AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.4.3.1

The process of electrolysis

Past-paper questions

Tier	**Foundation**
Question groups	**39**
Available paper years	**2008–2025**

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.

4.4.3.1 The process of electrolysis

Question 01

January 2008 | CHY2F | Original Q4 | Legacy

4 The electrolysis of sodium chloride solution produces useful substances.

(a) (i) Choose a word from the box to complete the sentence.

covalent	**ionic**	**non-metallic**

Electrolysis takes place when electricity passes through ..... compounds when they are molten or in solution.

(1 mark)

(ii) Choose a word from the box to complete the sentence.

alkenes	**elements**	**salts**

During electrolysis the compound is broken down to form ..... .

(1 mark)

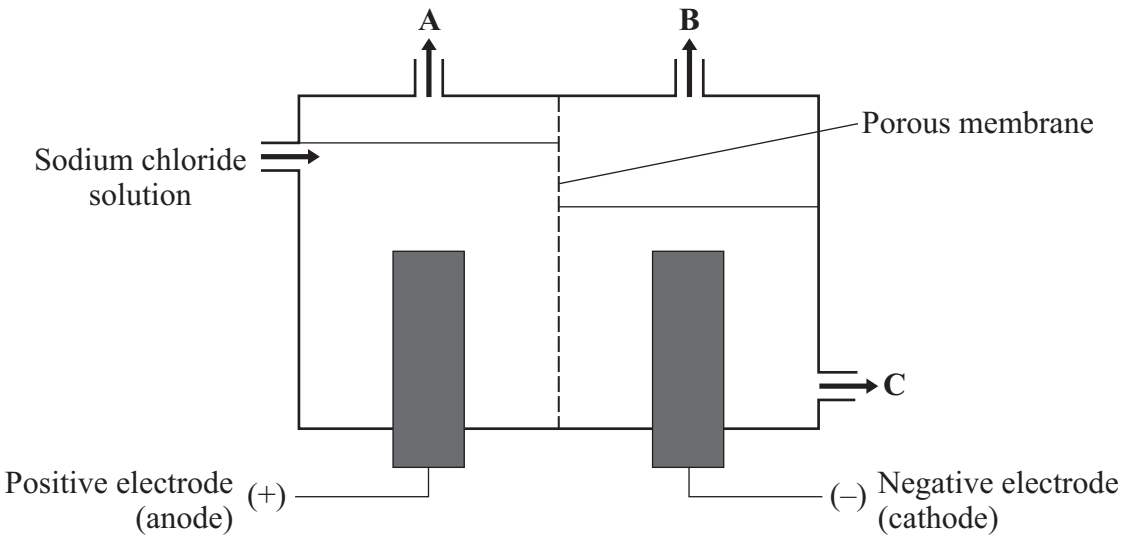
4.4.3.1 The process of electrolysis

Question 01 · continued

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(b) The table of ions on the Data Sheet may help you to answer this question.

The diagram shows an apparatus used for the electrolysis of sodium chloride solution.



Identify the products **A**, **B** and **C** on the diagram using substances from the box.

chlorine gas	**hydrogen gas**	**oxygen gas**
sodium hydroxide solution		**sodium metal**

(i) **A** is ..... .
(1 mark)

(ii) **B** is ..... .
(1 mark)

(iii) **C** is ..... .
(1 mark)

5

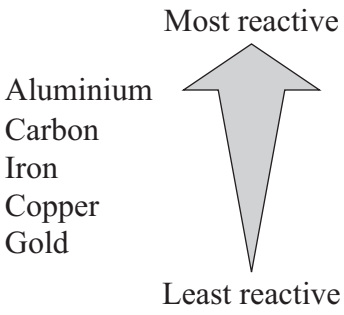
4.4.3.1 The process of electrolysis

Question 02

March 2008 | CHY1AP | Original Q5 | Legacy

QUESTION FIVE

This is the order of reactivity for five elements.



Match metals, **A**, **B**, **C** and **D**, with the numbers **1–4** in the table.

A iron

B aluminium

C copper

D gold

	What we can say about the metal
1	It will **not** react with oxygen or water even at high temperatures.
2	It is made in the blast furnace by the reduction of its oxide with carbon.
3	It can be extracted from its molten ore with electricity but **not** with carbon.
4	It can be extracted from its ore with carbon and is purified by electrolysis.

4.4.3.1 The process of electrolysis

Question 03

June 2008 | CHY2F | Original Q4 | Legacy

4 Instant cold packs are used to treat sports injuries.



One type of cold pack has a plastic bag containing water. Inside this bag is a smaller bag containing ammonium nitrate.

The outer bag is squeezed so that the inner bag bursts. The pack is shaken and quickly gets very cold as the ammonium nitrate dissolves in the water.

4 (a) **One** of the statements in the table is correct.

Put a tick (✓) next to the correct statement.

Statement	(✓)
The bag gets cold because heat energy is given out to the surroundings.	
The bag gets cold because heat energy is taken in from the surroundings.	
The bag gets cold because plastic is a good insulator.	

(1 mark)

4.4.3.1 The process of electrolysis

Question 03 · continued

for mark

4 (b) Draw a ring around the word that best describes the change when ammonium nitrate dissolves in water.

electrolysis **endothermic** **exothermic**

(1 mark)

4 (c) Suggest and explain why the pack is shaken after the inner bag has burst.

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(2 marks)

4

Turn over for the next question

4.4.3.1 The process of electrolysis

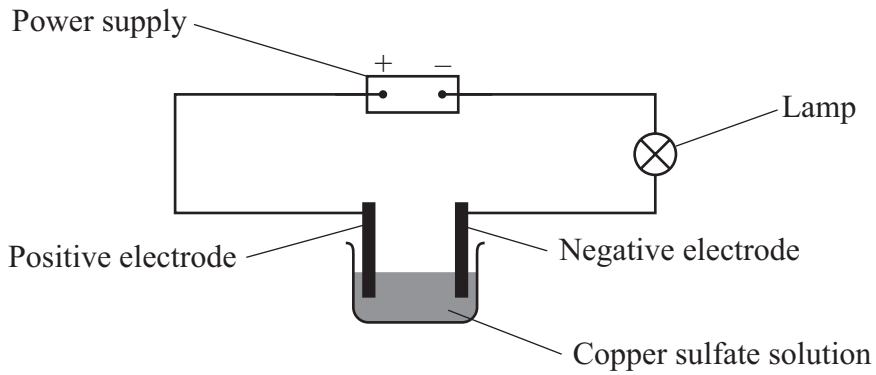
Question 04

June 2008 | CHY2F | Original Q8 | Legacy

8 A student investigated the electrolysis of copper sulfate solution.
The student's method is shown in the box.

Two clean pieces of copper were weighed. One piece was used as the positive electrode and the other piece was used as the negative electrode.

The circuit was set up as shown in the diagram.



After the electrolysis, the pieces of copper were:

- washed with distilled water
- washed with propanone (a liquid with a lower boiling point than water)
- allowed to dry
- weighed.

8 (a) Explain why the electrode would dry faster when washed with propanone instead of water.

.....

.....

(1 mark)

8 (b) The student's results are given in the table.

	Positive electrode	**Negative electrode**
mass of electrode before electrolysis, in grams	16.41	15.46
mass of electrode after electrolysis, in grams	16.10	15.75

The mass of the positive electrode decreased by 0.31 g.

4.4.3.1 The process of electrolysis

Question 04 · continued

for mark

8 (b) (i) What is the change in mass of the negative electrode? ..... g

(1 mark)

8 (b) (ii) The mass lost by the positive electrode should equal the mass gained by the negative electrode.

Suggest **two** reasons why the results were **not** as expected.

1 .....

.....

2 .....

.....

(2 marks)

8 (c) Describe and explain how electrolysis is used to make pure copper from a lump of impure copper.

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(4 marks)

8

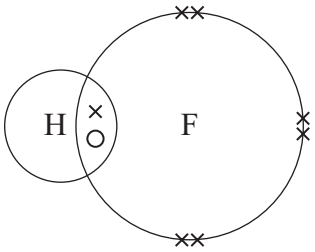
4.4.3.1 The process of electrolysis

Question 05

June 2009 | CHY2F | Original Q4 | Legacy

4 This question is about fluorine and some of its compounds.

4 (a) The diagram represents a molecule of hydrogen fluoride.



Draw a ring around the type of bonding that holds the hydrogen and fluorine atoms together in this molecule.

covalent **ionic** **metallic**

(1 mark)

4 (b) Fluorine is made in industry by the electrolysis of a mixture of potassium fluoride and hydrogen fluoride.

4 (b) (i) Use **one** word from the box to complete the sentence.

gas	**liquid**	**solid**

To allow electrolysis to take place the mixture of potassium fluoride and hydrogen fluoride must be ..... . *(1 mark)*

4.4.3.1 The process of electrolysis

Question 05 · continued

for mark

4 (b) (ii) The mixture of potassium fluoride and hydrogen fluoride contains fluoride ions (F^-), hydrogen ions (H^+) and potassium ions (K^+).

Use **one** word from the box to complete the sentence.

fluorine	**hydrogen**	**potassium**

During electrolysis the element formed at the **positive** electrode is

..... . *(1 mark)*

4 (c) Fluoride ions are sometimes added to drinking water. It is thought that these ions help to reduce tooth decay.

4 (c) (i) Tick (✓) **one** question that **cannot** be answered by scientific investigation alone.

Question	Tick (✓)
Do fluoride ions in drinking water reduce tooth decay?	
Are fluoride ions in drinking water harmful to health?	
Should fluoride ions be added to drinking water?	

(1 mark)

4 (c) (ii) Explain why you have chosen this question.

.....

.....

(1 mark)

5

4.4.3.1 The process of electrolysis

Question 06

November 2009 | CHY1AP | Original Q9 | Legacy

QUESTION NINE

Duralumin is an alloy which contains copper and magnesium mixed with aluminium.

Aluminium is a low density metal but duralumin is used more often in making aeroplanes.

9A Aluminium, copper and magnesium are extracted from their naturally occurring compounds.

The method used for the extraction depends on . . .

1 the density of the metal.

2 the abundance of the metal compound in the Earth's crust.

3 the melting point of the metal compound.

4 the reactivity of the metal.

9B Copper can be extracted by strongly heating a mixture of the copper compound and carbon.

In this reaction, the copper compound is . . .

1 oxidised.

2 electrolysed.

3 reduced.

4 distilled.

9C Aluminium and magnesium are extracted by electrolysis.

One reason why this method is expensive is that . . .

1 the metals are resistant to corrosion.

2 the process requires a large amount of energy.

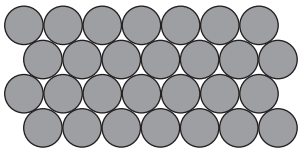
3 the metals are less reactive than carbon.

4 the metal ores are very abundant.

4.4.3.1 The process of electrolysis

Question 06 · continued

9D The diagram shows the arrangement of the atoms in pure aluminium.



Which row in the table correctly shows how the structure and properties are different in duralumin?

	Structure	Properties
1	The layers of atoms are distorted.	The alloy is harder.
2	The copper atoms attach strongly to the aluminium atoms.	The alloy is softer.
3	The layers of atoms are distorted.	The alloy is softer.
4	The magnesium atoms attach strongly to the aluminium atoms.	The alloy is harder.

END OF TEST

4.4.3.1 The process of electrolysis

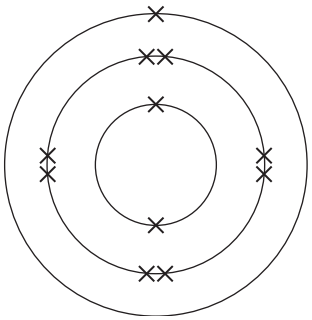
Question 07

7 Sodium chloride is a raw material.

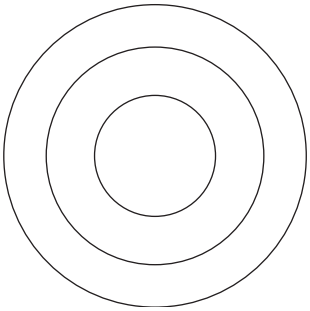
7 (a) The electronic structure of a sodium atom is shown below.

Complete the diagram for the electronic structure of a chlorine atom. A chlorine atom has 17 electrons.

Sodium atom



Chlorine atom



(1 mark)

7 (b) When sodium and chlorine react to form sodium chloride they form sodium ions (Na^+) and chloride ions (Cl^-).

How does a sodium atom change into a sodium ion?

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.....

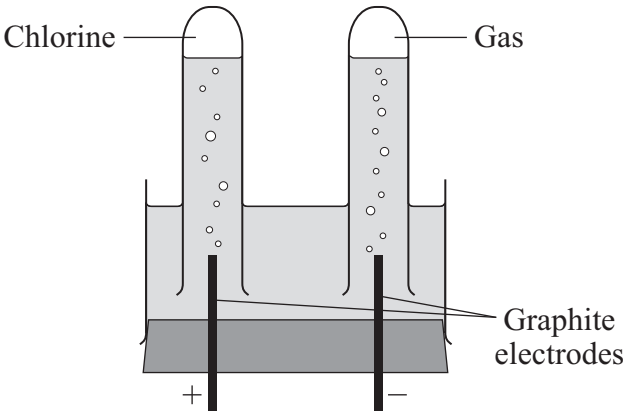
(2 marks)

4.4.3.1 The process of electrolysis

Question 07 · continued

for mark

7 (c) The diagram shows apparatus used in a school laboratory for the electrolysis of sodium chloride solution.



The solution contains sodium ions (Na^+), chloride ions (Cl^-), hydrogen ions (H^+) and hydroxide ions (OH^-).

7 (c) (i) Why do chloride ions move to the positive electrode?

.....

(1 mark)

7 (c) (ii) Name the gas formed at the negative electrode.

.....

(1 mark)

Question 7 continues on the next page

4.4.3.1 The process of electrolysis

for mark

7 (d) Chlorine and chlorine compounds are used to bleach wood pulp that is used to make paper.

The article below is from a newspaper.

> Local people have been protesting outside a paper factory. They say:
> 'We want the company to stop using chlorine compounds. Chlorine compounds release poisons into the environment. The company should use safer compounds.'
>
> The company replied:
> 'Chlorine has been used safely for many years to treat drinking water. Only tiny amounts of chlorine are released, which cause no harm. Using other compounds will be more expensive and may put us out of business.'

7 (d) (i) Why are some local people worried about the use of chlorine compounds?

.....

.....

(1 mark)

7 (d) (ii) Why might other local people want the company to continue to use chlorine compounds?

.....

.....

(1 mark)

7 (d) (iii) It is decided to have an enquiry.
Why should this be done by independent scientists?

.....

.....

(1 mark)

8

4.4.3.1 The process of electrolysis

Question 08

March 2010 | CHY1AP | Original Q2 | Legacy

QUESTION TWO

This question is about metals.

Match metals, **A**, **B**, **C** and **D**, with the numbers **1–4** in the table.

A iron

B aluminium

C gold

D stainless steel

1	It is found in the Earth as the metal itself.
2	It is an alloy which is resistant to corrosion.
3	It is extracted by reduction of its oxide in a blast furnace.
4	It is extracted from its oxide by electrolysis.

4.4.3.1 The process of electrolysis

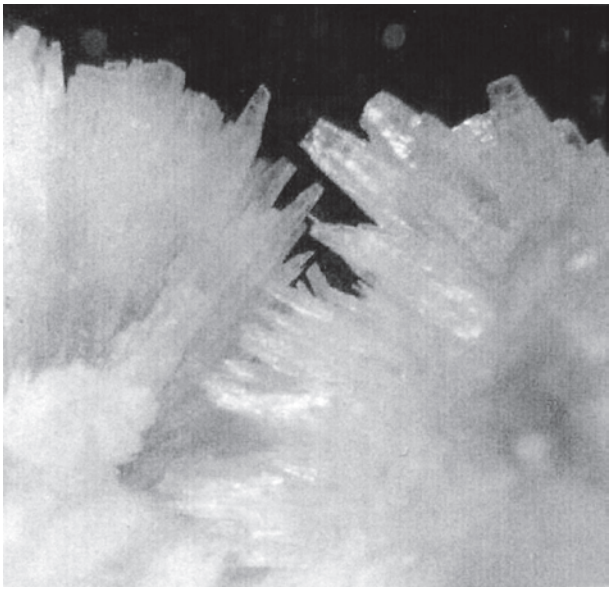
Question 09

June 2010 | CHY2F | Original Q7 | Legacy

7 (a) Read the article about the mineral strontianite.

Strontianite is a mineral that was discovered near the village of Strontian in Scotland. At first some scientists thought that strontianite was barium carbonate.

Strontianite



In 1790, Professor Adair Crawford and William Cruikshank were both lecturers in chemistry and doctors of medicine. They investigated the properties of strontianite. They found that strontianite had different properties from barium carbonate. They concluded that strontianite contained a new element.

After this, other scientists also showed that strontianite and barium carbonate had different properties. Strontianite is now known to be strontium carbonate.

7 (a) (i) What evidence did Crawford and Cruikshank use to prove that strontianite was **not** barium carbonate?

.....

.....

(1 mark)

7 (a) (ii) Crawford and Cruikshank's conclusion was immediately accepted by other scientists. Suggest why.

.....

.....

(1 mark)

7 (a) (iii) How was the reliability of the work of Crawford and Cruikshank confirmed?

.....

.....

(1 mark)

4.4.3.1 The process of electrolysis

Question 09 · continued

7 (b) One of Crawford and Cruikshank's experiments was repeated in a school laboratory. Samples of strontianite and barium carbonate were reacted with hydrochloric acid to produce strontium chloride and barium chloride.

Solid strontium chloride and solid barium chloride were separately added to water. The change in temperature of the water was measured.

The results of the experiments are shown below.

	Experiment 1 Strontium chloride dissolved in water	**Experiment 2** Barium chloride dissolved in water
Temperature of water before adding the chloride in ºC	19.5	19.6
Temperature of water after adding the chloride in ºC	21.2	17.5

7 (b) (i) State **one** variable that should be controlled to make it a fair test.

.....

.....

(1 mark)

7 (b) (ii) Which experiment, **1** or **2**, is endothermic?

Explain how you know.

Experiment ☐ because .....

.....

(1 mark)

7 (b) (iii) The results prove that strontium chloride and barium chloride must be different even if all of the variables had not been controlled when they were dissolved. Explain why.

.....

.....

(1 mark)

7 (c) In 1808, Humphry Davy was the first person to extract strontium. He did this by the electrolysis of molten strontium chloride. Strontium formed at the negative electrode.

Suggest why strontium ions are attracted to the negative electrode.

.....

.....

(1 mark)

7

4.4.3.1 The process of electrolysis

Question 10

November 2010 | CHY1AP | Original Q5 | Legacy

QUESTION FIVE

This question is about how we obtain some metals.

