C6
RATE OF REACTION
TEST 2

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 effect of concentration on the rate of the reaction between sodium thiosulfate and dilute hydrochloric acid.

Figure 1 shows the apparatus the student used.

**Figure 1**

![Apparatus](image)

Sodium thiosulfate and dilute hydrochloric acid

(a) The symbol equation for the reaction is:

\[ \text{Na}_2\text{S}_2\text{O}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{SO}_2 + \text{H}_2\text{O} + \text{S} \]

Complete the word equation for the reaction.

sodium thiosulphate + hydrochloric acid → _____________ + sulfur dioxide + water + sulfur

(b) The table shows the results.

<table>
<thead>
<tr>
<th>Concentration of sodium thiosulfate in mol/dm³</th>
<th>Time for student to no longer see the cross in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>41</td>
</tr>
<tr>
<td>0.20</td>
<td>21</td>
</tr>
<tr>
<td>0.30</td>
<td>20</td>
</tr>
<tr>
<td>0.40</td>
<td>10</td>
</tr>
<tr>
<td>0.50</td>
<td>8</td>
</tr>
</tbody>
</table>
Plot the data from the table on Figure 2.

Draw a line of best fit.

(c) The student determined the time for a concentration of 0.15 mol/dm³

What is the concentration when the reaction is 20 seconds faster?

You should show your working on Figure 2.

Concentration = ____________________ mol/dm³

(d) Estimate the time taken for the reaction when the concentration of sodium thiosulfate is 0.60 mol/dm³

Time taken = ____________________ s

(Total 7 marks)
A student investigates how the concentration of an acid affects the rate of a reaction.

This is the method used.

1. Put a 3 cm piece of magnesium ribbon into a conical flask.
2. Add 50 cm³ of 0.5 mol / dm³ hydrochloric acid to the flask.
3. Collect and measure the volume of gas produced at 10 second intervals.
4. Repeat with different concentrations of hydrochloric acid using the same length of magnesium ribbon and volume of acid.

The student’s results are shown in the figure below.
(a) How do the results show that increasing the concentration of acid increases the rate of reaction?

You **must** use data from the graph in your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)

(b) Explain why the rate of reaction changes as the concentration of the acid increases.

You should answer in terms of particles.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(3)
(c) Student A said that the final volume of gas collected was lower for a concentration of 0.5 mol dm$^3$ because the reaction had not finished.

Student B said it was because all the acid had reacted.

Describe further experimental work the students could do to find out which student was correct.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)
(Total 7 marks)

Lead nitrate solution reacts with potassium iodide solution.

The reaction produces a solid.

Figure 1 shows the reaction occurring.

Figure 1

Lead Iodide By Der Kreole (own work) (CC-BY-3.0) via Wikimedia Commons
(a) (i) Give the name of this type of reaction.

Tick (✓) one box.
Combustion
Neutralisation
Precipitation

(ii) Write the missing state symbols in the chemical equation.

\[ \text{Pb(NO}_3\text{)}_2(aq) + 2\text{KI}(___) \rightarrow \text{PbI}_2(___) + 2\text{KNO}_3(aq) \]

(iii) Complete the word equation for the reaction.

lead nitrate + _________ → lead iodide + _________

(iv) How is solid lead iodide separated from the solution?

Draw a ring around the correct answer.
Distillation Electrolysis Filtration
(b) A group of students investigated the movement of particles.

The students filled a container with water.

The students added a crystal of lead nitrate at position X and a crystal of potassium iodide at position Y, as shown in Figure 2.

**Figure 2 – view from above**

After 3 minutes solid lead iodide started to form at the position shown in Figure 3.

**Figure 3 – view from above**

(i) Tick (✓) the correct box to complete the sentence.

Lead ions and iodide ions move through the water by

- diffusion. ☐
- evaporation. ☐
- neutralisation. ☐
(ii) What conclusion can you make about the speed of movement of lead ions compared with iodide ions? 

Give a reason for your answer.

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

(2)

(iii) The students repeated the experiment at a higher temperature. 

The solid lead iodide formed after a shorter period of time. 

Explain why, in terms of particles.

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

(2)

(Total 11 marks)

This question is about catalysts.

(a) Why are catalysts used in reactions?

____________________________________________________________________________

____________________________________________________________________________

(1)
Figure 1 shows the reaction profile for a reaction without a catalyst.

(b) Label the activation energy ($E_A$) for the reaction on Figure 1.

(c) Label the energy change for the reaction on Figure 1.

(d) Draw the reaction profile for the reaction with a catalyst on Figure 1.
(e) **Figure 2** shows three different shapes of the same catalyst. Each catalyst has the same volume.

**Figure 2**

Evaluate the effectiveness of the shapes of the catalyst in **Figure 2**.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(3) (Total 8 marks)
This question is about ammonia.

(a) **Figure 1** shows the outer electron shells in an ammonia molecule.

Complete **Figure 1** to show a dot and cross diagram for an ammonia molecule.

Show the outer shell electrons only.

![Figure 1](image)

(b) Explain why ammonia is a gas at room temperature.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(3)
In industry, ammonia is produced by reacting nitrogen with hydrogen.

