AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.4.3.3

# Using electrolysis to extract metals

## Past-paper questions

| | |
|---|---|
| Tier | **Higher** |
| Question groups | **37** |
| Available paper years | **2007–2025** |

## 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.

**4.4.3.3 Using electrolysis to extract metals**

**Question 01**

March 2007 | CHY1A | Original Q4 | Legacy

## QUESTION FOUR

Aluminium can be obtained by extracting it from aluminium ore, and by recycling used objects made from aluminium.

**4A** One disadvantage of extracting aluminium from aluminium ore is that . . .

**1** aluminium ore contains very small amounts of aluminium.

**2** aluminium ore is a limited resource.

**3** the aluminium obtained corrodes easily.

**4** the aluminium obtained has a high density.

**4B** It is better to recycle aluminium than to extract it from aluminium ore because . . .

**1** aluminium ore contains few impurities.

**2** aluminium ore produces low grade aluminium.

**3** digging up aluminium ore destroys the local environment.

**4** recycling produces ‘smart’ aluminium alloys.

**4C** It makes economic sense to recycle aluminium because extracting it from its ore . . .

**1** is a cheap process.

**2** takes too long.

**3** employs more people.

**4** uses large amounts of energy.

**4D** If aluminium cans are not recycled, they can affect the environment by . . .

**1** causing acid rain.

**2** filling up landfill rubbish tips.

**3** producing poisonous gases.

**4** rapidly corroding in lakes and rivers.

4.4.3.3 Using electrolysis to extract metals

Question 02

June 2007 | CHY1A | Original Q7 | Legacy

## QUESTION SEVEN

In the United Kingdom, about 40 % of all the aluminium used is recycled.
To produce aluminium from recycling uses just 5 % of the energy needed for extraction of the metal from its ores.

Recycling 1 kilogram of aluminium saves about:

- 8 kilograms of aluminium ore
- 4 kilograms of raw materials used in extracting the metal from its ores
- 14 kilowatt-hours of electricity.

**7A** To make metal recycling worthwhile, there must be a steady supply of scrap and the necessary technology to separate the required metal from scrap materials.

Another factor that may increase the amount of metal that is recycled is . . .

**1** that new deposits of the ore are discovered.

**2** that the price of the metal falls.

**3** that the recycling process is much cheaper than extraction from the ore.

**4** that the cost of raw materials used in extraction falls.

**7B** One benefit of more recycling is that . . .

**1** the aluminium metal produced is of higher quality.

**2** there will be less destruction of the landscape by mining.

**3** recycled aluminium is a softer metal.

**4** landfill sites can be redeveloped more quickly.

**7C** Reducing the amount of energy required to produce the aluminium could also . . .

**1** increase the amount of gases which cause acid rain.

**2** increase the cost of producing the metal.

**3** reduce carbon dioxide emissions.

**4** increase the number of stages needed in the process.

4.4.3.3 Using electrolysis to extract metals

Question 02 · continued



**7D** How many kilowatt-hours of electricity are needed to produce 1 kg of aluminium from its ore?

**1** 0.7 kWh

**2** 14.0 kWh

**3** 14.7 kWh

**4** 28.0 kWh

**Turn over for the next question**

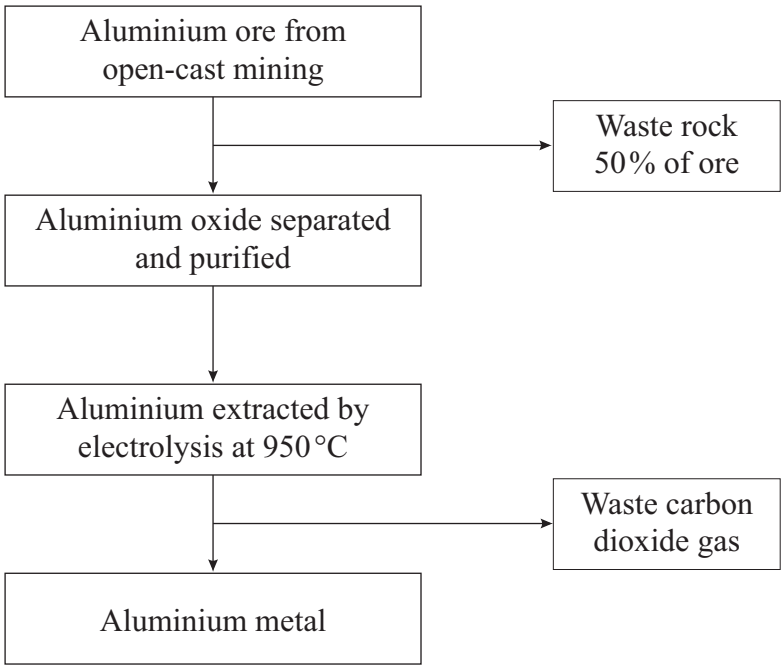
### 4.4.3.3 Using electrolysis to extract metals

**Question 03**

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)*

**4.4.3.3 Using electrolysis to extract metals**

**Question 03 · continued**



*BLANK*

(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**

**4.4.3.3 Using electrolysis to extract metals**

**Question 04**

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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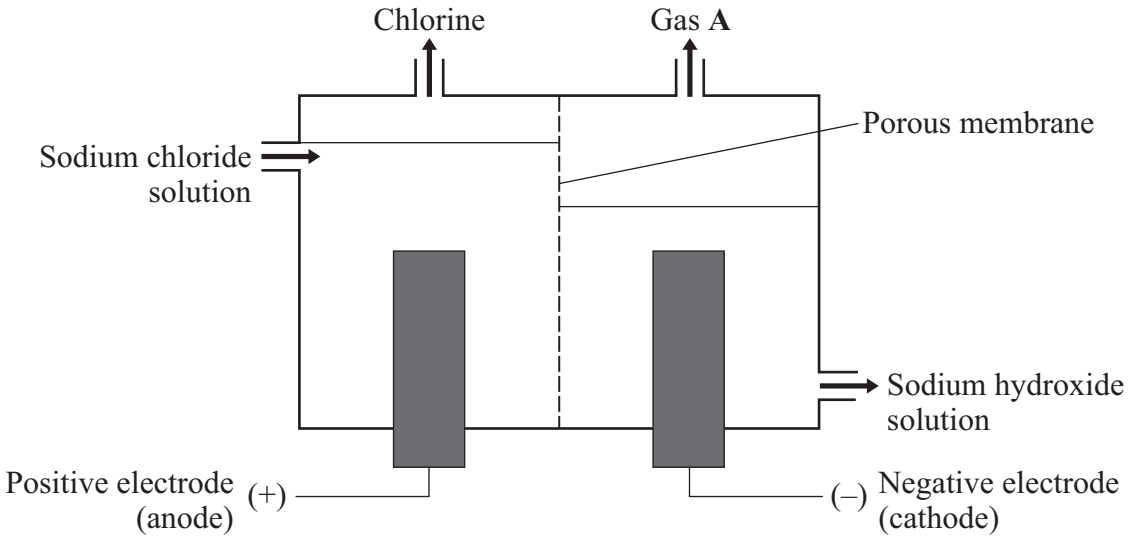
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*(2 marks)*

(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

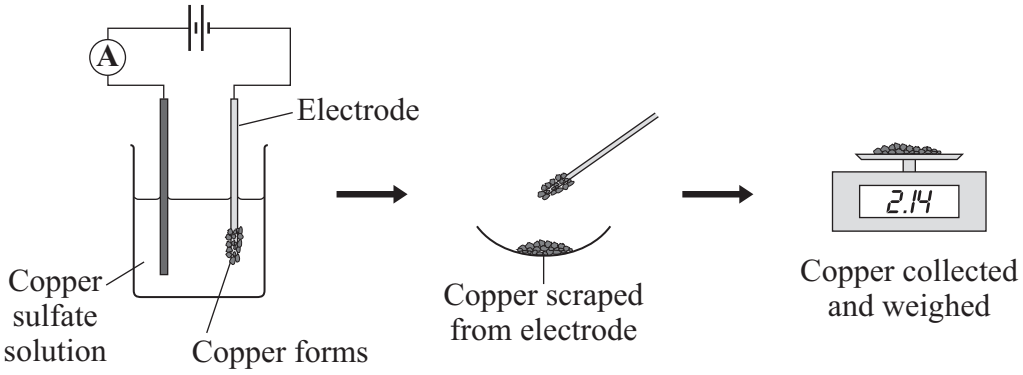
**4.4.3.3 Using electrolysis to extract metals**

**Question 05**

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

4.4.3.3 Using electrolysis to extract metals

Question 05 · 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.

**4.4.3.3 Using electrolysis to extract metals**

**Question 06**

June 2008 | CHY1AP | Original Q3 | Legacy

## QUESTION THREE

- Iron is obtained by reducing its oxide ore with carbon.
- Aluminium **cannot** be obtained by reducing its oxide ore with carbon.
- Gold occurs as the metal itself.

**3A** From the information above, which row in the table shows the order of reactivity of the four elements?

| | most reactive → least reactive | | | |
|---|---|---|---|---|
| **1** | aluminium | carbon | iron | gold |
| **2** | iron | aluminium | carbon | gold |
| **3** | iron | aluminium | gold | carbon |
| **4** | aluminium | iron | gold | carbon |

**3B** Iron obtained directly from the blast furnace was used to build the Iron Bridge in Shropshire.

This bridge is unsuitable for use by modern lorries because . . .

