AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.4.2.1

Reactions of acids with metals

Past-paper questions

Tier	**Higher**
Question groups	**12**
Available paper years	**2018–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

5.4.2.1 Reactions of acids with metals

Question 01

June 2018 | 8464/C/1H | Original Q8

0 8 This question is about iron.

Iron reacts with dilute hydrochloric acid to produce iron chloride solution and one other product.

0 8 . 1 Name the other product.

[1 mark]

0 8 . 2 Suggest how any unreacted iron can be separated from the mixture.

[1 mark]

Magnesium reacts with iron chloride solution.

$$3\ Mg + 2\ FeCl_3 \rightarrow 2\ Fe + 3\ MgCl_2$$

0 8 . 3 0.120 g of magnesium reacts with excess iron chloride solution.

Relative atomic masses (A_r): Mg = 24 Fe = 56

Calculate the mass of iron produced, in mg

[5 marks]

Mass of iron = _____ mg

Question 8 continues on the next page

5.4.2.1 Reactions of acids with metals

Question 01 · continued

0 8 . 4 Explain which species is reduced in the reaction between magnesium and iron chloride.

$$3\ Mg + 2\ FeCl_3 \rightarrow 2\ Fe + 3\ MgCl_2$$

Your answer should include the half equation for the reduction.

[3 marks]

10

5.4.2.1 Reactions of acids with metals

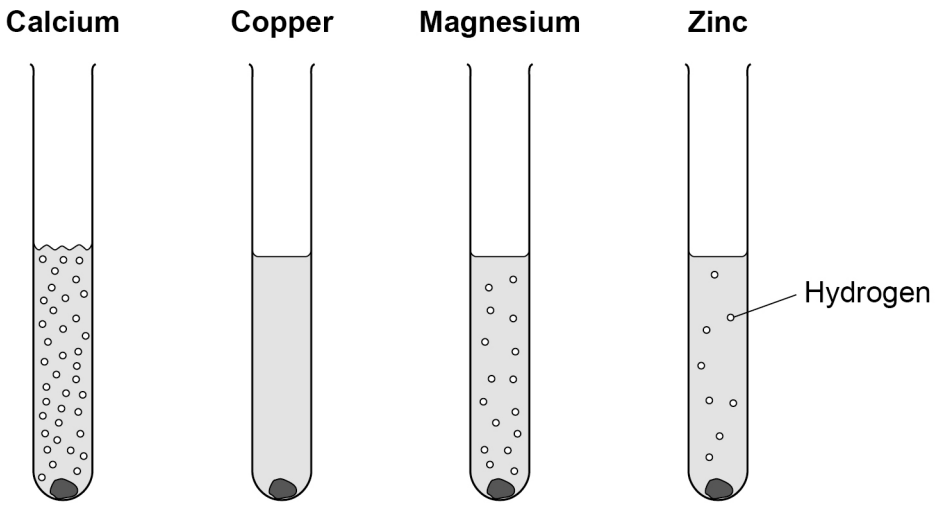
Question 02

June 2019 | 8464/C/1H | Original Q1

0 1 This question is about reactions of metals.

Figure 1 shows what happens when calcium, copper, magnesium and zinc are added to hydrochloric acid.

Figure 1



0 1 . 1 What is the order of decreasing reactivity of these four metals?

[1 mark]

Tick (✓) **one** box.

Zn Ca Cu Mg ☐

Ca Cu Mg Zn ☐

Cu Zn Ca Mg ☐

Ca Mg Zn Cu ☐

5.4.2.1 Reactions of acids with metals

Question 02 · continued

A student wants to make a fair comparison of the reactivity of the metals with hydrochloric acid.

0 1 . 2 Name **two** variables that must be kept constant.

[2 marks]

1 _____

_____

2 _____

_____

0 1 . 3 What is the independent variable in this reaction?

[1 mark]

_____

_____

0 1 . 4 Predict the reactivity of beryllium compared with magnesium.

Give a reason for your answer.

Use the periodic table.

[2 marks]

_____

Reason _____

_____

_____

0 1 . 5 A solution of hydrochloric acid contains 3.2 g of hydrogen chloride in 50 cm^3

Calculate the concentration of hydrogen chloride in g per dm^3

[3 marks]

_____

_____

_____

_____

Concentration = _____ g per dm^3

9

5.4.2.1 Reactions of acids with metals

Question 03

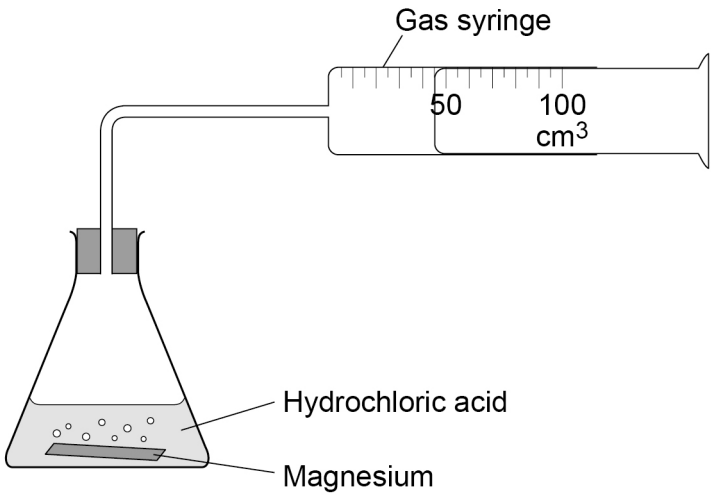
June 2019 | 8464/C/2H | Original Q5

0 5 This question is about magnesium.