The equation for this reaction is:

\[ \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \]

(c) Calculate the minimum mass of nitrogen required to produce 72.0 grams of ammonia.

Assume all the nitrogen reacts to produce ammonia.

Relative atomic masses (A_r):  
\[ A_r(\text{H}) = 1 \quad A_r(\text{N}) = 14 \]

\[ \begin{align*}
\text{mass of nitrogen} &= \text{(mass of ammonia)} \times \left( \frac{\text{mass of nitrogen}}{\text{mass of ammonia}} \right) \\
&= 72.0 \text{ g} \times \left( \frac{14}{28} \right)
\end{align*} \]

\[ \text{Mass of nitrogen} = \boxed{36.0} \text{ grams} \]
Figure 2 shows information about the percentage yield of ammonia under varying conditions.

The conditions used in the industrial process to produce ammonia are:

- 200 atmospheres pressure
- 450 °C
- iron catalyst.

(d) What is the percentage yield of ammonia under these conditions?

Percentage of ammonia = ____________________ %

(1)
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 g of marble chips into the flask.
2. Add 50 cm$^3$ of hydrochloric acid, connect the gas syringe and start a timer.
3. Record the volume of gas produced every 10 seconds.
Figure 1 shows the apparatus.

(a) Complete the equation for the reaction.

\[ \text{CaCO}_3 + \quad \text{HCl} \quad \rightarrow \quad \text{_______________________________} \]

(2)

Figure 2 shows the student’s results.
(b) Describe the trend shown in Figure 2

Use values in your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(c) Describe how you would use Figure 2 to find the rate of the reaction at 15 seconds.

You do not need to do a calculation.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(d) Give the units for the rate of this reaction.

___________________________________________________________________

The table below shows the results of the investigation.

<table>
<thead>
<tr>
<th>Relative size of marble chips</th>
<th>Volume of gas produced in cm(^3) after given time in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 s</td>
</tr>
<tr>
<td>Small</td>
<td>35</td>
</tr>
<tr>
<td>Medium</td>
<td>21</td>
</tr>
<tr>
<td>Large</td>
<td>14</td>
</tr>
</tbody>
</table>

(e) Give one conclusion about how the size of the marble chips affects the rate of the reaction.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
(f) Suggest why all three sizes of marble chips produce a maximum volume of 60 cm$^3$ of gas.

___________________________________________________________________

___________________________________________________________________

Figure 3 shows eight small cubes, each 1 cm $\times$ 1 cm $\times$ 1 cm, and one large cube, 2 cm $\times$ 2 cm $\times$ 2 cm

![Figure 3](image)

Total volume of small cubes = 8 cm$^3$  
Volume of large cube = 8 cm$^3$

Total surface area of small cubes = 48 cm$^2$

Calculate the surface area of the large cube.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

Surface area of the large cube = ______________________________ cm$^2$

(2)

(h) Explain why the size of the marble chips affects the rate of the reaction.

Give your answer in terms of ‘collision theory’.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

(2)
(i) The student repeated the investigation with small marble chips using hydrochloric acid with a lower concentration.

Figure 4 shows the volume of gas produced during the first 40 seconds.

![Figure 4](image)

Explain why the results for the lower concentration of acid are different from the results for the higher concentration of acid.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(3)
(Total 17 marks)
A student investigated the rate of the reaction between sodium thiosulfate solution and dilute hydrochloric acid.

**Figure 1** shows the apparatus.

The table shows the time taken for the student to no longer see the cross at different temperatures.

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Time in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>89</td>
</tr>
<tr>
<td>32</td>
<td>62</td>
</tr>
<tr>
<td>44</td>
<td>33</td>
</tr>
<tr>
<td>55</td>
<td>17</td>
</tr>
<tr>
<td>64</td>
<td>8</td>
</tr>
<tr>
<td>75</td>
<td>5</td>
</tr>
<tr>
<td>85</td>
<td>4</td>
</tr>
</tbody>
</table>
(a) Plot the data from the table on Figure 2.

Draw a line of best fit.

![Figure 2]

(b) Describe the trend in Figure 2.

Use values from Figure 2.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(3)
(c) The student also investigated the effect of concentration on the time taken for the reaction.

**Figure 3** shows the student’s results.

![Figure 3](image_url)  

**Figure 3** shows the student’s results.

Draw a tangent to the curve at 0.20 mol/dm³

Calculate the gradient (slope) of the tangent at 0.20 mol/dm³

Give the unit.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Gradient = ____________________ Unit ____________________

(4)
(d) Explain why the rate decreases during a reaction between sodium thiosulfate and dilute hydrochloric acid.

Write about particles in your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)
(Total 12 marks)

This question is about ammonia (NH₃).

(a) Complete the diagram to show the bonding electrons in ammonia.

Show the outer electrons only.

![Diagram of ammonia molecule]

(2)

Ammonia is produced from nitrogen and hydrogen.

\[ \text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) = 2\text{NH}_3(\text{g}) \]

The forward reaction is exothermic.

(b) A low pressure is used.

Explain the effect on the yield of ammonia.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)
(c) A high temperature is used.

Explain the effect on the yield of ammonia.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)

(d) Ammonia is removed from the reaction mixture.

Explain the effect on the position of equilibrium.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)

(Total 8 marks)