C6
RATE OF REACTION
TEST 1

GCSE
CHEMISTRY
AQA - COMBINED SCIENCE

Materials
For this paper you must have:
• Ruler
• Pencil, Rubber, Protractor and Compass
• Scientific calculator, which you are expected to use when appropriate

Instructions
• Answer all questions
• Answer questions in the space provided
• All working must be shown
• Do all rough work in this book. Cross out any rough work you don't want to be marked

Information
• The marks for the questions are shown in brackets
A student investigated the rate of reaction of magnesium with dilute hydrochloric acid.

This is the method used.

1. Add 50 cm$^3$ of dilute hydrochloric acid to a conical flask.
2. Add 0.2 g of magnesium ribbon to the dilute hydrochloric acid in the conical flask.
3. Attach a gas syringe to the conical flask.
4. Record the volume of gas in the gas syringe every 10 seconds.

The graph below shows the student’s results.

(a) Calculate the mean rate of reaction in the first 10 seconds.

Use the graph above and the equation:

\[
\text{mean rate of reaction} = \frac{\text{volume of gas produced after 10 seconds}}{\text{time taken}}
\]

___________________________________________________________________

___________________________________________________________________

Mean rate of reaction = ___________________
(b) What is the unit for the mean rate of the reaction calculated in part (a)?

Tick one box.

- cm³/s
- g/s
- s/cm³
- s/g

(c) Give two conclusions you can make about the reaction from 90 s to 120 s.

Use the graph above.

1. ________________________________
   _____________________________________________________________________
   _____________________________________________________________________

2. ________________________________
   _____________________________________________________________________
   _____________________________________________________________________

(d) The student repeated the method using magnesium powder instead of magnesium ribbon. All other variables were kept the same.

What is the independent variable in the investigation?

Tick one box.

- Surface area of magnesium
- Temperature of reaction
- Volume of gas collected
- Volume of hydrochloric acid

(e) Sketch a line on the graph above to show the expected results for the experiment using magnesium powder.

(Total 8 marks)
A student investigated the effect of different catalysts on the decomposition of hydrogen peroxide.

Figure 1 shows the apparatus the student used.

(a) Oxygen gas is produced.

Table 1 shows the student’s observations.

<table>
<thead>
<tr>
<th>Catalyst</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese dioxide</td>
<td>A lot of gas and hydrogen peroxide bubbles up into gas syringe</td>
</tr>
<tr>
<td>Potato</td>
<td>Steady bubbles of gas</td>
</tr>
<tr>
<td>Copper oxide</td>
<td>Few bubbles of gas</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>Very few bubbles of gas</td>
</tr>
</tbody>
</table>

Which is the most useful catalyst?

Explain your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
(b) **Figure 2** shows the gas syringe during the investigation.

![Figure 2](image)

What is the volume of gas?

Tick **one** box.

- [ ] 52 cm$^3$
- [ ] 55 cm$^3$
- [ ] 70 cm$^3$
- [ ] 75 cm$^3$

(1)

(c) For one of the catalysts the student measures the volume of gas given off every 20 seconds for 2 minutes.

The volume of gas was zero at the start of the experiment.

The measured volumes of gas are:

- 23 cm$^3$
- 42 cm$^3$
- 59 cm$^3$
- 72 cm$^3$
- 80 cm$^3$
- 88 cm$^3$

Complete **Table 2** to show these results.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

(4)
(d) Suggest why the readings might be lower than expected.

_________________________________________________________________
_________________________________________________________________

(1)

(e) The student did the experiment with four different catalysts.

Give two variables the student should keep constant.

1. _________________________________________________________________
2. _________________________________________________________________

(2)

(Total 10 marks)

A student investigated the effect of the size of marble chips on the rate of the reaction between marble chips and hydrochloric acid.

This is the method used.

1. Add 10.0 g of marble chips into the flask.
2. Add 50 cm$^3$ of hydrochloric acid and start a timer.
3. Record the mass lost from the flask every 10 seconds.
4. Repeat steps 1 to 3 with different sizes of marble chips.

**Figure 1** shows the apparatus.
(a) Draw **one** line from each type of variable to the correct example of the variable.