Match statements, **A**, **B**, **C** and **D**, with the numbers **1–4** in the table.

A uses another metal

B does **not** use a chemical reaction

C could be done in a blast furnace

D is called electrolysis

1	Aluminium is made when an electric current passes through a molten aluminium compound.
2	Gold can be found at the bottom of some streams.
3	Titanium is made by reacting titanium chloride with magnesium.
4	Zinc is made when a mixture of zinc oxide and carbon is heated.

4.4.3.1 The process of electrolysis

Question 11

January 2011 | CHY1F | Original Q6 | Legacy

6 The flow diagram shows the main stages used to extract a metal from its ore.

mining the ore → purifying the ore → extracting the metal

The table shows some information about three metals.

Metal	Metal ore	Purified ore	% of metal in the ore	% of metal in the Earth's crust
aluminium	bauxite	aluminium oxide, Al_2O_3	28.0	8.0
copper	chalcocite	copper sulfide, Cu_2S	0.5	0.001
iron	haematite	iron oxide, Fe_2O_3	29.0	5.0

6 (a) Use the information in the table and your knowledge and understanding to help you to answer the questions.

6 (a) (i) Suggest why purifying the copper ore produces large quantities of waste.

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(1 mark)

6 (a) (ii) Suggest why the annual world production of iron is forty times greater than that of aluminium.

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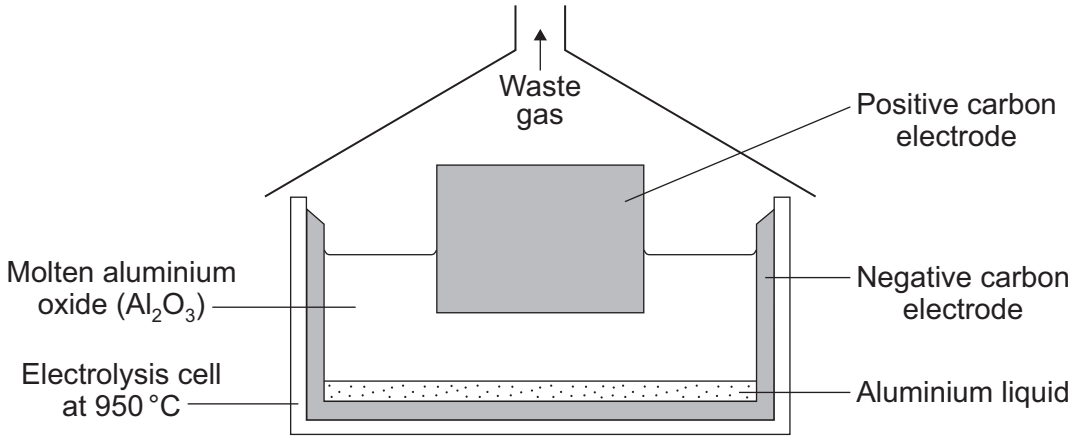
.....

(1 mark)

4.4.3.1 The process of electrolysis

Question 11 · continued

6 (b) Aluminium is used for drinks cans.
Aluminium is extracted from its purified ore by electrolysis.



6 (b) (i) Suggest why the aluminium produced in the electrolysis cell is a liquid.

.....

.....

(1 mark)

6 (b) (ii) In this electrolysis, aluminium and oxygen gas are produced from the aluminium oxide.

Use the information in the diagram to suggest why most of the waste gas is carbon dioxide and not oxygen.

.....

.....

.....

.....

(2 marks)

6 (b) (iii) Aluminium is the most abundant metal in the Earth's crust.

Suggest **two** reasons why we should recycle aluminium drinks cans.

1 .....

.....

2 .....

.....

(2 marks)

7

4.4.3.1 The process of electrolysis

Question 12

January 2011 | CHY2F | Original Q3 | Legacy

3 (a) A magnesium atom contains 12 protons (●),12 neutrons (o) and 12 electrons (×).

Which diagram, **A**, **B** or **C**, represents this magnesium atom?

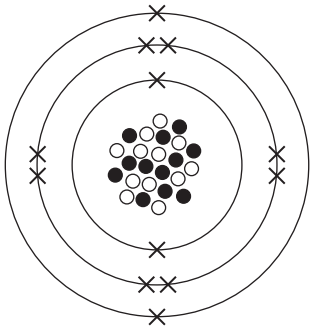


Diagram A

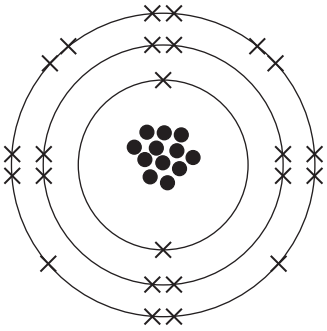


Diagram B

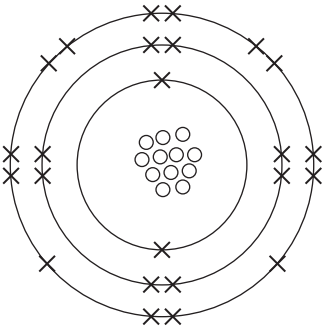
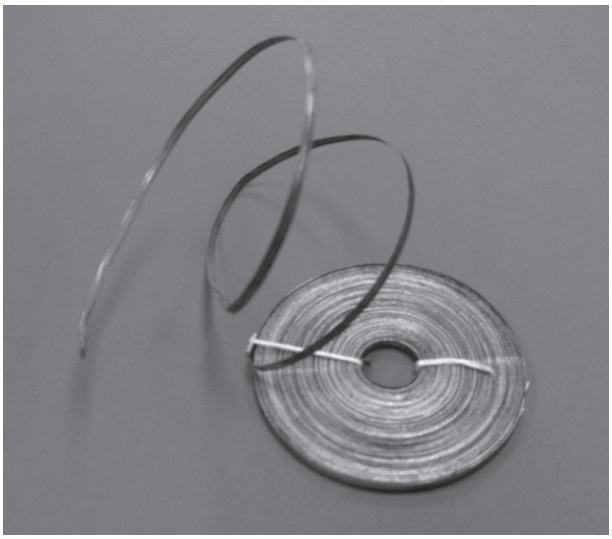


Diagram C

This magnesium atom is **Diagram** ☐ .

(1 mark)

3 (b) Magnesium metal is shaped to make magnesium ribbon.



Tick (✓) **two** reasons which explain why metals can be shaped.

Reason why	Tick (✓)
The atoms are all joined by covalent bonds.	
The atoms can slide over each other.	
The atoms are large.	
The atoms are in layers.	

(2 marks)

4.4.3.1 The process of electrolysis

Question 12 · continued January 2011 | CHY2F | Original Q3 | Legacy

3 (c) Magnesium sulfate is a salt of magnesium.

It can be prepared by the reaction of magnesium metal with an acid. The equation for the reaction of magnesium with this acid is:

Mg(s)	+	H_2SO_4(aq)	→	$MgSO_4$(aq)	+	H_2(g)
magnesium		acid		magnesium sulfate solution		hydrogen

3 (c) (i) Draw a ring around the name of the acid used in this reaction.

hydrochloric **nitric** **sulfuric**

(1 mark)

3 (c) (ii) Use the equation to help you to answer this question.

Tick (✓) **two** things that happen when this reaction takes place.

	Tick (✓)
Bubbles are produced.	
The magnesium disappears.	
A solid is formed.	
Water is formed.	

(2 marks)

3 (c) (iii) Draw a ring around a method to get solid magnesium sulfate from magnesium sulfate solution.

crystallisation **electrolysis** **oxidation**

(1 mark)

7

4.4.3.1 The process of electrolysis

Question 13

January 2011 | CHY2F | Original Q6 | Legacy

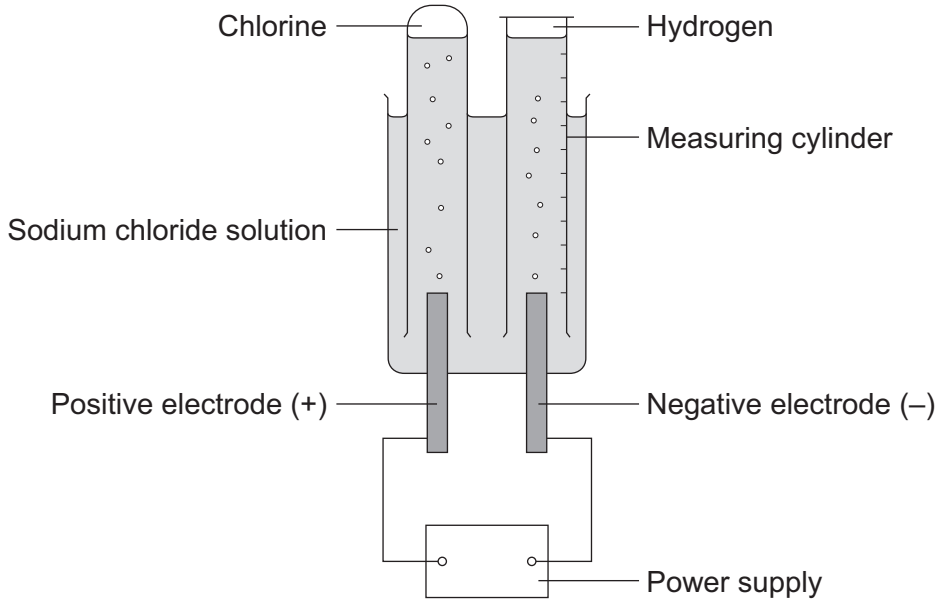
6 A student investigated the electrolysis of sodium chloride solution.

Five sodium chloride solutions were made. Each solution had a different concentration.

To make each solution the student:

- weighed the amount of sodium chloride needed
- dissolved it in water
- added more water until the total volume was one cubic decimetre (1 dm^3).

The solutions were placed one at a time in the apparatus shown below.



The student measured the volume of hydrogen gas produced in ten minutes.

The results are shown on the graph on the next page.

6 (a) Sodium chloride does not conduct electricity when it is solid.

Explain, in terms of ions, why sodium chloride solution conducts electricity.

.....

.....

(1 mark)

6 (b) Chlorine is produced at the positive electrode.

Why are chloride ions attracted to the positive electrode?

.....

(1 mark)

Question 6 continues on the next page

4.4.3.1 The process of electrolysis

Question 13 · continued

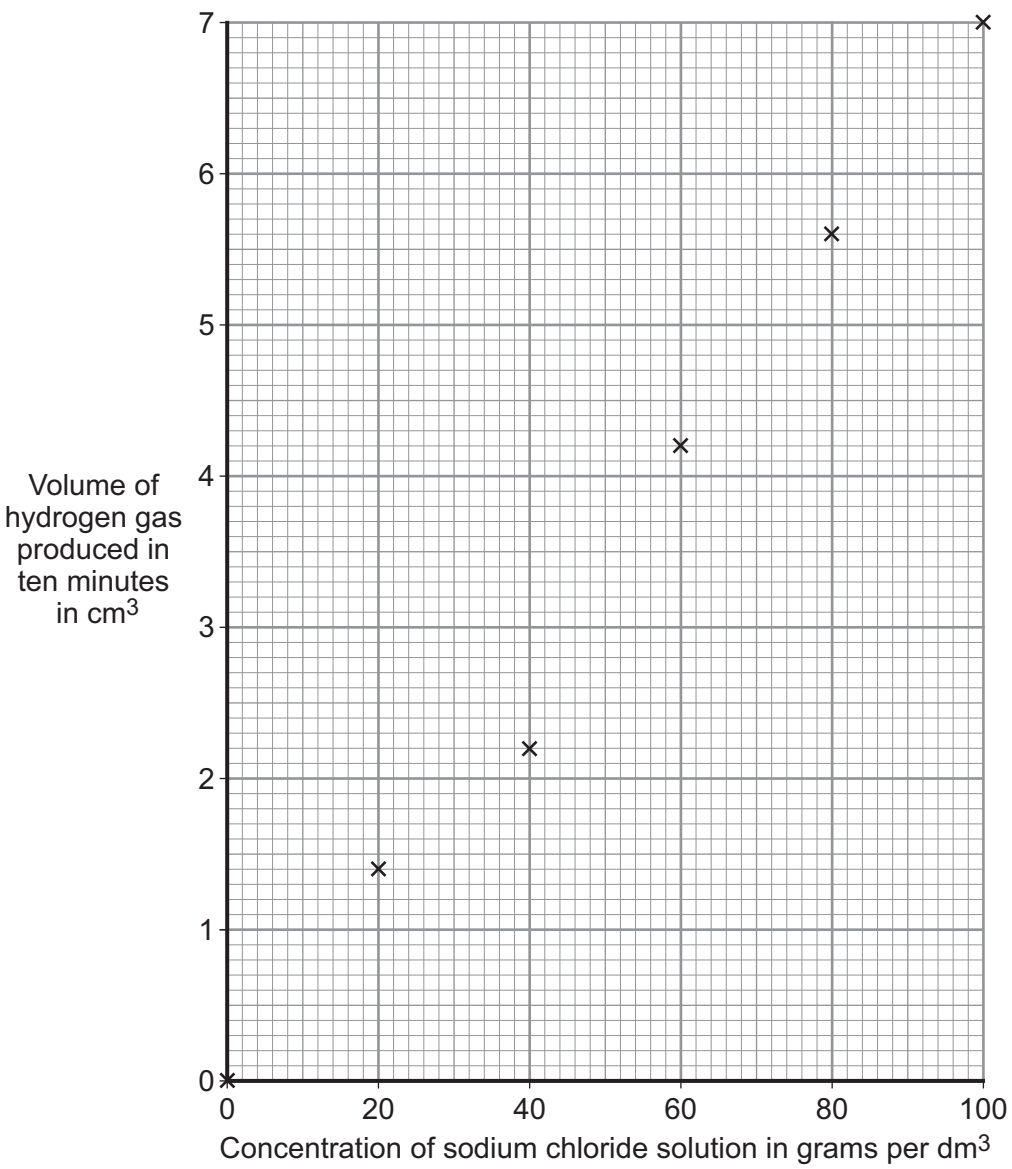
6 (c) The solution left at the end of each experiment contains sodium hydroxide.

Draw a ring around **one** number which could be the pH of this solution.

2 **5** **7** **13**

(1 mark)

6 (d) The results for the experiment on the previous page are shown on the graph.



4.4.3.1 The process of electrolysis

Question 13 · continued

6 (d) (i) Draw a line of best fit on the graph.

(1 mark)

6 (d) (ii) The result for one concentration is anomalous.
Which result is anomalous?

The result at concentration ..... grams per dm^3

(1 mark)

6 (d) (iii) Suggest **two** possible causes of this anomalous result.

1 .....

.....

2 .....

.....

(2 marks)

6 (d) (iv) Suggest how the student could check the reliability of the results.

.....

.....

(1 mark)

6 (d) (v) How did an increase in the concentration of the sodium chloride solution affect the volume of hydrogen gas produced in ten minutes?

.....

.....

(1 mark)

9

4.4.3.1 The process of electrolysis

Question 14

June 2011 | CHY1F | Original Q7 | Legacy

7 The raw materials used to make the polymer polyvinyl chloride (PVC) are crude oil and sea salt (sodium chloride).

7 (a) There are three main stages in the production of PVC.

7 (a) (i) **Stage 1** Cracking of hydrocarbons from crude oil produces ethene, C_2H_4

$$C_{10}H_{22} \longrightarrow C_8H_{18} + C_2H_4$$

How are hydrocarbons cracked?

.....

.....

.....

.....

(2 marks)

7 (a) (ii) **Stage 2** Electrolysis of sodium chloride solution produces chlorine.
Ethene from **Stage 1** is then reacted with this chlorine.
One of the hydrogen atoms in each ethene molecule is replaced by a chlorine atom to produce vinyl chloride.

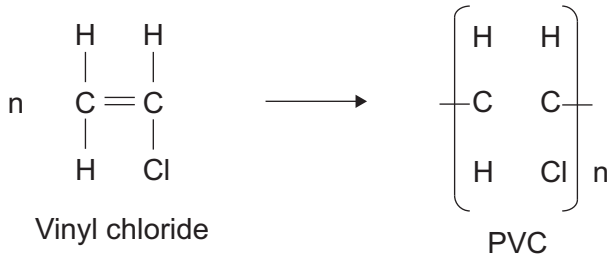
Complete the chemical equation by writing in the formula of the product vinyl chloride.

$$C_2H_4 + Cl_2 \longrightarrow \text{.....} + HCl$$

(1 mark)

7 (a) (iii) **Stage 3** Polymerisation of vinyl chloride produces polyvinyl chloride (PVC).

Complete the chemical equation by drawing in the missing bonds of the product, PVC.



(1 mark)

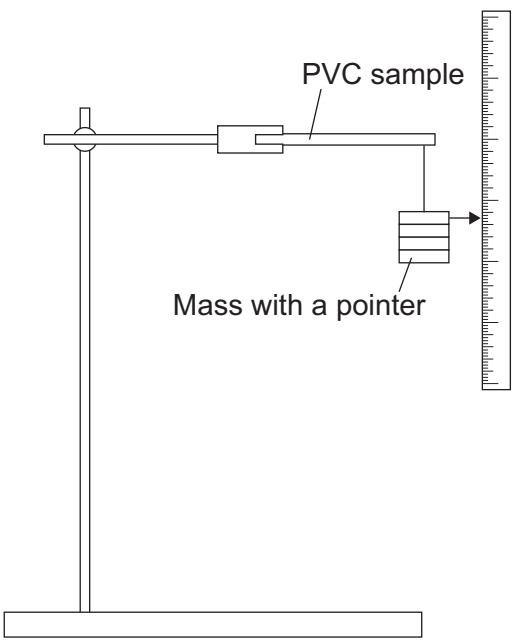
Question 7 continues on the next page

4.4.3.1 The process of electrolysis

Question 14 · continued

7 (b) Unplasticised polyvinyl chloride (uPVC) is used to make door and window frames.
PVC with a plasticiser added is used to make cling film for wrapping food.
A plasticiser is a chemical compound.

A student investigated how the percentage of plasticiser added to PVC affected its flexibility.
The student measured the bending of PVC samples when a mass was added.



The student's results are shown in the table.

Sample of PVC	Percentage (%) of plasticiser added	Bending of PVC sample in mm				
		Test 1	Test 2	Test 3	Test 4	Mean
A	**0**	2	3	3	4	3
B	**5**	22	15	23	24	
C	**10**	27	27	29	29	28
D	**15**	34	35	35	36	35

7 (b) (i) Each PVC sample should be the same size to make it a fair test.
Explain why.

.....

.....

(1 mark)

4.4.3.1 The process of electrolysis

Question 14 · continued

7 (b) (ii) The student repeated the test four times for each sample.
Explain why.

.....

.....

(1 mark)

7 (b) (iii) Calculate the mean value for sample **B**.

