Edexcel Chemistry GCSE

CP 6: Investigate the effects of changing the conditions of a reaction on the rates of chemical reactions

Notes

Measuring the Production of Gas

Aim

Investigate the effects of changing the conditions of a reaction on the rates of chemical reactions by measuring the production of a gas (in the reaction between hydrochloric acid and marble chips).

Equipment list

- Gas syringe and clamp stand/ measuring cylinder and water trough
- Delivery tube and bung
- 100 cm^3 conical flask
- 25 cm^3 measuring cylinder
- Timer
- Digital balance and weighing boat
- Pestle and mortar

Chemicals required

- Hydrochloric acid (variety of concentrations)
- Marble chips

Method

1. Set up the apparatus as shown in figure 1 or figure 2. If using a gas syringe, support it horizontally in a clamp stand and attach the delivery tube. If using a measuring cylinder, fill a trough and measuring cylinder with water then turn the measuring cylinder upside-down in the trough. Insert the delivery tube into the measuring cylinder.
2. Add 50 cm^3 of dilute hydrochloric acid to the conical flask.
3. Add 0.4 g of marble chips to the conical flask. Immediately attach the bung - this should be connected to the gas collection vessel via the delivery tube. Start the timer.
4. For every 10 cm^3 of gas produced, record the time in a results table.
5. Repeat steps 1-4 for different concentrations of acid.
6. The experiment may be repeated, changing the size of the marble chips instead of the concentration of acid. The marble chips can be made smaller by crushing them in a pestle and mortar. For this to be a fair test, the concentration and volume of HCl and the mass of marble chips must be controlled.

Key points

- The equation for this reaction is: $2HCl(aq) + CaCO_3(s) \longrightarrow H_2O(l) + CaCl_2(aq) + CO_2(g)$
- The gas collected in the gas syringe/upturned measuring cylinder is carbon dioxide.
- The bung must be immediately attached to the conical flask to ensure minimal gas escapes.
- If using a measuring cylinder to collect the gas, ensure it is completely filled with water before adding the marble chips to the acid to ensure the final volume of gas in the measuring cylinder only includes the carbon dioxide produced in the experiment.
- When using an upturned measuring cylinder, the carbon dioxide produced by the reaction displaces the water in the measuring cylinder, allowing the volume of gas to be measured.

- Increasing the concentration of hydrochloric acid increases the rate of reaction because there are more particles in the same volume so more frequent successful collisions.
- Increasing the surface area of the marble chips increases the rate of reaction because more particles are exposed so more frequent successful collisions.