<table>
<thead>
<tr>
<th>Type of variable</th>
<th>Example of variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass lost from flask</td>
<td>Independent</td>
</tr>
<tr>
<td></td>
<td>Size of flask</td>
</tr>
<tr>
<td></td>
<td>Size of marble chips</td>
</tr>
<tr>
<td></td>
<td>Control</td>
</tr>
<tr>
<td></td>
<td>Time taken</td>
</tr>
<tr>
<td></td>
<td>Volume of acid</td>
</tr>
</tbody>
</table>

(b) The equation for the reaction is:

\[
\text{CaCO}_3(\text{s}) + 2\text{HCl(}aq\text{)} \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O(l)} + \text{CO}_2(\text{g})
\]

Name the **three** products.

1. ______________________________
2. ______________________________
3. ______________________________

(c) Another student suggests putting some cotton wool in the top of the flask.

Suggest why this improves the investigation.

___________________________________________________________________
___________________________________________________________________
(d) The reaction produces 1.6 g of gas in 30 seconds.

Calculate the mean rate of the reaction in the first 30 seconds.

Use the equation:

\[
\text{mean rate of reaction} = \frac{\text{mass of product produced in grams}}{\text{time in seconds}}
\]

Mean rate of reaction = _________________________

(e) What is the unit for the mean rate of reaction calculated in part (d)?

Tick one box.

- g
- g/s
- s
- s/g

(f) The table below shows the student’s results.

<table>
<thead>
<tr>
<th>Time in seconds</th>
<th>Mass of gas produced in g</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>10</td>
<td>0.8</td>
</tr>
<tr>
<td>20</td>
<td>0.6</td>
</tr>
<tr>
<td>30</td>
<td>1.6</td>
</tr>
<tr>
<td>40</td>
<td>1.8</td>
</tr>
<tr>
<td>50</td>
<td>2.0</td>
</tr>
<tr>
<td>60</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Plot the data from the table above on **Figure 2**

Draw a line of best fit.

![Figure 2](image)

(g) **Figure 3** shows a large marble chip and eight small marble chips.

![Figure 3](image)

The large marble chip has the same total volume as the eight small marble chips, but a different surface area.
Why do the eight small marble chips react faster than the large marble chip?

Tick one box.

The eight small marble chips have a larger surface area, so less frequent collisions.

The eight small marble chips have a larger surface area, so more frequent collisions.

The eight small marble chips have a smaller surface area, so less frequent collisions.

The eight small marble chips have a smaller surface area, so more frequent collisions.

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The following steps show how to use a type of glue.

**Step 1** Measure out equal amounts of the liquids from tubes A and B.

**Step 2** Mix the liquids to make the glue.
Put a thin layer of the glue onto each of the surfaces to be joined.

**Step 3** Assemble the pieces to be joined and then hold them together with tape.

**Step 4** Leave the glue to set.
(a) When liquids A and B are mixed a chemical reaction takes place.

(i) This reaction is exothermic.

State how the temperature of the mixture will change as the glue is mixed.

_____________________________________________________________________
_____________________________________________________________________

(1)

(ii) When the glue sets it forms a giant covalent structure.

Explain why substances with giant covalent structures have high melting points.

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(2)

(b) The time taken for the glue to set at different temperatures is given in the table below.

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Time taken for the glue to set</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>3 days</td>
</tr>
<tr>
<td>60</td>
<td>6 hours</td>
</tr>
<tr>
<td>90</td>
<td>1 hour</td>
</tr>
</tbody>
</table>

Explain, in terms of particles, why increasing the temperature changes the rate of the reaction which causes the glue to set.

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_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
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(2)

(Total 5 marks)
A student investigated the reaction between magnesium metal and dilute hydrochloric acid.

The student placed 25 cm$^3$ of dilute hydrochloric acid in a conical flask and set up the apparatus as shown in the diagram.

The student:

• took the bung out of the flask and added a single piece of magnesium ribbon 8 cm long
• put the bung back in the flask and started a stopwatch
• recorded the volume of gas collected after 1 minute
• repeated the experiment using different temperatures of acid.

The student plotted his results on a graph.
(a) Write the correct state symbols in the equation.

Choose from (s) for solid, (l) for liquid, (g) for gas and (aq) for aqueous.

\[ \text{Mg (______) } + \text{ 2 HCl (______) } \rightarrow \text{ MgCl}_2 (______) + \text{ H}_2 (______) \]  

(b) The diagram shows a gas syringe after 1 minute.

(i) What volume of gas has been collected in the gas syringe after 1 minute?

Volume = _______________ cm³  

(ii) Use the graph to determine the temperature of the acid used in this experiment.