**1** it **cannot** be stopped from rusting.

**2** it will easily bend out of shape.

**3** it is too heavy to support its own weight.

**4** it is too brittle and so it will break.

**4.4.3.3 Using electrolysis to extract metals**

**Question 06 · continued** June 2008 | CHY1AP | Original Q3 | Legacy

- Aluminium waste of high purity can be recycled.
- Any iron and other impurities are removed.
- The aluminium is then melted and processed in the same way as aluminium that has been extracted from its ore.
- Recycling aluminium in this way creates only 5% of the carbon dioxide produced by extracting aluminium from its ore.

**3C** Which of the following benefits an aluminium recycling company financially?

**1** a fall in the price of aluminium

**2** the high melting point of aluminium

**3** the high purity of the aluminium waste arriving at the recycling plant

**4** the metal can be purified by electrolysis

**3D** An environmental disadvantage of recycling aluminium is that . . .

**1** the aluminium waste has to be transported for recycling.

**2** land fill sites would **not** be filled so quickly.

**3** the process creates only 5% of the carbon dioxide produced by extracting aluminium from its ore.

**4** the price of aluminium will fall.

**4.4.3.3 Using electrolysis to extract metals**

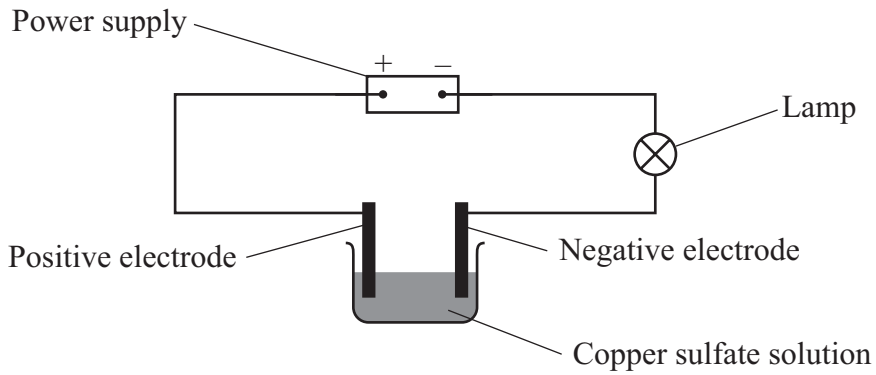
**Question 07**

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.

**4.4.3.3 Using electrolysis to extract metals**

**Question 07 · 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)*

**8**

**4.4.3.3 Using electrolysis to extract metals**

**Question 08**

June 2009 | CHY1AP | Original Q7 | Legacy

## QUESTION SEVEN

This question is about three metals, copper, lead and zinc.

**7A** Copper is found in the Earth's crust as the metal itself.

Lead and zinc are also found in the Earth's crust, but only as compounds such as oxides and sulfides.

These facts suggest that . . .

**1** copper is a very reactive metal.

**2** lead and zinc are transition metals, but copper is not.

**3** lead and zinc react rapidly with oxygen and sulfur, but copper does not.

**4** lead and zinc are more reactive than copper.

**7B** A naturally occurring compound of zinc is hydrozincite, $2ZnCO_3.3Zn(OH)_2$

Which row in the table correctly shows the number of elements, and the number of atoms of oxygen in the formula for hydrozincite?

| | Number of elements | Number of atoms of oxygen |
|---|---|---|
| **1** | 4 | 12 |
| **2** | 4 | 8 |
| **3** | 5 | 5 |
| **4** | 6 | 4 |

Question 08 · continued



**7C** Zinc is also found as zincite, ZnO.

The metal can be extracted from zincite by mixing it with carbon and heating strongly.

Which row in the table correctly shows the name for this process and the products?

| | Name of process | Products |
|---|---|---|
| **1** | electrolysis | zinc and carbon dioxide |
| **2** | leaching | zinc and oxygen |
| **3** | reduction | zinc and oxygen |
| **4** | reduction | zinc and carbon dioxide |

Lead and zinc compounds are often found together in the same ore.

The metals can be extracted by mixing the ore with carbon and heating strongly in a furnace. They can then be separated.

The table shows the melting points and boiling points of lead and zinc.

| | Lead | Zinc |
|---|---|---|
| **Melting point in °C** | 328 | 420 |
| **Boiling point in °C** | 1740 | 907 |

The furnace operates at a temperature of 1200 °C.

**7D** How will the lead and zinc be separated?

**1** Molten lead remains in the furnace and the zinc evaporates.

**2** Molten lead and molten zinc form two separate layers in the furnace.

**3** Molten zinc remains in the furnace and the lead evaporates.

**4** Zinc and lead vapours leave the furnace and are separated in a condenser.

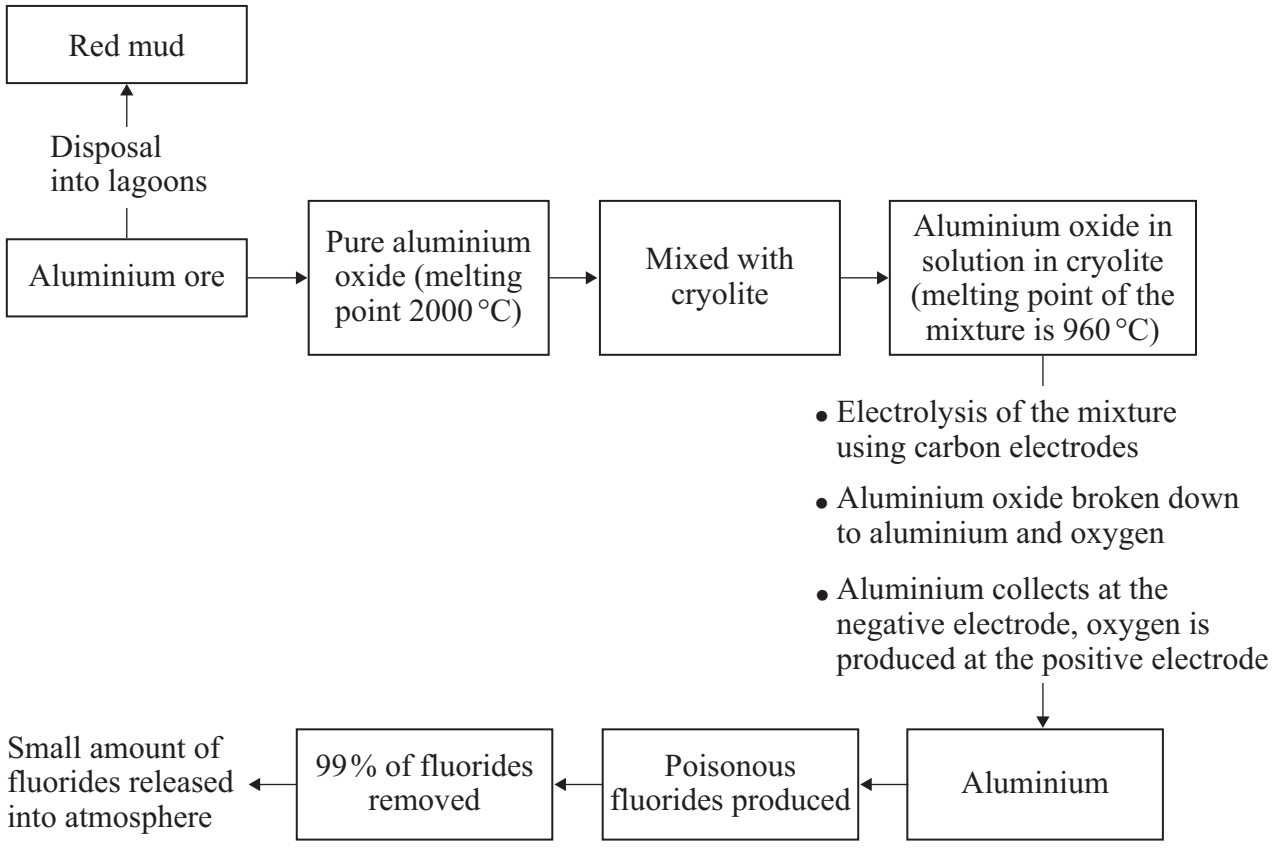
**4.4.3.3 Using electrolysis to extract metals**

**Question 09**

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.

4.4.3.3 Using electrolysis to extract metals



**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**

**4.4.3.3 Using electrolysis to extract metals**

**Question 10**

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)*

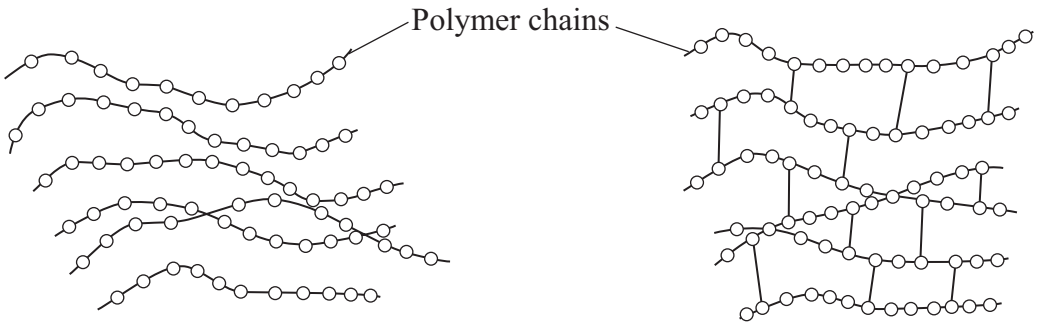
**6** (a) (ii) PEX is a shape memory polymer. What property does a shape memory polymer have?

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*(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)*

**4.4.3.3 Using electrolysis to extract metals**

**Question 10 · 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

4.4.3.3 Using electrolysis to extract metals

Question 11

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.