.....

.....

.....

.....

(2 marks)

7 (b) (iv) Each of the samples bent the most in test **4**.
Suggest a possible reason for this.

.....

.....

(1 mark)

7 (c) Suggest why unplasticised polyvinyl chloride (uPVC) is used to make door and window frames.

.....

.....

(1 mark)

10

4.4.3.1 The process of electrolysis

Question 15

November 2011 | CHY1AP | Original Q9 | Legacy

QUESTION NINE

Iron oxide can be reduced to iron by mixing the oxide with carbon and heating strongly.

Aluminium oxide cannot be reduced to aluminium in this way. Aluminium is obtained from aluminium oxide by electrolysis.

9A Why is it possible to obtain iron but not aluminium by carbon reduction?

1 Iron is more reactive than aluminium.

2 Carbon is more reactive than aluminium but less reactive than iron.

3 Carbon is more reactive than iron but less reactive than aluminium.

4 Aluminium and iron are both more reactive than carbon.

9B The extraction of aluminium by electrolysis is an expensive process because . . .

1 aluminium easily corrodes in air.

2 a large amount of energy is needed.

3 aluminium oxide is difficult to mine.

4 aluminium reacts with carbon.

9C As electrolysis is expensive, an increasing amount of aluminium is being recycled.

Another important reason to recycle aluminium is that . . .

1 it saves limited aluminium oxide reserves.

2 the recycled aluminium is purer.

3 aluminium scrap does not corrode easily.

4 recycling aluminium does not use energy.

4.4.3.1 The process of electrolysis

Question 15 · continued

9D Which two of the following statements could explain why aluminium is preferred to iron for making cans for drinks?

W Aluminium has a lower density than iron.

X Aluminium is a better conductor than iron.

Y Aluminium corrodes less easily than iron.

Z Aluminium is not as strong as iron.

1 **W** and **X**

2 **W** and **Y**

3 **X** and **Y**

4 **Y** and **Z**

END OF TEST

4.4.3.1 The process of electrolysis

Question 16

January 2012 | CH1FP | Original Q2 | Legacy

2 Cans for food and drinks are made from steel or aluminium.
The main metal in steel is iron.

2 (a) Reacting iron oxide with carbon produces iron.

Draw a ring around the correct answer to complete the sentence.

The reaction to produce iron from iron oxide is

- decomposition.
- oxidation.
- reduction.

(1 mark)

2 (b) Aluminium cannot be produced by reacting aluminium oxide with carbon.

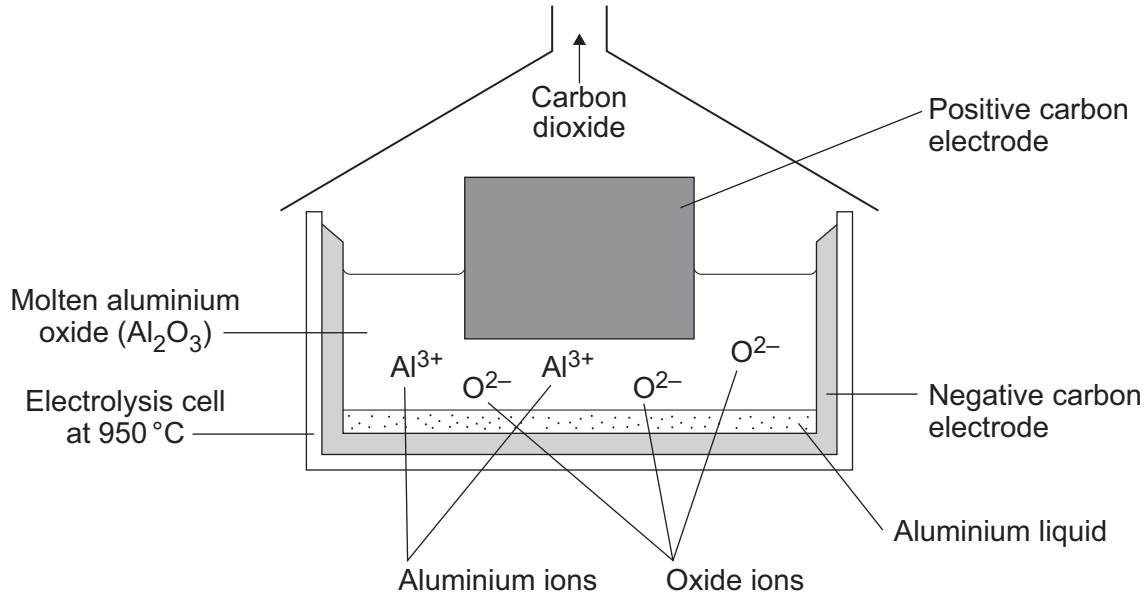
Why does aluminium oxide **not** react with carbon?

Tick (✓) the correct answer.

Answer	Tick (✓)
aluminium is less reactive than carbon	
carbon is less reactive than aluminium	
oxygen is more reactive than carbon	

(1 mark)

2 (c) Aluminium can be produced by electrolysis.



4.4.3.1 The process of electrolysis

Question 16 · continued

Why do the aluminium ions collect at the negative electrode?

.....

.....

.....

.....

(2 marks)

2 (d) Some statements about aluminium are given below.

Tick (✓) **two** statements that are correct reasons why aluminium is used to make cans.

Statement	Tick (✓)
aluminium conducts electricity	
aluminium is not a transition metal	
aluminium has a low density	
aluminium is resistant to corrosion	

(2 marks)

2 (e) Recycling aluminium cans uses less fossil fuels than producing aluminium from its ore.

Tick (✓) **one** advantage and tick (✓) **one** disadvantage of recycling aluminium to make aluminium cans.

Statement	Advantage Tick (✓)	Disadvantage Tick (✓)
aluminium is the most common metal in the Earth's crust		
less carbon dioxide is produced		
more aluminium ore needs to be mined		
used aluminium cans have to be collected and transported		

(2 marks)

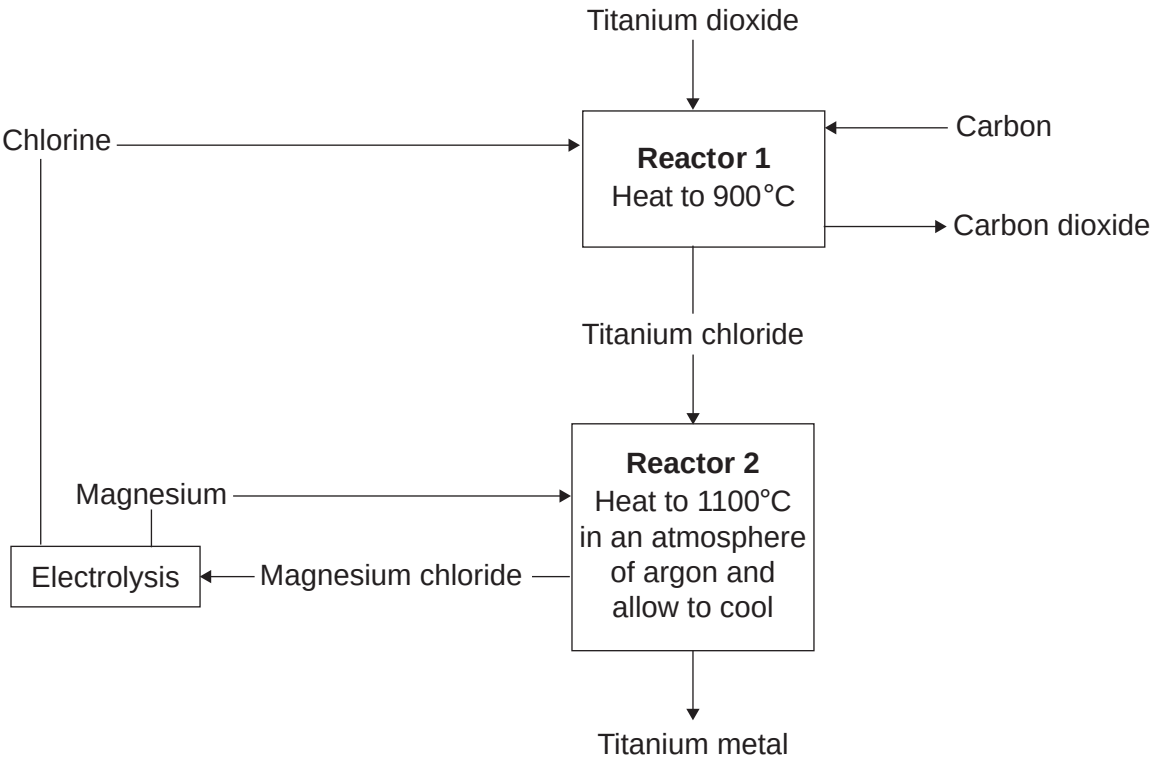
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4.4.3.1 The process of electrolysis

Question 17

June 2012 | CH1FP | Original Q7 | Legacy

7 Rutile is an ore of titanium. Rutile contains titanium dioxide.
The flow chart shows how titanium metal is extracted from titanium dioxide.



7 (a) Titanium is much more expensive than iron.

Give **one** reason why.

.....

.....

(1 mark)

7 (b) Name the only waste product shown on the flow chart.

.....

(1 mark)

4.4.3.1 The process of electrolysis

Question 17 · continued

7 (c) Describe the example of recycling shown on the flow chart.

.....

.....

.....

.....

(2 marks)

7 (d) The air is removed from **Reactor 2**. An atmosphere of argon is used for the reaction between titanium chloride and magnesium metal.

Explain why.

.....

.....

.....

.....

(2 marks)

Question 7 continues on the next page

4.4.3.1 The process of electrolysis

Question 17 · continued

7 (e) Titanium metal is produced by reacting titanium chloride with magnesium.

950 kg of titanium chloride was mixed with 240 kg of magnesium metal. The mixture was heated and produced 950 kg of magnesium chloride.

Calculate the mass of titanium metal produced.

.....

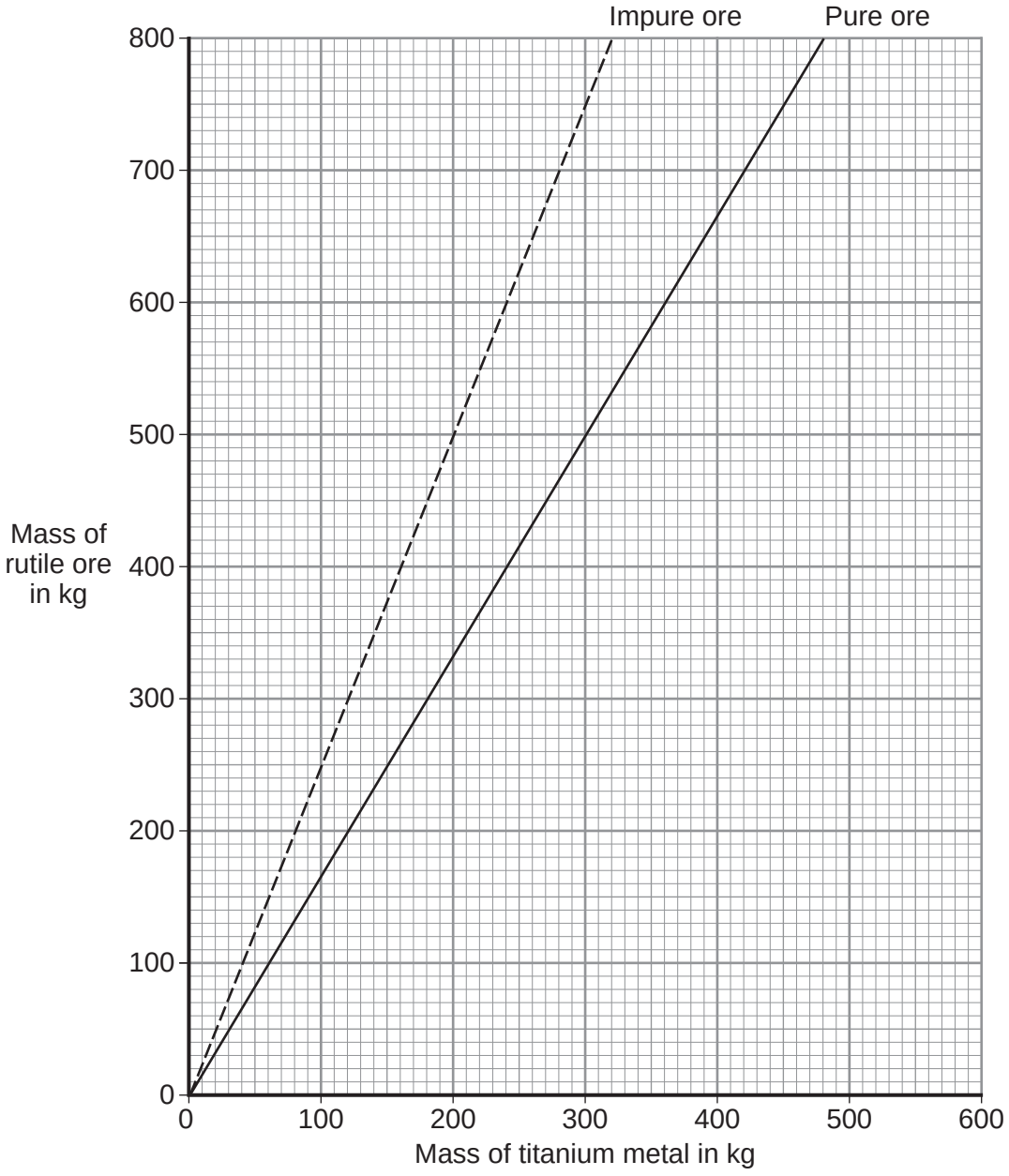
Mass = ... kg

(1 mark)

4.4.3.1 The process of electrolysis

Question 17 · continued

7 (f) The graph shows the mass of titanium metal produced from a pure rutile ore and from an impure rutile ore.



The difference between the two lines represents the amount of waste rock in the impure ore.

300 kg of titanium metal was produced from the impure ore.

Calculate the mass of waste rock in the impure ore.

.....

Mass = ... kg

(1 mark)

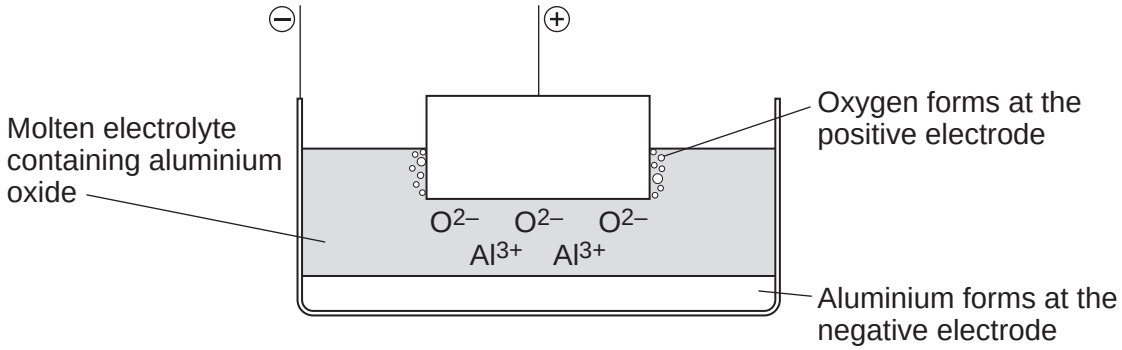
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4.4.3.1 The process of electrolysis

Question 18

June 2012 | CH2FP | Original Q4 | Legacy

4 The diagram represents an electrolysis cell for extracting aluminium.
The current will only flow when the electrolyte is molten.



4 (a) The electrolyte is aluminium oxide mixed with another substance.

4 (a) (i) What is the name of the other substance in the electrolyte?

Draw a ring around the correct answer.

cryolite **rock salt** **limestone**

(1 mark)

4 (a) (ii) Draw a ring around the correct answer to complete the sentence.

This other substance is added to

condense the aluminium oxide.
lower the melting point of the aluminium oxide.
raise the boiling point of the aluminium oxide.

(1 mark)

4 (b) (i) Oxide ions (O^{2-}) move to the positive electrode.

Explain why.

.....

.....

.....

.....

(2 marks)

4.4.3.1 The process of electrolysis

Question 18 · continued

4 (b) (ii) Oxygen is formed at the positive electrode. The oxygen then forms carbon dioxide.

The equation for the reaction is shown below.

$$C + O_2 \rightarrow CO_2$$

Complete the sentence.

The name of the element which reacts with oxygen is ..... .

(1 mark)

4 (b) (iii) The positive electrode gets smaller.

Suggest why.

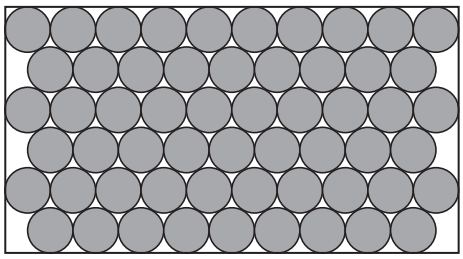
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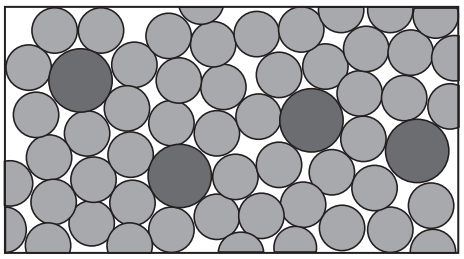
(1 mark)

4 (c) Aluminium is used in an alloy with magnesium to make drinks cans.

The diagrams show the arrangement of atoms in pure aluminium and in the alloy.



Pure aluminium



Alloy

The alloy is harder than pure aluminium.

Explain why. Use the diagrams to help you.

.....

.....

.....

.....

(2 marks)

8

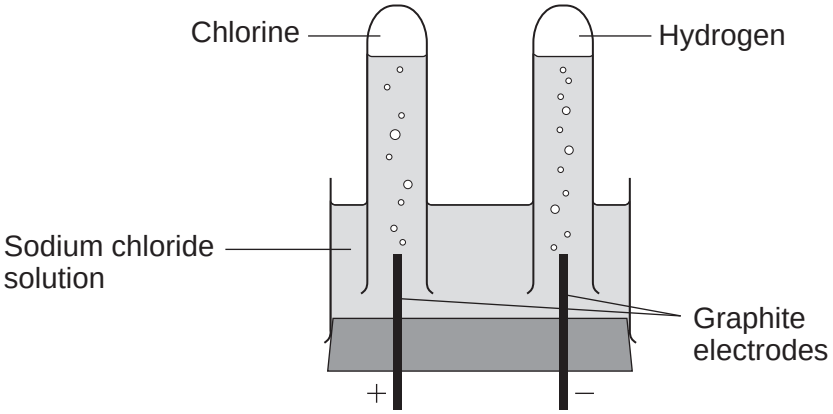
4.4.3.1 The process of electrolysis

Question 19

January 2013 | CH2FP | Original Q8 | Legacy

8 The electrolysis of sodium chloride solution is an industrial process.

The diagram shows the apparatus used in a school experiment.



