AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.4.3.1

The process of electrolysis

Past-paper questions

Tier	**Higher**
Question groups	**42**
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.

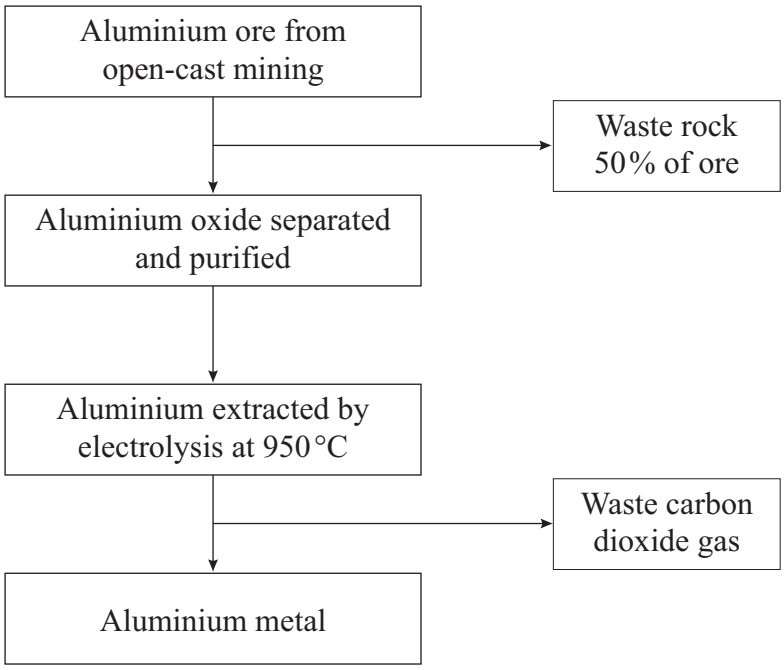
4.4.3.1 The process of electrolysis

Question 01

January 2008 | CHY1H | Original Q4 | Legacy

4 Aluminium has many uses because of its low density, good electrical conductivity, flexibility and resistance to corrosion.

The main steps in the extraction of aluminium are shown in the flow chart.



(a) Use the information in the flow chart to suggest the benefits of recycling aluminium.

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(3 marks)

4.4.3.1 The process of electrolysis

Question 01 · continued

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(b) Pure aluminium is rarely used for the construction of large objects. Small amounts of other metals are usually mixed with aluminium.

Explain why.

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(2 marks)

5

Turn over for the next question

4.4.3.1 The process of electrolysis

Question 02

January 2008 | CHY2H | Original Q4 | Legacy

4 The *electrolysis* of sodium chloride solution produces useful substances.

(a) Explain the meaning of *electrolysis*.

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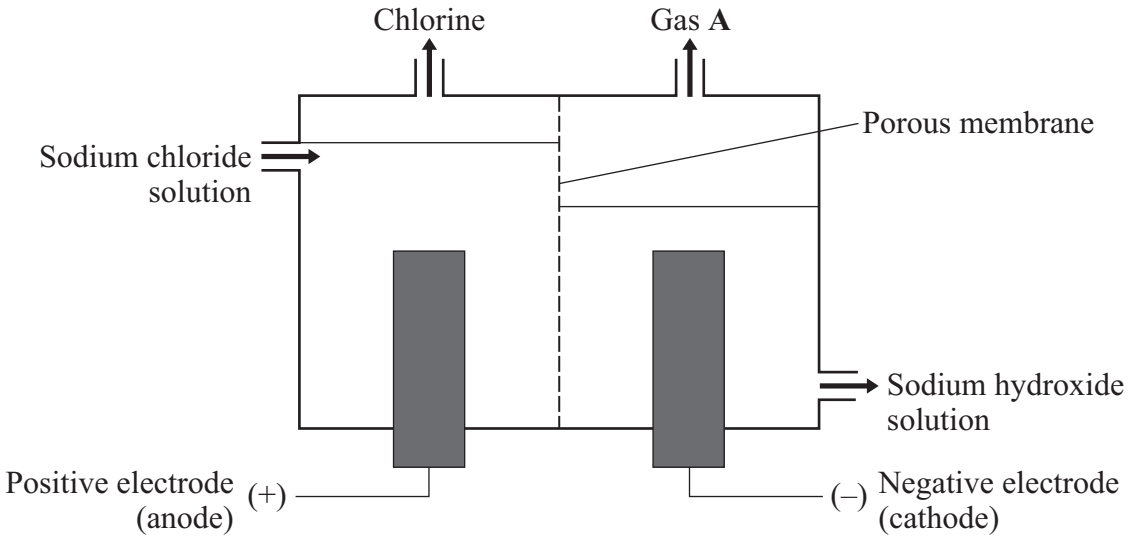
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(2 marks)

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



The electrolysis produces two gases, chlorine and Gas **A**.

Name Gas **A** .....

(1 mark)

(c) The electrodes used in this process can be made of graphite. Explain why graphite conducts electricity.

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(2 marks)

5

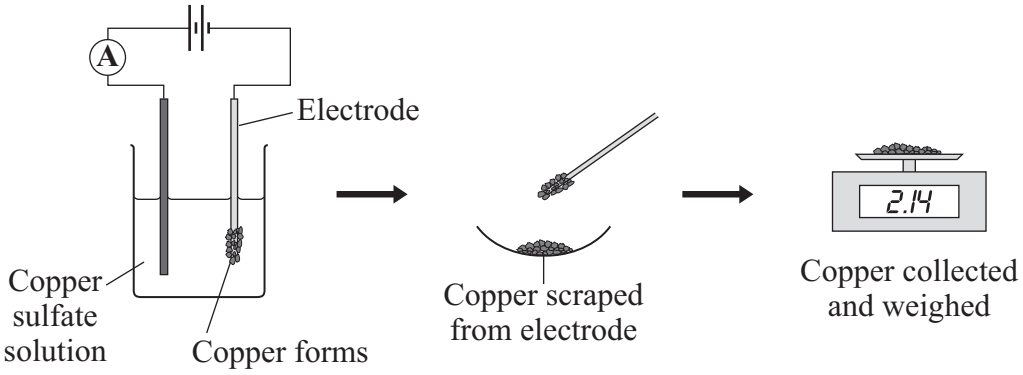
4.4.3.1 The process of electrolysis

Question 03

March 2008 | CHY1AP | Original Q5 | Legacy

QUESTION FIVE

The diagram shows how copper can be extracted from a solution of copper sulfate using electrolysis.



The table shows how the mass of copper extracted in one minute changes with the current used in the experiment.

Current in amps	Mass of copper extracted in g per minute
1.0	0.12
1.5	0.14
2.0	0.24
2.5	0.30
3.0	0.36

5A There is an anomalous result at a current of . . .

1 1.5 A

2 2.0 A

3 2.5 A

4 3.0 A

4.4.3.1 The process of electrolysis

Question 03 · continued

5B All the results in the experiment were slightly higher than expected.

To provide more accurate results, the experiment could be repeated . . .

1 using a balance measuring to three decimal places.

2 using a wider range of currents.

3 drying the copper to constant mass before the final weighing.

4 carrying out the experiment three times at each current.

5C The results show that generally the amount of copper produced is . . .

1 directly proportional to the current used.

2 indirectly proportional to the current used.

3 independent of the current used.

4 inversely proportional to the current used.

5D The copper scraped from the electrode may **not** be 100% pure.

This is because . . .

1 it may contain some copper sulfate.

2 it still contains some of its original ore.

3 the copper produced quickly forms an alloy.

4 the electricity contaminates it.

4.4.3.1 The process of electrolysis

Question 04

June 2008 | CHY1AP | Original Q8 | Legacy

QUESTION EIGHT

Cars are being developed that use hydrogen as a fuel instead of petrol or diesel. When hydrogen burns, the only product is water. Hydrogen can be used to power fuel cells that produce electricity to run the car, rather than burning it in a traditional engine.

Hydrogen can be obtained from water by electrolysis. This method is both expensive and slow, so scientists are trying other methods.
A company has developed cells that can convert 8% of solar energy directly into hydrogen. They must reach an efficiency of 10% before the process becomes commercially viable.

8A In the electrolysis of water, the products are hydrogen together with . . .

1 oxygen only.

2 oxygen and carbon dioxide.

3 carbon dioxide only.

4 carbon dioxide and nitrogen.

8B One advantage that a hydrogen-powered vehicle has over a petrol-powered vehicle is that . . .

1 no sulfur dioxide is produced.

2 it causes only half the global dimming.

3 hydrogen-powered cars run on solar energy.

4 it is safer because hydrogen does not burn.

8C Hydrogen-powered cars are **not** common on roads yet because . . .

1 hydrogen resources are scarce.

2 fuel cell technology has been expensive to develop.

3 the vehicles will only move during summer.

4 electrolysis is a slow process in the car.

4.4.3.1 The process of electrolysis

A scientist has claimed that there are a number of technical and financial stumbling blocks. He said that the development of hydrogen-powered cars also required development of the cells to produce hydrogen. He described this by saying, 'there is a chicken and egg issue here'.

8D The statement, 'there is a chicken and egg issue here' made by the scientist means that . . .

1 the technology is basic at the moment but it will develop well by 2020.

2 there is no point producing a hydrogen-powered car if hydrogen fuel is not widely available.

3 people will **not** want to buy the first hydrogen cars as they will be slow.

4 we must develop other fuels before oil runs out.

Turn over for the next question

4.4.3.1 The process of electrolysis

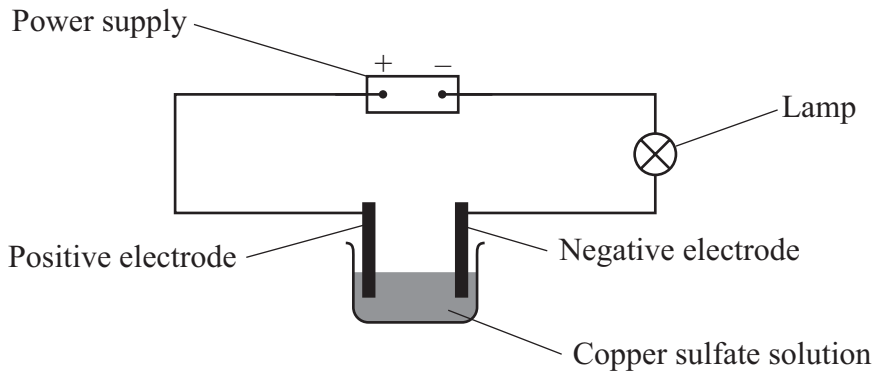
Question 05

June 2008 | CHY2H | Original Q2 | Legacy

2 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.

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

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(1 mark)

2 (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 05 · continued

for mark

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

(1 mark)

2 (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 .....

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2 .....

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(2 marks)

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

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(4 marks)

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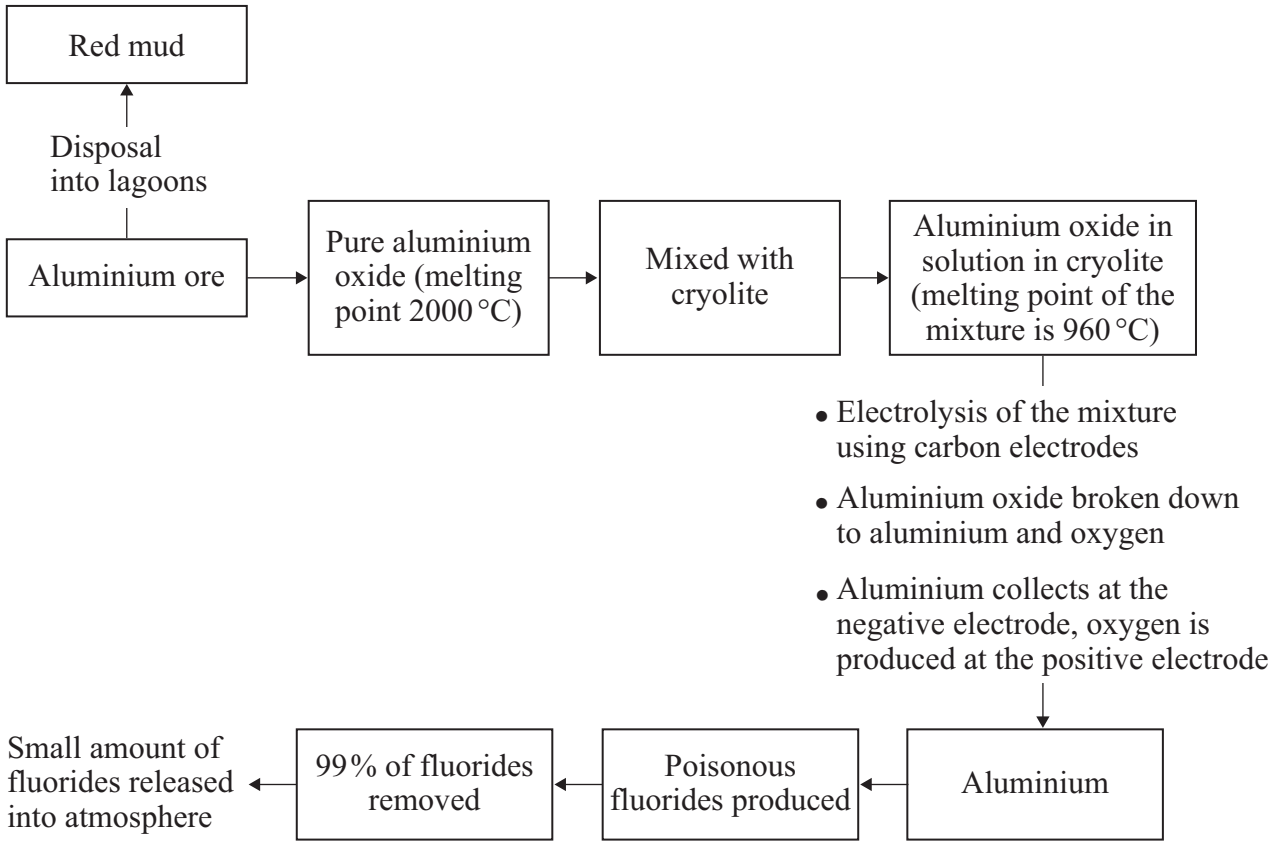
4.4.3.1 The process of electrolysis

Question 06

June 2009 | CHY1AP | Original Q9 | Legacy

QUESTION NINE

The flow chart shows the stages in the extraction of aluminium.



9A The red mud from the aluminium ore is disposed of by dumping in lagoons. The red mud contains iron oxide.

The most likely reason why iron is **not** extracted from the red mud is that . . .

1 the iron oxide evaporates too quickly.

2 there is no transportation system nearby.

3 it is **not** economic compared to other sources of iron.

4 iron oxide from the lagoons cannot be reduced by carbon.

4.4.3.1 The process of electrolysis

9B Why is pure aluminium oxide mixed with cryolite before electrolysis?

1 to produce an aluminium alloy

2 to reduce the breakdown of aluminium oxide

3 to lower the melting point so less energy is used during electrolysis

4 to react with impurities in the aluminium oxide

9C During electrolysis, the positive carbon electrode is rapidly used up causing emissions.

The main component of these emissions contributes to . . .