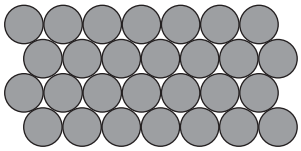
**4** the metal ores are very abundant.

**4.4.3.3 Using electrolysis to extract metals**

**Question 11 · 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. |

**4.4.3.3 Using electrolysis to extract metals**

**Question 12**

January 2010 | CHY1H | Original Q5 | Legacy

**5** In the UK copper is produced from imported blister copper (98% pure), which has been extracted from copper ores.

**5** (a) In the first stage of purification, air is blown into molten blister copper to remove any sulfur.

**5** (a) (i) The sulfur reacts to form a gas that should **not** be allowed to escape into the atmosphere.

Explain why.

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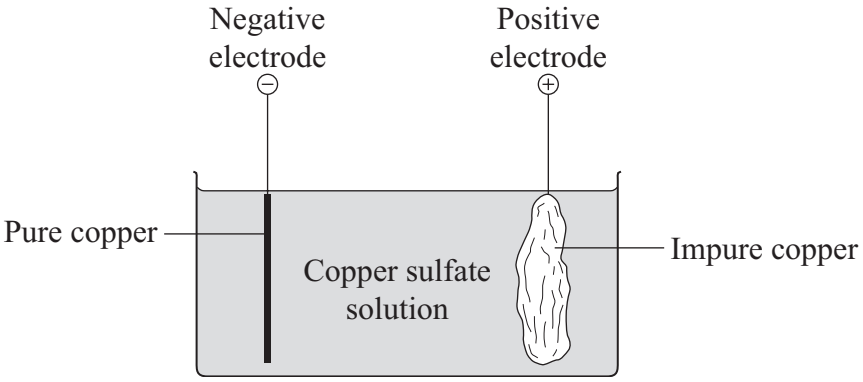
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*(2 marks)*

**5** (a) (ii) After the removal of sulfur the slightly impure copper is cast into anodes. The copper in these anodes is purified by the process shown.




What is the name of this type of process?

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*(1 mark)*

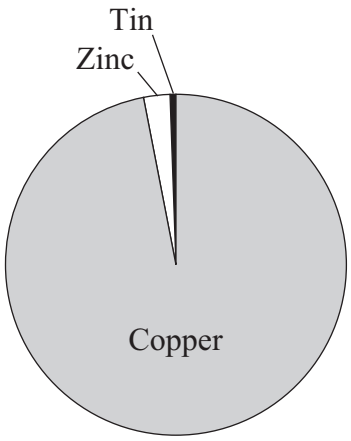
4.4.3.3 Using electrolysis to extract metals

Question 12 · continued



*for mark*

**5** (b) One use of copper is to make 2p coins.




The composition of a 2p coin in 1991

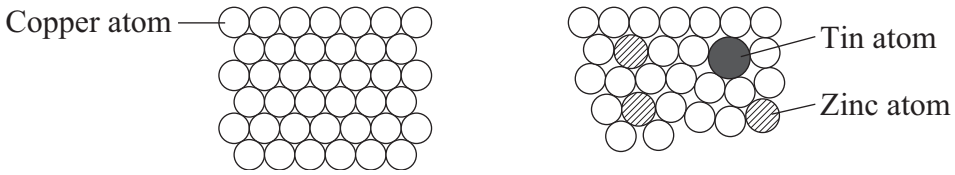
**5** (b) (i) How was copper made harder for use in 2p coins in 1991?

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*(1 mark)*

**5** (b) (ii) Use the diagrams to help you to explain why the metal used in 2p coins was harder than pure copper.




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*(2 marks)*

6

### 4.4.3.3 Using electrolysis to extract metals

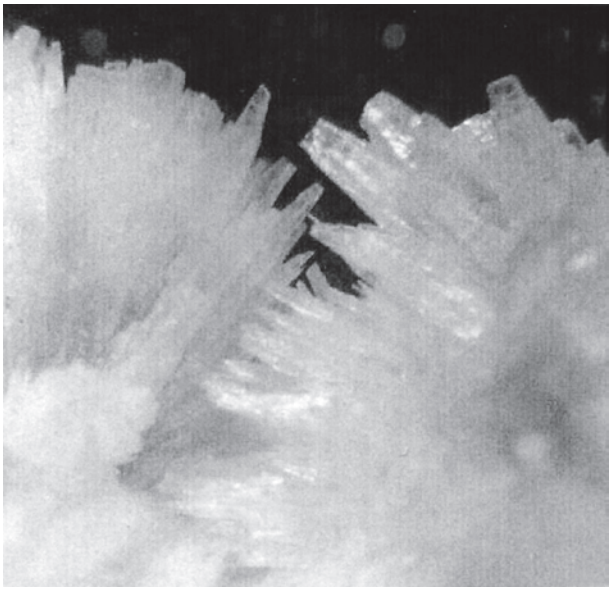
**Question 13**

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?

.....

.....

*(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)*

4.4.3.3 Using electrolysis to extract metals

Question 13 · 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.

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*(1 mark)*

7

### 4.4.3.3 Using electrolysis to extract metals

**Question 14**

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. |

### 4.4.3.3 Using electrolysis to extract metals

**Question 15**

November 2010 | CHY1AP | Original Q4 | Legacy

**QUESTION FOUR**

Aluminium is extracted from a substance called bauxite. Bauxite contains aluminium oxide and impurities such as sand. Bauxite is first purified to make pure aluminium oxide. Then electricity is passed through the molten aluminium oxide. The molten aluminium oxide splits to make aluminium and oxygen.

**4A** Bauxite is an example of . . .

**1** an element.

**2** a compound.

**3** an ore.

**4** a solution.

**4B** The process used to extract aluminium is . . .

**1** thermal decomposition.

**2** reduction.

**3** corrosion.

**4** distillation.

**4C** Aluminium **cannot** be extracted from aluminium oxide using carbon because . . .

**1** aluminium is more reactive than carbon.

**2** the density of aluminium is too low.

**3** carbon is higher in the reactivity series than aluminium.

**4** aluminium is covered in a layer of aluminium oxide.

**4D** Aluminium is often recycled.

Which one of the following is **not** a good reason to recycle aluminium?

**1** Recycling is cheaper than extracting aluminium from bauxite.

**2** Drinks cans must be made from aluminium.

**3** Recycling reduces the amount of energy used to make aluminium.

**4** Bauxite reserves will last longer.

### 4.4.3.3 Using electrolysis to extract metals

**Question 16**



**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.

.....

.....

.....

*(1 mark)*

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

.....

.....

.....

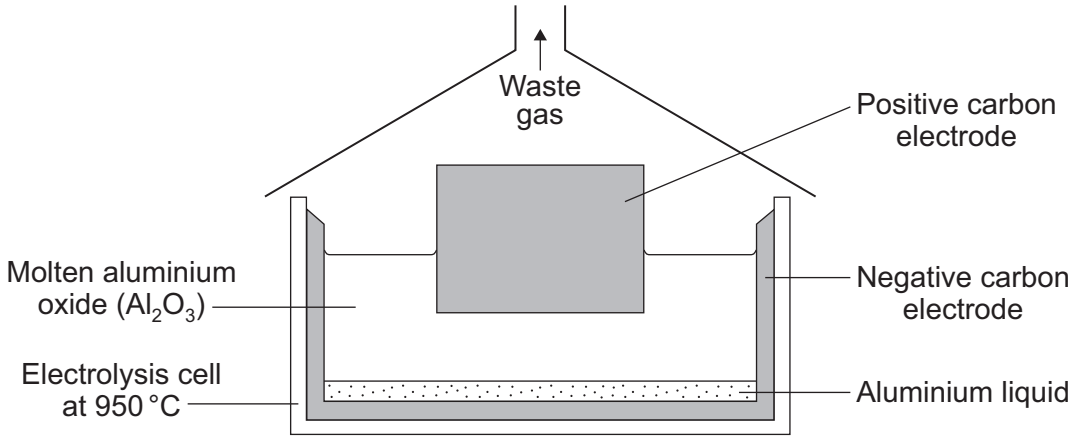
*(1 mark)*

4.4.3.3 Using electrolysis to extract metals

Question 16 · 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.

.....

.....

*(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.

.....

.....

.....

.....

*(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 .....

.....

2 .....

.....

*(2 marks)*

7

### 4.4.3.3 Using electrolysis to extract metals

**Question 17**

January 2011 | CHY2H | Original Q1 | Legacy

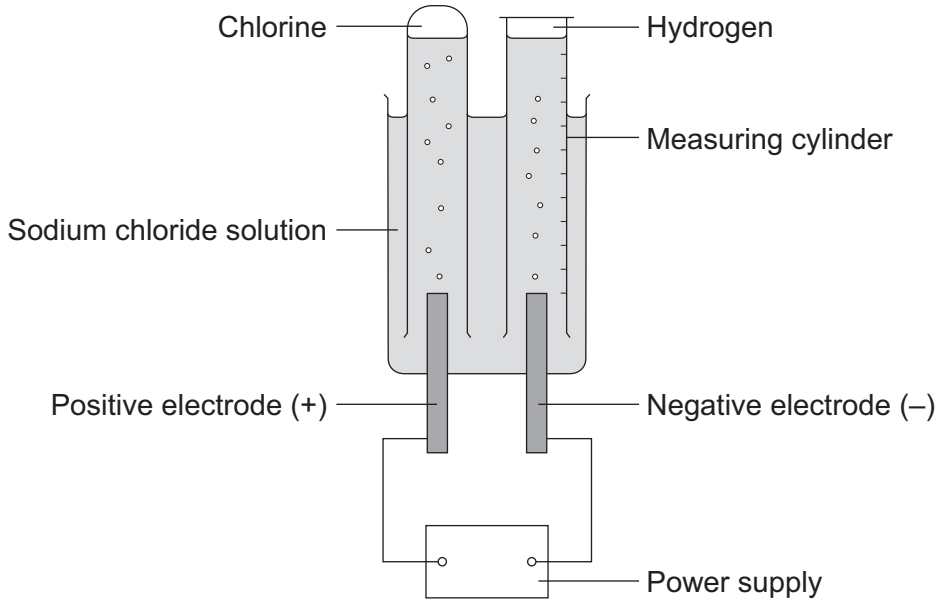
**1** A student investigated the electrolysis of sodium chloride solution.