8 (a) One of the products of the electrolysis of sodium chloride solution is hydrogen.

8 (a) (i) Why do hydrogen ions move to the negative electrode?

.....

.....

(1 mark)

8 (a) (ii) How does a hydrogen ion change into a hydrogen atom?

.....

.....

(1 mark)

4.4.3.1 The process of electrolysis

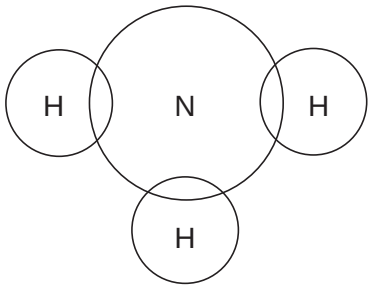
Question 19 · continued

8 (b) Hydrogen is used to make ammonia (NH_3).

Complete the diagram to show the bonding in ammonia.

Use dots (●) and crosses (x) to show electrons.

Show only outer shell electrons.



(2 marks)

8 (c) The table shows the ions in sodium chloride solution.

Positive ions	Negative ions
hydrogen	chloride
sodium	hydroxide

In industry, some of the waste from the electrolysis of sodium chloride solution is alkaline and has to be neutralised.

8 (c) (i) Which ion makes the waste alkaline?

.....

(1 mark)

8 (c) (ii) This waste must be neutralised.

Write the ionic equation for the neutralisation reaction.

.....

(1 mark)

Question 8 continues on the next page

4.4.3.1 The process of electrolysis

Question 19 · continued

8 (d) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

The electrolysis of sodium chloride solution also produces chlorine and sodium hydroxide.

In industry, the electrolysis of sodium chloride solution can be done in several types of electrolysis cell.

Some information about two different types of electrolysis cell is given below.

	Mercury cell	Membrane cell
Cost of construction	Expensive	Relatively cheap
Additional substances used	Mercury, which is recycled. Mercury is toxic so any traces of mercury must be removed from the waste.	Membrane, which is made of a polymer. The membrane must be replaced every 3 years.
Amount of electricity used for each tonne of chlorine produced in kWh	3400	2950
Quality of chlorine produced	Pure	Needs to be liquefied and distilled to make it pure.
Quality of sodium hydroxide solution produced	50% concentration. Steam is used to concentrate the sodium hydroxide solution produced.	30% concentration. Steam is used to concentrate the sodium hydroxide solution produced.

Use the information and your knowledge and understanding to compare the environmental and economic advantages and disadvantages of these **two** types of electrolysis cell.

.....

.....

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.....

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4.4.3.1 The process of electrolysis

Question 20

June 2013 | CH1FP | Original Q7 | Legacy

7 Metals are extracted from their ores.

Many copper ores contain only 2% of copper compounds.

7 (a) Copper is now extracted from ores containing a low percentage of copper compounds.

Suggest **two** reasons why.

.....

.....

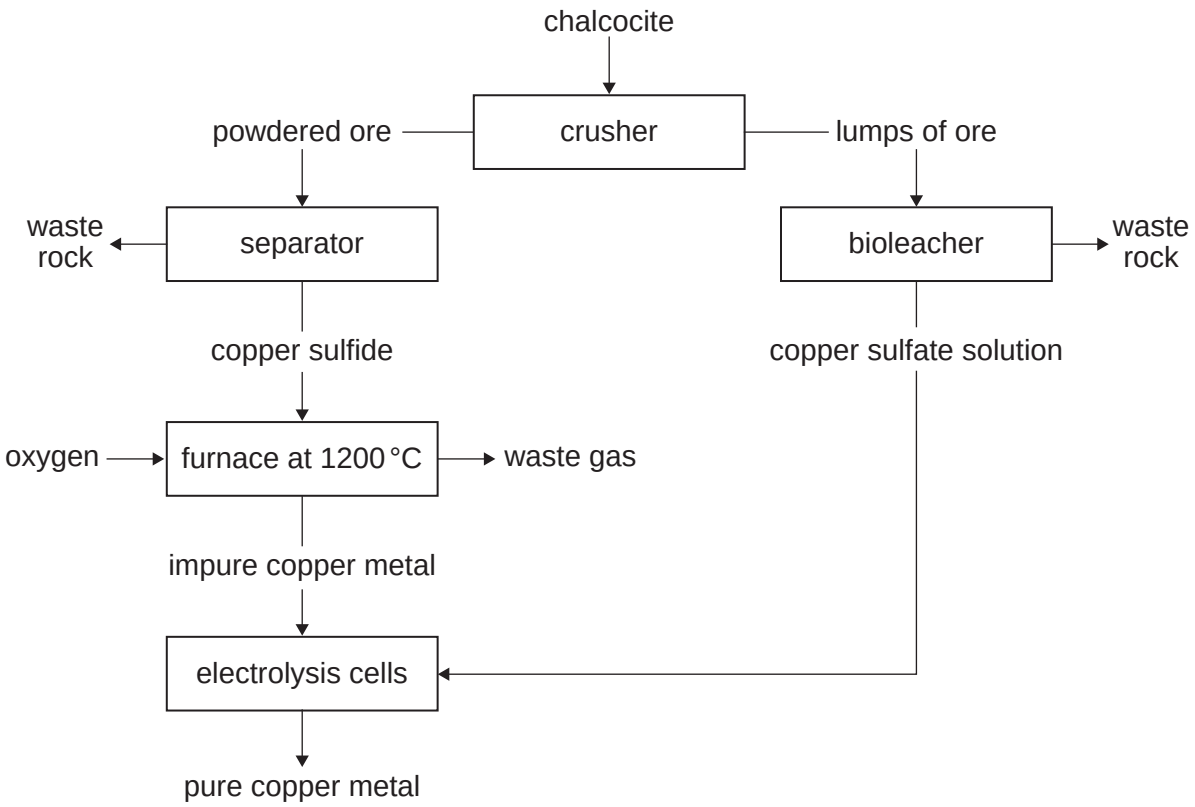
.....

.....

(2 marks)

7 (b) Chalcocite, an ore of copper, contains copper sulfide.

The flow diagram shows how copper metal is extracted from chalcocite.



4.4.3.1 The process of electrolysis

Question 20 · continued

7 (b) (i) Suggest **one** reason why it is difficult to dispose of the waste rock.

.....

.....

(1 mark)

7 (b) (ii) The reaction in the furnace could cause environmental pollution.
Explain how.

.....

.....

.....

.....

(2 marks)

7 (b) (iii) The extraction of pure copper is expensive.
Give **one** reason why.

.....

.....

(1 mark)

7 (b) (iv) Pure copper is produced by electrolysis of copper sulfate solution.

Which electrode do the copper ions move towards?
Give a reason for your answer.

.....

.....

.....

.....

(2 marks)

7 (b) (v) Large areas of land are contaminated with copper compounds.
Phytomining can be used to remove these copper compounds from the land.

What is used in phytomining to remove copper compounds from the land?

.....

.....

(1 mark)

9

4.4.3.1 The process of electrolysis

Question 21

June 2013 | CH2FP | Original Q4 | Legacy

4 Humphrey Davy was a professor of chemistry.

In 1807 Humphrey Davy did an electrolysis experiment to produce potassium.

4 (a) (i) Humphrey Davy was the first person to produce potassium.

Draw a ring around the correct answer to complete the sentence.

Humphrey Davy's experiment to produce this new element was quickly accepted by

other scientists because he

- had a lot of money.
- had a lot of staff to help.
- was well qualified.

(1 mark)

4 (a) (ii) Other scientists were able to repeat Davy's experiment.

Draw a ring around the correct answer to complete the sentence.

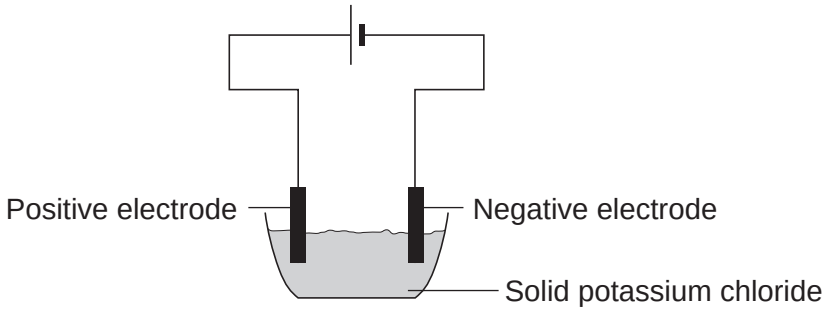
Being able to repeat Davy's experiment is important because

other scientists can

- check the results of the experiment.
- see if the experiment is safe.
- take the credit for the discovery.

(1 mark)

4 (b) A student tried to electrolyse potassium chloride.



Potassium chloride contains potassium ions (K^+) and chloride ions (Cl^-).

4.4.3.1 The process of electrolysis

Question 21 · continued

4 (b) (i) The student found that solid potassium chloride does not conduct electricity.

Use the correct answer from the box to complete the sentence.

are too big	**cannot move**	**have no charge**

Solid potassium chloride does not conduct electricity because

the ions ..... .

(1 mark)

4 (b) (ii) What could the student do to the potassium chloride to make it conduct electricity?

.....

(1 mark)

4 (b) (iii) During electrolysis why do potassium ions move to the negative electrode?

.....

(1 mark)

4 (b) (iv) Draw a ring around the correct answer to complete the sentence.

When the potassium ions reach the negative electrode

they turn into potassium

atoms.

electrodes.

molecules.

(1 mark)

6

4.4.3.1 The process of electrolysis

Question 22

June 2014 | CH1FP | Original Q5 | Legacy

5 Where copper ore has been mined there are areas of land that contain very low percentages of copper compounds.

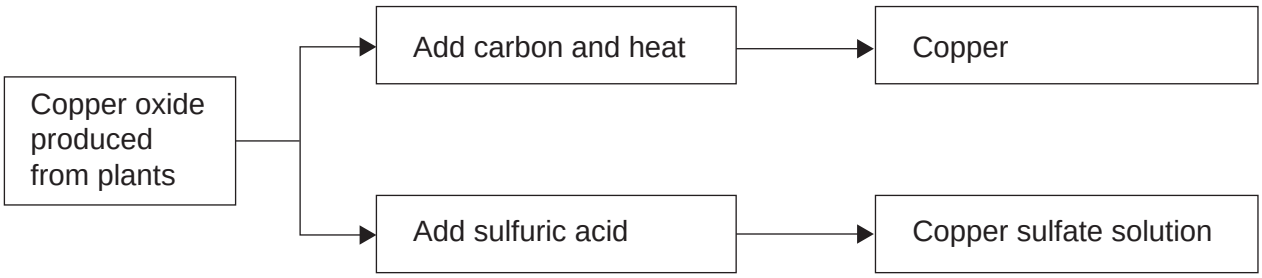
One way to extract the copper is to grow plants on the land.

The plants absorb copper compounds through their roots.

The plants are burned to produce copper oxide.

The copper oxide produced from plants can be reacted to produce copper or copper sulfate solution, as shown in **Figure 6**.

Figure 6



5 (a) Draw a ring around the correct answer to complete each sentence.

5 (a) (i) Copper ores contain enough copper to make extraction of the metal

carbon neutral.
economical.
reversible.

[1 mark]

5 (a) (ii) Using plants to extract metals is called

photosynthesis.
phytomining.
polymerisation.

[1 mark]

5 (a) (iii) Copper oxide reacts with carbon to produce copper and

carbon dioxide.
oxygen.
sulfur dioxide.

[1 mark]

4.4.3.1 The process of electrolysis

Question 22 · continued

5 (b) Copper is produced from copper sulfate solution by displacement using iron or by electrolysis.

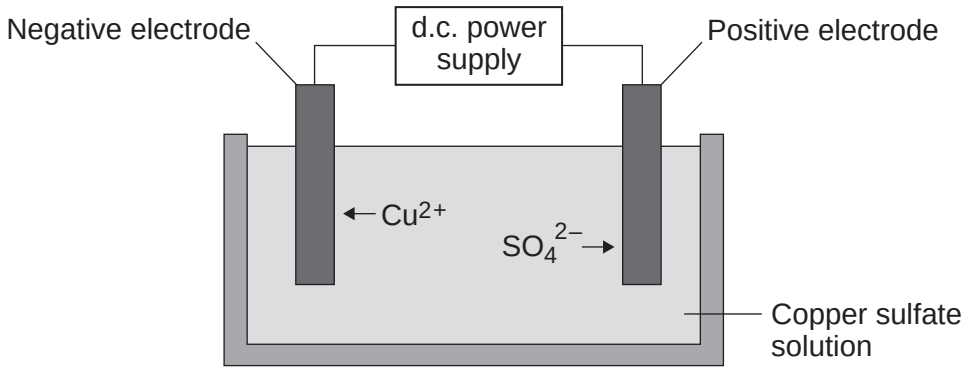
5 (b) (i) Complete the word equation.

[2 marks]

copper sulfate + iron ⟶ ..... + ...

5 (b) (ii) **Figure 7** shows the electrolysis of copper sulfate solution.

Figure 7



Why do copper ions go to the negative electrode?

[1 mark]

.....

.....

5 (c) Suggest **two** reasons why copper should **not** be disposed of in landfill sites.

[2 marks]

.....

.....

.....

.....

8

4.4.3.1 The process of electrolysis

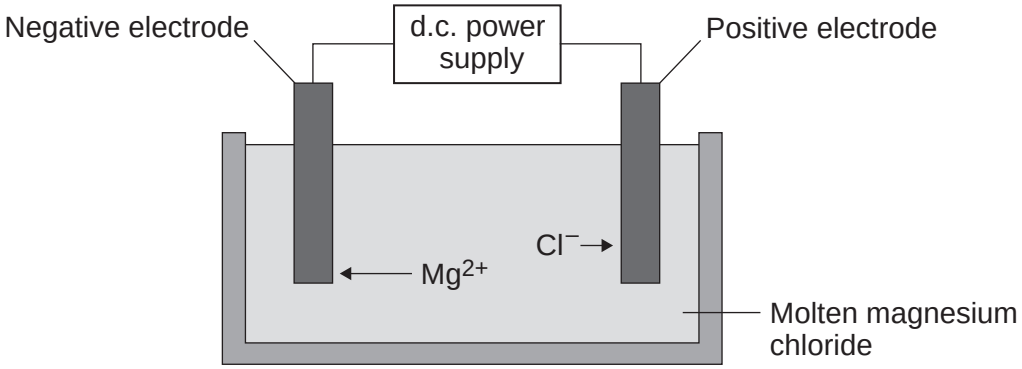
Question 23

June 2014 | CH2FP | Original Q5 | Legacy

5 Some students investigated reactions to produce magnesium.

5 (a) The students used electrolysis to produce magnesium from magnesium chloride, as shown in **Figure 7**.

Figure 7



5 (a) (i) Magnesium chloride contains magnesium ions and chloride ions.

Why does solid magnesium chloride **not** conduct electricity?

[1 mark]

.....

.....

5 (a) (ii) One of the products of the electrolysis of molten magnesium chloride is magnesium.

Name the other product.

[1 mark]

.....

5 (a) (iii) Why do magnesium ions (Mg^{2+}) move to the negative electrode?

[1 mark]

.....

.....

4.4.3.1 The process of electrolysis

Question 23 · continued

5 (a) (iv) At the negative electrode, the magnesium ions (Mg^{2+}) gain electrons to become magnesium atoms.

How many electrons does each magnesium ion gain?

[1 mark]

.....

5 (b) The students did the experiment four times and weighed the magnesium produced.

Table 1 shows their results.

Table 1

Experiment	Mass of magnesium produced in grams
1	1.13
2	0.63
3	1.11
4	1.09

5 (b) (i) There is an anomalous result.

Suggest **one** possible reason for the anomalous result.

[1 mark]

.....

.....

5 (b) (ii) Calculate the mean mass of magnesium produced, taking account of the anomalous result.

[2 marks]

.....

.....

.....

Mean mass = ... g

4.4.3.1 The process of electrolysis

Question 23 · continued

5 (c) The formula of magnesium chloride is $MgCl_2$

The relative formula mass of magnesium chloride is 95.

The relative atomic mass of magnesium is 24.

5 (c) (i) Use the equation to calculate the percentage mass of magnesium in magnesium chloride.

$$\text{Percentage mass of magnesium} = \frac{\text{mass of magnesium}}{\text{mass of magnesium chloride}} \times 100\%$$

[2 marks]

.....

.....

.....

Percentage mass of magnesium in magnesium chloride = ... %

5 (c) (ii) Draw a ring around the relative mass of chlorine in $MgCl_2$

[1 mark]

71 **95** **119**

4.4.3.1 The process of electrolysis

Question 23 · continued

5 (d) Magnesium is also produced from the reaction of magnesium oxide with silicon.

5 (d) (i) The equation for the reaction is:

$$2\ MgO(s) + Si(s) \rightleftharpoons SiO_2(s) + 2\ Mg(s)$$

What is the meaning of this symbol $\rightleftharpoons$?

Draw a ring around the correct answer.

[1 mark]

neutralisation reaction **precipitation reaction** **reversible reaction**

5 (d) (ii) The forward reaction is endothermic.

Draw a ring around the correct answer to complete the sentence.

[1 mark]

In an endothermic reaction the temperature of the surroundings

- decreases.
- increases.
- stays the same.

12

4.4.3.1 The process of electrolysis

Question 24

June 2015 | CH2FP | Original Q4 | Legacy

4 This question is about electrolysis.

4 (a) Metal spoons can be coated with silver.
This is called electroplating.

Suggest **one** reason why spoons are electroplated.

[1 mark]

.....

.....

4 (b) When sodium chloride solution is electrolysed the products are hydrogen and chlorine.

4 (b) (i) What is made from chlorine?

[1 mark]

Tick (✓) **one** box.

Bleach ☐

Fertiliser ☐

Soap ☐

4 (b) (ii) Sodium chloride solution contains two types of positive ions, hydrogen ions (H^+) and sodium ions (Na^+).

Why is hydrogen produced at the negative electrode and **not** sodium?

[1 mark]

Tick (✓) **one** box.

Hydrogen is a gas. ☐

Hydrogen is less reactive than sodium. ☐

Hydrogen ions move faster than sodium ions. ☐

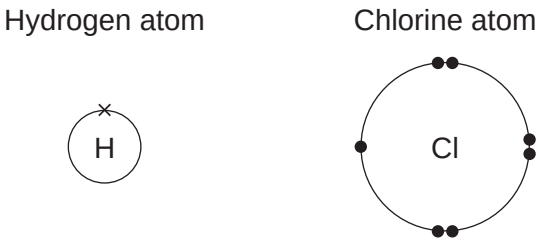
4.4.3.1 The process of electrolysis

Question 24 · continued

4 (b) (iii) Hydrogen and chlorine can be used to produce hydrogen chloride.