1 global dimming.

2 global warming.

3 acid rain.

4 red mud lagoons.

9D It is important to monitor the amount of poisonous fluorides released into the atmosphere.

Plants absorb these fluorides. The amounts of fluorides in plants can be found by chemical analysis.

The best information would be found by chemical analysis of plants that are growing . . .

1 in all the workers' homes.

2 at exactly one kilometre in all directions from the factory.

3 at various distances in all directions from the factory.

4 at various distances in an easterly direction from the factory.

END OF TEST

4.4.3.1 The process of electrolysis

Question 07

June 2009 | CHY1H | Original Q6 | Legacy

6 (a) PEX is a material that is used as an alternative to copper for hot water pipes. PEX is made from poly(ethene).

6 (a) (i) Describe how ethene forms poly(ethene).

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(2 marks)

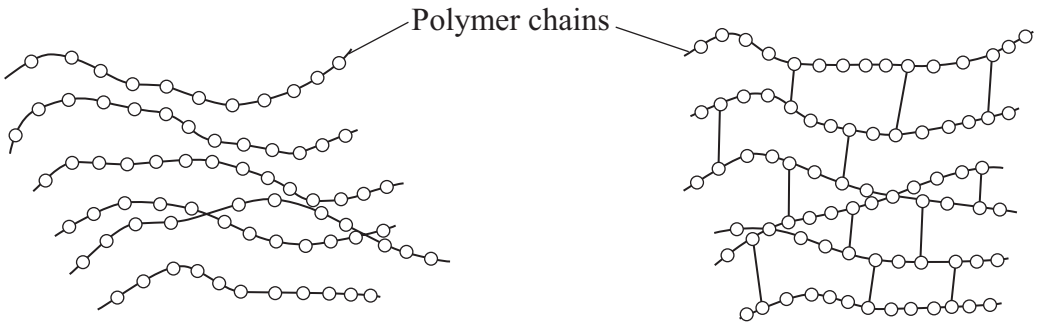
6 (a) (ii) PEX is a shape memory polymer. What property does a shape memory polymer have?

.....

.....

(1 mark)

6 (a) (iii) The simplified structures of poly(ethene) and PEX are shown.



Poly(ethene) **PEX**

Poly(ethene) is a thermoplastic that softens easily when heated.

Suggest and explain how the structure of PEX changes this property.

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(3 marks)

4.4.3.1 The process of electrolysis

Question 07 · continued

for mark

6 (b) Copper was considered to be the most suitable material to use for hot water pipes. PEX is now used as an alternative material for hot water pipes.

Copper is extracted from its ore by a series of processes.

1 The low-grade ore is powdered and concentrated.
2 Smelting is carried out in an oxygen flash furnace. This furnace is heated to 1100 °C using a hydrocarbon fuel. The copper ore is blown into the furnace with air, producing impure, molten copper.
3 Oxygen is blown into the impure, molten copper to remove any sulfur. The copper is cast into rectangular slabs.
4 The final purification of copper is done by electrolysis.

PEX is made from crude oil by a series of processes.

1 Fractional distillation
2 Cracking
3 Polymerisation
4 Conversion of poly(ethene) into PEX

Suggest the possible environmental advantages of using PEX instead of copper for hot water pipes.

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(4 marks)

10

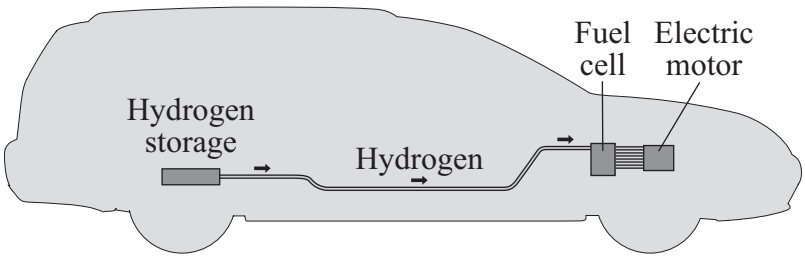
4.4.3.1 The process of electrolysis

Question 08

June 2009 | CHY2H | Original Q5 | Legacy

5 Read the article and then answer the questions that follow.

Hydrogen fuel for cars?



Hydrogen is an excellent fuel. It can be made by the electrolysis of potassium hydroxide solution.

Hydrogen gas can be stored under pressure in a cylinder but a leak of the gas could cause an explosion.

It has been found that lithium nitride can absorb and then release large volumes of hydrogen. A chemical reaction takes place between the hydrogen and the lithium nitride. The hydrogen is held in the resulting compounds by chemical bonds.

The problem is that the rate at which hydrogen is absorbed and then released from normal sized particles of lithium nitride is slow.

Recently scientists have made 'nanosized' particles of lithium nitride. These particles absorb hydrogen in the same way as normal sized lithium nitride particles. The 'nanosized' particles have the advantage that they absorb and release the hydrogen much faster when needed in the fuel cell.

It is hoped that 'nanosized' particles of lithium nitride may provide a safe method of storing hydrogen in the future.

4.4.3.1 The process of electrolysis

Question 08 · continued June 2009 | CHY2H | Original Q5 | Legacy

for mark

5 (a) Hydrogen is produced at the negative electrode during the electrolysis of potassium hydroxide solution.

5 (a) (i) Why are hydrogen ions attracted to the negative electrode?

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(1 mark)

5 (a) (ii) Potassium ions are also attracted to the negative electrode.

Explain why hydrogen gas is formed but not potassium.

.....

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(1 mark)

5 (b) Lithium nitride is made by reacting lithium with nitrogen.

Balance the equation for this reaction.

..... Li + N_2 → ..... Li_3N

(1 mark)

Question 5 continues on the next page

4.4.3.1 The process of electrolysis

Question 08 · continued June 2009 | CHY2H | Original Q5 | Legacy

for mark

5 (c) (i) The equation for the reaction of lithium nitride with hydrogen is:

$$Li_3N + 2H_2 \rightleftharpoons LiNH_2 + 2LiH$$

What feature of this reaction allows the hydrogen to be released?

.....

.....

(1 mark)

5 (c) (ii) Hydrogen stored in a fuel tank filled with lithium nitride would be safer in an accident than a cylinder full of hydrogen.

Suggest and explain why.

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(2 marks)

5 (d) (i) State how 'nanosized' particles will be different from normal sized particles of lithium nitride.

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(1 mark)

5 (d) (ii) Suggest why the 'nanosized' particles of lithium nitride absorb and release the hydrogen more quickly than normal sized particles.

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(1 mark)

4.4.3.1 The process of electrolysis

Question 08 · continued June 2009 | CHY2H | Original Q5 | Legacy

for mark

5 (e) Lithium nitride is an ionic compound which contains lithium ions (Li^{+}) and nitride ions (N^{3-}).

5 (e) (i) The formation of a lithium ion from a lithium atom is an oxidation reaction.

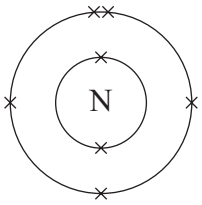
Explain why.

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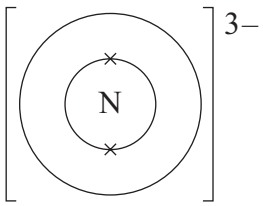
.....

(1 mark)

5 (e) (ii) The diagram shows the electronic structure of a nitrogen atom.



Complete the diagram below to show the electronic structure of a nitride ion (N^{3-}).



(1 mark)

10

4.4.3.1 The process of electrolysis

Question 09

November 2009 | CHY1AP | Original Q4 | Legacy

QUESTION FOUR

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.

4A 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.

4B 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.

4C 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.

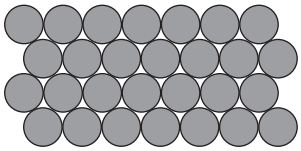
3 the metals are less reactive than carbon.

4 the metal ores are very abundant.

4.4.3.1 The process of electrolysis

Question 09 · continued

4D 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.

4.4.3.1 The process of electrolysis

Question 10

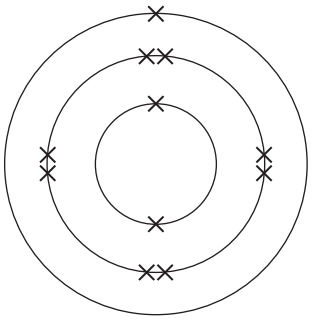
January 2010 | CHY2H | Original Q1 | Legacy

1 Sodium chloride is a raw material.

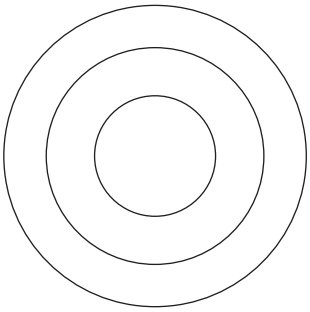
1 (a) The electronic structure of a sodium atom is shown below.

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

Sodium atom



Chlorine atom



(1 mark)

1 (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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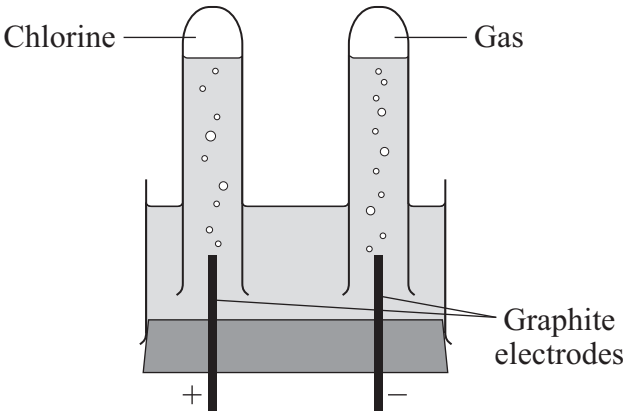
(2 marks)

4.4.3.1 The process of electrolysis

Question 10 · continued

for mark

1 (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^-).

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

.....

(1 mark)

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

.....

(1 mark)

Question 1 continues on the next page

4.4.3.1 The process of electrolysis

Question 10 · continued

for mark

1 (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.'

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

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(1 mark)

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

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(1 mark)

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

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(1 mark)

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4.4.3.1 The process of electrolysis

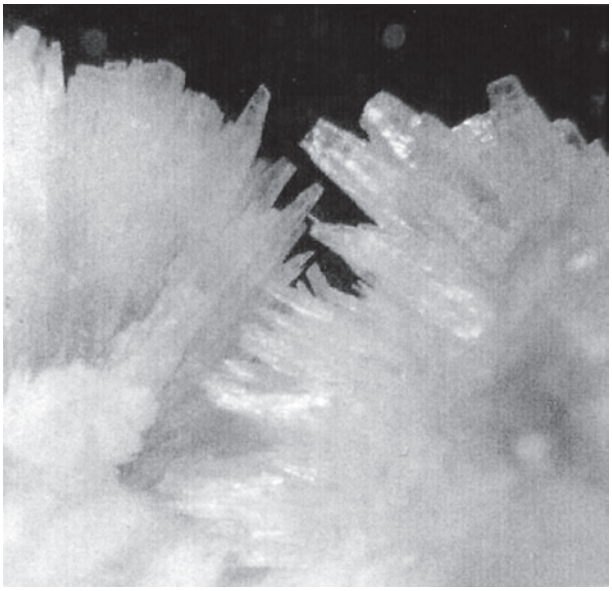
Question 11

June 2010 | CHY2H | Original Q2 | Legacy

2 (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.

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

.....

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(1 mark)

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

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(1 mark)

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

.....

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(1 mark)

4.4.3.1 The process of electrolysis

Question 11 · continued

2 (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

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

.....

.....

(1 mark)

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

Explain how you know.

Experiment ☐ because .....

.....

(1 mark)

2 (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.

.....

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(1 mark)

2 (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 12

November 2010 | CHY1AP | Original Q1 | Legacy

QUESTION ONE

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 13

January 2011 | CHY1H | Original Q1 | Legacy

1 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

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

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

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(1 mark)

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

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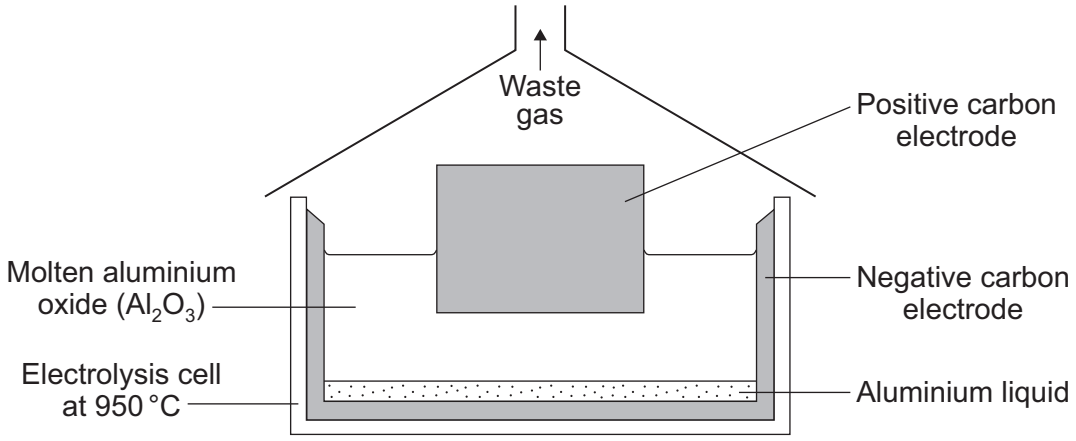
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(1 mark)

4.4.3.1 The process of electrolysis

Question 13 · continued

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



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

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(1 mark)

1 (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.

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(2 marks)

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

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

1 .....

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2 .....

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(2 marks)

7

4.4.3.1 The process of electrolysis

Question 14

January 2011 | CHY2H | Original Q1 | Legacy

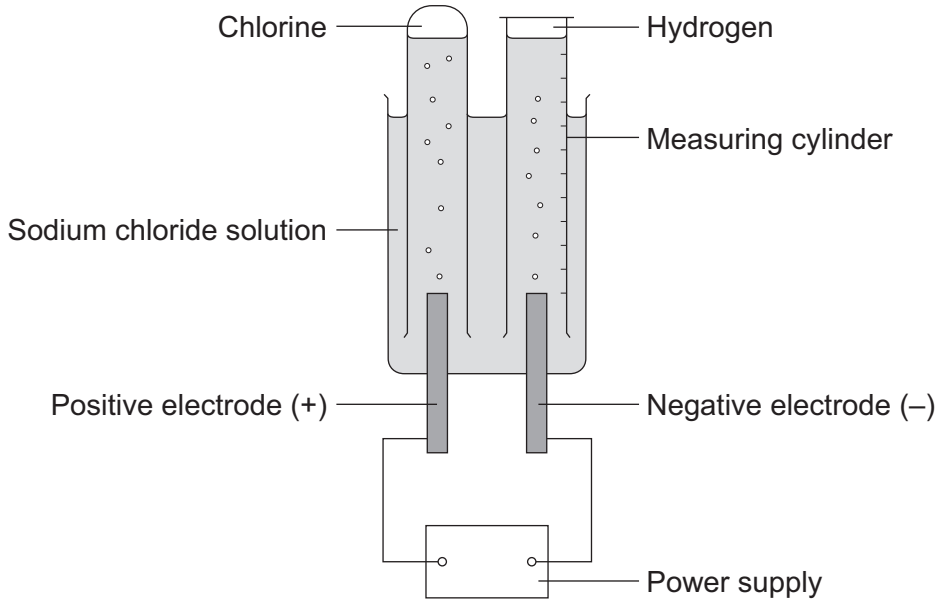
1 A student investigated the electrolysis of sodium chloride solution.