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**

**4.4.3.3 Using electrolysis to extract metals**

**Question 17 · continued**



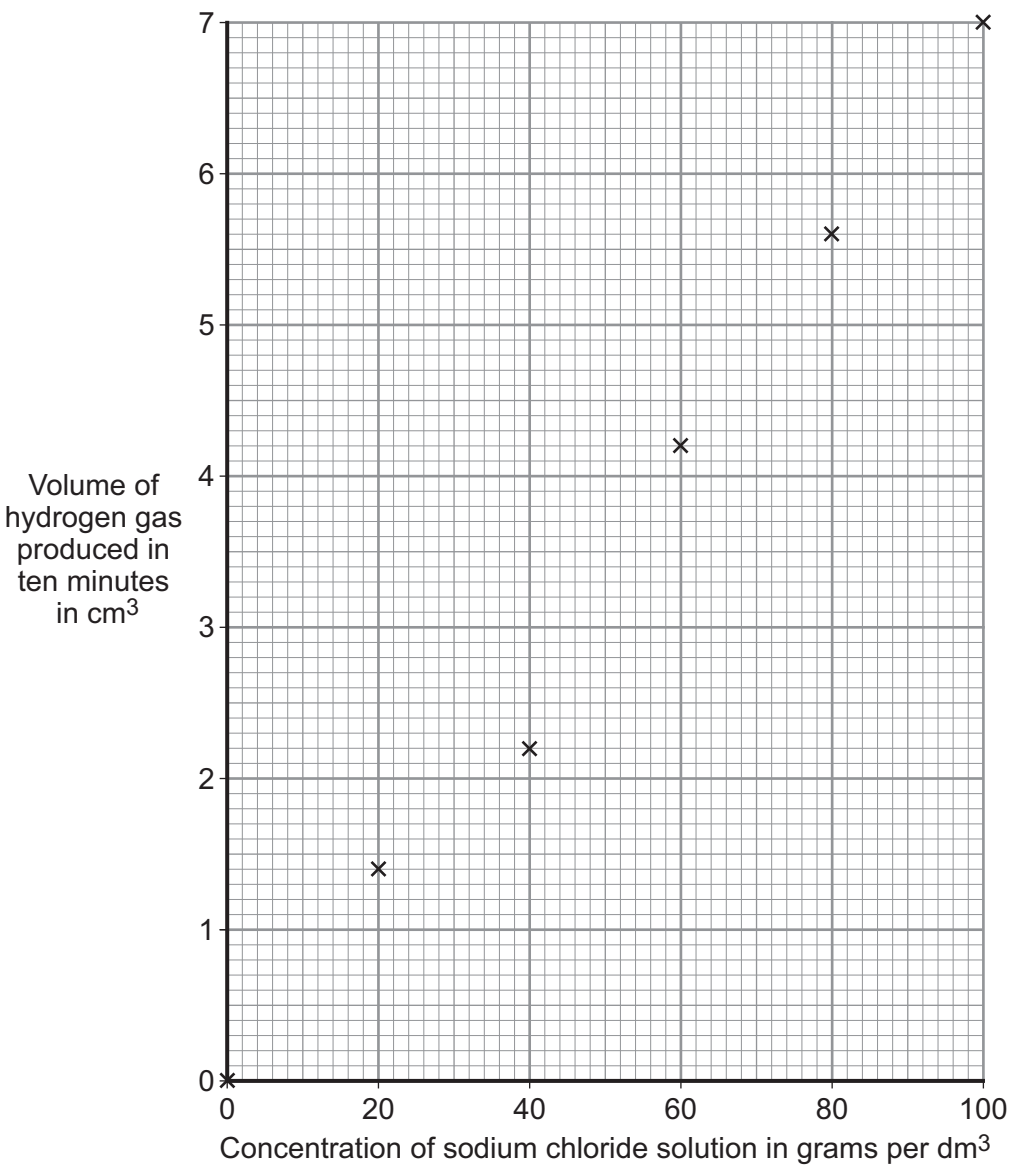
**1 (c)** The solution left at the end of each experiment contains sodium hydroxide.

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.



4.4.3.3 Using electrolysis to extract metals

Question 17 · 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.

.....

.....

*(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

4.4.3.3 Using electrolysis to extract metals

Question 18

June 2011 | CHY1AP | Original Q9 | Legacy

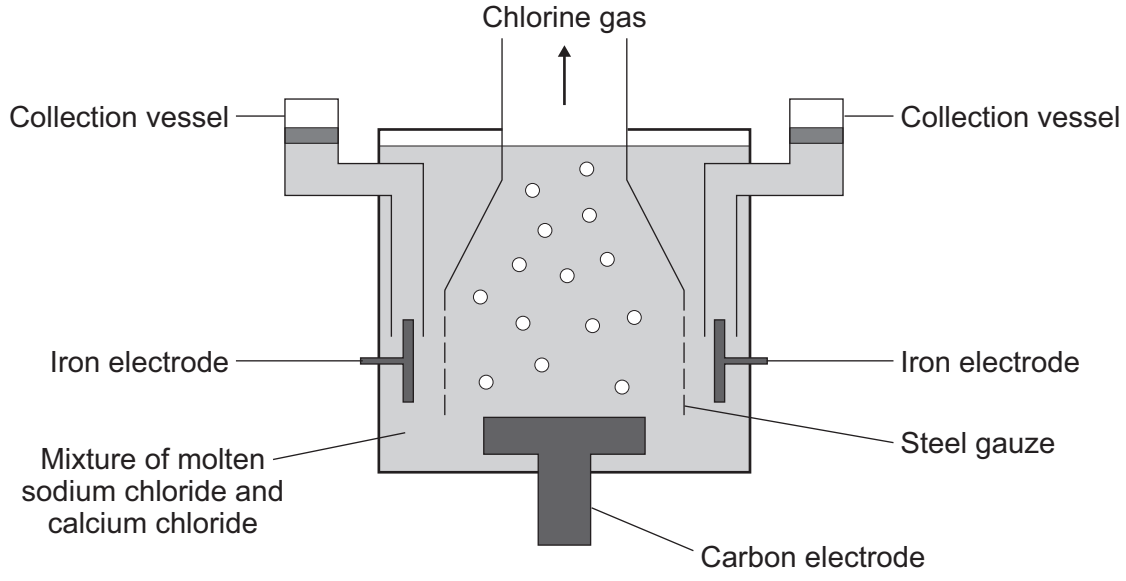
**QUESTION NINE**

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.

4.4.3.3 Using electrolysis to extract metals

Question 18 · 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.

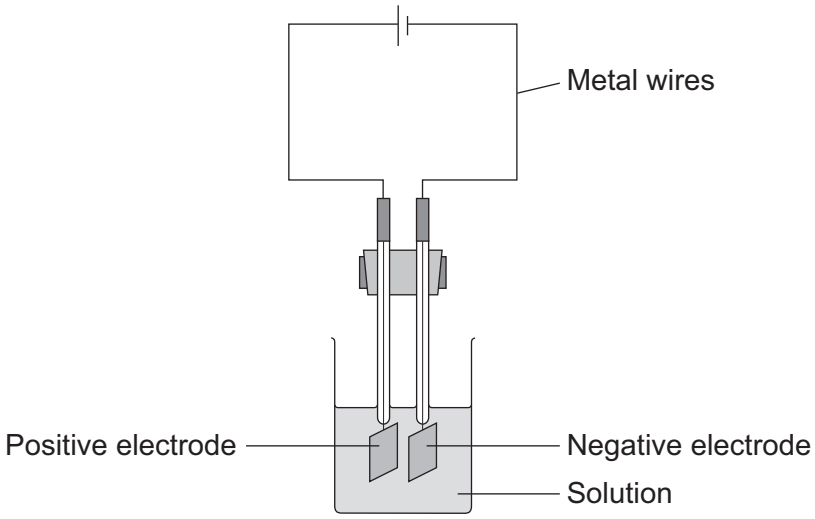
**END OF TEST**

### 4.4.3.3 Using electrolysis to extract metals

**Question 19**

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)*

4.4.3.3 Using electrolysis to extract metals

Question 19 · 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

4.4.3.3 Using electrolysis to extract metals

Question 20

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.

4.4.3.3 Using electrolysis to extract metals

Question 20 · continued



**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**

### 4.4.3.3 Using electrolysis to extract metals

**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.

.....