The diagrams in **Figure 4** show how the outer electrons are arranged in an atom of hydrogen and an atom of chlorine.

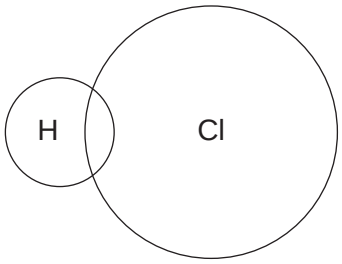
Figure 4



Complete **Figure 5** to show how the outer electrons are arranged in a molecule of hydrogen chloride (HCl).

[1 mark]

Figure 5



4 (b) (iv) What is the type of bond in a molecule of hydrogen chloride?

[1 mark]

Tick (✓) **one** box.

Covalent ☐

Ionic ☐

Metallic ☐

Question 4 continues on the next page

4.4.3.1 The process of electrolysis

Question 24 · continued

4 (b) (v) Why is hydrogen chloride a gas at room temperature (20 °C)?

[2 marks]

Tick (✓) **two** boxes.

Hydrogen chloride has a low boiling point. ☐

Hydrogen chloride has a high melting point. ☐

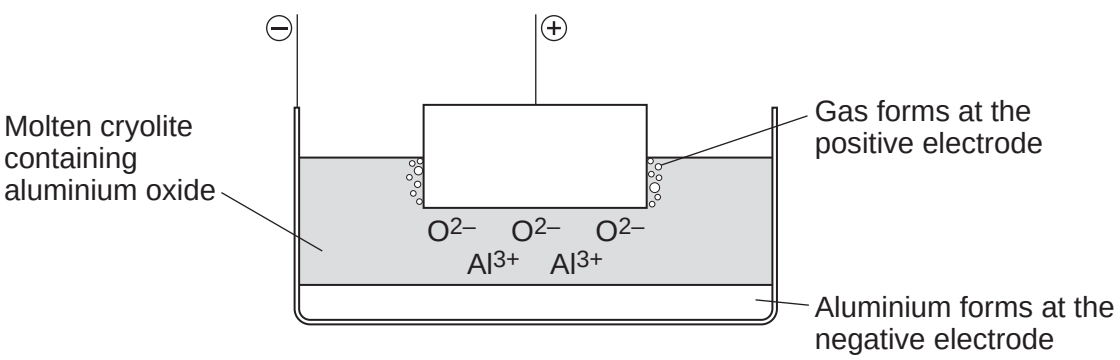
Hydrogen chloride is made of simple molecules. ☐

Hydrogen chloride does not conduct electricity. ☐

Hydrogen chloride has a giant structure. ☐

4 (c) Aluminium is produced by electrolysis of a molten mixture of aluminium oxide and cryolite.
This is shown in **Figure 6**.

Figure 6



4 (c) (i) Name a gas produced at the positive electrode.

[1 mark]

.....

4.4.3.1 The process of electrolysis

Question 24 · continued

4 (c) (ii) Aluminium ions move to the negative electrode.

Explain why.

[2 marks]

.....

.....

.....

.....

4 (c) (iii) At the negative electrode, the aluminium ions gain electrons to produce aluminium.

What is this type of reaction called?

[1 mark]

Tick (✓) **one** box.

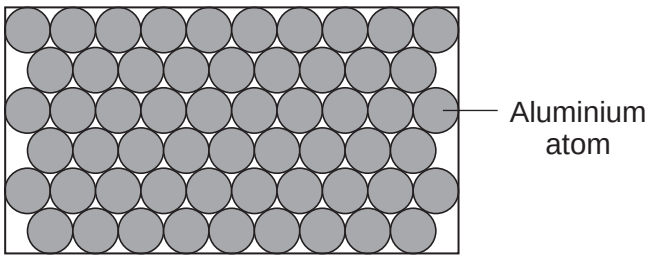
Combustion ☐

Oxidation ☐

Reduction ☐

4 (c) (iv) Aluminium has layers of atoms, as shown in **Figure 7**.

Figure 7



Complete the sentence.

[1 mark]

Metals can be bent and shaped because the layers of atoms can ..... .

Question 4 continues on the next page

4.4.3.1 The process of electrolysis

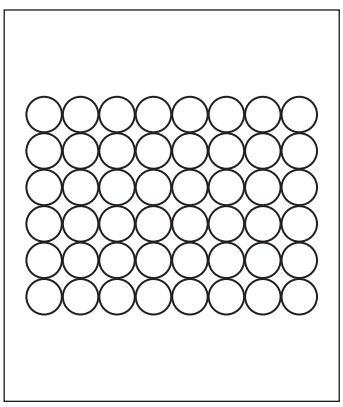
Question 24 · continued

4 (d) Electrodes used in the production of aluminium are made from graphite.

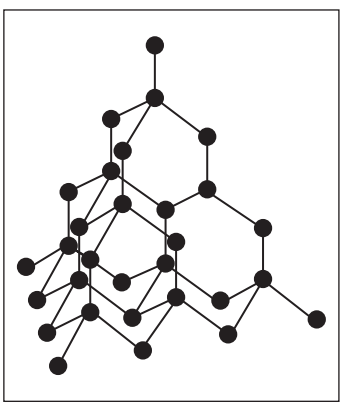
4 (d) (i) Which diagram, **A**, **B** or **C**, shows the structure of graphite?

[1 mark]

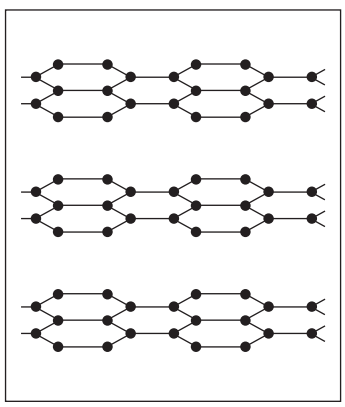
A



B



C



The structure of graphite is shown in diagram ☐.

4 (d) (ii) The temperature for the electrolysis is 950 °C.

Use the correct answer from the box to complete the sentence.

[1 mark]

cross links	**a giant ionic lattice**	**strong covalent bonds**

The graphite does not melt at 950 °C because

graphite has ..... .

14

4.4.3.1 The process of electrolysis

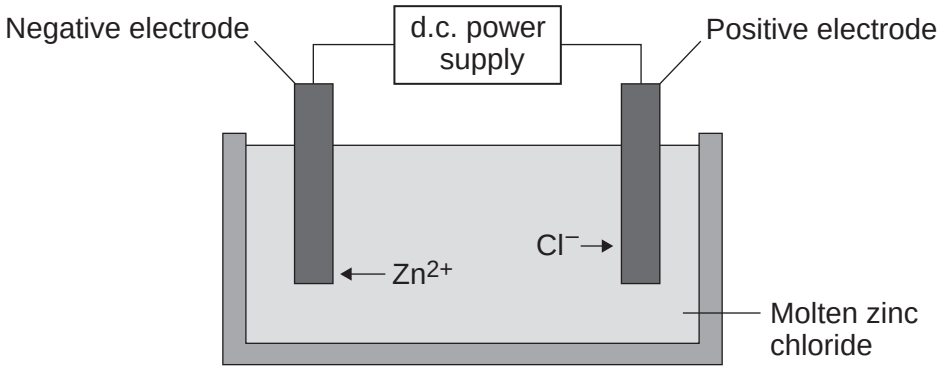
Question 25

June 2016 | CH2FP | Original Q3 | Legacy

3 This question is about zinc.

Figure 7 shows the electrolysis of molten zinc chloride.

Figure 7



3 (a) Zinc chloride is an ionic substance.
Complete the sentence.

[1 mark]

When zinc chloride is molten, it will conduct _____ .

3 (b) Zinc ions move towards the negative electrode where they gain electrons to produce zinc.

3 (b) (i) Name the product formed at the positive electrode.

[1 mark]

_____

3 (b) (ii) Explain why zinc ions move towards the negative electrode.

[2 marks]

_____

_____

_____

_____

4.4.3.1 The process of electrolysis

Question 25 · continued

3 (b) (iii) What type of reaction occurs when the zinc ions gain electrons?

[1 mark]

Tick (✓) **one** box.

Neutralisation ☐

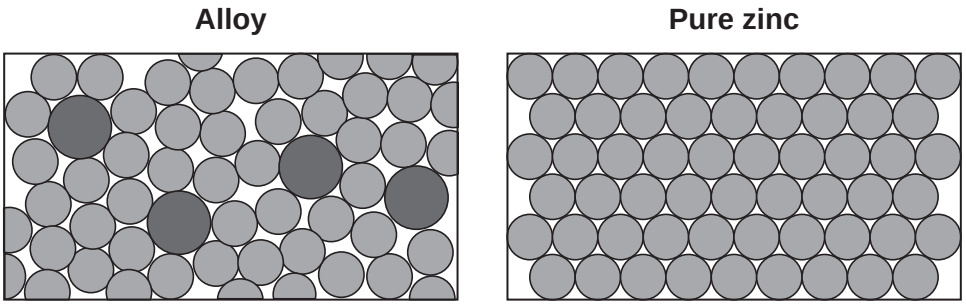
Oxidation ☐

Reduction ☐

3 (c) Zinc is mixed with copper to make an alloy.

3 (c) (i) **Figure 8** shows the particles in the alloy and in pure zinc.

Figure 8



Use **Figure 8** to explain why the alloy is harder than pure zinc.

[2 marks]

3 (c) (ii) Alloys can be bent. Some alloys return to their original shape when heated.

What name is used for these alloys?

[1 mark]

8

4.4.3.1 The process of electrolysis

Question 26

June 2017 | CH2FP | Original Q4 | Legacy

4 This question is about sodium chloride.

4 (a) Calculate the relative formula mass (M_r) of sodium chloride (NaCl).

Relative atomic masses (A_r): Na = 23; Cl = 35.5

[1 mark]

_____

_____

Relative formula mass (M_r) = _____

4 (b) A student reacted hydrochloric acid and sodium hydroxide solution to produce sodium chloride and another product.

Use the correct answer from the box to complete the word equation for the reaction.

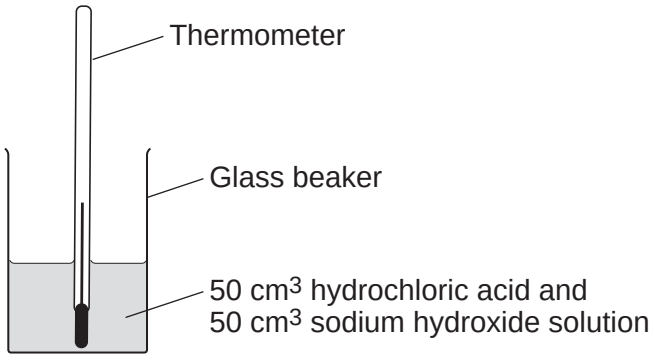
[1 mark]

chlorine	**hydrogen**	**oxygen**	**water**

hydrochloric acid + sodium hydroxide ⟶ sodium chloride + _____

4 (c) **Figure 7** shows the apparatus the student used to measure the temperature change in the reaction between hydrochloric acid and sodium hydroxide solution.

Figure 7



The student:

- measured 50 cm^3 hydrochloric acid into a glass beaker
- measured the temperature of the hydrochloric acid
- added 50 cm^3 of sodium hydroxide solution
- measured the highest temperature of the solution
- repeated the experiment with insulation around the glass beaker.

4.4.3.1 The process of electrolysis

Question 26 · continued

4 (c) (i) Suggest **one** reason why the insulation around the glass beaker gives more accurate results.

[1 mark]

_____

_____

4 (c) (ii) The student did the investigation using the insulation three times.

Table 2 shows the results.

Table 2

Experiment number	Temperature of acid before reaction in °C	Highest temperature of solution in °C	Temperature change in °C
1	20	33	13
2	20	34	14
3	19	32	

Calculate the temperature change in **Experiment 3**.

Write your answer in **Table 2**.

[1 mark]

4 (c) (iii) How does **Table 2** show that the results are repeatable?

[1 mark]

_____

_____

4 (c) (iv) Complete the sentence.

[1 mark]

The temperature increase shows that the reaction between hydrochloric acid and sodium hydroxide is _____ .

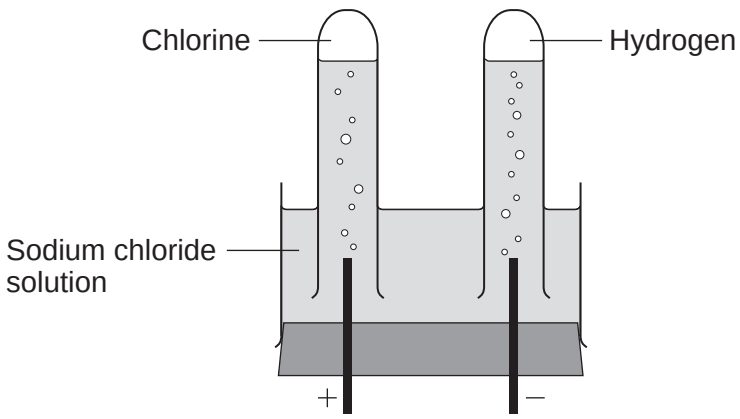
Question 4 continues on the next page

4.4.3.1 The process of electrolysis

Question 26 · continued

4 (d) A student investigated the electrolysis of sodium chloride solution, as shown in **Figure 8**.

Figure 8



4 (d) (i) State, in terms of ions, why sodium chloride solution conducts electricity.

[1 mark]

_____

_____

4 (d) (ii) Chlorine is produced at the positive electrode.

Why are chloride ions attracted to the positive electrode?

[1 mark]

_____

_____

4 (d) (iii) When sodium chloride solution is electrolysed, sodium hydroxide is also produced.

What can be manufactured from sodium hydroxide?

[1 mark]

Tick (✓) **one** box.

Alloys ☐

Poly(ethene) ☐

Soap ☐

4.4.3.1 The process of electrolysis

Question 26 · continued

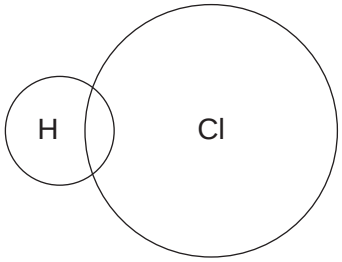
4 (d) (iv) The products chlorine and hydrogen react to form hydrogen chloride.

Hydrogen atoms have one electron in their outer shell. Chlorine atoms have seven electrons in their outer shell.

Complete **Figure 9** to show how the outer electrons are arranged in a molecule of hydrogen chloride (HCl).

[2 marks]

Figure 9



4 (d) (v) Which calculation shows the percentage of hydrogen in hydrogen chloride?

Relative atomic masses (A_r): H = 1; Cl = 35.5

Relative formula mass (M_r): HCl = 36.5

[1 mark]

Tick (✓) **one** box.

$\frac{35.5}{36.5} \times 100$ ☐

$\frac{1}{35.5} \times 100$ ☐

$\frac{1}{36.5} \times 100$ ☐

$\frac{1}{72.0} \times 100$ ☐

12

4.4.3.1 The process of electrolysis

Question 27

June 2018 | 8462/1F | Original Q1

0 1 This question is about mixtures.

0 1 . 1 Substances are separated from a mixture using different methods.

Draw **one** line from each substance and mixture to the best method of separation.

[3 marks]

Substance and mixture	Method of separation
	Chromatography
Ethanol from ethanol and water	
	Crystallisation
Salt from sea water	Electrolysis
	Filtration
The different colours in black ink	
	Fractional distillation

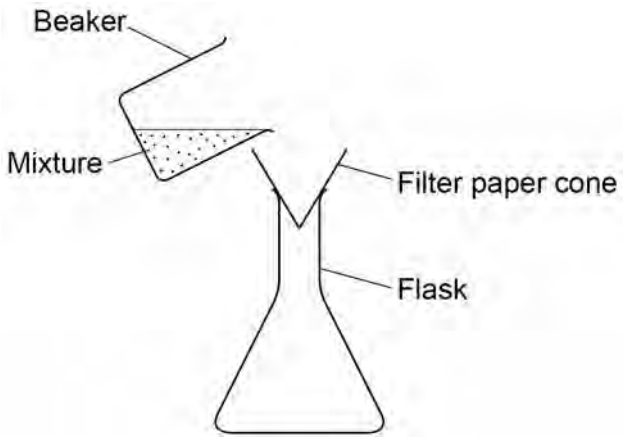
4.4.3.1 The process of electrolysis

Question 27 · continued

0 1 . 2 A student filters a mixture.

Figure 1 shows the apparatus.

Figure 1



Suggest **one** improvement to the apparatus.

[1 mark]

_____

_____

0 1 . 3 Complete the sentences.

Choose answers from the box.

[2 marks]

condense	**evaporate**	**freeze**	**melt**	**solidify**

In simple distillation, the mixture is heated to make the liquid _____.

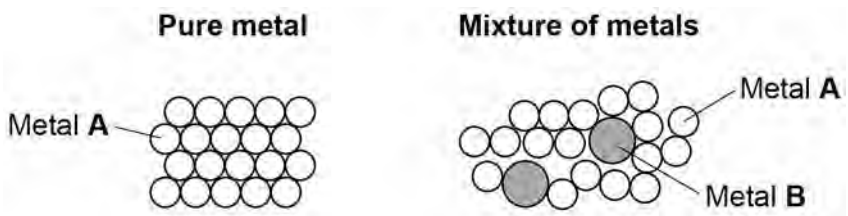
The vapour is then cooled to make it _____.

4.4.3.1 The process of electrolysis

Question 27 · continued

Figure 2 shows the arrangement of atoms in a pure metal and in a mixture of metals.

Figure 2



0 1 . 4 Calculate the percentage of metal **B** atoms in the mixture of metals shown in **Figure 2**.

[2 marks]

Percentage of metal **B** atoms = _____ %

0 1 . 5 What is a mixture of metals called?

[1 mark]

Tick **one** box.

- An alloy ☐
- A compound ☐
- A molecule ☐
- A polymer ☐

Question 27 · continued

0 1 . 6 Why is the mixture of metals in **Figure 2** harder than the pure metal?

[1 mark]

Tick **one** box.

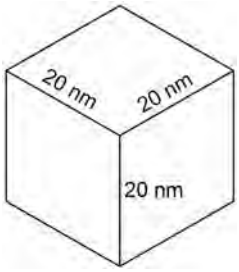
- The atoms in the mixture are different shapes. ☐
- The layers in the mixture are distorted. ☐
- The layers in the mixture slide more easily. ☐
- The mixture has a giant structure. ☐

0 1 . 7 A nanoparticle of pure metal **A** is a cube.

Each side of the cube has a length of 20 nm.