A student investigated the rate of the reaction between magnesium and hydrochloric acid.

Figure 2 shows the apparatus.

Figure 2



0 5 . 1 Which is the correct ionic equation for the reaction?

[1 mark]

Tick (✓) **one** box.

$Mg + 2H^+ \rightarrow Mg^{2+} + H_2$ ☐

$Mg^{2+} + 2Cl^- \rightarrow MgCl_2$ ☐

$Mg + 2HCl \rightarrow MgCl_2 + H_2$ ☐

$Mg^+ + Cl^- \rightarrow MgCl$ ☐

5.4.2.1 Reactions of acids with metals

Question 03 · continued

0 5 . 2 What happens in the reaction between magnesium and hydrochloric acid?

[1 mark]

Tick (✓) **one** box.

Electron sharing ☐

Electron transfer ☐

Proton transfer ☐

Question 5 continues on the next page

5.4.2.1 Reactions of acids with metals

Question 03 · continued

0 5 . 3 **Table 2** shows the student's results.

Table 2

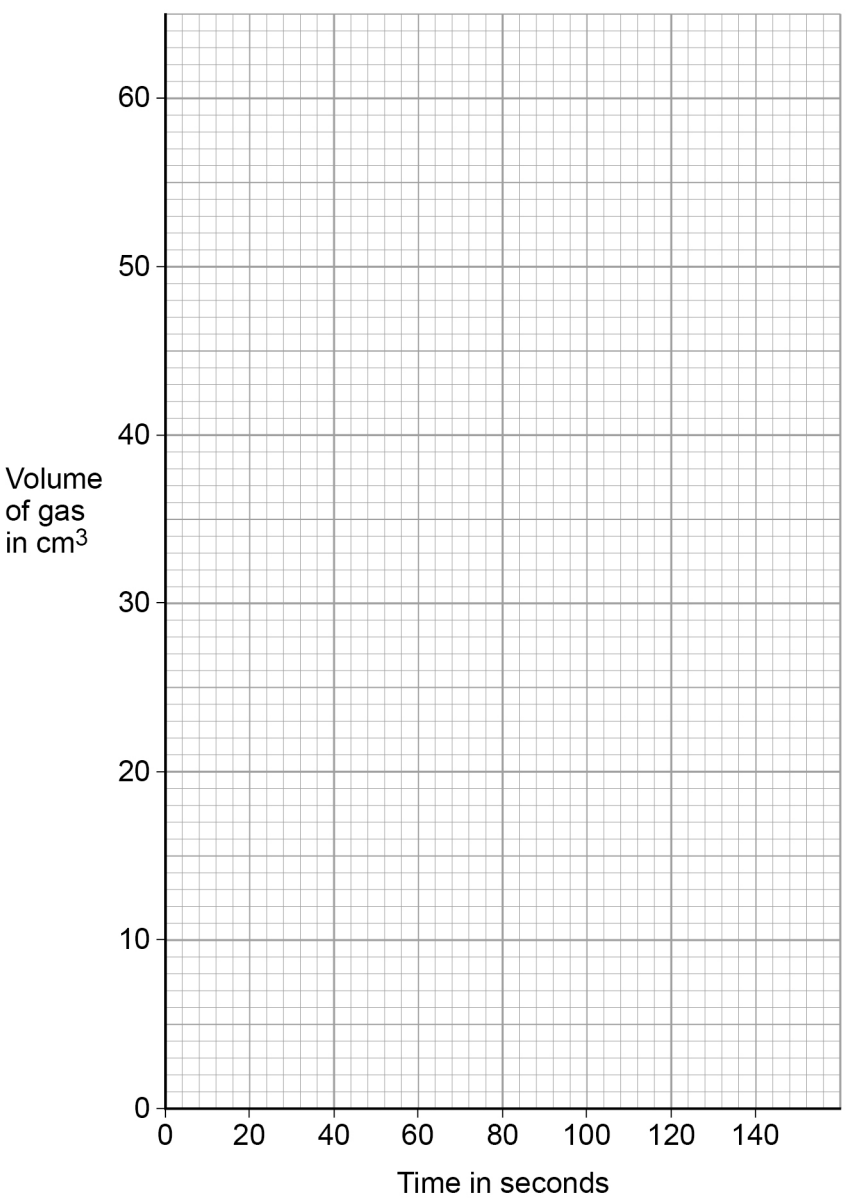
Time in seconds	0	10	35	50	95	120	140
Volume of gas in cm^3	0.0	12.5	36.0	43.5	59.0	60.0	60.0

Plot the data from **Table 2** on **Figure 3**.