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.

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

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

.....

.....

(1 mark)

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

Why are chloride ions attracted to the positive electrode?

.....

(1 mark)

Question 1 continues on the next page

4.4.3.1 The process of electrolysis

Question 14 · continued

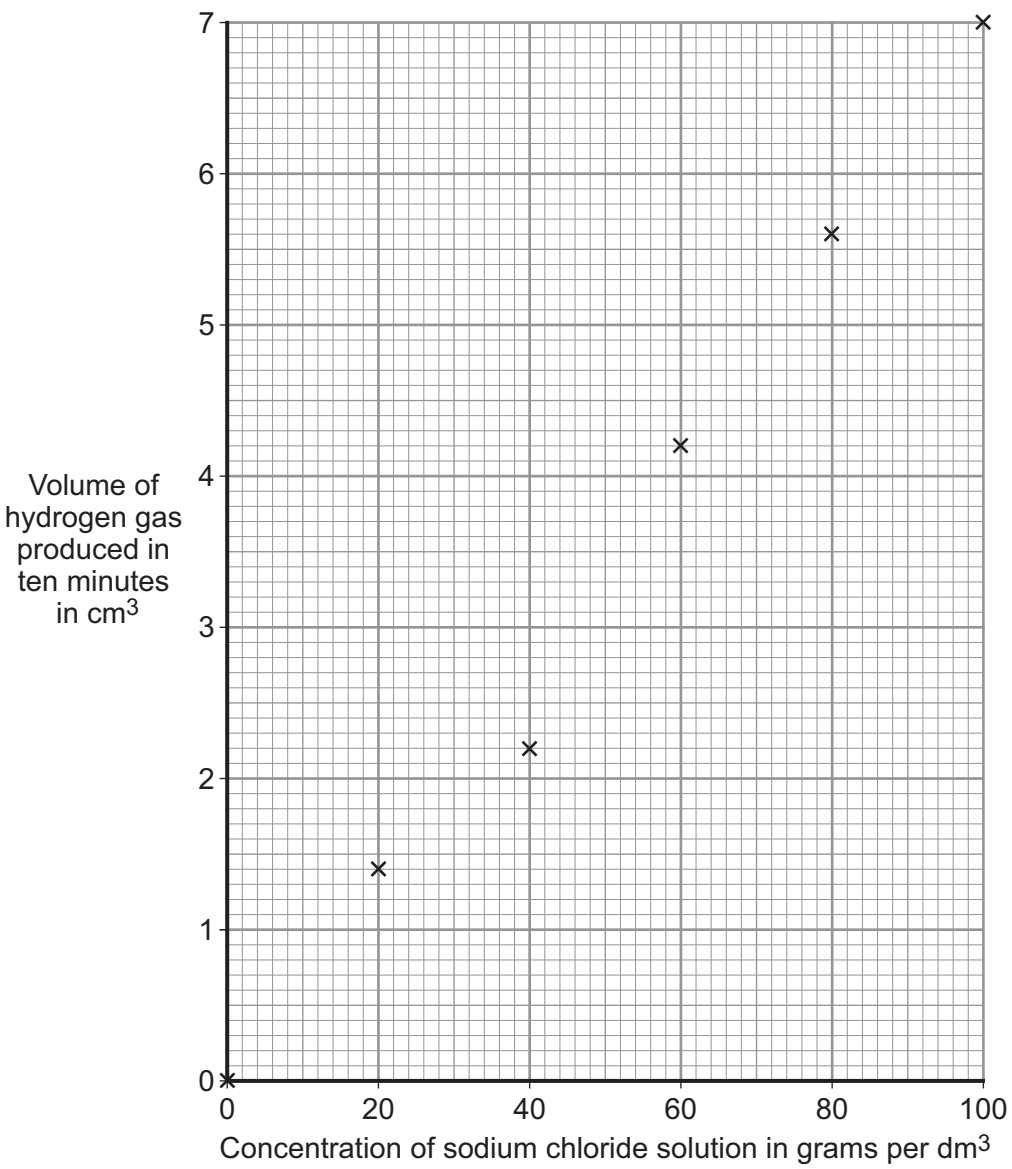
1 (c) The solution left at the end of each experiment contains sodium hydroxide.

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

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

(1 mark)

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



4.4.3.1 The process of electrolysis

Question 14 · continued

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

(1 mark)

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

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

(1 mark)

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

1 .....

.....

2 .....

.....

(2 marks)

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

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.....

(1 mark)

1 (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 15

June 2011 | CHY1AP | Original Q5 | Legacy

QUESTION FIVE

Iron and copper can be extracted from their oxides by reduction with carbon.
Aluminium cannot be extracted from its oxide in this way.

Copper can be found in the Earth's crust as the metal itself.
Iron and aluminium are found only as compounds in the Earth's crust.

5A Which row in the table shows the order of reactivity of the four elements in the passage above?

Most reactive ⟶ **Least reactive**

1	copper	iron	aluminium	carbon
2	aluminium	carbon	iron	copper
3	carbon	copper	iron	aluminium
4	iron	aluminium	copper	carbon

5B Iron can be extracted from iron oxide, Fe_2O_3, by mixing the oxide with carbon and heating strongly in air.

Which row in the table below shows the name of the process and the products of the reaction?

	Name of the process	**Products of the reaction**
1	electrolysis	Fe, O_2 and CO_2
2	reduction	Fe and CO_2
3	electrolysis	Fe and CO_2
4	reduction	Fe, O_2 and CO_2

4.4.3.1 The process of electrolysis

Question 15 · continued June 2011 | CHY1AP | Original Q5 | Legacy

5C Copper is extracted from high grade ores by first heating them strongly in a furnace to obtain impure copper. This is called smelting. Pure copper is then obtained by electrolysis.

Copper is extracted from low grade ores by leaching. A solution of sulfuric acid is run through the ores to produce a solution of copper sulfate. Electrolysis of this solution gives pure copper.

An advantage of leaching over smelting is that . . .

1 leaching uses less energy.

2 leaching causes no environmental damage.

3 leaching leaves no waste.

4 leaching produces purer copper.

5D Extraction of aluminium from its ores requires a lot of energy. Aluminium obtained by recycling scrap aluminium saves about 95% of this energy.

Another advantage of recycling scrap aluminium is that . . .

1 large, new aluminium ore mines will be developed.

2 alternative metals will replace aluminium in making drinks cans.

3 deposits of aluminium ore will last longer.

4 recycled aluminium contains other metals.

4.4.3.1 The process of electrolysis

Question 16

June 2011 | CHY1AP | Original Q9 | Legacy

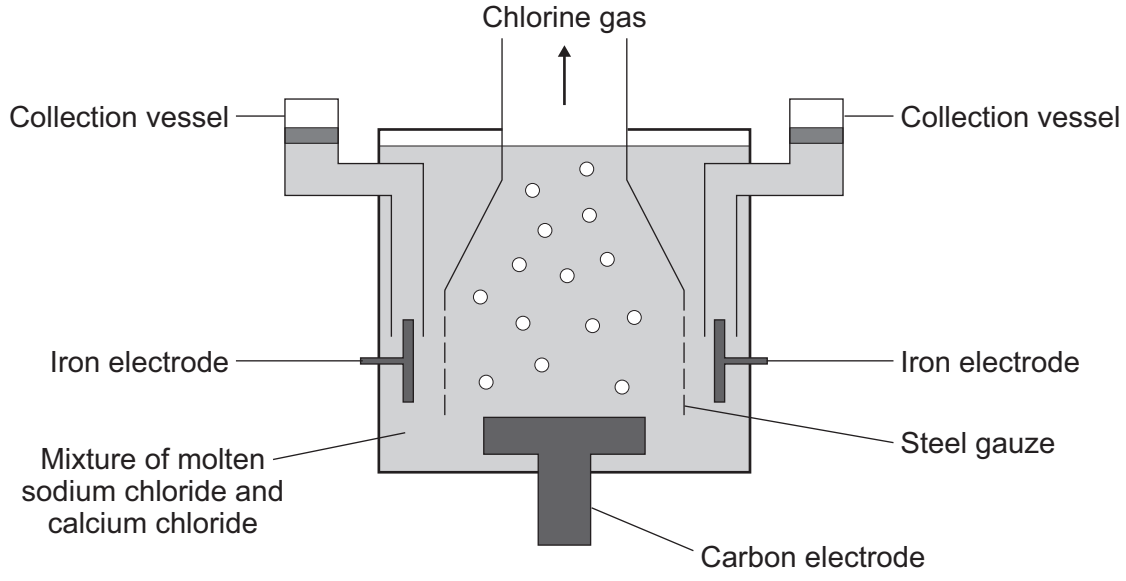
QUESTION NINE

Sodium cannot be extracted from its oxide by reduction with carbon.

Sodium metal is extracted by electrolysis of molten sodium chloride. The melting point of sodium chloride is very high (800°C), so calcium chloride is added to reduce the melting point of the mixture to about 550°C.

During electrolysis, both sodium and calcium are obtained at the iron electrodes, and chlorine at the carbon electrode.

The diagram shows the electrolysis cell used for the extraction of sodium.



The table shows some properties of sodium and calcium.

	Melting point in °C	Density in g per cm^3	Reactivity
Sodium	97	0.97	Very reactive
Calcium	839	1.55	Reactive

9A In the extraction of sodium, a mixture of sodium chloride and calcium chloride is used to . . .

1 reduce the amount of energy required to melt the mixture.

2 obtain a pure sample of sodium.

3 absorb the chlorine gas.

4 increase the temperature of the mixture.

4.4.3.1 The process of electrolysis

Question 16 · continued

9B The purpose of the steel gauze is to prevent the reaction of . . .

1 sodium with calcium.

2 sodium with chlorine.

3 iron electrodes with sodium chloride.

4 sodium chloride with calcium chloride.

9C In the collection vessel there is . . .

1 solid sodium below a layer of liquid calcium.

2 solid calcium below a layer of liquid sodium.

3 a mixture of liquid sodium and liquid calcium.

4 a mixture of solid calcium and solid sodium.

9D The information in the diagram suggests that the element carbon . . .

1 has a melting point lower than 550 °C.

2 reacts rapidly with chlorine gas.

3 is an electrical conductor.

4 is more reactive than iron.

END OF TEST

4.4.3.1 The process of electrolysis

Question 17

June 2011 | CHY1H | Original Q2 | Legacy

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

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

2 (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)

2 (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.

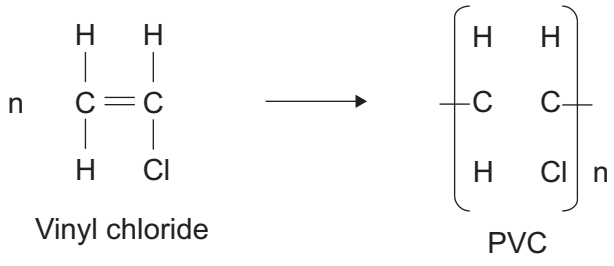
Complete the chemical equation by writing in the formula of the product vinyl chloride.

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

(1 mark)

2 (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)

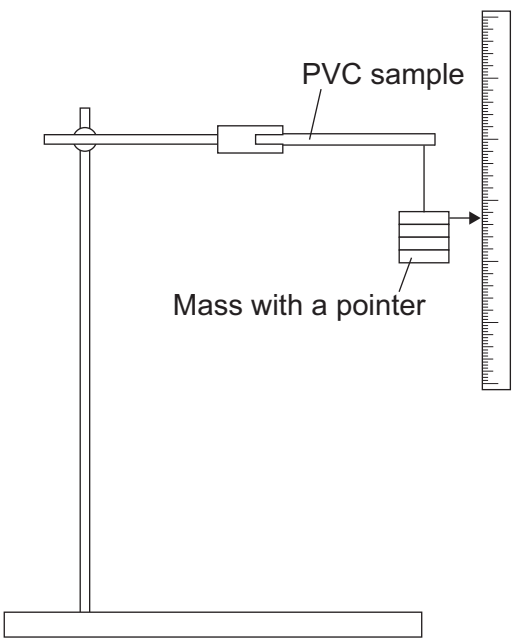
Question 2 continues on the next page

4.4.3.1 The process of electrolysis

Question 17 · continued June 2011 | CHY1H | Original Q2 | Legacy

2 (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

2 (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 17 · continued

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

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(1 mark)

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

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(2 marks)

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

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.....

(1 mark)

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

.....

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(1 mark)

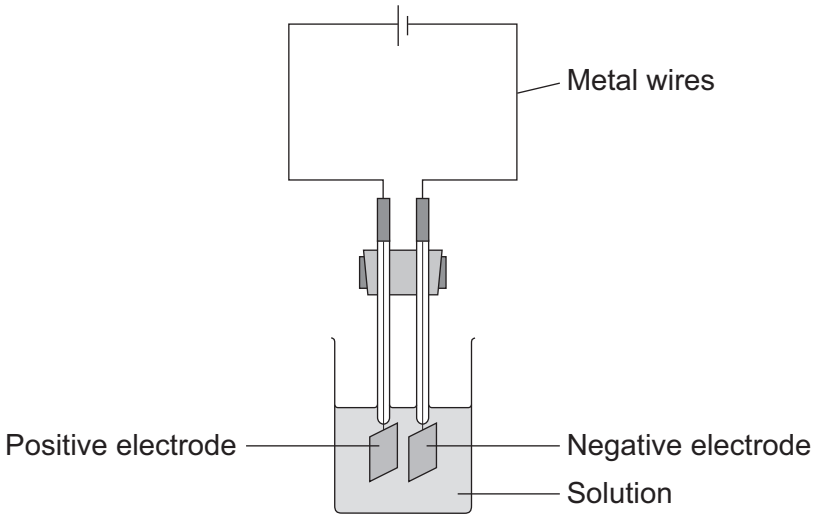
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4.4.3.1 The process of electrolysis

Question 18

June 2011 | CHY2H | Original Q5 | Legacy

5 The diagram shows apparatus used by a student to investigate electrolysis.



The student was given a solution by the teacher. The solution contained a mixture of ionic compounds.

5 (a) Name the particles which carry the electric current through:

5 (a) (i) the metal wires.....

(1 mark)

5 (a) (ii) the solution. .....

(1 mark)

5 (b) The table shows the ions in the solution.

Positive ions in the solution	Negative ions in the solution
Zinc ion (Zn^{2+})	Chloride ion (Cl^-)
Iron(III) ion (Fe^{3+})	Hydroxide ion (OH^-)
Hydrogen ion (H^+)	Nitrate ion (NO_3^-)
Copper(II) ion (Cu^{2+})	Sulfate ion (SO_4^{2-})

The reactivity series on the Data Sheet may help you to answer this question.