Figure 3 shows the cube.

Figure 3



What is the volume of the nanoparticle?

[1 mark]

Tick **one** box.

- 20 nm^3 ☐
- 60 nm^3 ☐
- 400 nm^3 ☐
- 8000 nm^3 ☐

11

4.4.3.1 The process of electrolysis

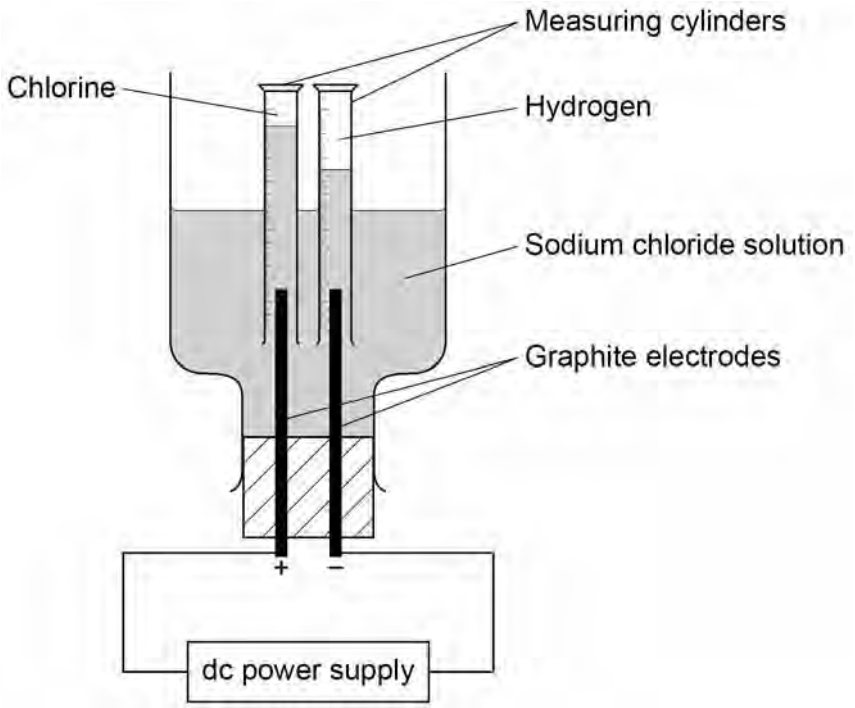
Question 28

June 2018 | 8462/1F | Original Q4

0 4 A student investigated the electrolysis of sodium chloride solution.

Figure 4 shows the apparatus.

Figure 4



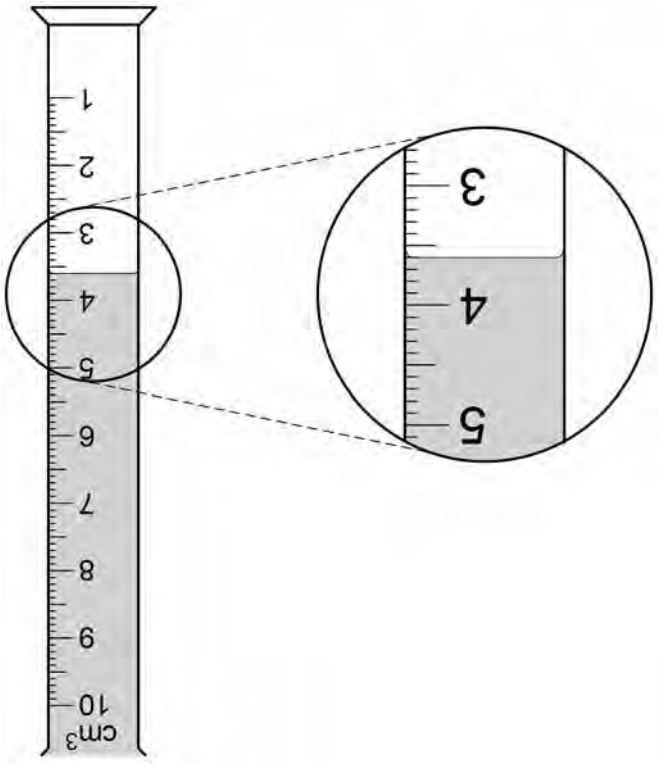
The student measured the volume of gas collected in each measuring cylinder every minute for 20 minutes.

4.4.3.1 The process of electrolysis

Question 28 · continued

0 4 . 1 **Figure 5** shows the volume of hydrogen gas collected in the measuring cylinder after 8 minutes.

Figure 5



What is the volume of hydrogen gas collected?

[1 mark]

Volume = _____ cm^3

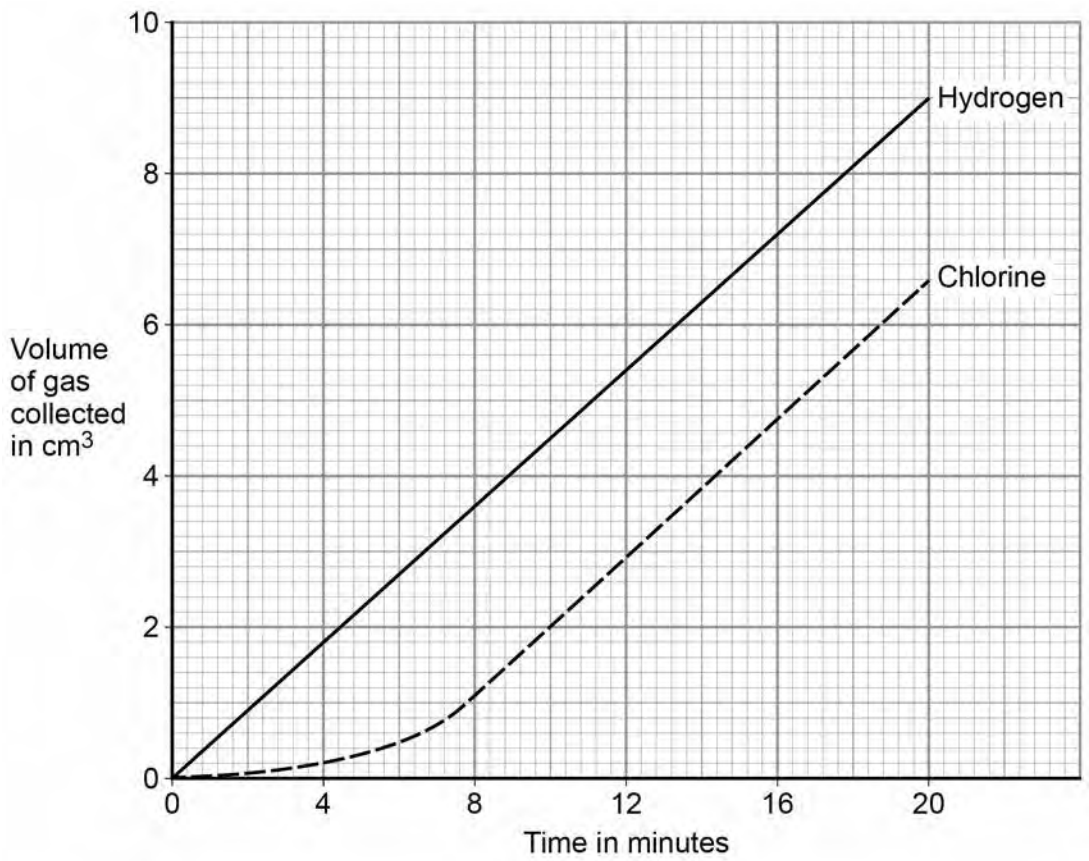
Question 4 continues on the next page

4.4.3.1 The process of electrolysis

Question 28 · continued

Figure 6 shows the results of the investigation.

Figure 6



0 4 . 2 Which of the lines on **Figure 6** show that the volume of gas collected is directly proportional to the time?

[1 mark]

Tick **one** box.

- Both lines ☐
- Chlorine line only ☐
- Hydrogen line only ☐
- Neither line ☐

4.4.3.1 The process of electrolysis

Question 28 · continued

0 4 . 3 Which of the lines on **Figure 6** show a positive correlation between the volume of gas collected and time?

[1 mark]

Tick **one** box.

- Both lines ☐
- Chlorine line only ☐
- Hydrogen line only ☐
- Neither line ☐

Question 4 continues on the next page

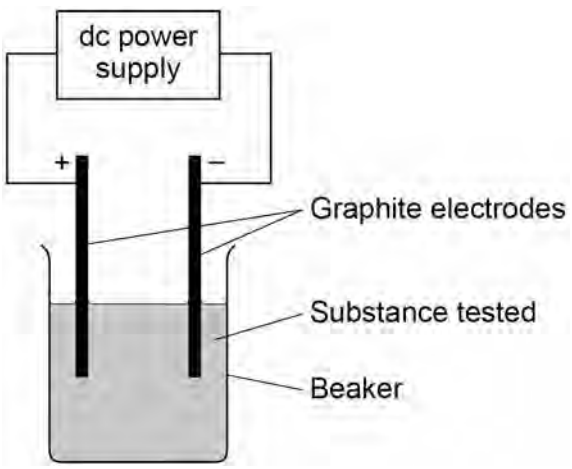
4.4.3.1 The process of electrolysis

Question 28 · continued

A teacher demonstrates the electrolysis of different substances using graphite electrodes.

Figure 7 shows the apparatus used.

Figure 7



0 4 . 4 Why can graphite conduct electricity?

[1 mark]

Tick **one** box.

Graphite exists in layers of atoms. ☐

Graphite has a giant structure. ☐

Graphite has a high melting point. ☐

Graphite has delocalised electrons. ☐

4.4.3.1 The process of electrolysis

Question 28 · continued

0 4 . 5 The teacher demonstrates the electrolysis of:

- molten zinc chloride
- potassium bromide solution.

Complete **Table 3** to predict the products.

Choose answers from the box.

[4 marks]

chlorine	**bromine**	**hydrogen**	**oxygen**	**potassium**	**zinc**

Table 3

Substance electrolysed	Product at cathode (negative electrode)	Product at anode (positive electrode)
Molten zinc chloride		
Potassium bromide solution		

4.4.3.1 The process of electrolysis

Question 29

June 2019 | 8462/1F | Original Q6

0 6 This question is about the extraction of metals.

0 6 . 1 Tungsten is a metal.

The symbol of tungsten is W

Tungsten is produced from tungsten oxide by reaction with hydrogen.

The equation for the reaction is:

$$WO_3 + 3H_2 \rightarrow W + 3H_2O$$

Calculate the percentage atom economy when tungsten is produced in this reaction.

Use the equation:

$$\text{percentage atom economy} = \frac{184}{(M_r\ WO_3) + (3 \times M_r\ H_2)} \times 100$$

Relative formula masses (M_r): $WO_3 = 232$ $H_2 = 2$

[2 marks]

Percentage atom economy = _____ %

4.4.3.1 The process of electrolysis

Question 29 · continued

June 2019 | 8462/1F | Original Q6

Aluminium is extracted from aluminium oxide.

0 6 . 2 38% of a rock sample is aluminium oxide.

Calculate the mass of aluminium oxide in 40 kg of the rock sample.

[2 marks]

Mass of aluminium oxide = _____ kg

0 6 . 3 The formula of aluminium oxide is Al_2O_3

Calculate the relative formula mass (M_r) of aluminium oxide.

Relative atomic masses (A_r): O = 16 Al = 27

[2 marks]

Relative formula mass (M_r) = _____

Question 6 continues on the next page

4.4.3.1 The process of electrolysis

Question 29 · continued

June 2019 | 8462/1F | Original Q6

0 6 . 4 60.0 kg of aluminium oxide produces a maximum of 31.8 kg of aluminium.

In an extraction process only 28.4 kg of aluminium is produced from 60.0 kg of aluminium oxide.

Calculate the percentage yield.

Give your answer to 3 significant figures.

Use the equation:

$$\text{percentage yield} = \frac{\text{mass of product actually made}}{\text{maximum theoretical mass of product}} \times 100$$

[3 marks]

Percentage yield = _____ %

0 6 . 5 Extracting metals by electrolysis is a very expensive process.

Explain why aluminium is extracted using electrolysis and not by reduction with carbon.

[2 marks]

11

4.4.3.1 The process of electrolysis

Question 30

November 2020 | 8462/1F | Original Q4

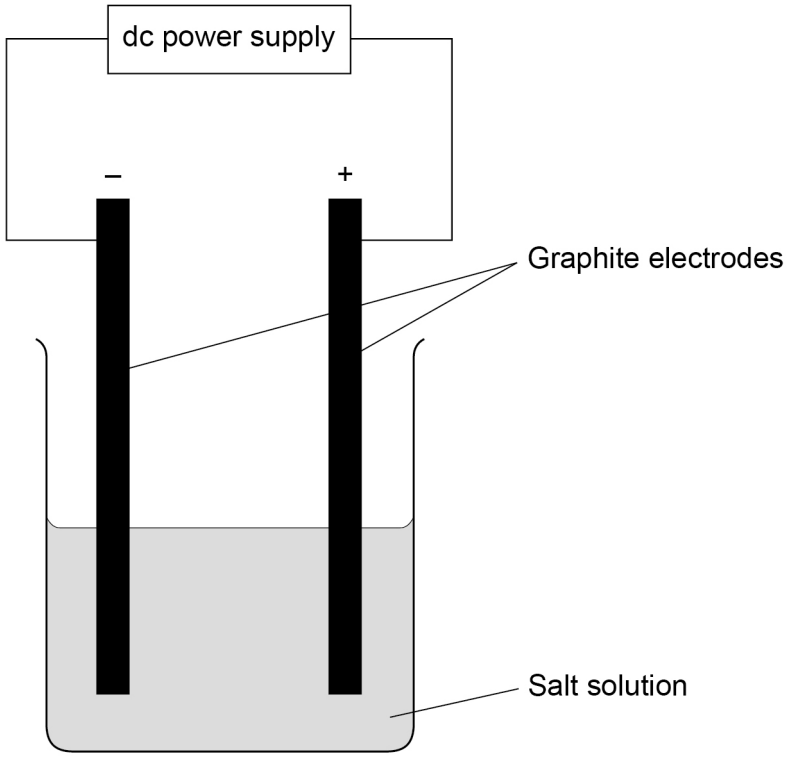
0 4 This question is about electrolysis.

A student investigated the hypothesis:

'The electrolysis of a salt solution produces a metal at the negative electrode and a gas at the positive electrode.'

Figure 4 shows the apparatus used.

Figure 4



0 4 . 1 What observation would be made at each electrode if the hypothesis is correct?

[2 marks]

Observation if metal produced at the negative electrode _____

_____

Observation if gas produced at the positive electrode _____

_____

4.4.3.1 The process of electrolysis

Question 30 · continued

Table 3 shows the student's results.

Table 3

Salt solution	Product at the negative electrode	Product at the positive electrode
Copper chloride	Copper	Chlorine
Potassium nitrate	Hydrogen	Oxygen
Silver nitrate	Silver	Oxygen

0 4 . 2 Which salt solution in **Table 3** does **not** match the student's hypothesis?

Give **one** reason why.

[2 marks]

Salt solution _____

Reason _____

_____

0 4 . 3 Give **two** reasons why graphite is used for the electrodes.

[2 marks]

1 _____

_____

2 _____

_____

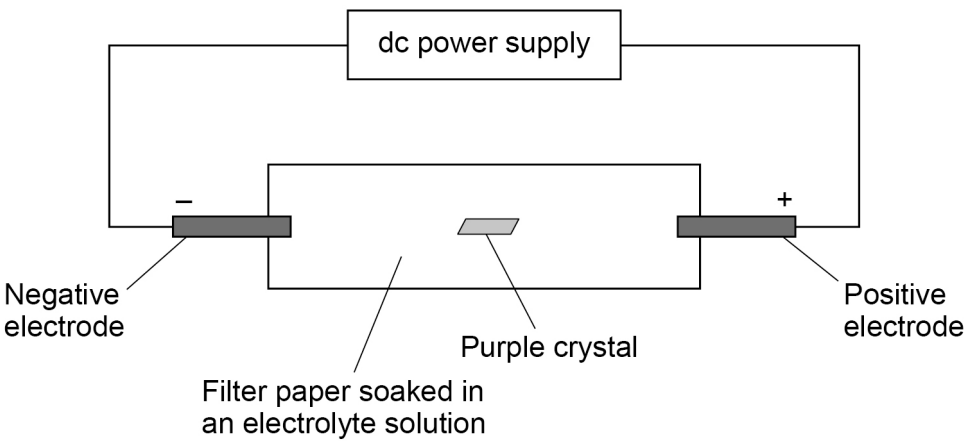
4.4.3.1 The process of electrolysis

Question 30 · continued

A different student investigated what happens during electrolysis.

Figure 5 shows the apparatus.

Figure 5



The purple crystal contained:

- colourless positive ions
- purple coloured negative ions.

The purple crystal dissolved in the electrolyte solution.

0 4 . 4 What happens to the purple coloured ions?

Give **one** reason for your answer.

[2 marks]

Tick (✓) **one** box.

The ions do not move. ☐

The ions move towards the negative electrode. ☐

The ions move towards the positive electrode. ☐

Reason _____

_____

8

4.4.3.1 The process of electrolysis

Question 31

November 2020 | 8462/1F | Original Q5

0 5 This question is about aluminium.

0 5 . 1 Aluminium is a metal.

Draw **one** line from each property of aluminium to the correct reason for that property.

[2 marks]

Property	Reason
	Aluminium has delocalised electrons
Conducts electricity	Aluminium has layers of atoms which can slide
	Aluminium has strong metallic bonds
High melting point	Aluminium has weak intermolecular forces
	Aluminium has a random arrangement of atoms

0 5 . 2 Aluminium can be used to make alloys.

What is meant by an 'alloy'?

[1 mark]

4.4.3.1 The process of electrolysis

Question 31 · continued

Aluminium is extracted from bauxite.

Bauxite is a mixture which contains aluminium oxide.

0 5 . 3 Bauxite contains between 15% and 25% aluminium.

Aluminium oxide always contains 53% aluminium.

How does this show that bauxite is a mixture and **not** a compound?

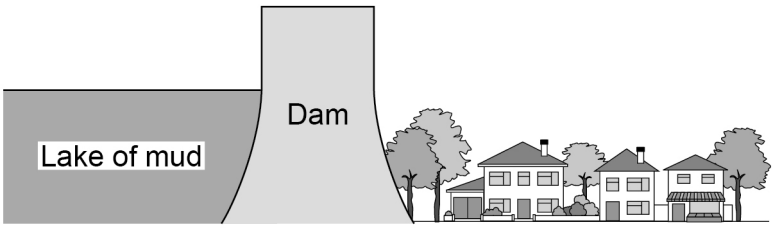
[1 mark]

0 5 . 4 The waste material from the bauxite is stored in lakes of mud.

The lakes of mud are held in place by dams.