Draw a line of best fit.

[3 marks]

Figure 3



5.4.2.1 Reactions of acids with metals

Question 03 · continued

June 2019 | 8464/C/2H | Original Q5

0 5 . 4 Describe the changes in the rate of this reaction.

[3 marks]

0 5 . 5 Explain why the rate of this reaction changes.

Give your answer in terms of collision theory.

[3 marks]

11

5.4.2.1 Reactions of acids with metals

Question 04

November 2020 | 8464/C/1H | Original Q4

0 4 This question is about acids, alkalis and bases.

A student reacted zinc oxide powder with hydrochloric acid to produce zinc chloride solution.

0 4 . 1 Complete the equation for the reaction by writing the state symbols.

[2 marks]

$$ZnO(_____) + 2\,HCl(_____) \rightarrow ZnCl_2(_____) + H_2O(_____)$$

0 4 . 2 Give **one** way that the student could speed up the reaction between zinc oxide powder and hydrochloric acid.

[1 mark]

Hydrochloric acid was the limiting reactant.

0 4 . 3 How could the student know when all the hydrochloric acid has reacted?

[1 mark]

0 4 . 4 How could the student obtain zinc chloride solution from the reaction mixture when all the hydrochloric acid has reacted?

[1 mark]

5.4.2.1 Reactions of acids with metals

Question 04 · continued

0 4 . 5 Describe how zinc chloride crystals are produced from zinc chloride solution.

[2 marks]

Sulfuric acid and sodium hydroxide react to produce sodium sulfate.

0 4 . 6 Sulfuric acid is gradually added to sodium hydroxide solution.

The pH of the mixture changes as the sulfuric acid is added until in excess.

Suggest the pH at:

- the start before sulfuric acid is added
- the end when sulfuric acid is in excess.

[2 marks]

pH at start = _____

pH at end = _____

0 4 . 7 Complete the symbol equation for the preparation of sodium sulfate.

You should balance the equation.

[2 marks]

_____ $NaOH$ + H_2SO_4 → _____ + _____

Question 4 continues on the next page

5.4.2.1 Reactions of acids with metals

Question 04 · continued

0 4 . 8 A solution of hydrochloric acid had a hydrogen ion concentration of 1.0 mol/dm^3

Water was added to the hydrochloric acid until the pH increased by 1

What was the hydrogen ion concentration of the hydrochloric acid after water had been added?

[1 mark]

Tick (✓) **one** box.

100 mol/dm^3 ☐

10 mol/dm^3 ☐

0.10 mol/dm^3 ☐

0.010 mol/dm^3 ☐

12

5.4.2.1 Reactions of acids with metals

Question 05

November 2021 | 8464/C/1H | Original Q2

0 2 Acids react to produce salts.

Universal indicator is added to water and then nitric acid is added to the mixture.

0 2 . 1 Give the colour change when nitric acid is added to the mixture of universal indicator and water.

[1 mark]

Tick (✓) **one** box.

- Blue to red ☐
- Green to purple ☐
- Green to red ☐
- Red to purple ☐

0 2 . 2 What happens to the pH of water when nitric acid is added?

[1 mark]

Tick (✓) **one** box.

- Decreases ☐
- Stays the same ☐
- Increases ☐

0 2 . 3 What is the state symbol for nitric acid?

[1 mark]

_____

5.4.2.1 Reactions of acids with metals

Question 05 · continued

Zinc carbonate reacts with nitric acid.

The word equation for the reaction is:

zinc carbonate (white solid) + nitric acid → zinc nitrate (colourless solution) + water + carbon dioxide

0 2 . 4 Give **two** observations that would be made when zinc carbonate is added to nitric acid until the zinc carbonate is in excess.

[2 marks]

1 _____

_____

2 _____

_____

0 2 . 5 The formula of the zinc ion is Zn^{2+}

The formula of the nitrate ion is NO_3^-

What is the formula for zinc nitrate?

[1 mark]

Tick (✓) **one** box.

- $ZnNO_3$ ☐
- $Zn(NO_3)_2$ ☐
- Zn_2NO_3 ☐
- $Zn_2(NO_3)_2$ ☐

Question 2 continues on the next page

5.4.2.1 Reactions of acids with metals

Question 05 · continued

0 2 . 6 Acids react with insoluble metal oxides to produce salts.

Plan a method to produce a pure, dry sample of the soluble salt copper chloride from an acid and a metal oxide.