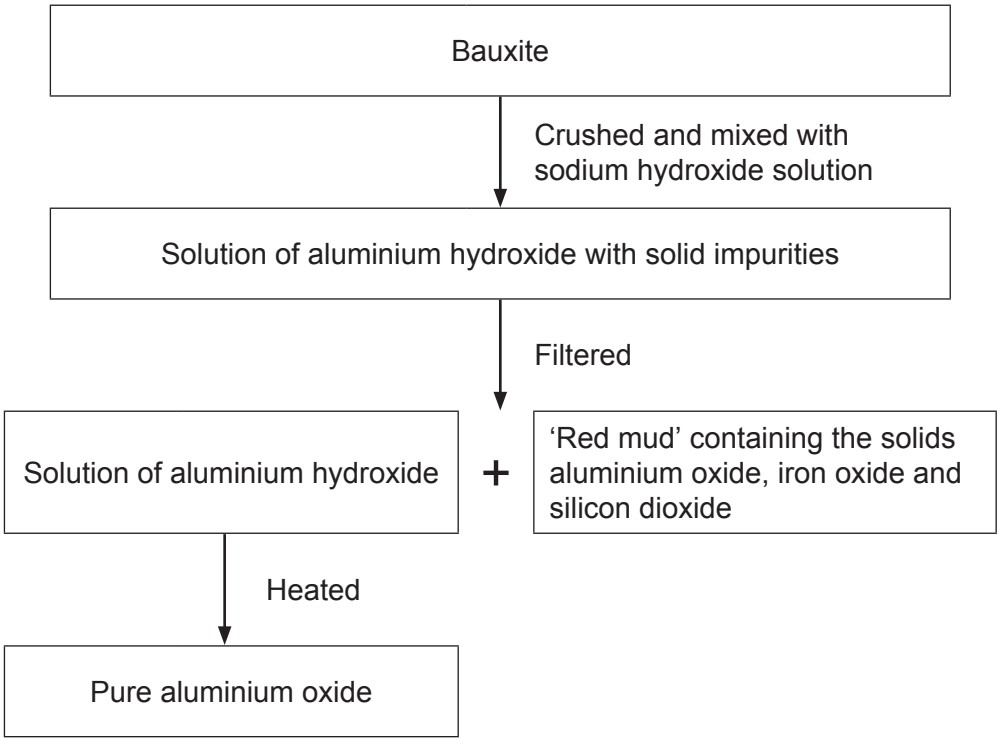
*(1 mark)*

**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.



4.4.3.3 Using electrolysis to extract metals

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)*

7

### 4.4.3.3 Using electrolysis to extract metals

**Question 22**

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.

.....

.....

.....

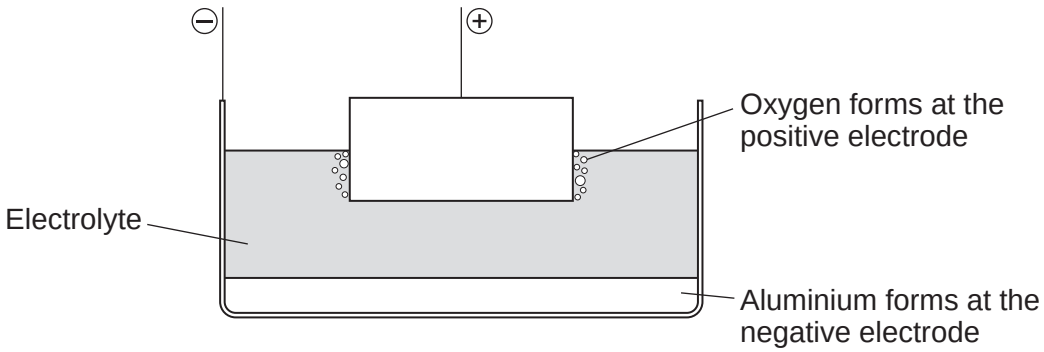
.....

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.



4.4.3.3 Using electrolysis to extract metals

Question 22 · 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.

.....

.....

.....

.....

.....

.....

*(2 marks)*

8

### 4.4.3.3 Using electrolysis to extract metals

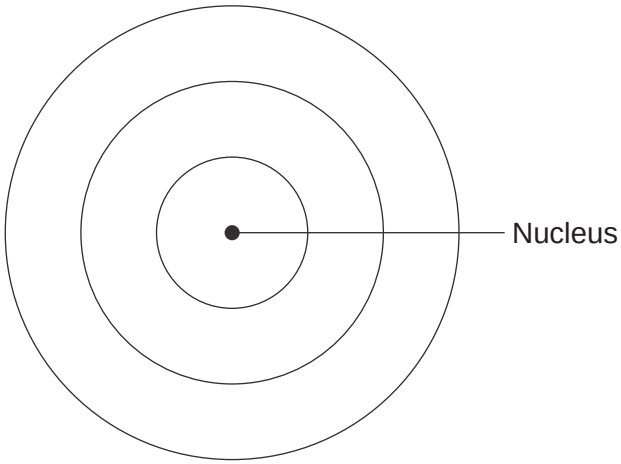
**Question 23**

June 2013 | CH1HP | Original Q1 | Legacy

**1** Aluminium has many uses.

**1 (a)** An aluminium atom has 13 electrons.

**1 (a) (i)** Draw the electronic structure of an aluminium atom.




*(1 mark)*

**1 (a) (ii)** Name the **two** sub-atomic particles in the nucleus of an aluminium atom.

..... and .....

*(1 mark)*

**1 (a) (iii)** Why is there no overall electrical charge on an aluminium atom?

.....

.....

*(1 mark)*

4.4.3.3 Using electrolysis to extract metals

Question 23 · continued



**1 (b)** Rail tracks are made from steel.

Molten iron is used to weld rail tracks.

The reaction of aluminium with iron oxide is used to produce molten iron.

**1 (b) (i)** Balance the chemical equation for the reaction.

.....Al + $Fe_2O_3$ ⟶ .....Fe + $Al_2O_3$

*(1 mark)*

**1 (b) (ii)** Why does aluminium react with iron oxide?

.....

.....

*(1 mark)*

5

**Turn over for the next question**

### 4.4.3.3 Using electrolysis to extract metals

**Question 24**

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.

.....

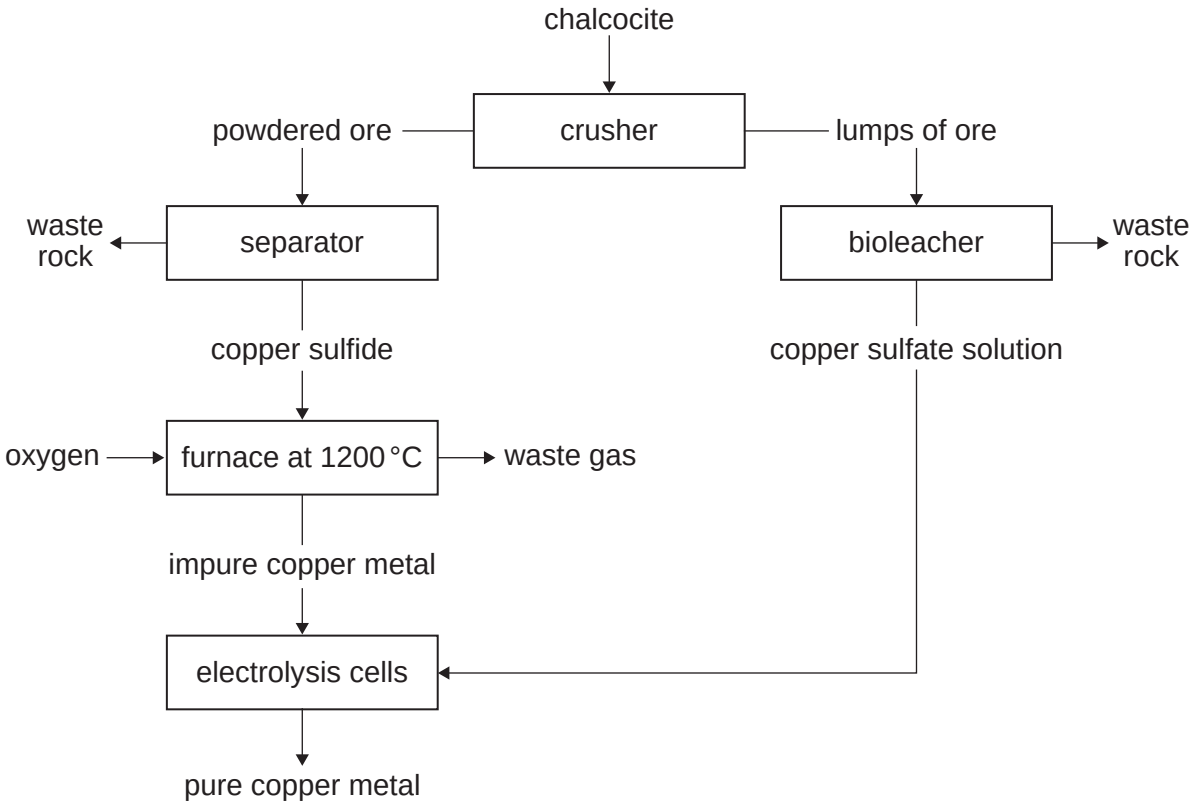
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*(2 marks)*

**2 (b)** Chalcocite, an ore of copper, contains copper sulfide.
The flow diagram shows how copper metal is extracted from chalcocite.



4.4.3.3 Using electrolysis to extract metals

Question 24 · 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.

.....

.....

.....

.....

*(2 marks)*

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

.....

.....

*(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.

.....

.....

.....

.....

*(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

### 4.4.3.3 Using electrolysis to extract metals

**Question 25**

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.

.....

.....

.....

.....

*(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.