5 (b) (i) Which element is most likely to be formed at the negative electrode?

.....

(1 mark)

4.4.3.1 The process of electrolysis

Question 18 · continued

5 (b) (ii) Explain, as fully as you can, why you have chosen this element.

.....

.....

.....

.....

(2 marks)

5 (c) The electrolysis of sodium chloride solution is an industrial process.

5 (c) (i) The reaction at one of the electrodes can be represented by the equation shown below.

$$2Cl^- \rightarrow Cl_2 + 2e^-$$

The chloride ions (Cl^-) are oxidised.

Explain why.

.....

.....

(1 mark)

5 (c) (ii) The reaction at the other electrode can be represented by an equation.

Complete and balance the equation for the reaction at the other electrode.

$$H^+ \rightarrow H_2$$

(1 mark)

7

4.4.3.1 The process of electrolysis

Question 19

November 2011 | CHY1AP | Original Q4 | Legacy

QUESTION FOUR

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.

4A 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.

4B 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.

4C 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

4D 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**

Turn over for the next question

4.4.3.1 The process of electrolysis

Question 20

November 2011 | CHY1AP | Original Q7 | Legacy

QUESTION SEVEN

Titanium (Ti) is extracted from the ore called rutile. Rutile is mainly made up of titanium oxide (TiO_2). Titanium is not very reactive so it should be possible to displace titanium from its oxide with carbon. But carbon reacts with titanium, making it very brittle.

Therefore, titanium is extracted by reacting titanium chloride ($TiCl_4$) with sodium. Titanium chloride is produced by reacting titanium oxide with chlorine. The sodium used for the reaction is obtained by electrolysis.

The titanium chloride is added to a reactor in which sodium has been heated to about 550 °C in an inert argon atmosphere. During the reaction, the temperature increases to about 1000 °C.
After the reaction is complete, and everything has cooled, which can take several days, the mixture is crushed and washed with water to remove the sodium chloride (NaCl).

7A Which row in the table is the correct order of reactivity for carbon, sodium and titanium?

	Most reactive ⟶		**Least reactive**
1	sodium	carbon	titanium
2	carbon	titanium	sodium
3	titanium	carbon	sodium
4	sodium	titanium	carbon

7B The equation for the reaction of titanium chloride with sodium is shown below.

$$TiCl_4 + 4Na \rightarrow Ti + 4NaCl$$

When 190 g of titanium chloride were reacted with sodium, 48 g of titanium and 234 g of sodium chloride were produced.

How much sodium is required to produce 48 g of titanium?

1 23 g

2 92 g

3 190 g

4 234 g

4.4.3.1 The process of electrolysis

Question 20 · continued

7C A student suggested that there are four possible reasons why titanium is expensive.

J the cost of the process used to remove the sodium chloride
K large amounts of energy are needed to produce the sodium
L it takes several days to complete the process of separating the mixture
M the reacting mixture needs to be cooled to a low temperature

Which two of these reasons are correct?

1 **J** and **M**

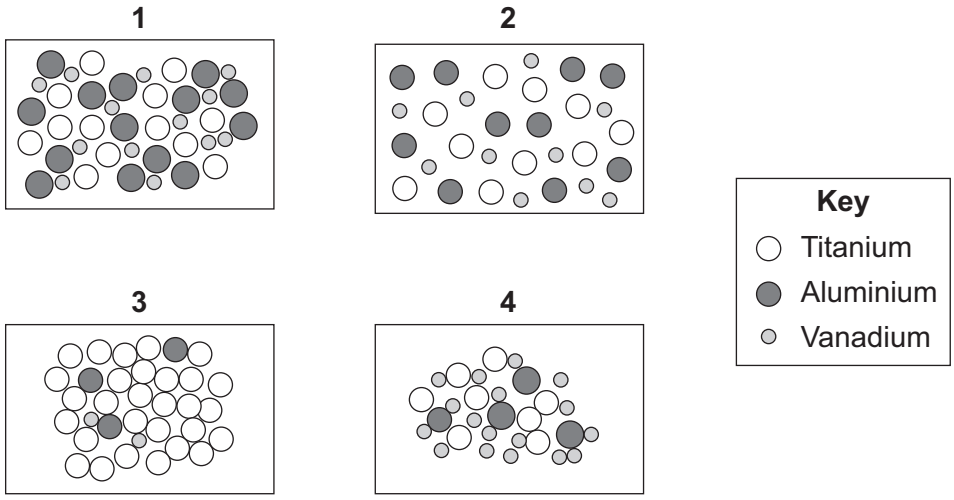
2 **K** and **L**

3 **J** and **K**

4 **L** and **M**

7D Titanium is often alloyed with small amounts of vanadium (4 %) and aluminium (6 %). This makes the titanium harder and stronger.

Which of the diagrams below shows the atoms in a sample of this titanium alloy?



4.4.3.1 The process of electrolysis

Question 21

January 2012 | CH1HP | Original Q4 | Legacy

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



4 (a) Iron is extracted by heating a mixture of iron oxide and carbon in a blast furnace.

4 (a) (i) Name this type of reaction.

.....

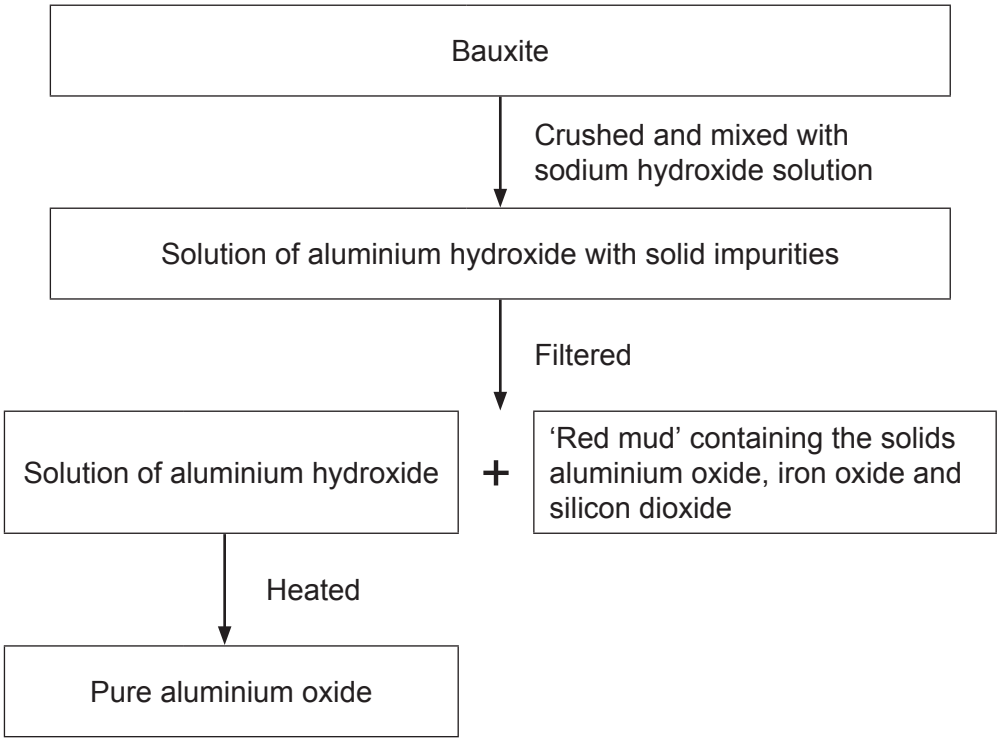
(1 mark)

4 (a) (ii) Balance the symbol equation for this reaction.

$2Fe_2O_3$ + ... C → ..... Fe + ... CO_2

(1 mark)

4 (b) Aluminium ore, bauxite, contains aluminium oxide, iron oxide and silicon dioxide.
Aluminium is extracted by electrolysis of aluminium oxide.



4.4.3.1 The process of electrolysis

Question 21 · continued

The 'red mud' which is dumped in very large ponds contains:

Name of solid	Percentage (%)
Aluminium oxide	10
Iron oxide	65
Silicon dioxide	25

4 (b) (i) 100 tonnes of bauxite produced 50 tonnes of pure aluminium oxide and 50 tonnes of 'red mud'.

What percentage of aluminium oxide did the bauxite contain?

.....

Answer = ... %

(1 mark)

4 (b) (ii) Apart from the solids shown in the table, name **one** other substance that would be in the 'red mud'.

.....

(1 mark)

4 (b) (iii) The purification of the aluminium oxide is usually done near to the bauxite quarries.

Suggest **one** reason why.

.....

(1 mark)

4 (c) Aluminium is used to make many things including cans.

During one year in the USA:
- 100 billion aluminium cans were sold
- 55 billion aluminium cans were recycled.

Give **one** environmental impact of recycling aluminium cans and **one** ethical or social impact of recycling aluminium cans.

Environmental .....

.....

Ethical or social .....

.....

(2 marks)

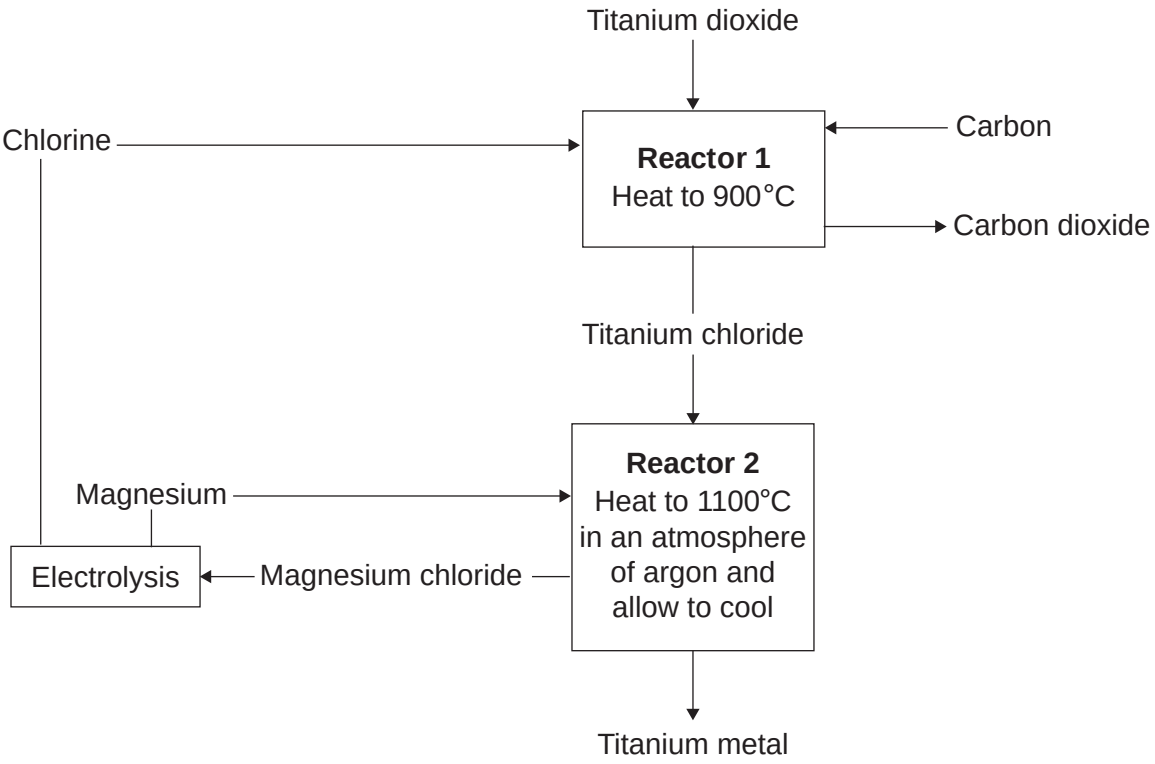
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4.4.3.1 The process of electrolysis

Question 22

June 2012 | CH1HP | Original Q2 | Legacy

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



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

Give **one** reason why.

.....

.....

(1 mark)

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

.....

(1 mark)

4.4.3.1 The process of electrolysis

Question 22 · continued

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

.....

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.....

.....

(2 marks)

2 (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.

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.....

.....

(2 marks)

Question 2 continues on the next page

4.4.3.1 The process of electrolysis

Question 22 · continued

2 (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.

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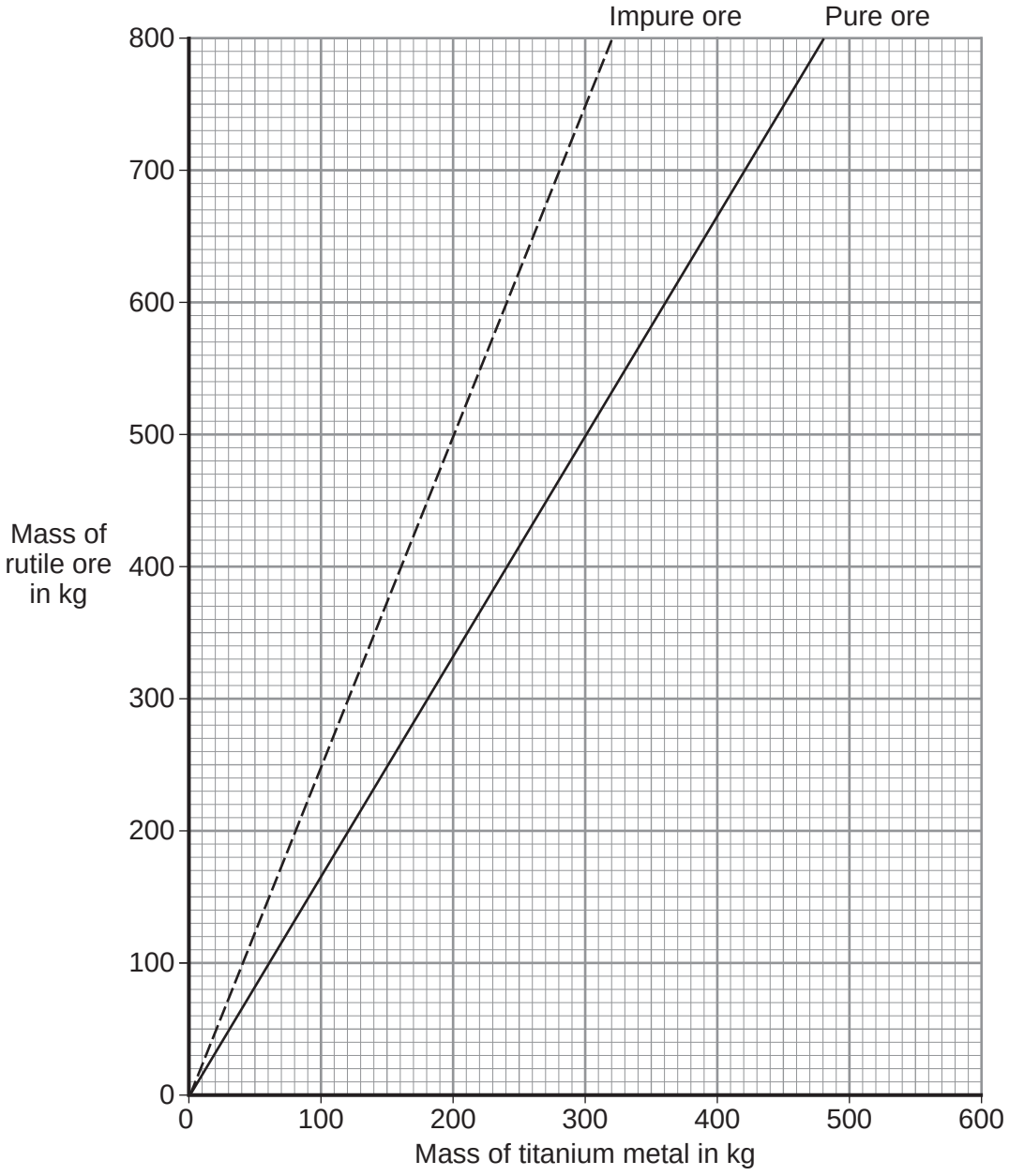
Mass = ... kg

(1 mark)

4.4.3.1 The process of electrolysis

Question 22 · continued

2 (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)

8

4.4.3.1 The process of electrolysis

Question 23

June 2012 | CH2HP | Original Q5 | Legacy

5 Aluminium is extracted from aluminium oxide.

5 (a) The formula of aluminium oxide is Al_2O_3

The relative formula mass (M_r) of aluminium oxide is 102.