[6 marks]

12

5.4.2.1 Reactions of acids with metals

Question 06

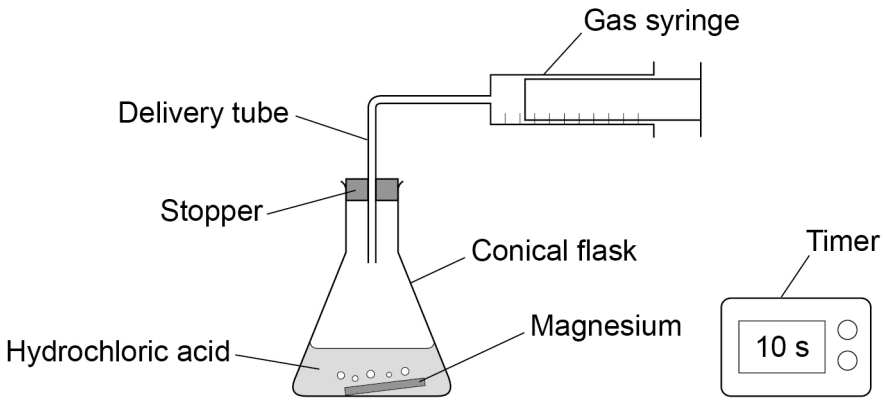
November 2021 | 8464/C/2H | Original Q1

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bo

0 1 A student investigated the reaction between magnesium and excess hydrochloric acid.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Pour 50 cm^3 of hydrochloric acid into a conical flask.

2. Add a piece of magnesium.

3. Insert stopper and delivery tube and start a timer.

4. Collect the gas produced in a gas syringe.

5. Record the volume of gas produced every 20 seconds for 2 minutes.

6. Repeat steps 1 to 5 with higher concentrations of hydrochloric acid.

0 1 . 1 Give the independent variable and **one** control variable in this investigation.

[2 marks]

Independent variable _____

Control variable _____

Question 1 continues on the next page

Question 06 · continued

Table 1 shows the results from the first experiment using hydrochloric acid with a low concentration.

Table 1

Time in seconds	0	20	40	60	80	100	120
Volume of gas in cm^3	0	48	72	90	97	98	98

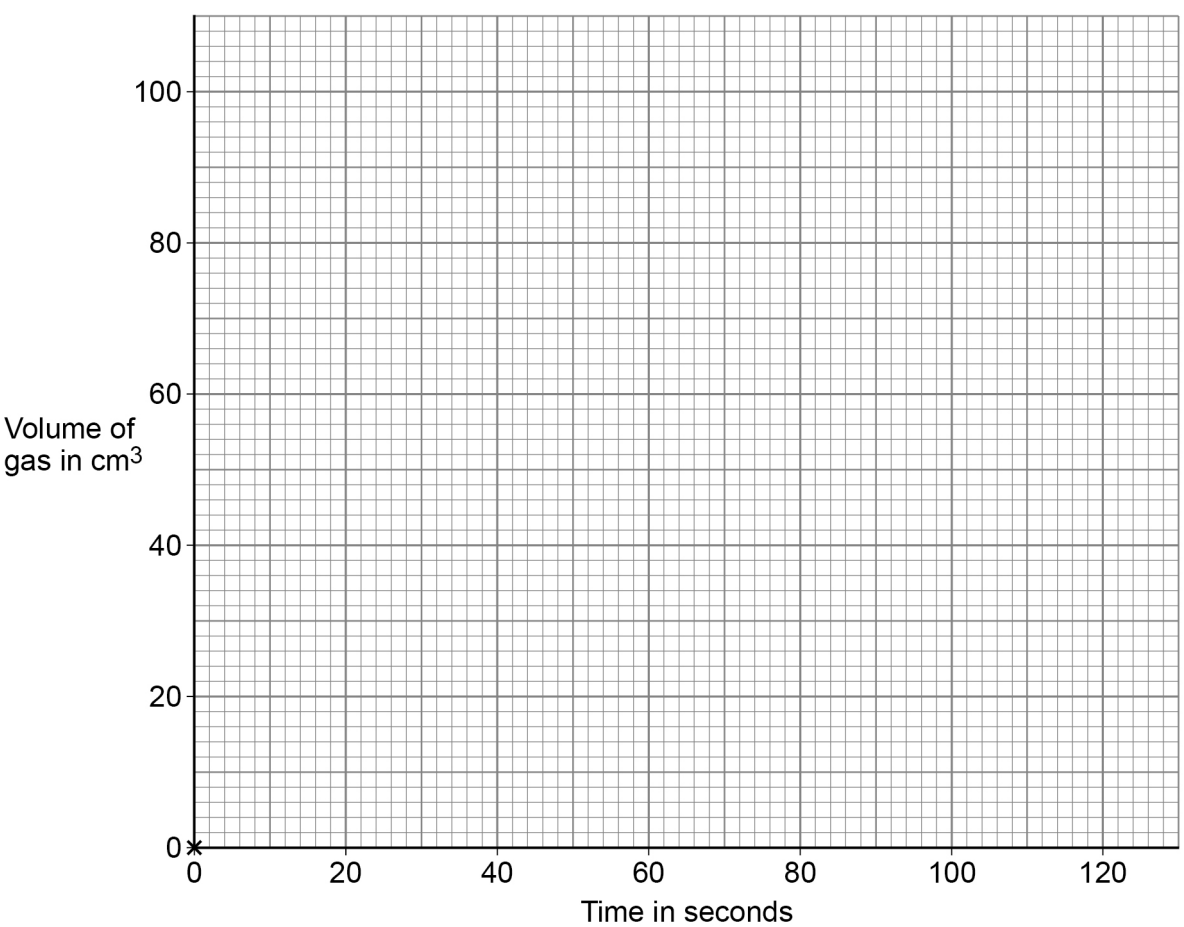
0 1 . 2 Complete **Figure 2**.