Figure 6 shows one of these lakes.

Figure 6



Suggest **two** possible problems with storing the waste material in lakes of mud.

[2 marks]

1

2

4.4.3.1 The process of electrolysis

Question 31 · continued

Aluminium is extracted by electrolysis.

The aluminium oxide is mixed with cryolite and melted.

The mixture is then electrolysed.

0 5 . 5 The formula of cryolite is Na_3AlF_6

Give the total number of atoms in the formula.

[1 mark]

Number of atoms = _____

0 5 . 6 What is the reason for adding cryolite to the aluminium oxide?

[1 mark]

Tick (✓) **one** box.

- To increase the amount of aluminium extracted ☐
- To lower the melting point of the mixture ☐
- To reduce the amount of aluminium oxide needed ☐

4.4.3.1 The process of electrolysis

Question 31 · continued

0 5 . 7 Complete the sentences.

Choose answers from the box.

[2 marks]

aluminium	**carbon**	**fluorine**
oxygen	**sodium**	

When the molten aluminium oxide and cryolite mixture is electrolysed the product at the positive electrode is _____.

This product reacts with the positive electrode because the positive electrode is made of _____.

0 5 . 8 A sample of bauxite contains 25% aluminium.

Calculate the maximum mass of aluminium that can be extracted from 300 000 kg of the sample of bauxite.

Give your answer in standard form.

[3 marks]

Maximum mass (in standard form) = _____ kg

13

4.4.3.1 The process of electrolysis

Question 32

0 2 This question is about chemical cells and batteries.

0 2 . 1 Three different types of battery can be used to power a TV remote control.

Table 1 gives information about these batteries.

Table 1

	Zinc-carbon battery	Alkaline battery	Nickel-metal hydride battery
Cost of battery in £ (pounds)	0.17	0.50	1.50
Rechargeable?	No	No	Yes
Time before needing to replace or recharge in months	5	12	8

Give **one** advantage of each type of battery.

[3 marks]

Zinc-carbon _____

_____

Alkaline _____

_____

Nickel-metal hydride _____

_____

0 2 . 2 **Figure 3** shows a symbol printed on batteries.

Figure 3



This symbol shows that batteries should not be put in household waste.

Suggest why batteries should **not** be put in household waste.

[1 mark]

_____

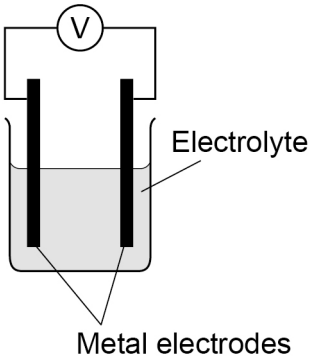
_____

4.4.3.1 The process of electrolysis

Question 32 · continued

Figure 4 shows a chemical cell.

Figure 4



0 2 . 3 The order of reactivity of three metals is shown below.

Iron	(Most reactive)
Tin	↑
Copper	(Least reactive)

Which combination of metal electrodes would give the highest voltage in the chemical cell in **Figure 4**?

[1 mark]

Tick (✓) **one** box.

Copper and iron ☐

Iron and tin ☐

Tin and copper ☐

0 2 . 4 The voltage produced by the cell in **Figure 4** depends on the type of electrodes and the type of electrolyte.

Suggest **one** other factor that could affect the voltage produced.

[1 mark]

4.4.3.1 The process of electrolysis

Question 32 · continued

0 2 . 5 Water is produced in a hydrogen fuel cell.

Complete the word equation to show the reaction that produces water in a hydrogen fuel cell.

[2 marks]

_____ + _____ → water

8

4.4.3.1 The process of electrolysis

Question 33

November 2021 | 8462/1F | Original Q7

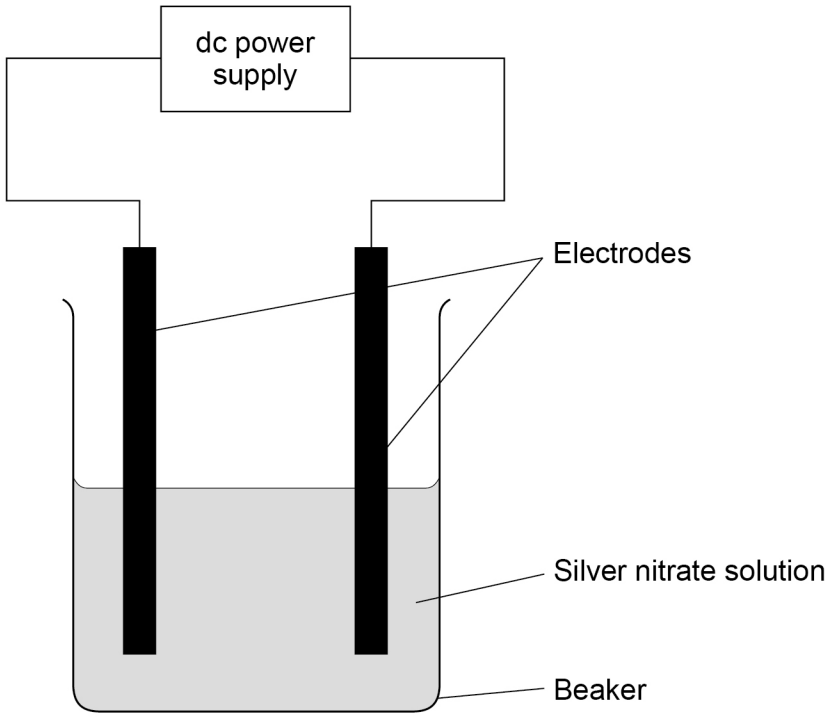
0 7 This question is about electrolysis.

Some students investigated the electrolysis of silver nitrate solution.

This electrolysis produces silver at the negative electrode.

Figure 11 shows the apparatus.

Figure 11



This is the method used.

1. Weigh the negative electrode.
2. Set up the apparatus shown in **Figure 11**.
3. Switch on the power supply.
4. Switch off the power supply after five minutes.
5. Rinse the negative electrode with water and allow to dry.
6. Reweigh the negative electrode.
7. Repeat steps 1 to 6 for different times.

4.4.3.1 The process of electrolysis

Question 33 · continued

0 7 . 1 Some silver did not stick to the negative electrode but fell to the bottom of the beaker.

The students needed to weigh this silver.

How could the students separate the silver from the silver nitrate solution?

[1 mark]

Tick (✓) **one** box.

By chromatography ☐

By crystallisation ☐

By distillation ☐

By filtration ☐

Table 5 shows the students' results.

Table 5

Time in minutes	Mass of silver in g
0	0.00
5	0.06
10	0.12
15	0.18
20	0.24
25	0.30

4.4.3.1 The process of electrolysis

Question 33 · continued

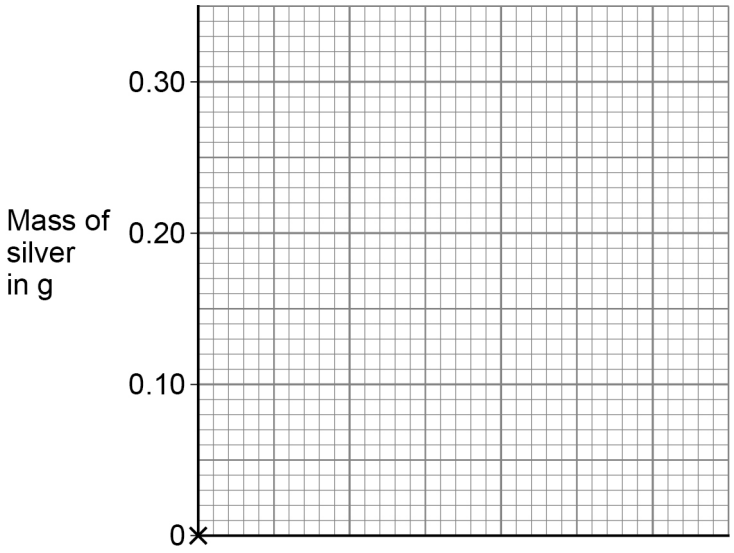
0 7 . 2 Draw a graph on **Figure 12**.

You should:

- use a suitable scale for the x-axis
- plot the data from **Table 5**
- draw a line of best fit.

[4 marks]

Figure 12



0 7 . 3 Determine the mass of silver that would be produced after 12 minutes.

Use **Figure 12**.

[1 mark]

Mass of silver = _____ g

Question 7 continues on the next page

4.4.3.1 The process of electrolysis

Question 33 · continued

0 7 . 4 A student investigated the electrolysis of two aqueous salt solutions.

Hydrogen is produced at the negative electrode when the metal in the salt solution is more reactive than hydrogen.

Complete **Table 6** to show what the student would **observe** at the negative electrode for each salt solution.

[2 marks]

Table 6

Salt solution	Observation at negative electrode
Copper sulfate	
Sodium chloride	

0 7 . 5 A teacher demonstrates the electrolysis of molten lead bromide.

The products at the electrodes are lead and bromine.

Why should the teacher do the demonstration in a fume cupboard?

[1 mark]

_____

_____

0 7 . 6 Two other molten compounds are electrolysed.

Complete **Table 7** to show the molten compounds and the products.

[3 marks]

Table 7

Molten compound electrolysed	Product at the negative electrode	Product at the positive electrode
Zinc chloride		
	Potassium	Iodine

12

4.4.3.1 The process of electrolysis

Question 34

June 2022 | 8462/1F | Original Q8

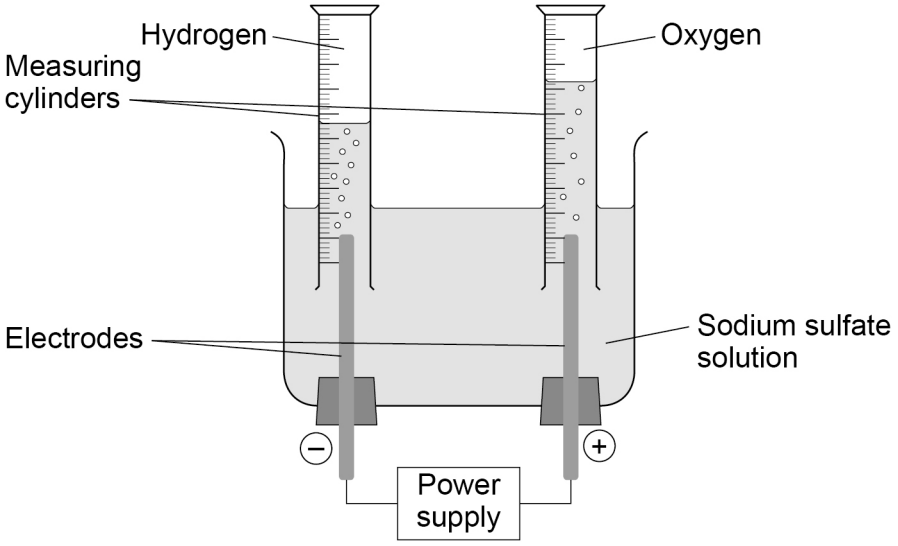
0 8 This question is about electrolysis.

Ionic compounds decompose when they are electrolysed.

A student electrolyses sodium sulfate solution.

Figure 13 shows the apparatus used.

Figure 13



0 8 . 1 Sodium sulfate solution contains:

- hydrogen ions
- hydroxide ions
- sodium ions
- sulfate ions.

Oxygen is produced at the positive electrode.

Which ions are discharged at the positive electrode to produce oxygen?

[1 mark]

Tick (✓) **one** box.

Hydrogen ions ☐

Hydroxide ions ☐

Sodium ions ☐

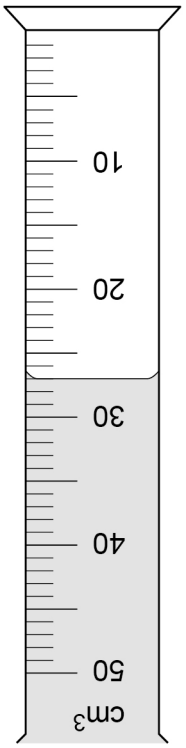
Sulfate ions ☐

4.4.3.1 The process of electrolysis

Question 34 · continued

0 8 . 2 **Figure 14** shows one of the measuring cylinders during the electrolysis.

Figure 14



What is the volume of gas in the measuring cylinder?

[1 mark]

Volume of gas = _____ cm^3

0 8 . 3 Ionic compounds can be electrolysed when molten or dissolved in water.

Why can ionic compounds **not** be electrolysed when solid?

You should answer in terms of ions.

[1 mark]

_____

_____

4.4.3.1 The process of electrolysis

Question 34 · continued

0 8 . 4 **Table 7** shows the products of electrolysis of two molten compounds.

Table 7

Molten compound	Product at negative electrode	Product at positive electrode
Potassium iodide	Potassium	_____
Zinc bromide	_____	Bromine

Complete **Table 7**.

[2 marks]

0 8 . 5 The electrolysis of molten sodium chloride is used to extract sodium metal.

Why is sodium metal extracted by electrolysis instead of by reduction with carbon?

[1 mark]

Tick (✓) **one** box.

Carbon conducts electricity. ☐

Carbon is less reactive than sodium. ☐

Carbon reduction uses more energy. ☐

0 8 . 6 What is the state symbol for molten sodium chloride?

[1 mark]

Tick (✓) **one** box.

(aq) ☐ (g) ☐ (l) ☐ (s) ☐

4.4.3.1 The process of electrolysis

Question 34 · continued

0 8 . 7 Titanium can be produced from titanium oxide by electrolysis.

The equation for the reaction is:

$$TiO_2 \rightarrow Ti + O_2$$

Calculate the percentage atom economy for the production of titanium from titanium oxide by electrolysis.

Use the equation:

$$\text{Percentage atom economy} = \frac{\text{Relative atomic mass of desired product}}{\text{Relative formula mass of reactant}} \times 100$$

Relative atomic mass (A_r): Ti = 48

Relative formula mass (M_r): TiO_2 = 80

[2 marks]

Percentage atom economy = _____ %

9

4.4.3.1 The process of electrolysis

Question 35

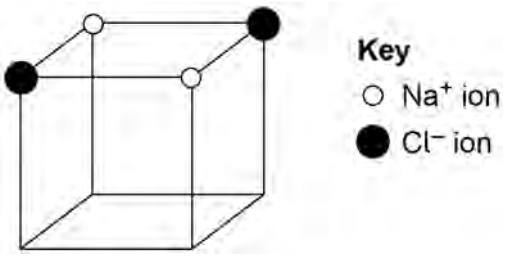
June 2023 | 8462/1F | Original Q7

0 7 This question is about ionic compounds and electrolysis.

Sodium chloride is an ionic compound.

0 7 . 1 **Figure 8** represents part of the structure of solid sodium chloride.

Figure 8



Complete **Figure 8**.

[2 marks]

0 7 . 2 Give **one** reason why molten sodium chloride conducts electricity.

Refer to ions in your answer.

[1 mark]

0 7 . 3 **Table 3** shows products of the electrolysis of two molten ionic compounds.

Complete **Table 3**.

[2 marks]

Table 3

Molten compound	Product at the negative electrode	Product at the positive electrode
Magnesium bromide	Magnesium	
Potassium chloride		Chlorine

4.4.3.1 The process of electrolysis

Question 35 · continued

0 7 . 4 Aluminium is extracted by electrolysis.

The electrolyte is a molten mixture of aluminium oxide and cryolite.

Why is a mixture used instead of pure aluminium oxide as the electrolyte?

[1 mark]

Tick (✓) **one** box.

The mixture has a lower melting point than pure aluminium oxide. ☐

The mixture has the same melting point as pure aluminium oxide. ☐

The mixture has a higher melting point than pure aluminium oxide. ☐

0 7 . 5 Electrolysis of an aqueous solution of sodium sulfate produces hydrogen and oxygen.

What is the source of the hydrogen and the oxygen produced during the electrolysis of aqueous sodium sulfate solution?

[1 mark]

Tick (✓) **one** box.

Air ☐

Sulfate ions ☐

Water ☐

Question 7 continues on the next page

4.4.3.1 The process of electrolysis

Question 35 · continued

Electrolysis of an aqueous solution of sodium sulfate produces hydrogen and oxygen.

0 7 . 6 Why is hydrogen produced instead of sodium in the electrolysis of aqueous sodium sulfate solution?

[1 mark]

Tick (✓) **one** box.

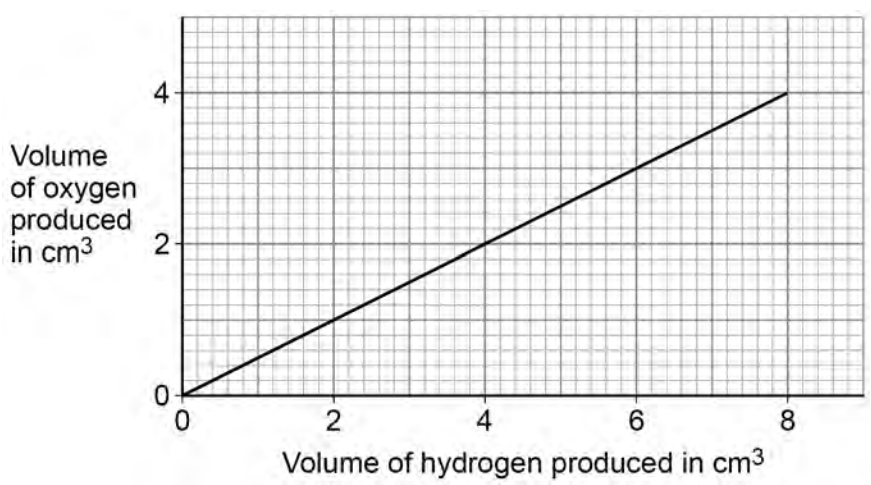
Hydrogen is less reactive than sodium. ☐

Hydrogen has the same reactivity as sodium. ☐

Hydrogen is more reactive than sodium. ☐

0 7 . 7 **Figure 9** shows the relationship between the volume of hydrogen and the volume of oxygen produced during the electrolysis.

Figure 9



Give **one** conclusion that can be made about the volume of hydrogen produced compared to the volume of oxygen produced.

[1 mark]

9

4.4.3.1 The process of electrolysis

Question 36

June 2024 | 8462/1F | Original Q6

0 6 This question is about electrolysis and the extraction of metals.

0 6 . 1 Why can some molten substances be electrolysed?

[1 mark]

Tick (✓) **one** box.

Electrons can move through the molten substance to the electrodes. ☐

Ions can move through the molten substance to the electrodes. ☐

Protons can move through the molten substance to the electrodes. ☐

0 6 . 2 **Table 3** shows the products of the electrolysis of some molten compounds.

Complete **Table 3**.