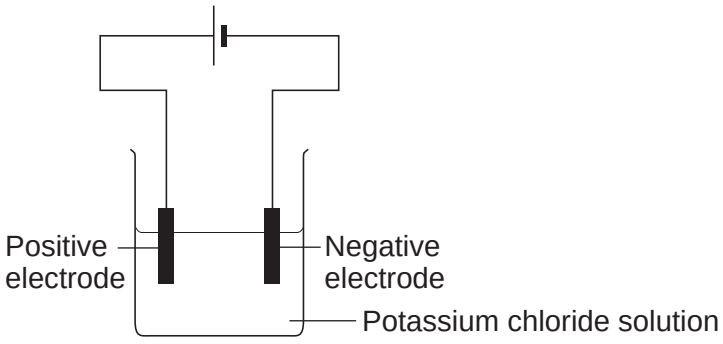
.....

.....

*(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.



4.4.3.3 Using electrolysis to extract metals

Question 25 · 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.

.....

.....

.....

.....

.....

.....

*(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.

.....

.....

.....

.....

*(2 marks)*

**Question 4 continues on the next page**

### 4.4.3.3 Using electrolysis to extract metals

**Question 25 · continued**

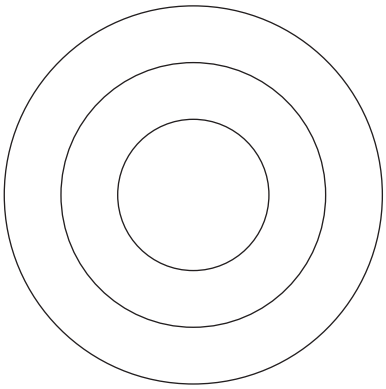


**4 (c) (ii)** Complete and balance the equation for the reaction at the positive electrode.

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

*(1 mark)*

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



*(1 mark)*

10

### 4.4.3.3 Using electrolysis to extract metals

**Question 26**

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.

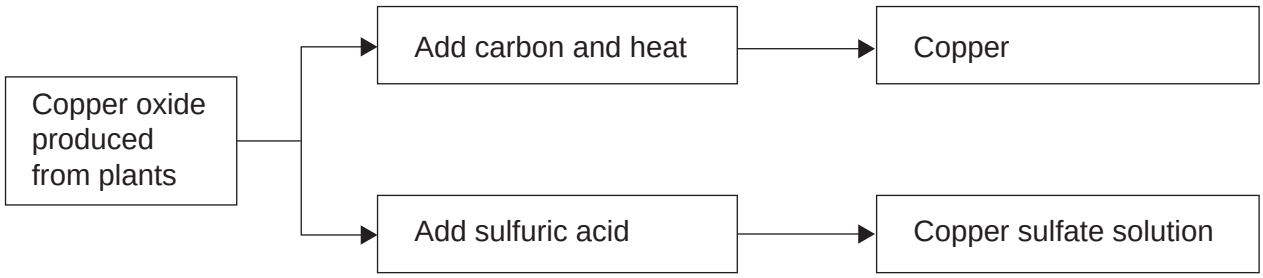
One way to extract the copper is to grow plants on the land.

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]**

.....

.....

.....

.....

.....

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

**[2 marks]**

.....CuO + C ⟶ ..... + $CO_2$

4.4.3.3 Using electrolysis to extract metals

Question 26 · 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]**

.....

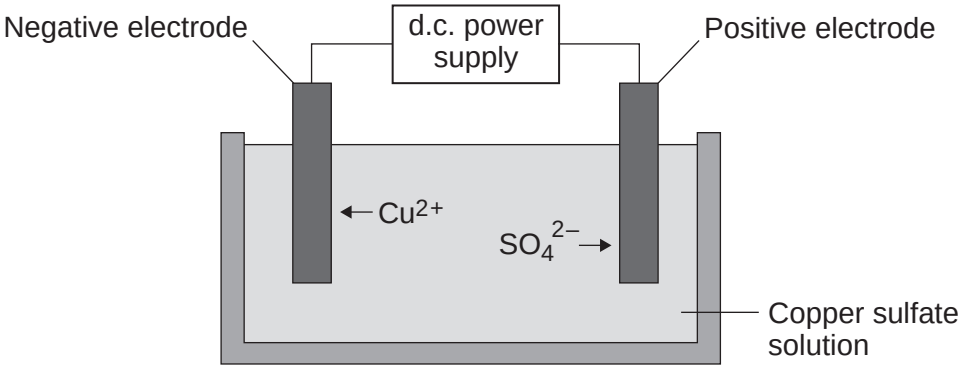
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**4 (b) (ii)** **Figure 4** shows the electrolysis of copper sulfate solution.

**Figure 4**




Describe what happens to the copper ions during electrolysis.

**[2 marks]**

.....

.....

.....

.....

9

### 4.4.3.3 Using electrolysis to extract metals

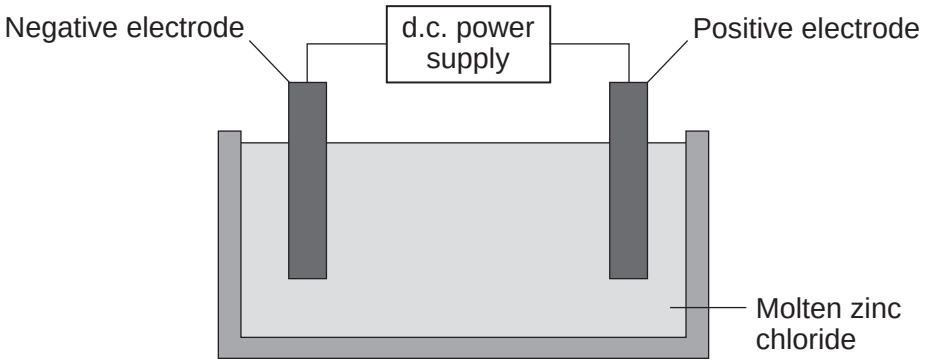
**Question 27**

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]**

.....

.....

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

**[3 marks]**

.....

.....

.....

.....

.....

.....

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

**[1 mark]**

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

4.4.3.3 Using electrolysis to extract metals

Question 27 · 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]**

.....

.....

**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]**

.....

.....

.....

.....

Mass of magnesium oxide needed = ..... tonnes

4.4.3.3 Using electrolysis to extract metals

Question 27 · 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**

### 4.4.3.3 Using electrolysis to extract metals

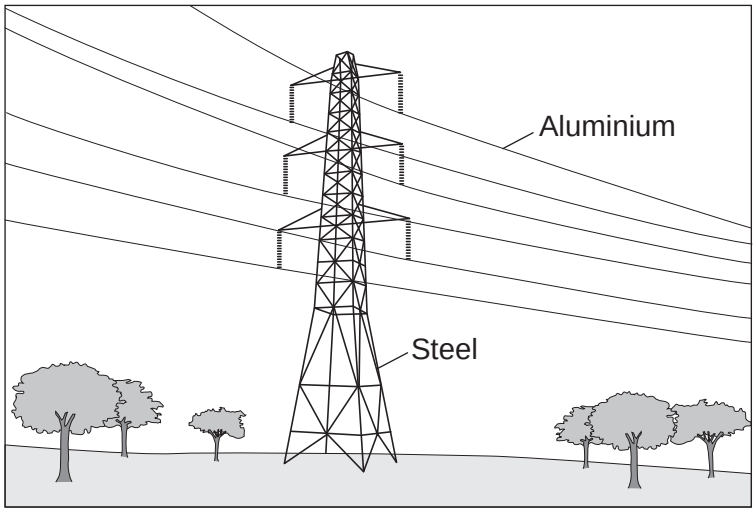
**Question 28**

June 2015 | CH1HP | Original Q4 | Legacy

**4** This question is about metals.

**Figure 4** shows the metals used to make pylons and the wires of overhead cables.

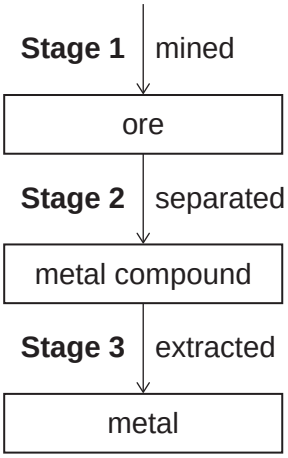
**Figure 4**




**4 (a)** An ore contains a metal compound.

A metal is extracted from its ore in three main stages, as shown in **Figure 5**.

**Figure 5**




Explain why **Stage 2** needs to be done.

**[2 marks]**

.....

.....

.....

.....

Question 28 · continued



**4 (b)** Cast iron from a blast furnace contains 96% iron and 4% carbon.

**4 (b) (i)** Cast iron is not suitable for the manufacture of pylons.

Give **one** reason why.

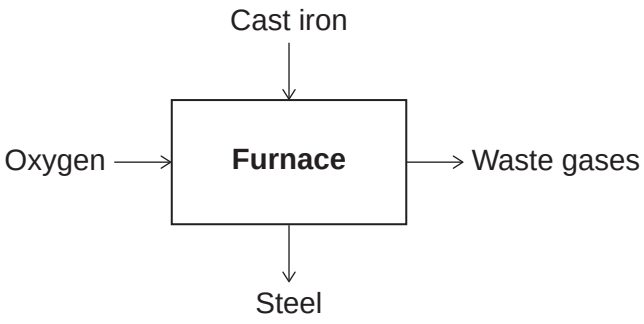
**[1 mark]**

.....

.....

**4 (b) (ii)** Most cast iron is converted into steel, as shown in **Figure 6**.

**Figure 6**




Describe how cast iron is converted into steel.

Use **Figure 6** to help you to answer this question.

**[2 marks]**

.....

.....

.....

.....