You should:

- plot the data from **Table 1** (the point 0,0 has been plotted for you)
- draw a line of best fit.

[3 marks]

Figure 2



5.4.2.1 Reactions of acids with metals

Question 06 · continued

0 1 . 3 How does the **rate** of this reaction change with time?

Use **Table 1**.

[1 mark]

Tick (✓) **one** box.

- The rate decreases. ☐
- The rate stays the same. ☐
- The rate increases. ☐

0 1 . 4 The student repeated the experiment using hydrochloric acid with a higher concentration.

Which statement is correct?

[1 mark]

Tick (✓) **one** box.

- The activation energy for the reaction was higher. ☐
- The magnesium reacted more quickly. ☐
- The reaction finished at the same time. ☐
- The total volume of gas collected was smaller. ☐

Question 1 continues on the next page

5.4.2.1 Reactions of acids with metals

Question 06 · continued

0 1 . 5 Temperature also affects the rate of the reaction.

Explain how increasing the temperature affects the **rate** of the reaction.

You should refer to particles and collisions.

[3 marks]

10

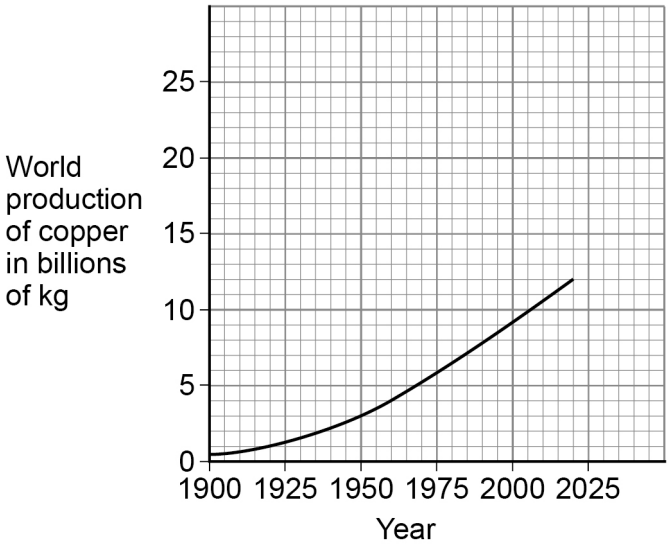
5.4.2.1 Reactions of acids with metals

Question 07

0 4 Industries use the Earth's natural copper resources to produce useful products.

Figure 4 shows the world production of copper from 1900 to 2020.

Figure 4



0 4 . 1 Describe the trend shown by the graph in **Figure 4**.

[2 marks]

0 4 . 2 Suggest **one** reason for the trend in **Figure 4**.

[1 mark]

5.4.2.1 Reactions of acids with metals

Question 07 · continued

0 4 . 3 Suggest **one** reason why the trend cannot be used to accurately predict the future world production of copper.

[1 mark]

Question 4 continues on the next page

5.4.2.1 Reactions of acids with metals

Question 07 · continued

0 4 . 4 High-grade copper resources are now difficult to find.

Phytomining is used to extract copper from low-grade ores.

There are five stages, **A**, **B**, **C**, **D** and **E**, in phytomining.

The stages are **not** in the correct order.

Stage **A** Copper compounds from ash are dissolved in acid.

Stage **B** Plants absorb metal compounds.

Stage **C** Plants are burned.

Stage **D** Plants are harvested.

Stage **E** Solution of copper compound is electrolysed.

What is the correct order of stages **A**, **B**, **C**, **D**, and **E**?

[1 mark]

Tick (✓) **one** box.

B, **C**, **D**, **E**, **A** ☐

B, **D**, **C**, **A**, **E** ☐

D, **B**, **C**, **E**, **A** ☐

D, **C**, **B**, **A**, **E** ☐

5.4.2.1 Reactions of acids with metals

Question 07 · continued

0 4 . 5 Give **two** disadvantages of phytomining compared with traditional mining methods.

Do **not** refer to cost in your answer.

[2 marks]

1 _____

_____

2 _____

_____

0 4 . 6 In one year, 8.89×10^9 kg of copper was produced.

41.0% of this copper was produced from recycled copper.

The energy needed to produce 1 kg of copper from copper ore is 70.4 MJ.

The energy needed to produce 1 kg of recycled copper is 27.2 MJ.

Calculate the difference in energy used if all the copper was produced from recycling.

Give your answer to 3 significant figures.

[5 marks]

_____

_____

_____

_____

_____

_____

_____

_____

Difference in energy used (3 significant figures) = _____ MJ

12

5.4.2.1 Reactions of acids with metals

Question 08

June 2022 | 8464/C/1H | Original Q3

0 3 Plan an investigation to find the order of reactivity of three metals.

You should use the temperature change when each metal reacts with hydrochloric acid.