[3 marks]

Table 3

Molten compound	Product at negative electrode	Product at positive electrode
Lead chloride	_____	Chlorine
Potassium iodide	Potassium	_____
_____	Zinc	Bromine

4.4.3.1 The process of electrolysis

Question 36 · continued

Aluminium is extracted by electrolysing molten aluminium oxide.

0 6 . 3 Balance the equation for the reaction.

Choose numbers from the box.

[2 marks]

2	**3**	**4**	**5**

$$2Al_2O_3 \rightarrow __ Al + __ O_2$$

0 6 . 4 Calculate the relative formula mass (M_r) of aluminium oxide (Al_2O_3).

Relative atomic masses (A_r): O = 16 Al = 27

[2 marks]

Relative formula mass (M_r) = _____

Question 6 continues on the next page

4.4.3.1 The process of electrolysis

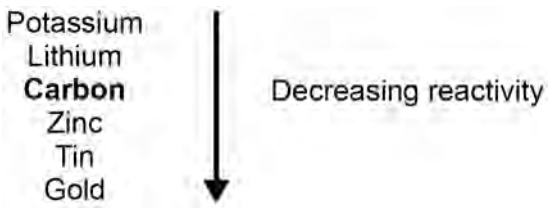
Question 36 · continued

June 2024 | 8462/1F | Original Q6

0 6 . 5 **Figure 13** shows part of the reactivity series of metals.

The non-metal carbon has been included.

Figure 13



Metals can be extracted from their compounds by:

- electrolysis
- reduction with carbon.

Electrolysis is more expensive than reduction with carbon.

Predict one metal that would be extracted by each method.

Use Figure 13.

[2 marks]

Extracted by electrolysis _____

Extracted by carbon reduction _____

10

4.4.3.1 The process of electrolysis

Question 37

June 2024 | 8462/1F | Original Q7

0 7 This question is about chemical cells.

0 7 . 1 A student connects four 1.5 V cells in series to make a battery.

What is the total voltage produced by the battery?

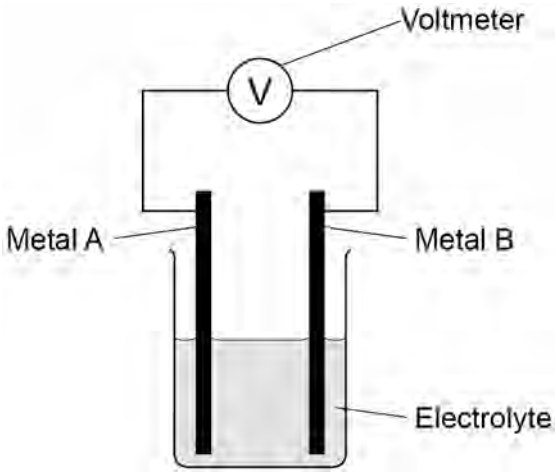
[1 mark]

Voltage = _____ V

A chemical cell can be made using two different metals in contact with an electrolyte.

Figure 14 shows a chemical cell.

Figure 14



0 7 . 2 Which is a suitable electrolyte for a chemical cell?

[1 mark]

Tick (✓) **one** box.

Pure water ☐

Solid lead bromide ☐

Sodium chloride solution ☐

4.4.3.1 The process of electrolysis

Question 37 · continued

0 7 . 3 A student made the hypothesis:

'The voltage produced by a cell depends on the difference in the reactivity of metal **A** and metal **B**.'

Plan an investigation to test this hypothesis.

Your plan should produce valid results.

Use **Figure 14**.

[6 marks]

8

4.4.3.1 The process of electrolysis

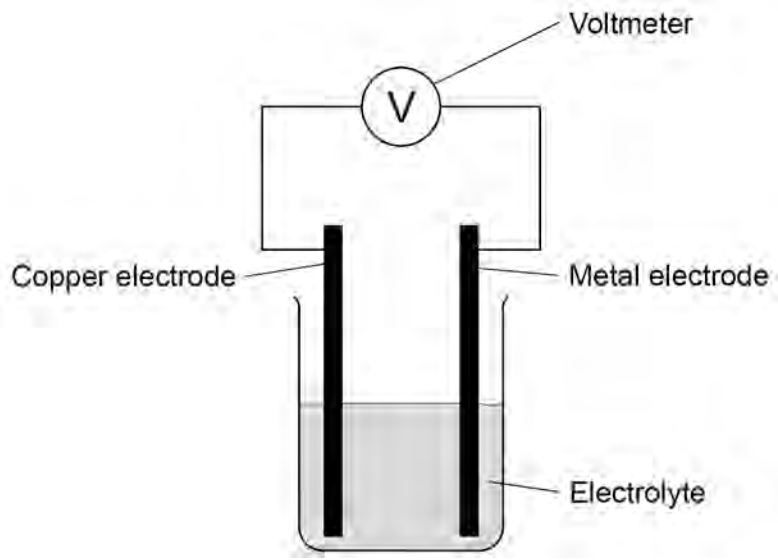
Question 38

0 3 Cells contain chemicals that react to produce electricity.

A student investigated the voltage produced by four different cells.

Figure 3 shows the apparatus.

Figure 3



This is the method used.

1. Measure the voltage produced by the cell using metal **A** as the metal electrode.
2. Repeat using different metals as the metal electrode.

Table 2 shows the results.

Table 2

Metal electrode	Voltage in volts
A	1.1
B	0.0
C	0.8
D	2.7

4.4.3.1 The process of electrolysis

Question 38 · continued

0 3 . 1 Which substance could be used as the electrolyte in the cell in **Figure 3**?

[1 mark]

Tick (✓) **one** box.

Pure water ☐

Sodium chloride solution ☐

Solid potassium bromide ☐

0 3 . 2 Which metal **A**, **B**, **C** or **D** was copper?

Give **one** reason for your answer.

Use **Figure 3** and **Table 2**.

[2 marks]

Metal _____

Reason _____

_____

0 3 . 3 Write the four metals **A**, **B**, **C** and **D** in order of reactivity.

Use **Table 2**.

[1 mark]

Most reactive _____

_____

_____

Least reactive _____

4.4.3.1 The process of electrolysis

Question 38 · continued

0 3 . 4 A battery consists of several cells connected together in series.

Each cell has a voltage of 3.6 V.

Calculate the number of cells needed to make a battery of voltage 14.4 V.

[2 marks]

Number of cells = _____

0 3 . 5 Fuel cells can be used to power electric cars.

Complete the sentence.

Choose the answer from the box.

[1 mark]

ammonia	**methane**	**water**

The overall reaction in a hydrogen fuel cell involves the oxidation of hydrogen to produce _____.

0 3 . 6 Rechargeable cells can be recharged when an external electrical current is supplied.

Complete the sentence.

[1 mark]

When an external electrical current is supplied to a rechargeable cell, the chemical reaction is _____.

8

4.4.3.1 The process of electrolysis

Question 39

0 5 This question is about electrolysis.

0 5 . 1 **Table 4** shows some of the products of electrolysis of two molten compounds.

Complete **Table 4**.

[2 marks]

Table 4

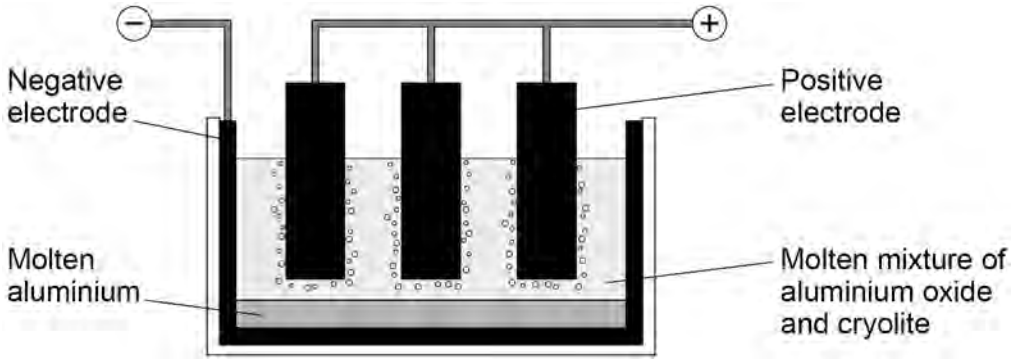
Molten compound	Product at the negative electrode	Product at the positive electrode
Copper chloride		Chlorine
Potassium bromide	Potassium	

Aluminium is extracted by electrolysis of a molten mixture of aluminium oxide and cryolite.

The products are molten aluminium and oxygen gas.

Figure 4 shows the electrolysis cell.

Figure 4



0 5 . 2 What is the formula of oxygen gas?

[1 mark]

Tick (✓) **one** box.

O ☐ O_2 ☐ O^2 ☐ 2O ☐

4.4.3.1 The process of electrolysis

Question 39 · continued

0 5 . 3 Aluminium oxide contains the ions Al^{3+} and O^{2-}

Explain why aluminium is produced at the **negative** electrode.

[2 marks]

0 5 . 4 The melting point of aluminium oxide is 2045 °C.

The melting point of the mixture of aluminium oxide and cryolite is 950 °C.

Explain why the electrolysis uses the mixture instead of pure aluminium oxide.

[2 marks]

0 5 . 5 The positive electrodes in the electrolysis cell are made of carbon.

Why do the positive electrodes need to be continually replaced?

[1 mark]

Tick (✓) **one** box.

Carbon reacts with the aluminium oxide. ☐

Carbon reacts with the aluminium produced. ☐

Carbon reacts with the oxygen produced. ☐

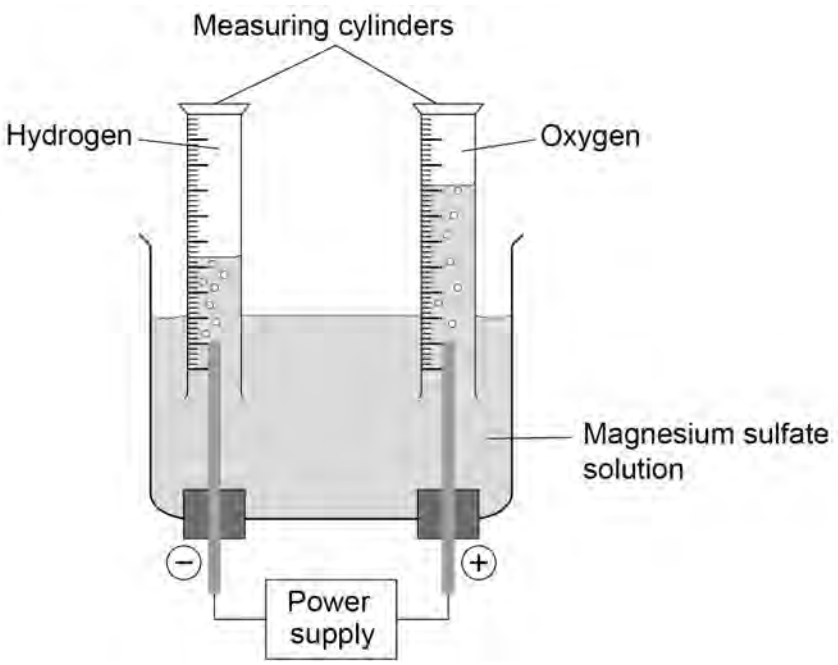
4.4.3.1 The process of electrolysis

Question 39 · continued

A student investigated the electrolysis of magnesium sulfate solution.

Figure 5 shows the apparatus.

Figure 5



This is the method used.

1. Set the power supply to give a current of 0.05 A.

2. Measure the volume of each gas every minute for 5 minutes.

3. Repeat steps 1 and 2 using a current of 0.10 A in step 1.

4.4.3.1 The process of electrolysis

Question 39 · continued

0 5 . 6 **Figure 6** shows a measuring cylinder during the electrolysis.

Figure 6



What is the volume of gas in the measuring cylinder?

[1 mark]

Tick (✓) **one** box.

2.7 cm^3 ☐ 3.4 cm^3 ☐ 4.6 cm^3 ☐

0 5 . 7 Hydrogen is produced instead of magnesium at the negative electrode.

Why is hydrogen produced at the negative electrode?

[1 mark]

Tick (✓) **one** box.

Hydrogen is less reactive than magnesium. ☐

Hydrogen has the same reactivity as magnesium. ☐

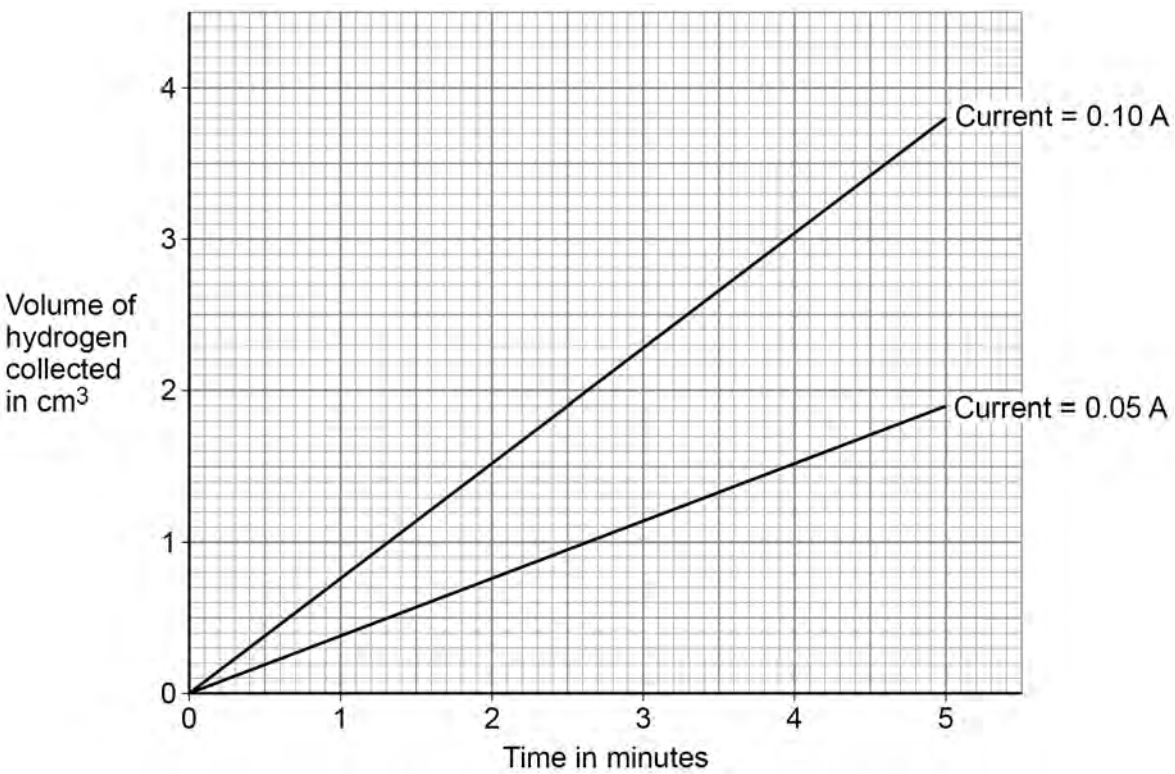
Hydrogen is more reactive than magnesium. ☐

4.4.3.1 The process of electrolysis

Question 39 · continued

0 5 . 8 **Figure 7** shows the results for the volume of hydrogen collected.

Figure 7



Which hypothesis explains the results in **Figure 7**?

[1 mark]

Tick (✓) **one** box.

The volume of hydrogen collected depends on **both** the current and the time. ☐

The volume of hydrogen collected depends on the current but **not** the time. ☐

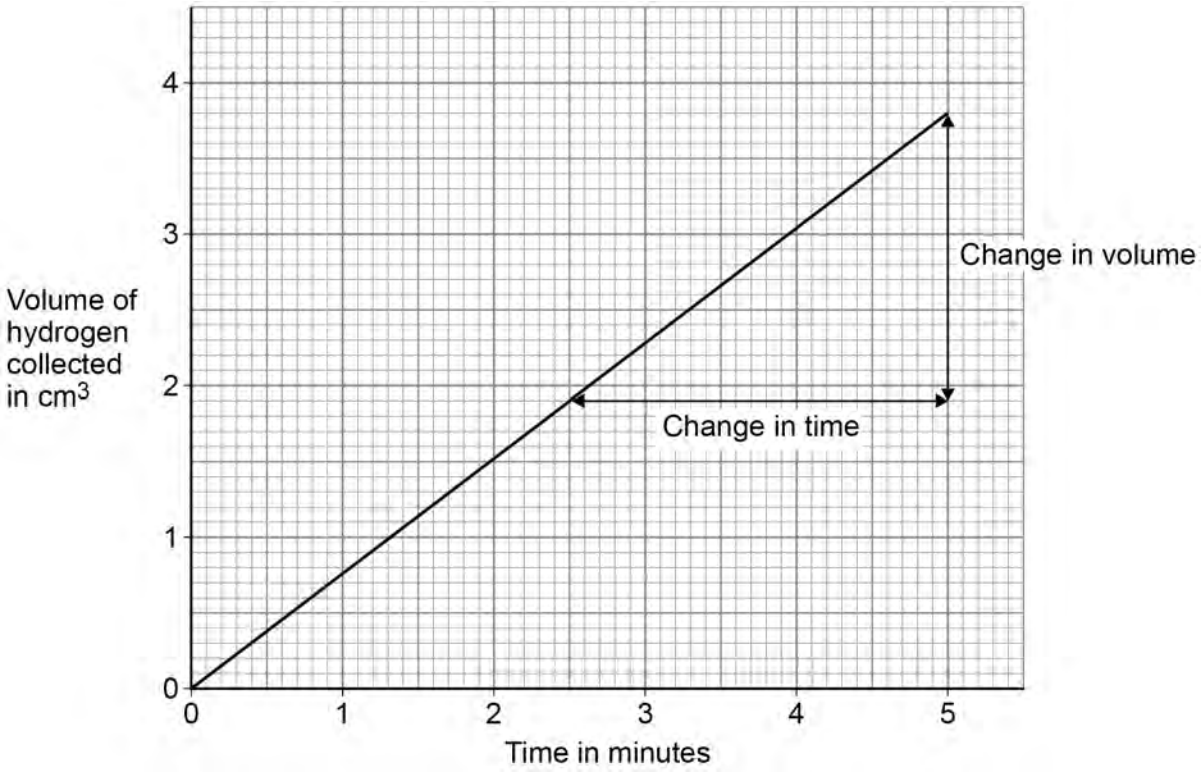
The volume of hydrogen collected depends on the time but **not** the current. ☐

4.4.3.1 The process of electrolysis

Question 39 · continued

0 5 . 9 **Figure 8** is a repeat of part of the graph for current = 0.10 A in **Figure 7**.

Figure 8



Determine the gradient of the graph in **Figure 8**.

Use the equation

$$\text{gradient} = \frac{\text{change in volume}}{\text{change in time}}$$

[4 marks]

Change in volume = _____ cm^3

Change in time = _____ min

Gradient = _____ cm^3/min

15