Calculate the percentage of aluminium in aluminium oxide.

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

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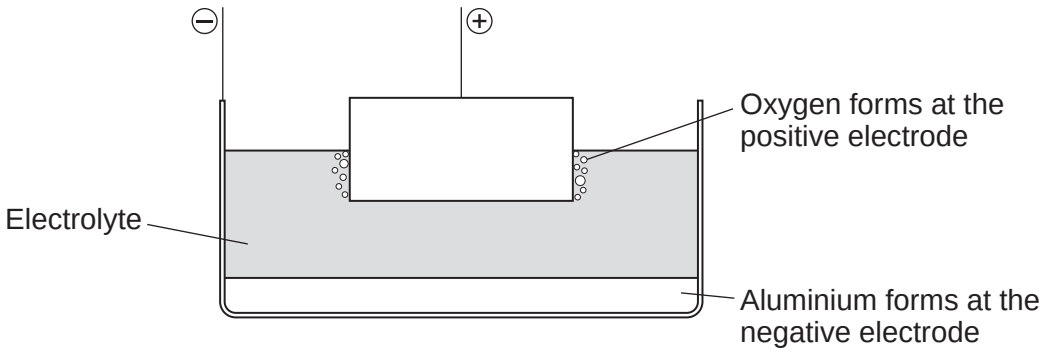
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Percentage of aluminium = ... %

(2 marks)

5 (b) Aluminium is extracted from aluminium oxide using electrolysis.

The diagram shows a cell used for the extraction of aluminium.



4.4.3.1 The process of electrolysis

Question 23 · continued

5 (b) (i) The electrolyte contains cryolite.

Explain why.

.....

.....

.....

.....

(2 marks)

5 (b) (ii) Oxygen is formed at the positive electrode. Complete and balance the equation for this reaction.

..... O^{2-} → O_2 + ...

(2 marks)

5 (b) (iii) The positive electrode in the cell is used up during the process.

Explain why.

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(2 marks)

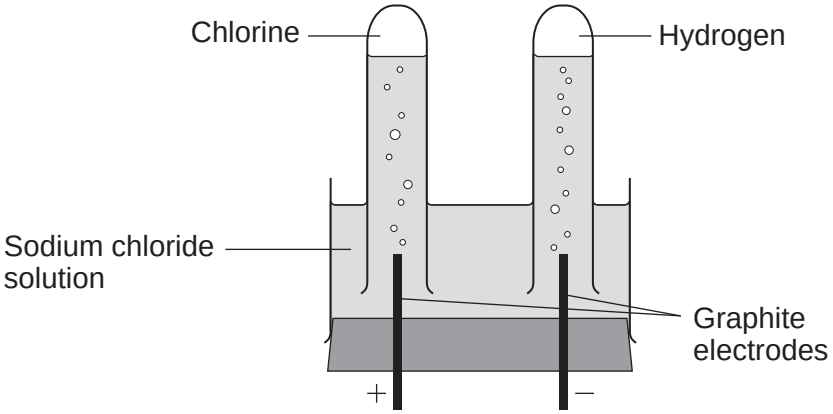
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4.4.3.1 The process of electrolysis

Question 24

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

The diagram shows the apparatus used in a school experiment.



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

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

.....

.....

(1 mark)

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

.....

.....

(1 mark)

4.4.3.1 The process of electrolysis

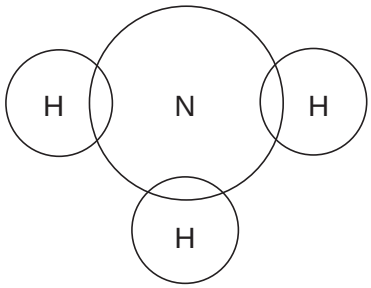
Question 24 · continued

2 (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)

2 (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.

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

.....

(1 mark)

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

Write the ionic equation for the neutralisation reaction.

.....

(1 mark)

Question 2 continues on the next page

4.4.3.1 The process of electrolysis

2 (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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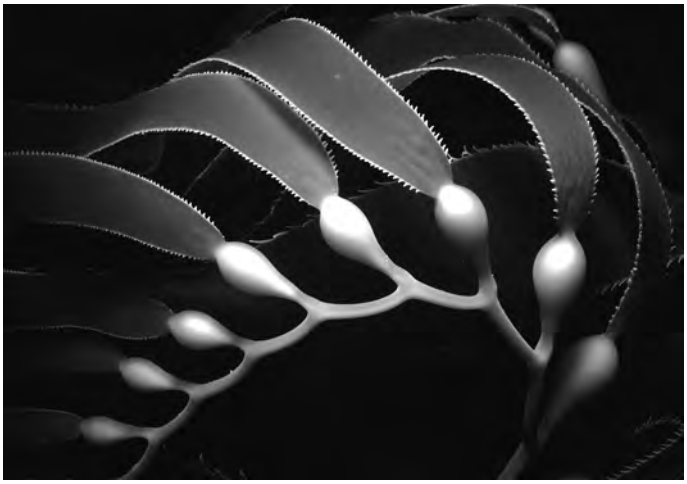
4.4.3.1 The process of electrolysis

Question 25

January 2013 | CH2HP | Original Q5 | Legacy

5 Kelp is a seaweed.

Kelp can be used in foods and as a renewable energy source.



5 (a) Scientific experiments, on their own, **cannot** fully answer one of the following questions. Which one?

Tick (✓) **one** box.

Questions	Tick (✓)
How much carbon dioxide is produced when 100 g of kelp is burned?	
Does kelp give out more heat energy than coal?	
Will kelp last longer than coal as an energy source?	
Which fuel, kelp or coal, produces the most ash when burned?	

(1 mark)

5 (b) Scientists cannot answer the question 'should people use kelp instead of coal as an energy source?'

Give **two** reasons why.

.....

.....

.....

.....

(2 marks)

4.4.3.1 The process of electrolysis

Question 25 · continued

5 (c) Sodium iodide can be produced from kelp.

5 (c) (i) How many electrons are in the outer shell of an iodine atom?

(1 mark)

5 (c) (ii) Sodium iodide contains sodium ions (Na^+) and iodide ions (I^-).

Describe, as fully as you can, what happens when sodium atoms react with iodine atoms to produce sodium iodide.

You may use a diagram in your answer

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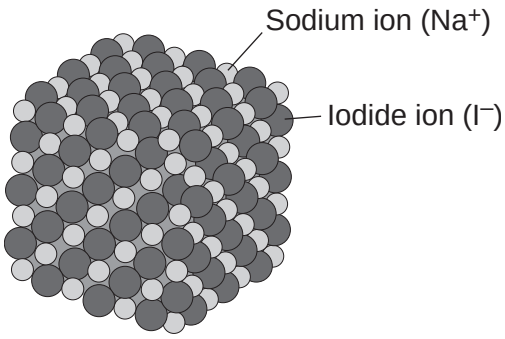
(3 marks)

Question 5 continues on the next page

4.4.3.1 The process of electrolysis

Question 25 · continued

5 (c) (iii) The diagram shows the structure of sodium iodide.



Solid sodium iodide does not conduct electricity.

Why does sodium iodide solution conduct electricity?

.....

.....

(1 mark)

5 (c) (iv) When sodium iodide solution is electrolysed, iodine is formed at the positive electrode.

Complete and balance the half equation for the formation of iodine.

..... I^- $\rightarrow$ I_2 + ... e^-

(1 mark)

5 (c) (v) What is formed at the negative electrode when sodium iodide solution is electrolysed?

Explain why.

.....

.....

.....

.....

(2 marks)

11

4.4.3.1 The process of electrolysis

Question 26

June 2013 | CH1HP | Original Q2 | Legacy

2 Metals are extracted from their ores.

Many copper ores contain only 2% of copper compounds.

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

Suggest **two** reasons why.

.....

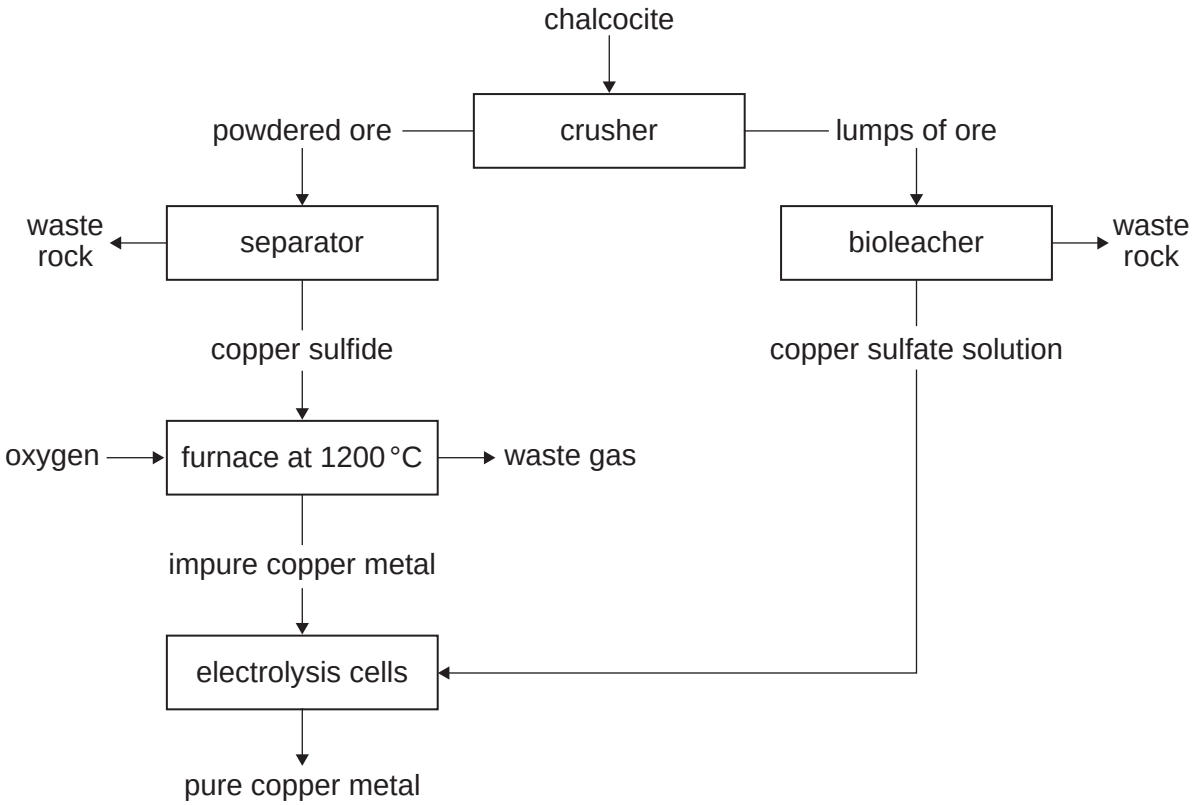
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(2 marks)

2 (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 26 · continued

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

.....

.....

(1 mark)

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

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(2 marks)

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

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(1 mark)

2 (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.

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.....

(2 marks)

2 (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 27

June 2013 | CH2HP | Original Q4 | Legacy

4 This question is about potassium.

4 (a) Humphrey Davy was a professor of chemistry.

In 1807 Davy did an electrolysis experiment to produce potassium.

4 (a) (i) Davy first tried to electrolyse a solid potassium salt to produce potassium.

Explain why this electrolysis did **not** work.

.....

.....

.....

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(2 marks)

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

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

Suggest why.

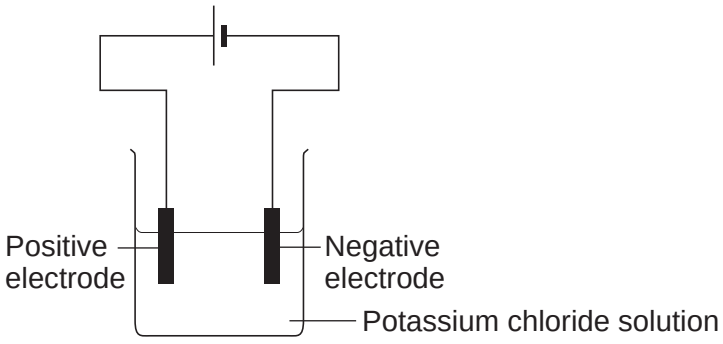
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(1 mark)

4 (b) A student dissolved some potassium chloride in water.
The student tried to electrolyse the potassium chloride solution to produce potassium.

The apparatus the student used is shown in the diagram.



4.4.3.1 The process of electrolysis

Question 27 · continued

The student expected to see potassium metal at the negative electrode, but instead saw bubbles of a gas.

- Name the gas produced at the negative electrode.
- Explain why this gas was produced at the negative electrode **and** why potassium was not produced.

The reactivity series of metals on the Chemistry Data Sheet may help you to answer this question.

.....

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(3 marks)

4 (c) The student tried to electrolyse molten potassium chloride to produce potassium.

4 (c) (i) Potassium metal was produced at the negative electrode.

Describe how potassium atoms are formed from potassium ions.

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(2 marks)

Question 4 continues on the next page

4.4.3.1 The process of electrolysis

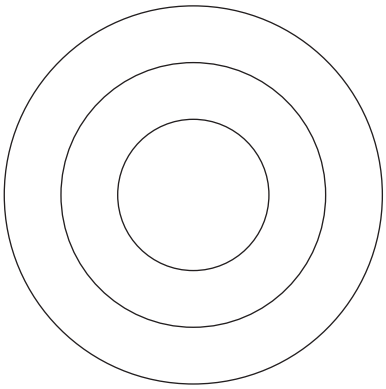
Question 27 · continued June 2013 | CH2HP | Original Q4 | Legacy

4 (c) (ii) Complete and balance the equation for the reaction at the positive electrode.

.....Cl^- $\longrightarrow$ Cl_2 + ...

(1 mark)

4 (c) (iii) Complete the diagram to show the electronic structure of a chloride ion (Cl^-).