[6 marks]

6

5.4.2.1 Reactions of acids with metals

Question 09

June 2022 | 8464/C/1H | Original Q6

0 6 This question is about hydrogen chloride and hydrochloric acid.

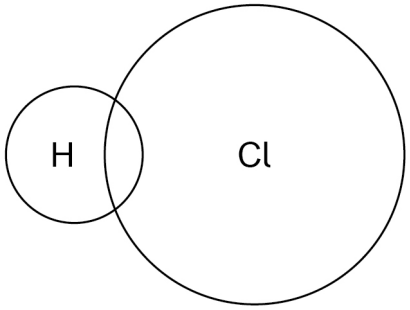
0 6 . 1 Complete the dot and cross diagram to represent the bonding in hydrogen chloride on **Figure 7**.

Use dots (o) and crosses (x) to represent electrons.

You should show only the electrons in the outer shells.

[2 marks]

Figure 7



0 6 . 2 Hydrogen chloride dissolves in water to produce hydrochloric acid.

Hydrochloric acid is a strong acid.

What is meant by the term strong acid?

[1 mark]

0 6 . 3 Describe how magnesium can be used to distinguish between a strong acid and a weak acid of the same concentration.

[2 marks]

5.4.2.1 Reactions of acids with metals

Question 09 · continued

0 6 . 4 The concentration of hydrochloric acid is increased by a factor of 100

What is the change in pH?

[2 marks]

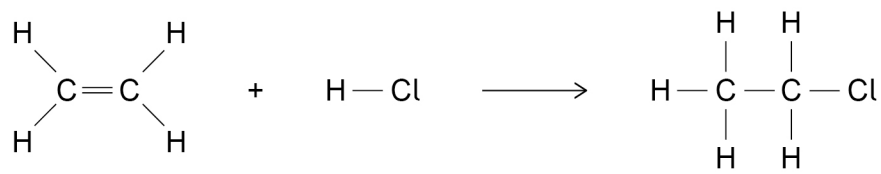
Question 6 continues on the next page

5.4.2.1 Reactions of acids with metals

Question 09 · continued

0 6 . 5 Ethene and hydrogen chloride react to produce chloroethane.

The displayed formulae equation for the reaction is:



The reaction is exothermic.

In the reaction the energy released forming new bonds is 56 kJ/mol greater than the energy needed to break existing bonds.

Table 1 shows some bond energies.

Table 1

Bond	H–C	C=C	H–Cl	C–C	C–Cl
Bond energy in kJ/mol	413	**X**	431	346	339

Calculate the bond energy **X**.

[4 marks]

X = _____ kJ/mol

11

5.4.2.1 Reactions of acids with metals

Question 10

June 2023 | 8464/C/1H | Original Q6

0 6 Acids react with some metals to produce soluble salts.

A student adds magnesium to hydrochloric acid until no more acid reacts and excess magnesium remains.

The equation for the reaction is:

$$Mg(s) + 2\,HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

0 6 . 1 Describe how solid magnesium chloride is obtained from the reaction mixture.

[2 marks]

0 6 . 2 The reaction between magnesium and hydrochloric acid is a redox reaction.

Explain what happens to the magnesium atoms in this reaction.

[2 marks]

5.4.2.1 Reactions of acids with metals

Question 10 · continued

0 6 . 3 0.72 g of magnesium is added to 100 cm^3 of hydrochloric acid.

The hydrochloric acid is in excess.

Calculate the concentration of the magnesium chloride ($MgCl_2$) solution produced in g/dm^3.

Relative atomic mass (A_r): Mg = 24

Relative formula mass (M_r): $MgCl_2$ = 95

[6 marks]

Concentration = _____ g/dm^3

10

5.4.2.1 Reactions of acids with metals

Question 11

June 2024 | 8464/C/1H | Original Q4

0 4 Nitric acid (HNO_3) is a strong acid.

0 4 . 1 What is meant by a 'strong acid'?

[1 mark]

0 4 . 2 Nitric acid is used as a dilute aqueous solution.

What is meant by 'dilute aqueous solution'?

[1 mark]

Question 4 continues on the next page

5.4.2.1 Reactions of acids with metals

Question 11 · continued

0 4 . 3 10 cm^3 of a nitric acid solution has a pH of 1

Water is added to the nitric acid solution to change the pH of the nitric acid solution to pH 3

How does the hydrogen ion concentration change?

[1 mark]

Tick (✓) **one** box.

- Decreases by a factor of 100 ☐
- Decreases by a factor of 10 ☐
- Increases by a factor of 10 ☐
- Increases by a factor of 100 ☐

0 4 . 4 Write the **ionic** equation for the reaction between an acid and an alkali.

[1 mark]

_____ + _____ → _____

5.4.2.1 Reactions of acids with metals

Question 11 · continued

The equation shows the reaction between magnesium carbonate and nitric acid.

$$MgCO_3 + 2\,HNO_3 \rightarrow Mg(NO_3)_2 + H_2O + CO_2$$

0 4 . 5 What is the ratio of the number of moles of magnesium carbonate to the number of moles of nitric acid in the reaction?