Temperature = _______________ °C  

(iii) Calculate the average rate of reaction, in cm³ of hydrogen made per second (cm³/s), for this experiment.

Rate of reaction = _______________ cm³/s
One of the results on the graph is anomalous.

(i) Draw a circle on the graph around the anomalous point.

(1)

(ii) Suggest what may have happened to cause this anomalous result.

Explain your answer.

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(2)
(d) Explain how the student could improve the accuracy of the volume of gas recorded at each temperature.

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(e) The student then used the same apparatus to measure the volume of gas produced every 10 seconds at 40 °C.

The student's results are shown on the graph.

![Graph showing volume of gas produced over time]
The rate at which the gas was produced got faster over the first 60 seconds.

The student’s teacher gave two possible explanations of why the reaction got faster.

**Explanation 1**
There was a layer of magnesium oxide on the surface of the magnesium. The layer of magnesium oxide prevented the magnesium reacting with the acid. As the magnesium oxide reacted slowly with the acid, the magnesium was exposed to the acid and hydrogen gas was produced.

**Explanation 2**
The reaction is exothermic, and so the temperature of the acid increased during the reaction.

(i) Describe further experimental work the student could do to see if **Explanation 1** is correct.

(ii) Describe further experimental work the student could do to see if **Explanation 2** is correct.

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The equation for a reaction to produce hydrogen is:

$$\text{CO(g)} + \text{H}_2\text{O(g)} \rightleftharpoons \text{CO}_2(g) + \text{H}_2(g)$$

(a) Explain why changing the pressure does **not** affect the yield of hydrogen at equilibrium.

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(Total 16 marks)
(b) Suggest why the best yield of hydrogen at equilibrium is obtained at low temperatures.

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(1)

(c) The temperature used in industry needs to be high enough for the reaction to take place quickly. Explain, in terms of particles, why the rate of reaction increases when the temperature is increased.

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(3)

(d) Scientists have developed catalysts which allow the reaction to take place quickly at lower temperatures. How could this be good for the manufacturer and for the environment?

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(2) (Total 7 marks)

Bleach is a solution of sodium hypochlorite (NaClO).

Chlorine gas is produced when bleach reacts with hydrochloric acid.

\[ \text{NaClO(aq) + 2HCl (aq) \rightarrow NaCl(aq) + H}_2\text{O(l) + Cl}_2\text{(g)} \]

(a) Give the test and result for chlorine gas.

___________________________________________________________________
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(2)
The diagram below shows a sealed flask of sodium hypochlorite and hydrochloric acid at equilibrium.

(b) Explain why equilibrium is reached in this reaction.

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(2)

(c) The stopper in the diagram above is removed and hydrochloric acid is added. The stopper is replaced.
Explain what happens to the equilibrium.
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(4)
Chlorine gas is also produced when hydrogen chloride decomposes.

\[2\text{HCl}(g) \rightleftharpoons \text{H}_2(g) + \text{Cl}_2(g)\]

The forward reaction is endothermic.

(d) Predict the effect of increasing the temperature on the amount of chlorine gas produced at equilibrium.

Explain your answer using Le Chatelier’s Principle.

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(2)

(e) Explain the effect of increasing the pressure on this equilibrium.

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(2)

(Total 12 marks)
A student investigated the effect of temperature on the rate of a reaction. The picture below shows an experiment.

The student:

- put sodium thiosulfate solution into a conical flask
- heated the sodium thiosulfate solution to the required temperature
- put the flask on a cross drawn on a piece of paper
- added dilute hydrochloric acid and started a stopclock
- stopped the stopclock when the cross could no longer be seen
- repeated the experiment at different temperatures.

The equation for the reaction is:

\[
\text{Na}_2\text{S}_2\text{O}_3(aq) + 2\text{HCl}(aq) \rightarrow 2\text{NaCl}(aq) + \text{H}_2\text{O}(l) + \text{SO}_2(g) + \text{S(s)}
\]

(a) Explain why the solution goes cloudy.

___________________________________________________________________
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(2)
(b) Give two variables the student must control to make the investigation a fair test.

1. _________________________________________________________________

2. _________________________________________________________________

(c) State the effect that increasing the temperature of the sodium thiosulfate solution has on the rate of the reaction. Explain this effect in terms of particles and collisions.

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(d) Suggest how the student should change the method to investigate the rate of reaction at 5°C.

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(Total 9 marks)