(1 mark)

10

4.4.3.1 The process of electrolysis

Question 28

June 2014 | CH1HP | Original Q4 | Legacy

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

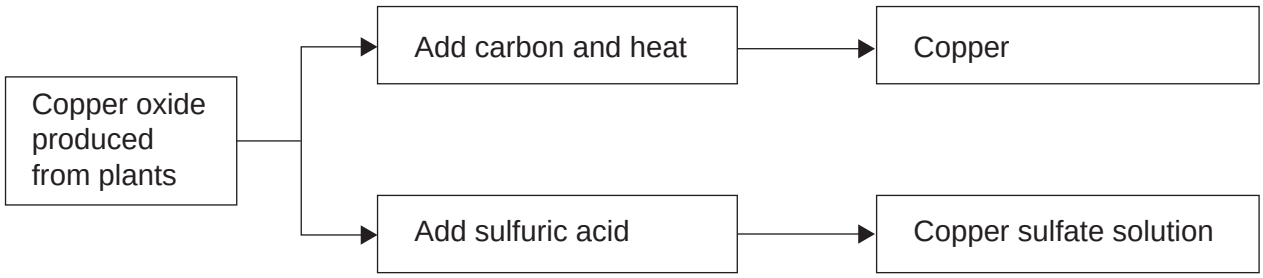
One way to extract the copper is to grow plants on the land.

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 3**.

Figure 3



4 (a) (i) Complete the sentence.

[1 mark]

Using plants to extract metals is called ..... .

4 (a) (ii) Suggest **two** reasons why copper from these areas of land is **not** extracted by smelting.

[2 marks]

.....

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.....

4 (a) (iii) Complete and balance the chemical equation for the reaction of copper oxide with carbon.

[2 marks]

.....CuO + C ⟶ ..... + CO_2

4.4.3.1 The process of electrolysis

Question 28 · continued

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

4 (b) (i) Use the Chemistry Data Sheet to help you to answer this question.

Give **two** reasons why scrap iron is used to displace copper.

[2 marks]

.....

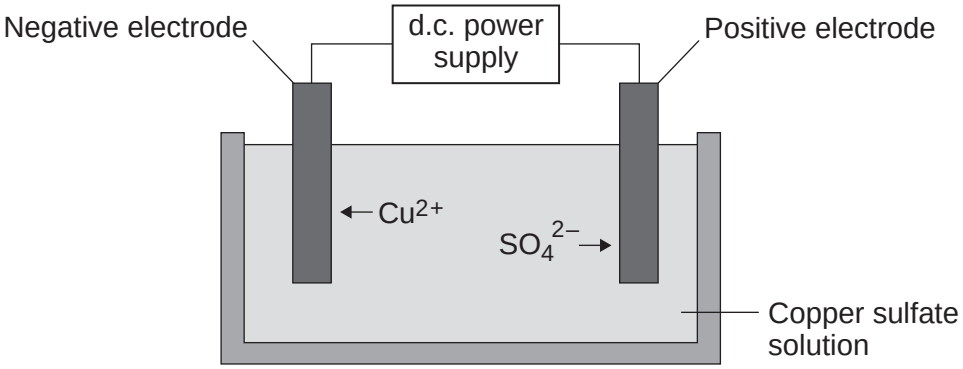
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4 (b) (ii) **Figure 4** shows the electrolysis of copper sulfate solution.

Figure 4



Describe what happens to the copper ions during electrolysis.

[2 marks]

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9

4.4.3.1 The process of electrolysis

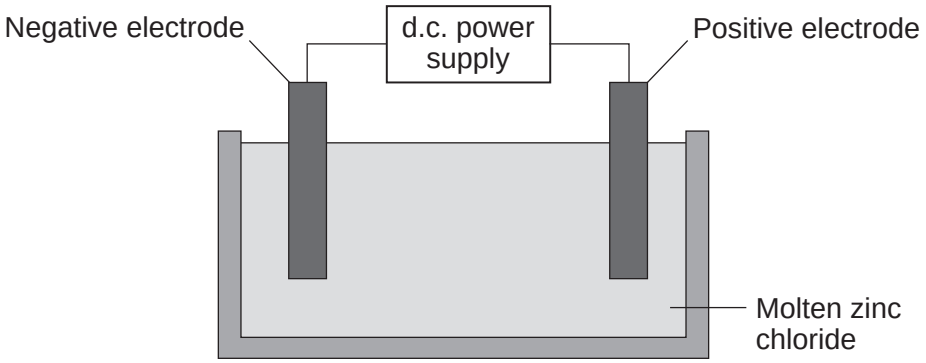
Question 29

June 2014 | CH2HP | Original Q4 | Legacy

4 This question is about zinc and magnesium.

Zinc is produced by electrolysis of molten zinc chloride, as shown in **Figure 4**.

Figure 4



4 (a) (i) Why must the zinc chloride be molten for electrolysis?

[1 mark]

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4 (a) (ii) Describe what happens at the negative electrode.

[3 marks]

.....

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.....

4 (a) (iii) Complete the half equation for the reaction at the positive electrode.

[1 mark]

..... $\longrightarrow$ Cl_2 + ... e^-

4.4.3.1 The process of electrolysis

Question 29 · continued

4 (b) Magnesium can be produced from magnesium oxide.

The equation for the reaction is:

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

4 (b) (i) How can you tell from the equation that the reaction is done at a high temperature?

[1 mark]

.....

.....

4 (b) (ii) This reaction to produce magnesium from magnesium oxide is **endothermic**.

What is meant by an **endothermic** reaction?

[1 mark]

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.....

4 (b) (iii) A company made magnesium using this reaction.

Calculate the mass of magnesium oxide needed to produce 1.2 tonnes of magnesium.

Relative atomic masses (A_r): O = 16; Mg = 24

[3 marks]

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.....

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.....

Mass of magnesium oxide needed = ... tonnes

4.4.3.1 The process of electrolysis

Question 29 · continued

4 (b) (iv) The company calculated that they would produce 1.2 tonnes of magnesium, but only 0.9 tonnes was produced.

Calculate the percentage yield.

[1 mark]

.....

.....

Percentage yield = ... %

4 (b) (v) Give **one** reason why the calculated yield of magnesium might not be obtained.

[1 mark]

.....

.....

12

Turn over for the next question

4.4.3.1 The process of electrolysis

Question 30

June 2015 | CH2HP | Original Q3 | Legacy

3 This question is about metals and alloys.

3 (a) Explain how electricity is conducted in a metal.

To gain full marks you must include a description of the structure and bonding of a metal.

[4 marks]

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3 (b) Describe how the structure of an alloy is different from the structure of a pure metal.

[2 marks]

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3 (c) Alloys are used to make dental braces and coins.

3 (c) (i) Nitinol is an alloy used in dental braces.

Why is Nitinol used in dental braces?

[1 mark]

.....

.....

4.4.3.1 The process of electrolysis

Question 30 · continued

3 (c) (ii) Suggest **one** reason why coins are not made of pure copper.

Do **not** give cost as a reason.

[1 mark]

.....

.....

3 (c) (iii) Some coins are made from an alloy of aluminium.

Complete the sentence.

[1 mark]

Aluminium is manufactured by the electrolysis of a molten mixture of

cryolite and ..... .

3 (c) (iv) Banks keep coins in poly(ethene) bags. These bags are made from low density poly(ethene).

High density poly(ethene) can also be made from the same monomer.

How can the same reaction produce two different products?

[1 mark]

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.....

3 (d) Give **two** reasons why instrumental methods of analysis are used to detect impurities in metals.

[1 mark]

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.....

11

4.4.3.1 The process of electrolysis

Question 31

June 2015 | CH2HP | Original Q6 | Legacy

6 This question is about sodium chloride and iodine.

6 (a) Describe the structure and bonding in sodium chloride.

[4 marks]

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6 (b) When sodium chloride solution is electrolysed, one product is chlorine.

Name the **two** other products from the electrolysis of sodium chloride solution.

[2 marks]

.....

.....

6 (c) Many people do not have enough iodine in their diet.

Sodium chloride is added to many types of food. Some scientists recommend that sodium chloride should have a compound of iodine added.

Give **one** ethical reason why a compound of iodine should **not** be added to sodium chloride used in food.

[1 mark]

.....

.....

4.4.3.1 The process of electrolysis

Question 31 · continued

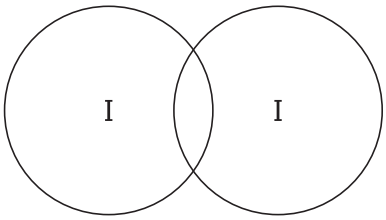
6 (d) The bonding in iodine is similar to the bonding in chlorine.

6 (d) (i) Complete **Figure 4** to show the bonding in iodine.

Show the outer electrons only.

[2 marks]

Figure 4



6 (d) (ii) Explain why iodine has a low melting point.

[3 marks]

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6 (d) (iii) Explain, in terms of particles, why liquid iodine does not conduct electricity.

[2 marks]

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14

4.4.3.1 The process of electrolysis

Question 32

June 2016 | CH2HP | Original Q5 | Legacy

5 This question is about magnesium and magnesium chloride.

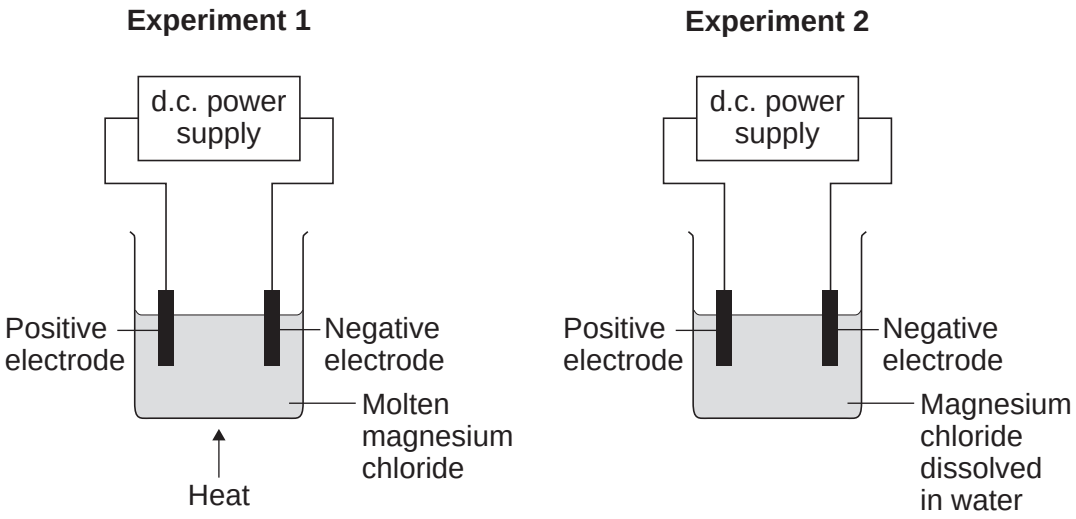
5 (a) Magnesium chloride contains magnesium ions (Mg^{2+}) and chloride ions (Cl^-).

Describe, in terms of electrons, what happens when a magnesium atom reacts with chlorine atoms to produce magnesium chloride.

[4 marks]

5 (b) Magnesium chloride can be electrolysed.
Figure 5 shows two experiments for electrolysing magnesium chloride.

Figure 5



4.4.3.1 The process of electrolysis

Question 32 · continued

5 (b) (i) Explain why magnesium chloride must be molten or dissolved in water to be electrolysed.

[2 marks]

5 (b) (ii) Explain how magnesium is produced at the negative electrode in **Experiment 1**.

[3 marks]

5 (b) (iii) In **Experiment 2** a gas is produced at the negative electrode.
Name the gas produced at the negative electrode.

[1 mark]

5 (b) (iv) Suggest why magnesium is **not** produced at the negative electrode in **Experiment 2**.

[1 mark]

Question 5 continues on the next page

4.4.3.1 The process of electrolysis

Question 32 · continued

5 (b) (v) Complete and balance the half equation for the reaction at the positive electrode.

[1 mark]



5 (c) Magnesium is a metal.
Explain why metals can be bent and shaped.

[2 marks]

14

4.4.3.1 The process of electrolysis

Question 33

June 2017 | CH2HP | Original Q6 | Legacy

6 This question is about sodium chloride.

6 (a) A student reacted hydrochloric acid and sodium hydroxide solution to produce sodium chloride solution.

The student:

- measured 50 cm^3 of hydrochloric acid into a glass beaker
- measured the initial temperature of the hydrochloric acid
- added 50 cm^3 of sodium hydroxide solution
- stirred the mixture and measured the highest temperature of the solution.

6 (a) (i) The hydrochloric acid and sodium hydroxide solution were the same concentration.

Suggest **one** reason why the temperature change could be greater than expected.

[1 mark]

Tick (✓) **one** box.

The volume of the sodium hydroxide solution was more than 50 cm^3. ☐

The volume of the hydrochloric acid was more than 50 cm^3. ☐

The initial temperature reading was too low. ☐

The highest temperature reading was too low. ☐

6 (a) (ii) The student did the investigation three times.

Table 2 shows the results.

Table 2

Experiment number	Initial temperature of the acid in °C	Highest temperature of solution in °C
1	20	33
2	19	30
3	20	32

4.4.3.1 The process of electrolysis

Question 33 · continued

What conclusion can you make about the reaction from the results in **Table 2**?

[1 mark]

6 (b) The student electrolysed sodium chloride solution.

6 (b) (i) Explain what happens at the negative electrode and why sodium is **not** produced.

[3 marks]

6 (b) (ii) Chlorine gas is produced at the positive electrode.
Complete the half equation.

[1 mark]

$$____\ Cl^- \longrightarrow _____ + _____$$

6 (b) (iii) Explain why the pH of the solution after electrolysis was 14

[2 marks]

8

4.4.3.1 The process of electrolysis

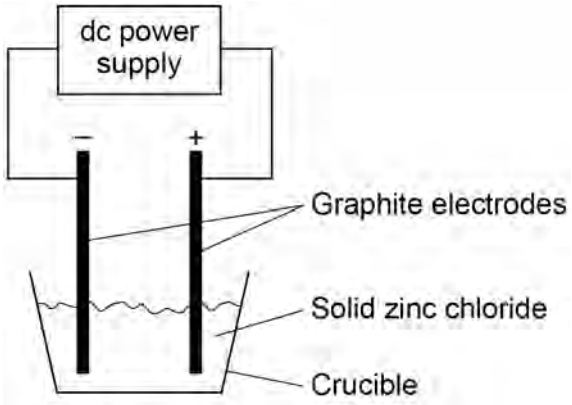
Question 34

June 2018 | 8462/1H | Original Q6

0 6 A student investigated the electrolysis of different substances.

Figure 6 shows the apparatus.

Figure 6



0 6 . 1 Explain why electrolysis would **not** take place in the apparatus shown in **Figure 6**.

[2 marks]

0 6 . 2 Explain why graphite conducts electricity.

Answer in terms of the structure and bonding in graphite.