[1 mark]

Tick (✓) **one** box.

1 : 1 ☐

1 : 2 ☐

2 : 1 ☐

2 : 2 ☐

0 4 . 6 A student mixed some magnesium carbonate with excess nitric acid.

The student then added two drops of universal indicator to the solution.

What colour was the solution after the addition of universal indicator?

[1 mark]

Tick (✓) **one** box.

Red ☐

Green ☐

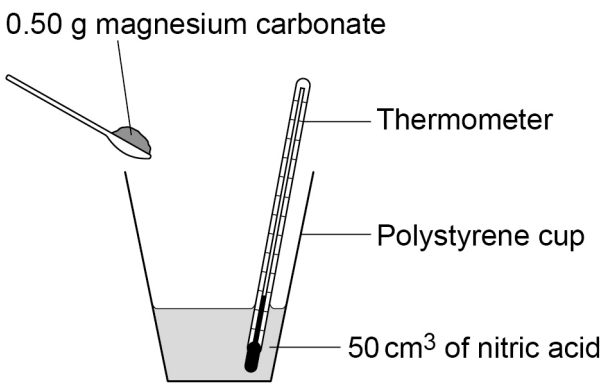
Blue ☐

Question 11 · continued

A student investigated the temperature change when different masses of magnesium carbonate were reacted with excess nitric acid.

Figure 6 shows the apparatus.

Figure 6



This is the method used.

1. Pour 50 cm^3 of nitric acid into a polystyrene cup.
2. Measure the temperature of the solution.
3. Add 0.50 g of magnesium carbonate.
4. Stir the mixture.
5. Measure the temperature.
6. Repeat steps 1 to 5 with different masses of magnesium carbonate.

0 4 . 7 Give **two** improvements to the **method** to produce more accurate results.

Do **not** refer to improvements to the apparatus in your answer.

[2 marks]

1 _____

_____

2 _____

_____

8

5.4.2.1 Reactions of acids with metals

Question 12

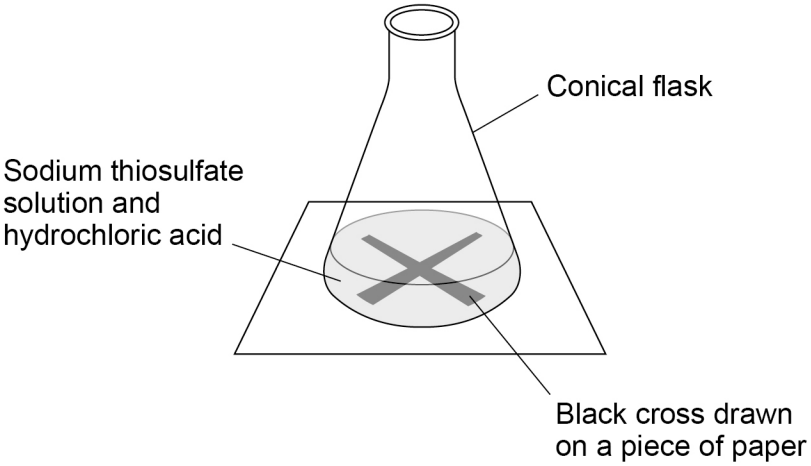
June 2025 | 8464/C/2H | Original Q5

0 5 Students investigated the effect of changing the concentration on the rate of chemical reactions.

A student reacted sodium thiosulfate solution with hydrochloric acid.

Figure 3 shows the apparatus.

Figure 3



This is the method used.

1. Measure 50 cm^3 of sodium thiosulfate solution into a conical flask.

2. Put the conical flask on a black cross drawn on a piece of paper.

3. Add 10 cm^3 of hydrochloric acid to the conical flask.

4. Start a timer.

5. Stop the timer when the cross is no longer visible.

6. Record the time taken.

7. Repeat steps 1 to 6 using different concentrations of sodium thiosulfate solution.

5.4.2.1 Reactions of acids with metals

Question 12 · continued

0 5 . 1 What is the dependent variable in this investigation?

[1 mark]

0 5 . 2 The equation for the reaction is:

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

The mixture becomes cloudy as the reaction takes place.

Explain why the mixture becomes cloudy.

[2 marks]

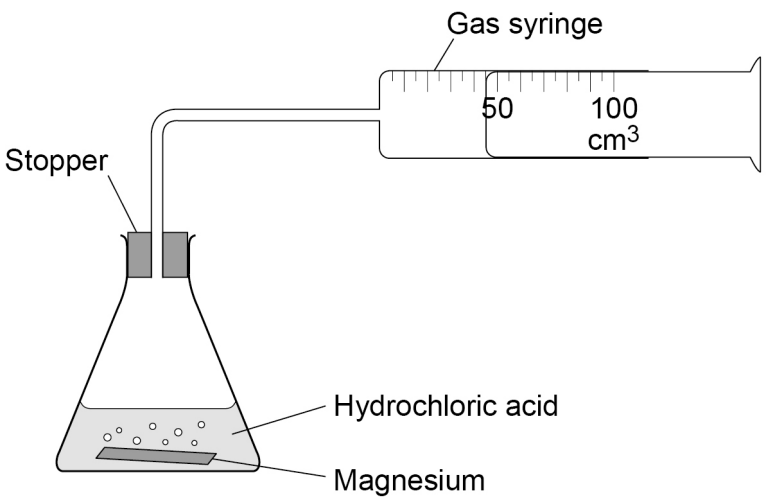
0 5 . 3 Explain the effect of changing the concentration of the sodium thiosulfate solution on the rate of reaction.

