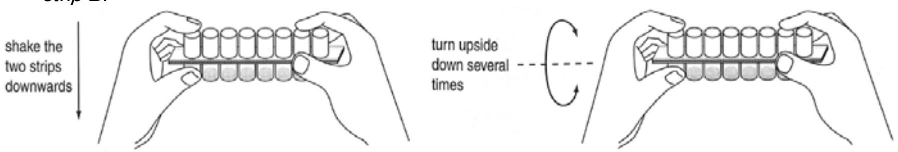
1. Using a pencil, trace the shape of eight reaction wells of an 8-well reaction strip on a piece of white paper. Label the well images *from 1 to 8* and mark a cross on each of the eight well images.
2. Using a clean micro-pipette, transfer drops of 0.15 M sodium thiosulphate solution to a clean 8-well reaction strip *(strip **A**)* as follows.



Strip A well number	*A1*	*A2*	*A3*	*A4*	*A5*	*A6*	*A7*	*A8*
no. of drops of 0.15 M $Na_2S_2O_3$(aq)	10	9	8	7	6	5	4	3

Strip B well number	*B1*	*B2*	*B3*	*B4*	*B5*	*B6*	*B7*	*B8*
no. of drops of 1.0 M H_2SO_4(aq)	1	1	1	1	1	1	1	1
no. of drops of deionized water	0	1	2	3	4	5	6	7

3. Using a clean micro-pipette, transfer drops of 1.0 M sulphuric acid and deionized water to another 8-well reaction strip *(strip **B**)* as above.
4. Invert *strip **A*** and stack it on top of *strip **B*** so that the wells of *strip **A*** are directly above those of *strip **B***.



5. Hold the two strips up firmly. Mix the solution in *strip **A*** to *strip **B*** by shaking the two strips downwards. Start the stopwatch at the same time. Turn the strip combination upside down several times in order to mix the solution in the wells together.
6. Shake down all the solutions to *strip **B*** and take away *strip **A***. Place *strip **B*** on the well images on the white paper that has been prepared in *step 1*.
7. Observe and record the results.
8. Clean the strips immediately after the experiment.

Results

Strip A well number	*A1*	*A2*	*A3*	*A4*	*A5*	*A6*	*A7*	*A8*
no. of drops of 0.15 M $Na_2S_2O_3$(aq)	10	9	8	7	6	5	4	3
Time (s)								

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Task 3: To investigate the effect of temperature on rate of reaction

In this experiment, when sodium thiosulphate solution reacts with dilute hydrochloric acid, a sulphur precipitate forms, which turns the reaction mixture cloudy.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + SO_2(aq) + H_2O(l) + S(s)$$

At a certain stage, we can no longer see through the solution. The time taken to reach this stage can be used to determine the reaction rate.

$$\text{reaction rate} \propto \frac{1}{\text{time taken to reach the opague stage}}$$

Apparatus and Chemicals

- 50 cm^3 beaker x 3
- 10 cm^3 measuring cylinder
- 100 cm^3 measuring cylinder
- thermometer
- stopwatch
- white paper and marker

Procedure

1. Place 25 cm^3 of sodium thiosulphate solution at room temperature (**A**) in a 50 cm^3 beaker.
2. Record the temperature of the solution.
3. Mark a cross on a piece of paper. Put the beaker on top of the paper.
4. Add 5 cm^3 of dilute hydrochloric acid to the sodium thiosulphate solution and start the stopwatch at the same time.
5. Swirl the beaker to mix the solutions.
6. Record the time taken for the cross to disappear.
7. Repeat *steps 1 to 6* with sodium thiosulphate solution from hot water bath (**B**) and then with sodium thiosulphate solution from the refrigerator (**C**).

(a) As the reactants are being mixed, the cross can be clearly seen.
(b) The cross gets fainter as more sulphur precipitate forms.
(c) The cross can no longer be seen as the solution becomes opaque.

Results

Sodium thiosulphate solution	***Temperature (^oC)***	***Time required for the cross to disappear (s)***	***Reaction rate (1/t) (s^{-1})***
A (room temperature)			
B (hot water bath)			
C (from the refrigerator)			

Questions for Further Thought

1. Is the reaction rate directly proportional to temperature? Explain your answer briefly.
2. Why do we use the same concentrations and quantities of reactants at the start of all cases?
3. State one example in our daily life to show the understanding of the effect of temperature on reaction rate is very important.