[3 marks]

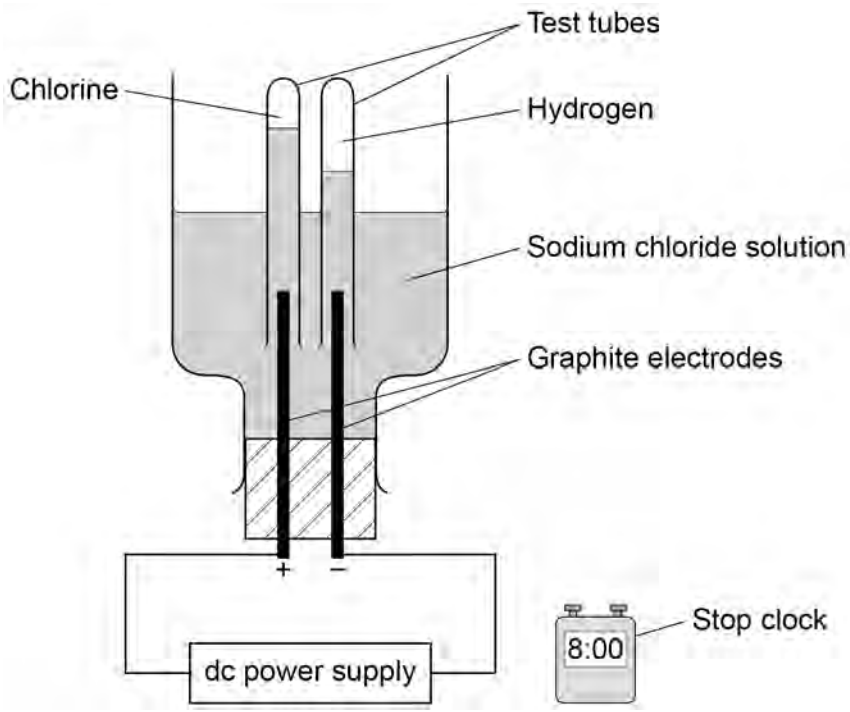
4.4.3.1 The process of electrolysis

Question 34 · continued

The student investigated how the volume of gases produced changes with time in the electrolysis of sodium chloride solution.

Figure 7 shows the apparatus.

Figure 7



0 6 . 3 The student made an error in selecting the apparatus for this investigation.

How should the apparatus be changed?

Give **one** reason for your answer.

[2 marks]

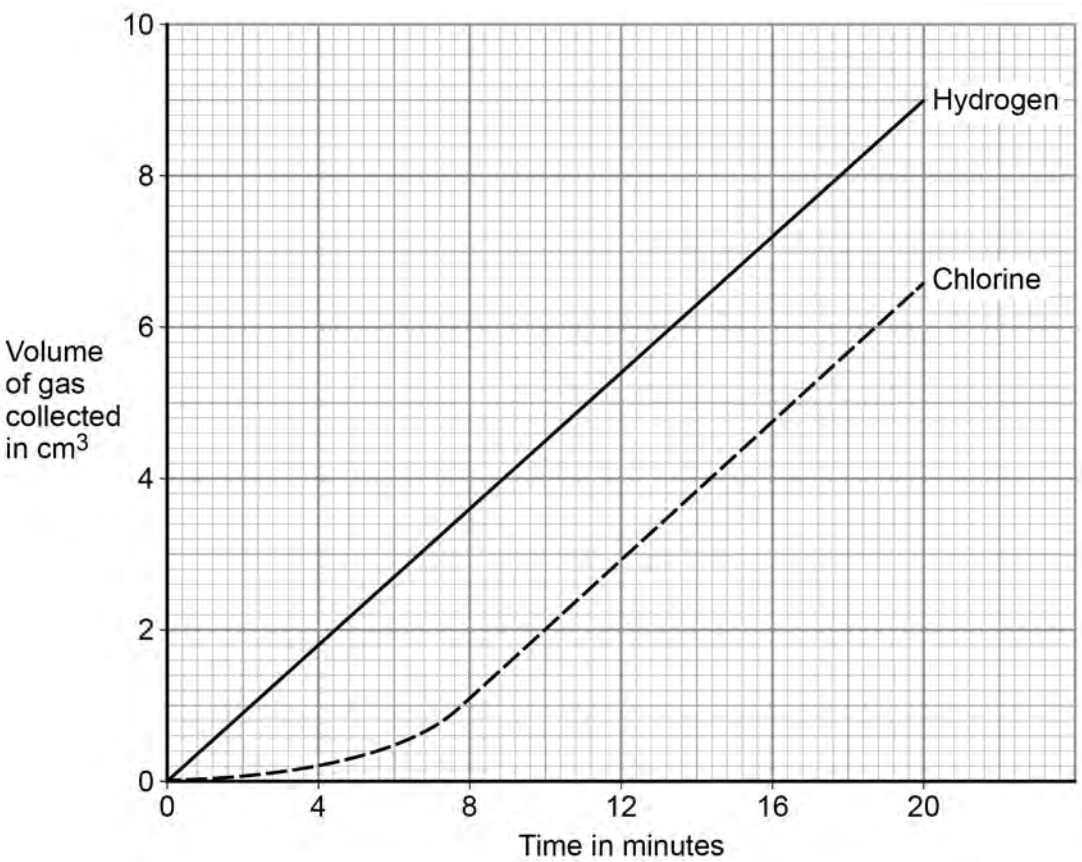
Question 34 · continued

Another student used the correct apparatus.

This student measured the volumes of gases collected every minute for 20 minutes.

Figure 8 shows the student's results.

Figure 8



0 6 . 4 Describe the trends shown in the results.

Use values from **Figure 8**.

[3 marks]

4.4.3.1 The process of electrolysis

Question 34 · continued

0 6 . 5 The number of moles of each gas produced at the electrodes is the same.

No gas escapes from the apparatus.

Suggest **one** reason for the difference in volume of each gas collected.

[1 mark]

0 6 . 6 Calculate the amount in moles of chlorine collected after 20 minutes.

Use **Figure 8**.

The volume of one mole of any gas at room temperature and pressure is 24.0 dm^3

Give your answer in standard form.

[3 marks]

Moles of chlorine = _____ mol

14

4.4.3.1 The process of electrolysis

Question 35

June 2019 | 8462/1H | Original Q7

0 7 This question is about electrolysis.

Aluminium is produced by electrolysing a molten mixture of aluminium oxide and cryolite.

0 7 . 1 Explain why a mixture is used as the electrolyte instead of using only aluminium oxide.

[2 marks]

0 7 . 2 What happens at the negative electrode during the production of aluminium?

[1 mark]

Tick (✓) **one** box.

- Aluminium atoms gain electrons. ☐
- Aluminium atoms lose electrons. ☐
- Aluminium ions gain electrons. ☐
- Aluminium ions lose electrons. ☐

0 7 . 3 Oxygen is produced at the positive electrode.

Complete the balanced half-equation for the process at the positive electrode.

[2 marks]

$\rightarrow \quad O_2 \quad +$

4.4.3.1 The process of electrolysis

Question 35 · continued

0 7 . 4 Explain why the positive electrode must be continually replaced.

[3 marks]

0 7 . 5 The overall equation for the electrolysis of aluminium oxide is:

$$2Al_2O_3 \rightarrow 4Al + 3O_2$$

Calculate the mass of oxygen produced when 2000 kg of aluminium oxide is completely electrolysed.

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

[4 marks]

Mass of oxygen = _____ kg

4.4.3.1 The process of electrolysis

Question 35 · continued

Sodium metal and chlorine gas are produced by the electrolysis of molten sodium chloride.

0 7 . 6 Explain why sodium chloride solution **cannot** be used as the electrolyte to produce sodium metal.

[2 marks]

0 7 . 7 Calculate the volume of 150 kg of chlorine gas at room temperature and pressure.

The volume of one mole of any gas at room temperature and pressure is 24.0 dm^3

Relative formula mass (M_r): Cl_2 = 71

[2 marks]

Volume = _____ dm^3

16

4.4.3.1 The process of electrolysis

Question 36

November 2020 | 8462/1H | Original Q4

0 4 This question is about electrolysis.

A student investigated the electrolysis of copper chromate solution.

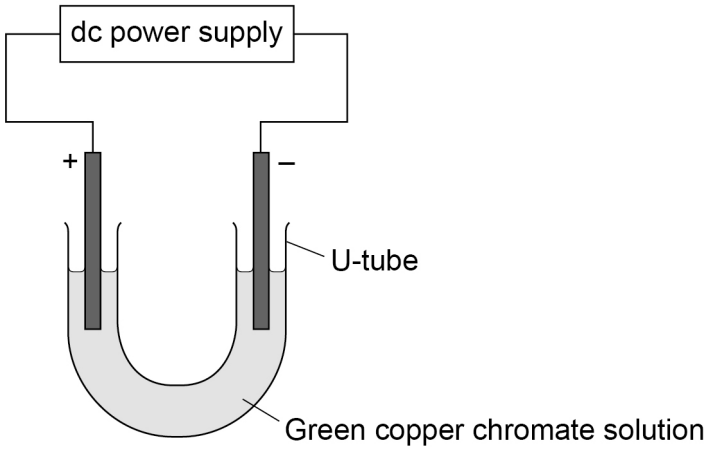
Copper chromate solution is green.

Copper chromate contains:

- blue coloured Cu^{2+} ions
- yellow coloured CrO_4^{2-} ions.

Figure 1 shows the apparatus used.

Figure 1



The student switched the power supply on.

The student observed the changes at each electrode.

Table 4 shows the student's observations.

Table 4

Changes at positive electrode	Changes at negative electrode
Solution turned yellow Bubbles formed at the electrode	Solution turned blue Solid formed on the electrode

4.4.3.1 The process of electrolysis

Question 36 · continued

0 4 . 1 Explain why the colour changed at the positive electrode.

[2 marks]

0 4 . 2 The gas produced at the positive electrode was oxygen.

The oxygen was produced from hydroxide ions.

Name the substance in the solution that provides the hydroxide ions.

[1 mark]

0 4 . 3 Describe how the solid forms at the negative electrode.

[3 marks]

0 4 . 4 The student repeated the investigation using potassium iodide solution instead of copper chromate solution.

Name the product at each electrode when potassium iodide solution is electrolysed.

[2 marks]

Negative electrode _____

Positive electrode _____

8

4.4.3.1 The process of electrolysis

Question 37

0 7 This question is about chemical reactions and electricity.

0 7 . 1 Electrolysis and chemical cells both involve chemical reactions and electricity.

Explain the difference between the processes in electrolysis and in a chemical cell.

[2 marks]

0 7 . 2 A teacher demonstrates the electrolysis of molten lead bromide.

Bromine is produced at the positive electrode.

Complete the half equation for the production of bromine.

You should balance the half equation.

[2 marks]

$$Br^- \rightarrow \quad + \quad$$

0 7 . 3 Two aqueous salt solutions are electrolysed using inert electrodes.

Complete **Table 4** to show the product at each electrode.

[3 marks]

Table 4

Salt solution	Product at positive electrode	Product at negative electrode
Copper nitrate		copper
Potassium iodide		

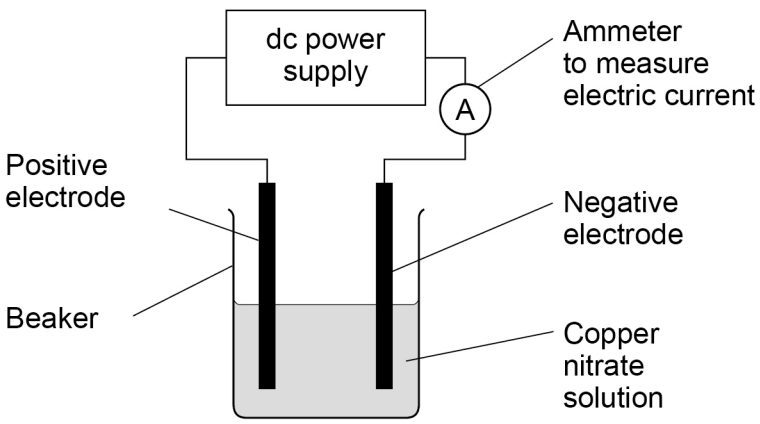
4.4.3.1 The process of electrolysis

Question 37 · continued

Some students investigated the electrolysis of copper nitrate solution using inert electrodes.

Figure 4 shows the apparatus.

Figure 4



The students investigated how the mass of copper produced at the negative electrode varied with:

- time
- current.

This is the method used.

1. Weigh the negative electrode.
2. Set up the apparatus shown in **Figure 4**.
3. Adjust the power supply until the ammeter shows a current of 0.3 A
4. Switch off the power supply after 5 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.
8. Repeat steps 1 to 7 at different currents.

4.4.3.1 The process of electrolysis

Question 37 · continued

0 7 . 4 Some of the copper produced did not stick to the negative electrode but fell to the bottom of the beaker.

Suggest how the students could find the total mass of copper produced.

[4 marks]

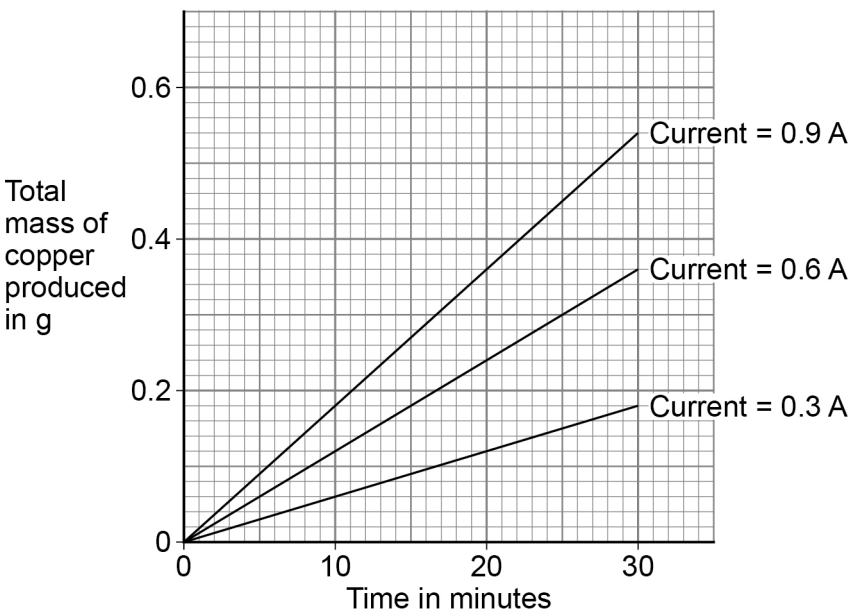
Question 7 continues on the next page

Question 37 · continued

The students plotted their results on a graph.

Figure 5 shows the graph.

Figure 5



A student correctly concluded that the total mass of copper produced is directly proportional both to the time and to the current.

0 7 . 5 How do the results in **Figure 5** support the conclusion that the total mass of copper produced is directly proportional to the time?

[1 mark]

0 7 . 6 How do the results in **Figure 5** support the conclusion that the total mass of copper produced is directly proportional to the current?

Use data from **Figure 5** in your answer.

[1 mark]

4.4.3.1 The process of electrolysis

Question 37 · continued

0 7 . 7 Copper nitrate solution is blue.

Suggest why the blue colour of the copper nitrate solution fades during the electrolysis.

[1 mark]

0 7 . 8 Determine the number of atoms of copper produced when copper nitrate solution is electrolysed for 20 minutes at a current of 0.6 A

Give your answer to 3 significant figures.