**Question 4 continues on the next page**

4.4.3.3 Using electrolysis to extract metals

Question 28 · continued



**4 (c)** Aluminium and copper are good conductors of electricity.

**4 (c) (i)** State **one** property that makes aluminium more suitable than copper for overhead cables.

**[1 mark]**

.....

.....

**4 (c) (ii)** How can you tell that copper is a transition metal and aluminium is **not** a transition metal from the position of each metal in the periodic table?

**[2 marks]**

.....

.....

.....

.....

**4 (c) (iii)** Copper can be extracted from solutions of copper salts by adding iron.

Explain why.

**[2 marks]**

.....

.....

.....

.....

10

### 4.4.3.3 Using electrolysis to extract metals

**Question 29**

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]**

.....

.....

.....

.....

.....

.....

.....

.....

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

**[2 marks]**

.....

.....

.....

.....

**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]**

.....

.....

4.4.3.3 Using electrolysis to extract metals

Question 29 · 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]**

.....

.....

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

**[1 mark]**

.....

.....

.....

11

### 4.4.3.3 Using electrolysis to extract metals

**Question 30**

June 2016 | CH1HP | Original Q3 | Legacy

**3** Metals are extracted from ores in the Earth's crust.

Some ores contain metal carbonates and some ores contain metal oxides.

**3 (a) (i)** Name the type of reaction that happens when a metal carbonate is heated.

**[1 mark]**

_____

**3 (a) (ii)** Which solid product is formed when copper carbonate is heated?

**[1 mark]**

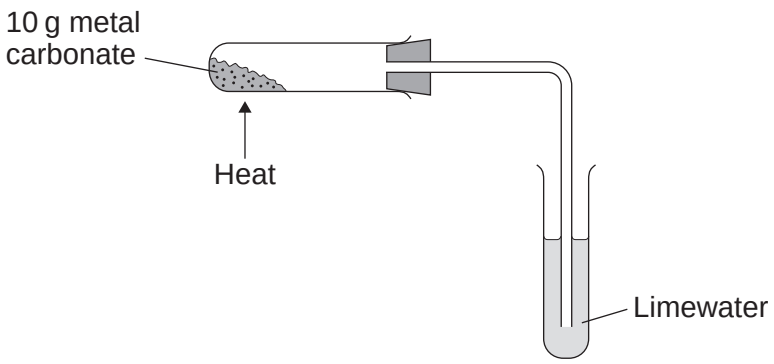
Tick (✓) **one** box.

- copper ☐
- copper nitrate ☐
- copper oxide ☐
- copper sulfide ☐

**3 (b)** A student investigated heating four metal carbonates.

**Figure 4** shows the apparatus used.

**Figure 4**



Question 30 · continued



The student heated each metal carbonate for five minutes.

**Table 3** shows the results.

**Table 3**

| Metal carbonate | Mass of metal carbonate at start in g | Mass of solid after heating for 5 minutes in g | Observations |
|---|---|---|---|
| Copper carbonate | 10.0 | 6.9 | Limewater turns cloudy |
| Magnesium carbonate | 10.0 | 9.1 | Limewater turns cloudy |
| Potassium carbonate | 10.0 | 10.0 | Limewater does not turn cloudy |
| Zinc carbonate | 10.0 | 8.3 | Limewater turns cloudy |

**3 (b) (i)** Explain the results for potassium carbonate.

**[3 marks]**

**3 (b) (ii)** Suggest how the reactivity series can be used to predict which metal carbonate reacts most easily when heated.

**[2 marks]**

**Question 3 continues on the next page**

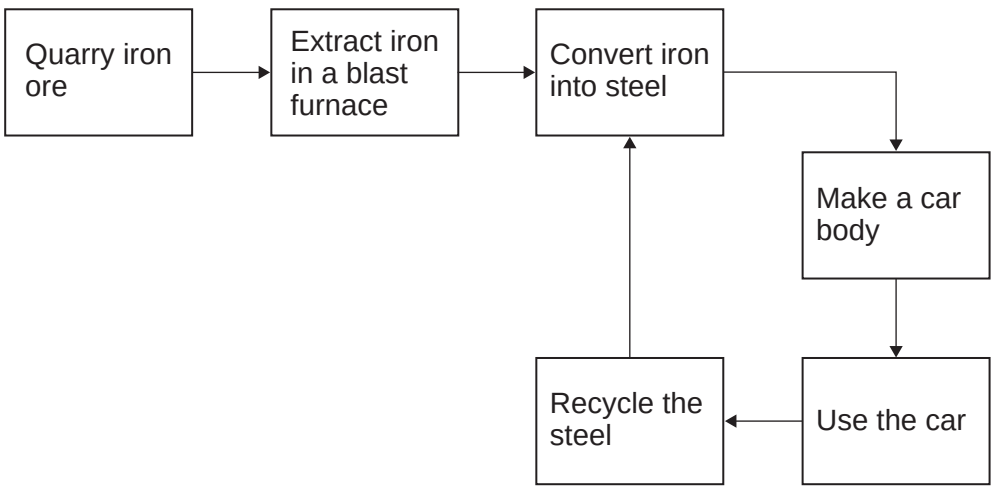
4.4.3.3 Using electrolysis to extract metals

Question 30 · continued



**3 (c)** **Figure 5** shows a simple life cycle of a car body.

**Figure 5**




**3 (c) (i)** Complete the sentence.

**[1 mark]**

Iron ores must contain enough iron to _____

_____

**3 (c) (ii)** Some iron ores contain iron oxide ($Fe_2O_3$).

Complete and balance the equation for a reaction to produce iron from iron oxide.

**[2 marks]**

_____ $Fe_2O_3$ + _____ C ⟶ _____ + _____ $CO_2$

**3 (c) (iii)** Give **two** reasons why iron produced in a blast furnace is converted into steel.

**[2 marks]**

_____

_____

_____

_____

4.4.3.3 Using electrolysis to extract metals

Question 30 · continued



**3 (c) (iv)** When a car reaches the end of its useful life, the car body can be:

- recycled
- reused
- sent to landfill.

Give **three** reasons why a steel car body should be recycled and **not** reused or sent to landfill.