Diagram

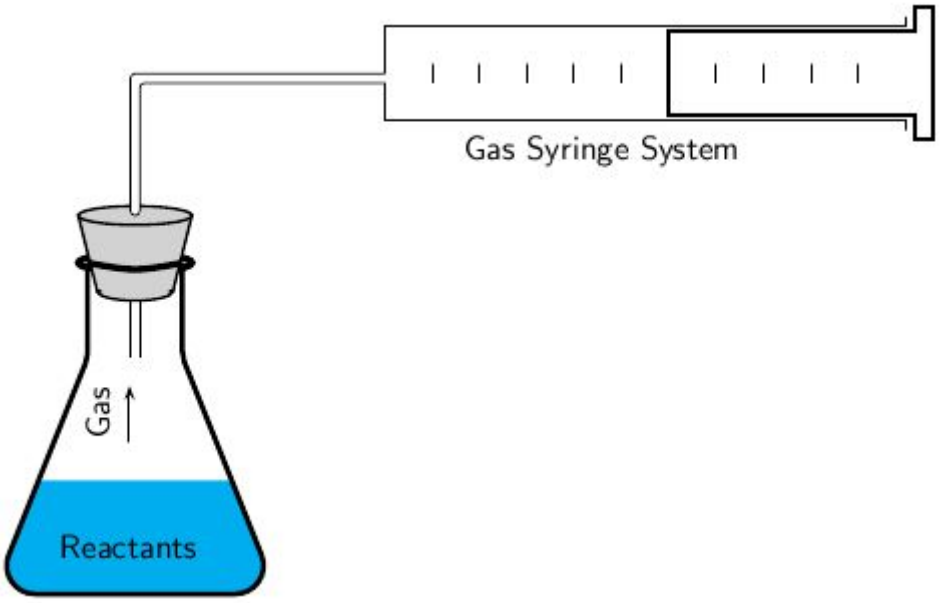


Figure 1: Experiment setup

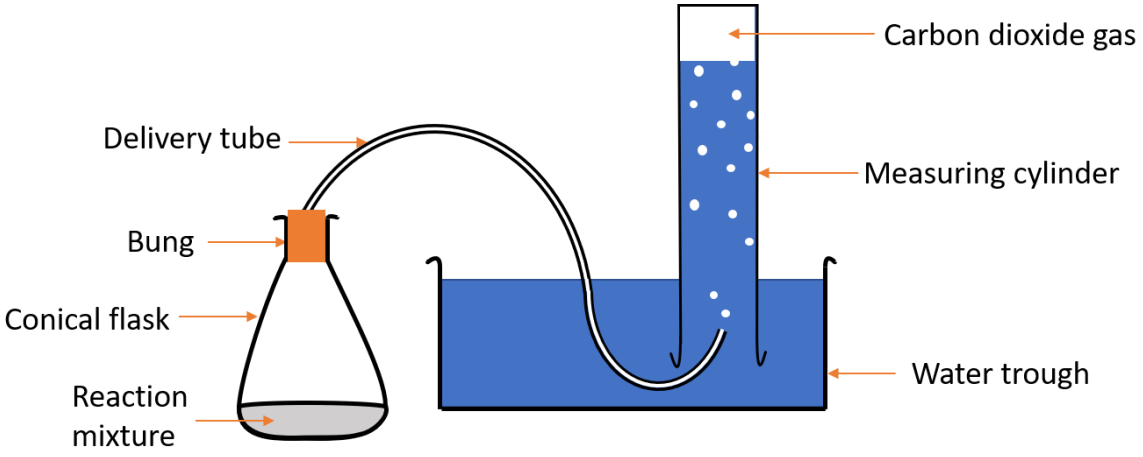


Figure 2: Experiment setup

Safety Precautions

- Take care when crushing the marble chips. Wear safety goggles and don't crush too vigorously.
- Clean up chemical spillages or broken glassware immediately.
- Hydrochloric acid is corrosive. Although a low concentration is being used in this experiment, avoid contact with skin and wash skin immediately if it comes into contact with the acid.

Analysis of Results

Rate of reaction = $\frac{\text{Volume of gas produced (cm}^3\text{)}}{\text{Time (s)}}$

The results for each concentration of acid or size of marble chips can be recorded in a table similar to the one below:

Volume (cm^3)	**Time (s)**
0	0
10	
20	

These results can be used to plot a graph of volume of gas produced against time. The graph should produce a curve. The gradient of the tangent to the curve at a certain time is the rate of reaction at this time.

These results should show that the rate of reaction increases as the concentration of hydrochloric acid increases. They should also show that the rate of reaction increases as the surface area of the marble chips increases.

Observing colour change

Aim

Investigate the effects of changing the conditions of a reaction on the rates of chemical reactions by observing a colour change (in the reaction between sodium thiosulfate and hydrochloric acid).

Equipment list

- 50 cm^3 measuring cylinder
- 10 cm^3 measuring cylinder
- 250 cm^3 conical flask
- Piece of paper
- Black marker pen
- Timer
- Thermometer
- Water bath
- Test tube