Use **Figure 5**.

Relative atomic mass (A_r): Cu = 63.5

The Avogadro constant = 6.02×10^{23} per mole

[3 marks]

Number of atoms (3 significant figures) = _____

17

4.4.3.1 The process of electrolysis

Question 38

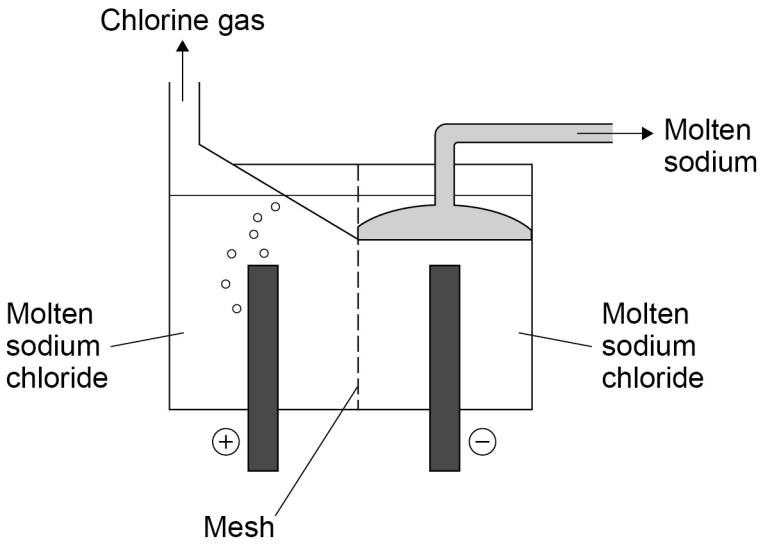
June 2022 | 8462/1H | Original Q6

0 6 This question is about electrolysis.

Molten sodium chloride is electrolysed in an industrial process to produce sodium.

Figure 8 shows a simplified version of the electrolysis cell used.

Figure 8



0 6 . 1 Which is the correct half equation for the production of sodium?

[1 mark]

Tick (✓) **one** box.

$Na + e^- \rightarrow Na^+$ ☐

$Na \rightarrow Na^+ + e^-$ ☐

$Na^+ + e^- \rightarrow Na$ ☐

$Na^+ \rightarrow Na + e^-$ ☐

4.4.3.1 The process of electrolysis

Question 38 · continued

A mesh is used to keep the products of the electrolysis apart.

0 6 . 2 Suggest **one** reason why the products of the electrolysis must be kept apart.

[1 mark]

0 6 . 3 Which type of particle passes through the mesh in the electrolysis of molten sodium chloride?

[1 mark]

Tick (✓) **one** box.

- Atom ☐
- Electron ☐
- Ion ☐
- Molecule ☐

Question 6 continues on the next page

4.4.3.1 The process of electrolysis

Question 38 · continued

Aqueous sodium chloride solution is electrolysed in a different industrial process.

Two gases and an alkaline solution are produced.

0 6 . 4 Which **two** ions are present in aqueous sodium chloride solution in addition to sodium ions and chloride ions?

[2 marks]

1 _____

2 _____

0 6 . 5 Name the alkaline solution produced.

[1 mark]

_____

0 6 . 6 Explain how the alkaline solution is produced.

You should refer to the processes at the electrodes.

[3 marks]

_____

_____

_____

_____

_____

_____

9

4.4.3.1 The process of electrolysis

Question 39

June 2023 | 8462/1H | Original Q7

0 7 This question is about electrolysis.

Aluminium is manufactured by electrolysing a molten mixture of aluminium oxide (Al_2O_3) and cryolite (Na_3AlF_6).

0 7 . 1 Complete the half equation for the reaction occurring at the negative electrode.

[1 mark]

$$Al^{3+} + ____ e^- \rightarrow Al$$

0 7 . 2 Cryolite contains Na^+ ions as well as Al^{3+} ions.

Suggest **one** reason why sodium is **not** a product of the electrolysis.

[1 mark]

Question 7 continues on the next page

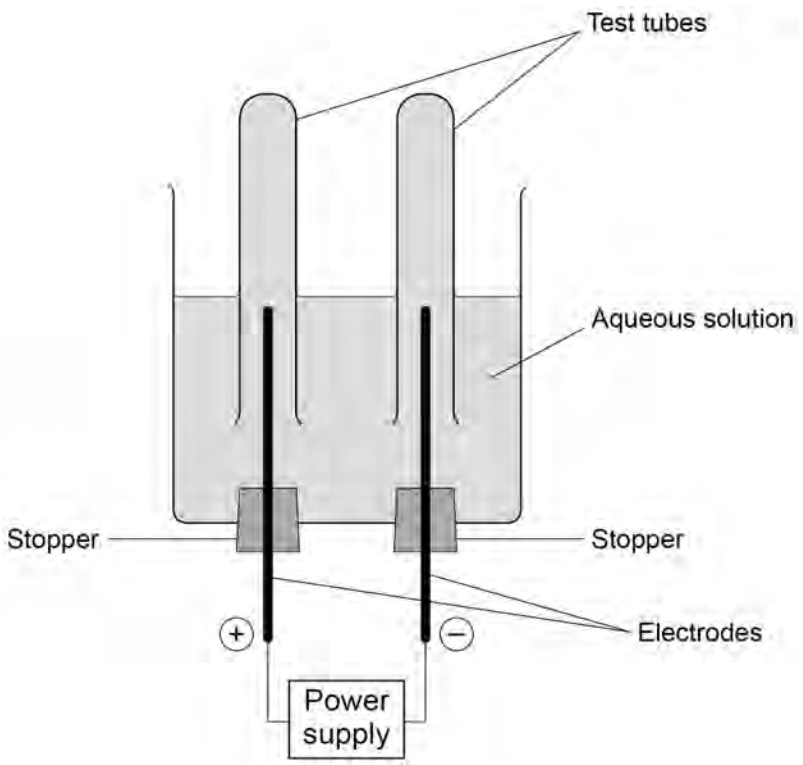
4.4.3.1 The process of electrolysis

Question 39 · continued

A student investigated the electrolysis of an aqueous solution of a different compound.

Figure 7 shows the apparatus.

Figure 7



4.4.3.1 The process of electrolysis

Question 39 · continued

Hydrogen was produced at the negative electrode and oxygen was produced at the positive electrode.

0 7 . 3 Explain how oxygen was produced from water during the electrolysis of this aqueous solution.

[4 marks]

0 7 . 4 The student compared the volumes of the two gases collected.

How can the student change the apparatus in **Figure 7** to compare the volumes of the two gases produced more accurately?

Give **one** reason for your answer.

[2 marks]

Change _____

Reason _____

0 7 . 5 The overall equation for the reaction is:

$$2\,H_2O(l) \rightarrow 2\,H_2(g) + O_2(g)$$

What is the volume of oxygen produced when 20 cm^3 of hydrogen has been produced?

[1 mark]

Tick (✓) **one** box.

10 cm^3 ☐ 20 cm^3 ☐ 30 cm^3 ☐ 40 cm^3 ☐

9

4.4.3.1 The process of electrolysis

Question 40

June 2024 | 8462/1H | Original Q5

0 5 This question is about ionic compounds and electrolysis.

Calcium chloride is an ionic compound.

0 5 . 1 Calcium and chlorine react to produce calcium chloride.

Describe what happens to calcium atoms and chlorine atoms when the ionic compound calcium chloride is formed.

[4 marks]

0 5 . 2 Solid calcium chloride **cannot** be electrolysed.

Give **one** reason why.

[1 mark]

0 5 . 3 Name the product formed at the negative electrode when aqueous calcium chloride solution is electrolysed.

[1 mark]

4.4.3.1 The process of electrolysis

Question 40 · continued

0 5 . 4 What is the half equation for the reaction at the positive electrode when aqueous calcium chloride solution is electrolysed?

[1 mark]

Tick (✓) **one** box.

$2Cl^- \rightarrow Cl_2 + 2e^-$ ☐

$Cl_2 + 2e^- \rightarrow 2Cl^-$ ☐

$4OH^- \rightarrow O_2 + 2H_2O + 4e^-$ ☐

$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$ ☐

Question 5 continues on the next page

Question 40 · continued

0 5 . 5 A student investigated the electrolysis of green copper chromate solution.

Figure 4 shows the apparatus.

Figure 4

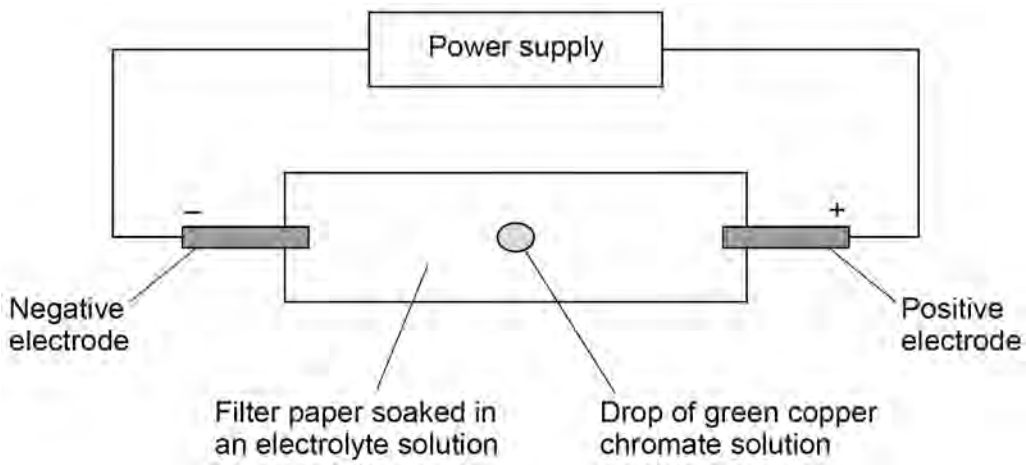
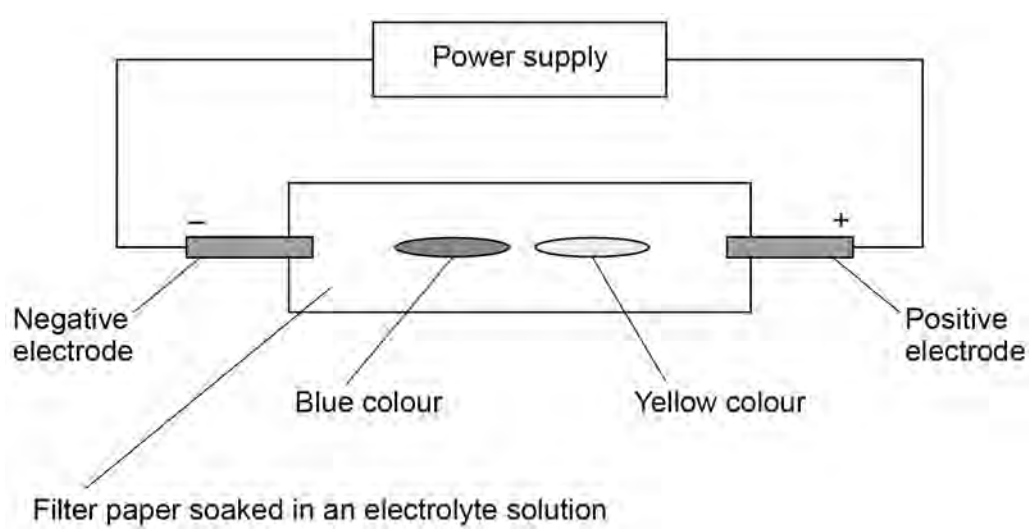


Figure 5 shows the results.

Figure 5



4.4.3.1 The process of electrolysis

Question 40 · continued

Copper chromate solution contains the ions Cu^{2+} and CrO_4^{2-}

Explain the results shown in **Figure 5**.

[3 marks]

10

Turn over for the next question

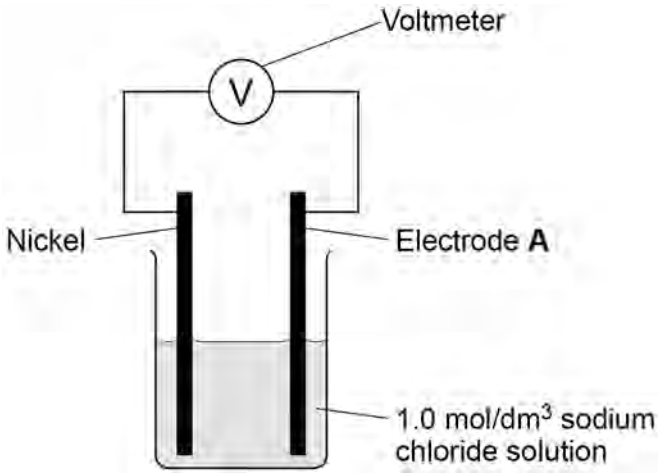
4.4.3.1 The process of electrolysis

Question 41

0 6 A student investigated the voltage produced by different pairs of metal electrodes in a chemical cell.

Figure 6 shows the apparatus.

Figure 6



This is the method used.

1. Place a nickel electrode and an electrode made from a different metal (electrode **A**) in 1.0 mol/dm^3 sodium chloride solution.
2. Measure the voltage produced.
3. Repeat using different metals for electrode **A**.

Table 3 shows the results.

Table 3

Electrode A	Symbol of metal	Voltage in volts
Copper	Cu	–0.59
Magnesium	Mg	2.12
Nickel	Ni	0.00
Silver	Ag	–1.05
Zinc	Zn	0.51

4.4.3.1 The process of electrolysis

Question 41 · continued

0 6 . 1 Write the symbols of the five metals in **Table 3** in order of reactivity.

Justify your answer.

[3 marks]

Most reactive _____ _____ _____ _____ _____ Least reactive

Justification _____

_____

0 6 . 2 The voltage produced by a chemical cell depends on the concentration of the electrolyte solution.

Plan an experiment to investigate how the voltage produced by a chemical cell varies with the **concentration** of the electrolyte solution.

The following substances are available:

- the metal electrodes in **Table 3**
- 1.0 mol/dm^3 sodium chloride solution
- pure water.

[6 marks]

4.4.3.1 The process of electrolysis

Question 41 · continued

0 6 . 3 Describe how a hydrogen fuel cell produces a potential difference.

[2 marks]

11

4.4.3.1 The process of electrolysis

Question 42

June 2025 | 8462/1H | Original Q6

0 6 Aluminium is extracted by the electrolysis of a molten mixture.

The mixture contains aluminium oxide and one other substance.

0 6 . 1 Aluminium oxide is an ionic compound.

Explain why aluminium oxide has a very high melting point.

[4 marks]

Extra space

0 6 . 2 Name the substance added to aluminium oxide to form the mixture.

[1 mark]

0 6 . 3 Give **one** reason why a mixture is used as the electrolyte.

[1 mark]

4.4.3.1 The process of electrolysis

Question 42 · continued

Oxygen is produced at the positive electrode.

0 6 . 4 Write the half equation for the reaction that produces oxygen at the positive electrode.

[2 marks]

_____ → _____ + _____

0 6 . 5 The positive electrode must be continually replaced.

Explain why.

[3 marks]

_____

_____

_____

_____

_____

_____

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