[3 marks]

A different student reacted magnesium with hydrochloric acid.

Figure 4 shows the apparatus.

Figure 4



This is the method used.

1. Measure 50 cm^3 of hydrochloric acid into a conical flask.
2. Add 0.1 g of magnesium ribbon to the conical flask.
3. Insert the stopper into the conical flask as quickly as possible.
4. Start a timer.
5. Record the volume of gas collected every 20 seconds for 5 minutes.
6. Repeat steps 1 to 5 using different concentrations of hydrochloric acid.

0 5 . 4 Why is the stopper inserted into the conical flask as quickly as possible in step 3?

[1 mark]

5.4.2.1 Reactions of acids with metals

Question 12 · continued

0 5 . 5 The equation for the reaction of magnesium with hydrochloric acid is:

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

Describe a test for the gas produced in the reaction.

Give the result of the test.

[2 marks]

Test _____

_____

Result _____

_____

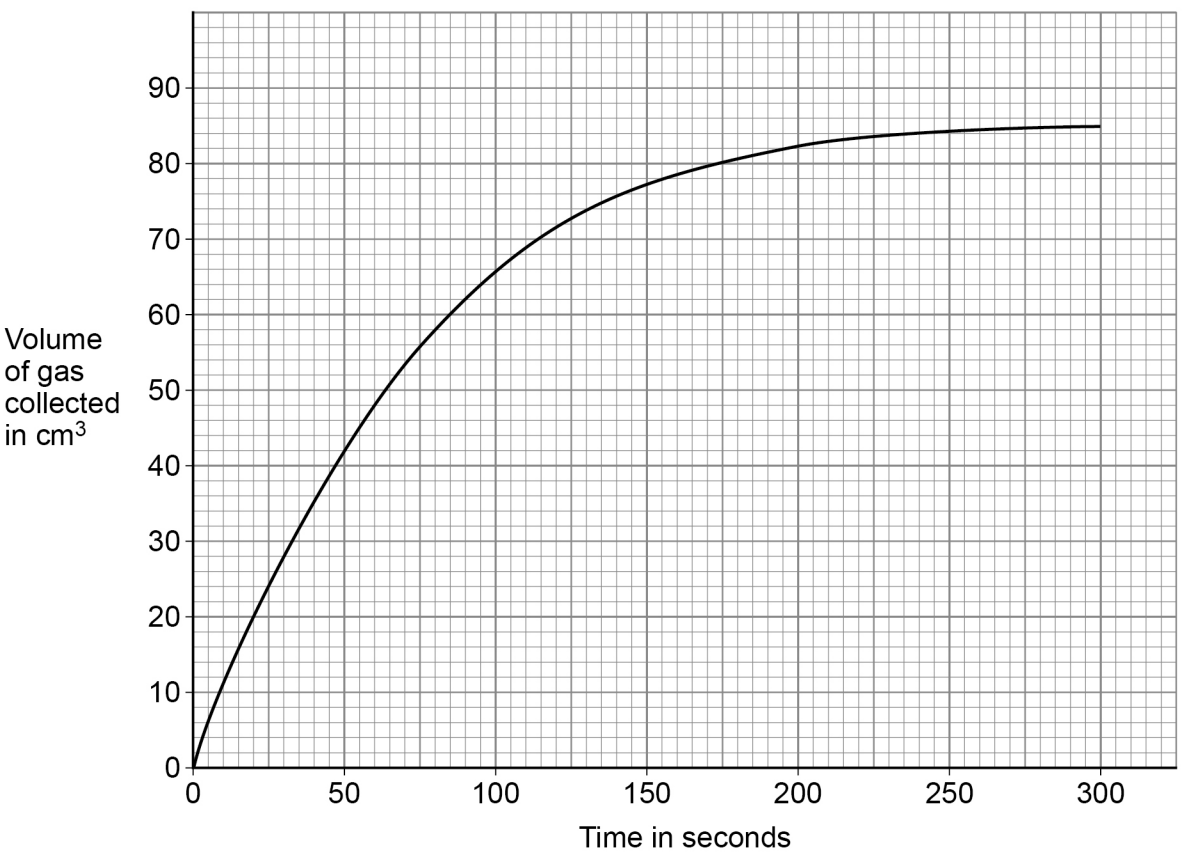
Question 5 continues on the next page

5.4.2.1 Reactions of acids with metals

Question 12 · continued

0 5 . 6 **Figure 5** shows the results for one concentration of hydrochloric acid.

Figure 5



Determine the rate of reaction at 75 seconds.

[4 marks]

Rate = _____ cm^3/s

13