Chemicals required

- Sodium thiosulfate solution
- Hydrochloric acid

Method

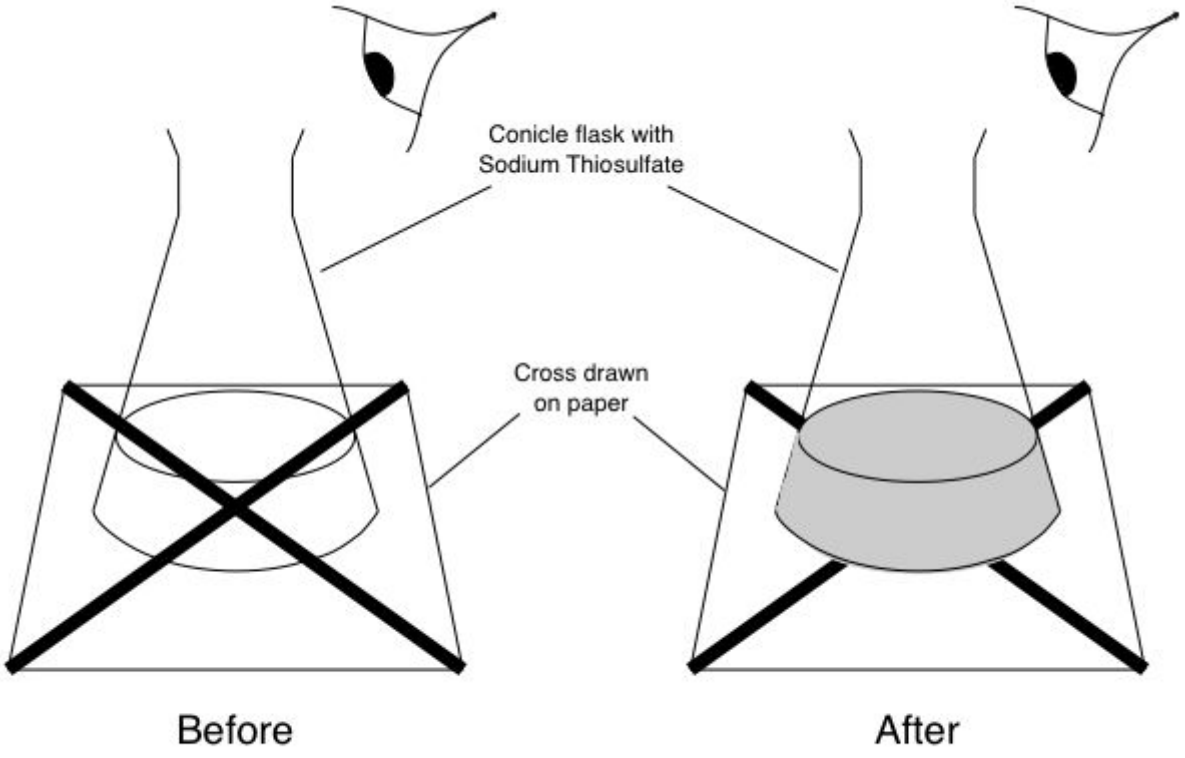
1. Using a 50 cm^3 measuring cylinder, measure 50 cm^3 of dilute sodium thiosulfate and pour into the conical flask.
2. Draw a cross on the paper using the marker pen then place the conical flask over this cross.
3. Use the 10 cm^3 measuring cylinder to measure 10 cm^3 of dilute hydrochloric acid. Add this to the conical flask, immediately swirl the flask to mix the reactants and start the timer.
4. Record the initial temperature of the mixture using the thermometer.
5. Observe the reaction mixture, stopping the timer as soon as the black cross is no longer visible.
6. Repeat steps 1 to 4 with different starting temperatures of reactants. This can be achieved by placing a conical flask of sodium thiosulfate and a test tube containing hydrochloric acid into a water bath and leaving them to reach the desired temperature. Remember to use a thermometer in step 4 to record the initial temperature.

Key points

- The equation is: $Na_2S_2O_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + SO_2(g) + S(s)$
- Sulfur, S(s), is the yellow-white precipitate formed in this reaction.
- Increasing initial temperature causes the rate of reaction to increase because the particles have more kinetic energy so move faster (more frequent collisions) and more particles have energy above the activation energy (more collisions are successful).
- This method for determining the rate of reaction has a low accuracy because it is very subjective since different people may disagree over the exact point at which the cross

disappears. To increase accuracy, the same person should observe the reaction mixture and decide when the cross has disappeared.

Diagram



Safety Precautions

- Sulfur dioxide is produced so be careful not to inhale it when watching over the conical flask. Ensure the room is well ventilated as some individuals be sensitive to sulfur dioxide.
- Clean up any breakages or spillages immediately.
- Don't heat the sodium thiosulfate solution above 60°C as the hot liquid can cause burns to skin.
- Hydrochloric acid is corrosive. Although a low concentration is being used in this experiment, avoid contact with skin and wash skin immediately if it comes into contact with the acid.

Analysis of Results

Rate of reaction (s^{-1}) = $\frac{1000}{\text{Time}}$

Results from this experiment can be recorded in a table similar to the one below:

Initial temperature (°C)	Reaction time (s)	Rate of reaction (s^{-1})

This data can then be used to plot a graph, temperature (°C) on the x axis and the rate of reaction (s^{-1}) on the y axis.