**[3 marks]**

15

4.4.3.3 Using electrolysis to extract metals

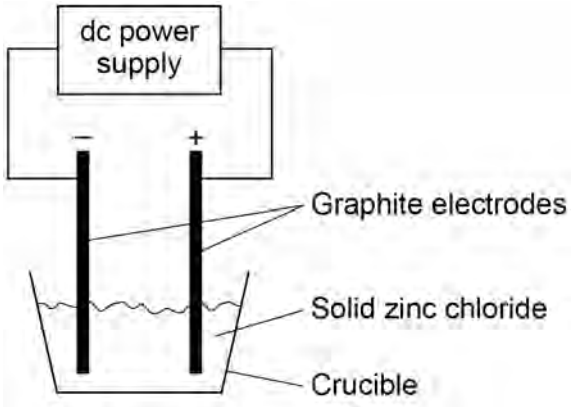
Question 31

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]**

4.4.3.3 Using electrolysis to extract metals

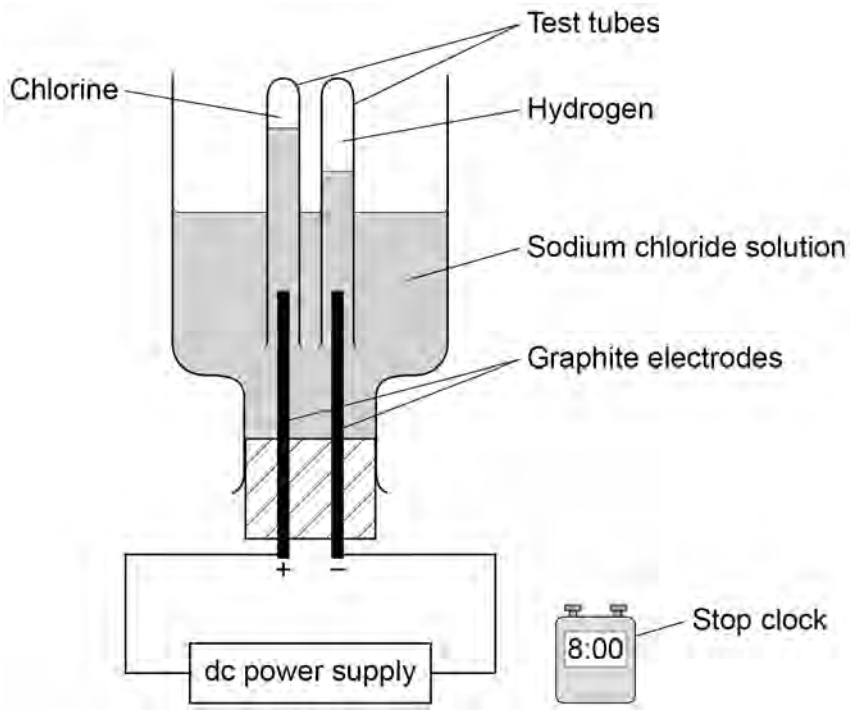
Question 31 · continued



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 31 · continued

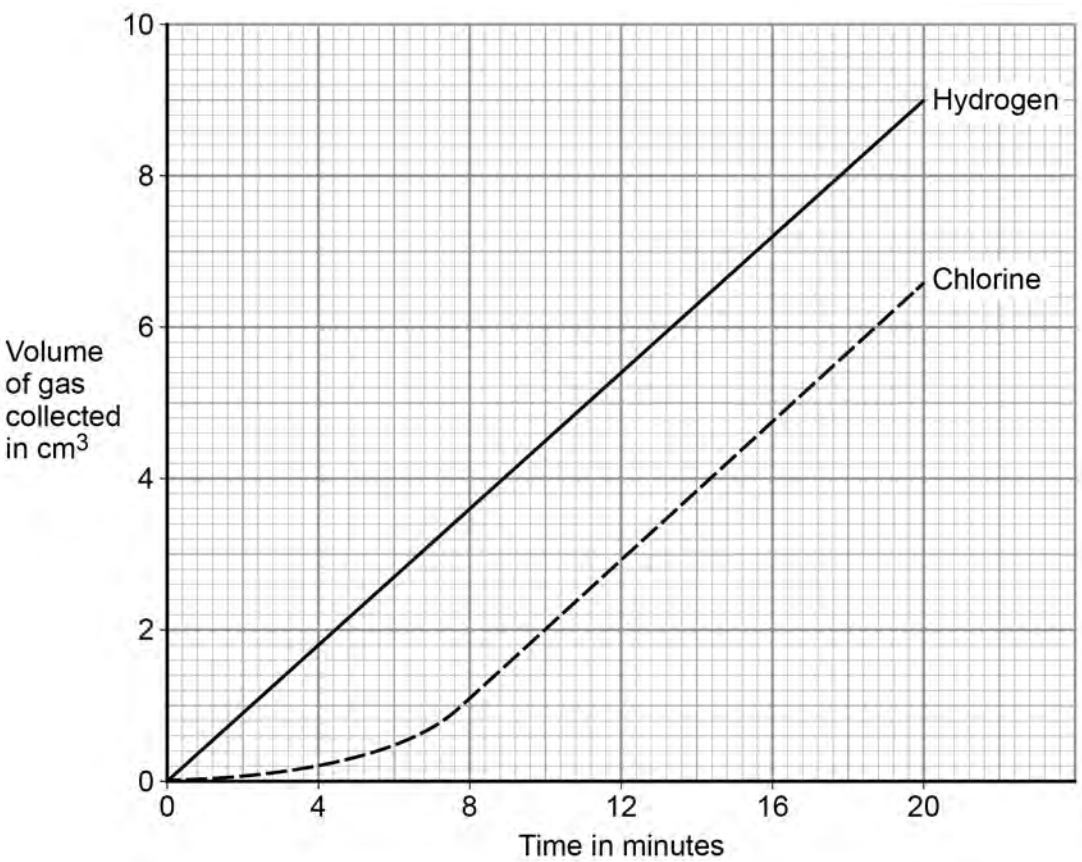


Another student used the correct apparatus.

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]**

4.4.3.3 Using electrolysis to extract metals

Question 31 · 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

### 4.4.3.3 Using electrolysis to extract metals

**Question 32**

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]**

$\rightarrow \quad O_2 \quad +$

4.4.3.3 Using electrolysis to extract metals

Question 32 · 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

4.4.3.3 Using electrolysis to extract metals

Question 32 · 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

4.4.3.3 Using electrolysis to extract metals

Question 33

November 2020 | 8462/1H | Original Q4

**0 4** This question is about electrolysis.

A student investigated the electrolysis of copper chromate solution.

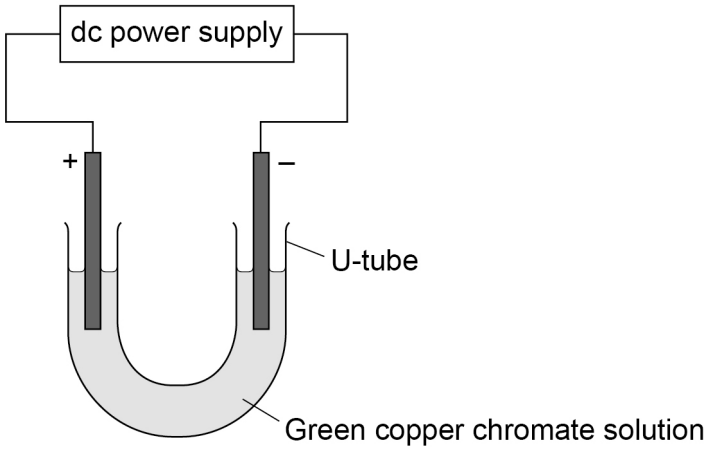
Copper chromate solution is green.

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<br>Bubbles formed at the electrode | Solution turned blue<br>Solid formed on the electrode |

4.4.3.3 Using electrolysis to extract metals

Question 33 · 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

4.4.3.3 Using electrolysis to extract metals

Question 34

November 2021 | 8462/1H | Original Q7

**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]**

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

**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 | | |

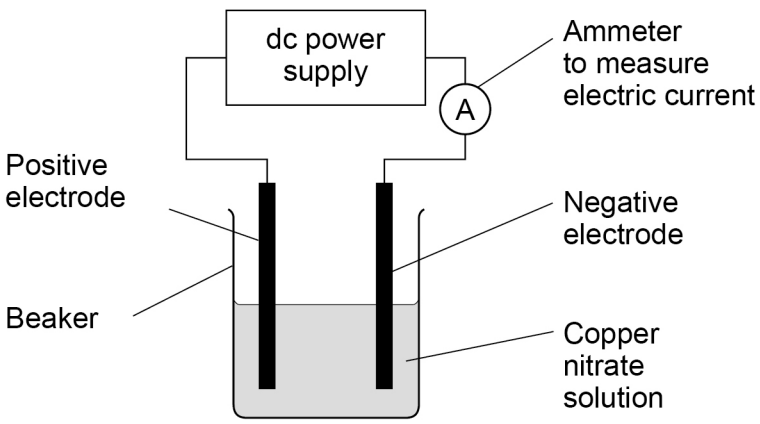
Question 34 · continued



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.

4.4.3.3 Using electrolysis to extract metals

Question 34 · 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**

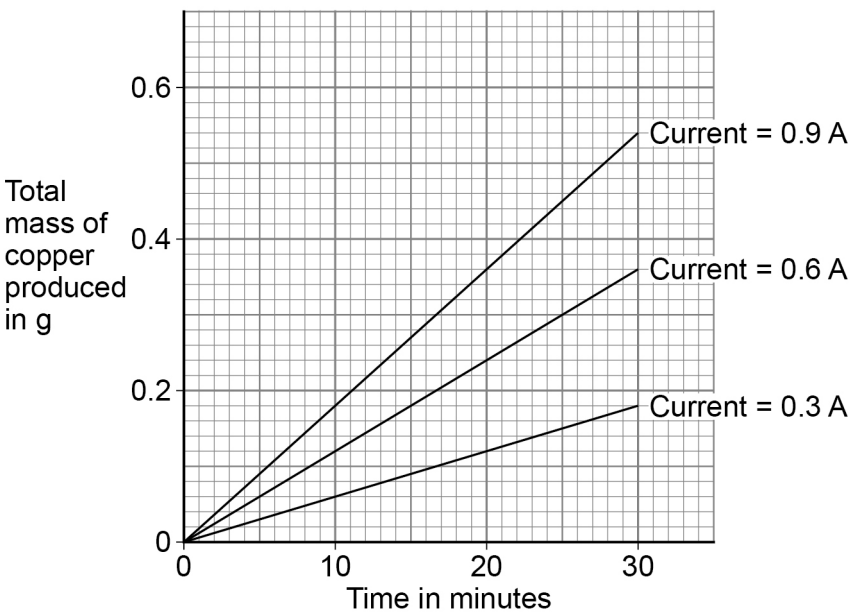
Question 34 · continued



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]**

4.4.3.3 Using electrolysis to extract metals

Question 34 · 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 = $6.02 \times 10^{23}$ per mole

**[3 marks]**

Number of atoms (3 significant figures) = _____

17

4.4.3.3 Using electrolysis to extract metals

Question 35

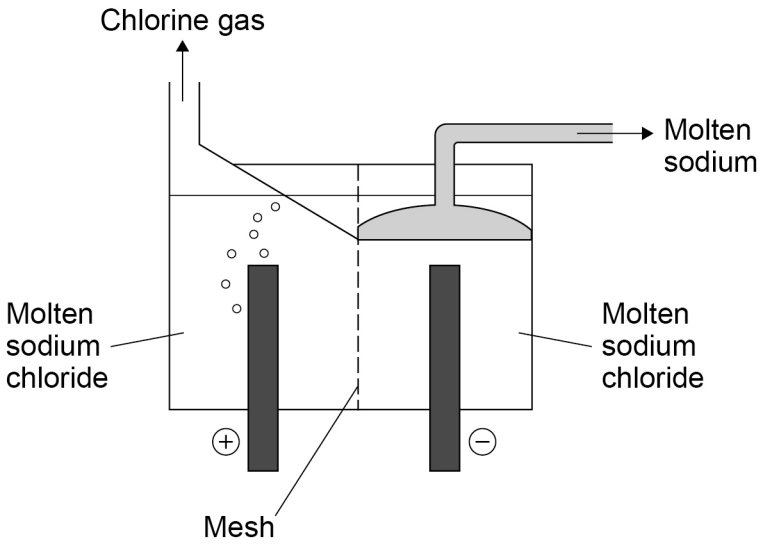
June 2022 | 8462/1H | Original Q6

**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.

$Na + e^- \rightarrow Na^+$ ☐

$Na \rightarrow Na^+ + e^-$ ☐

$Na^+ + e^- \rightarrow Na$ ☐

$Na^+ \rightarrow Na + e^-$ ☐

4.4.3.3 Using electrolysis to extract metals

Question 35 · 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**

Question 35 · 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

### 4.4.3.3 Using electrolysis to extract metals

**Question 36**

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**

4.4.3.3 Using electrolysis to extract metals

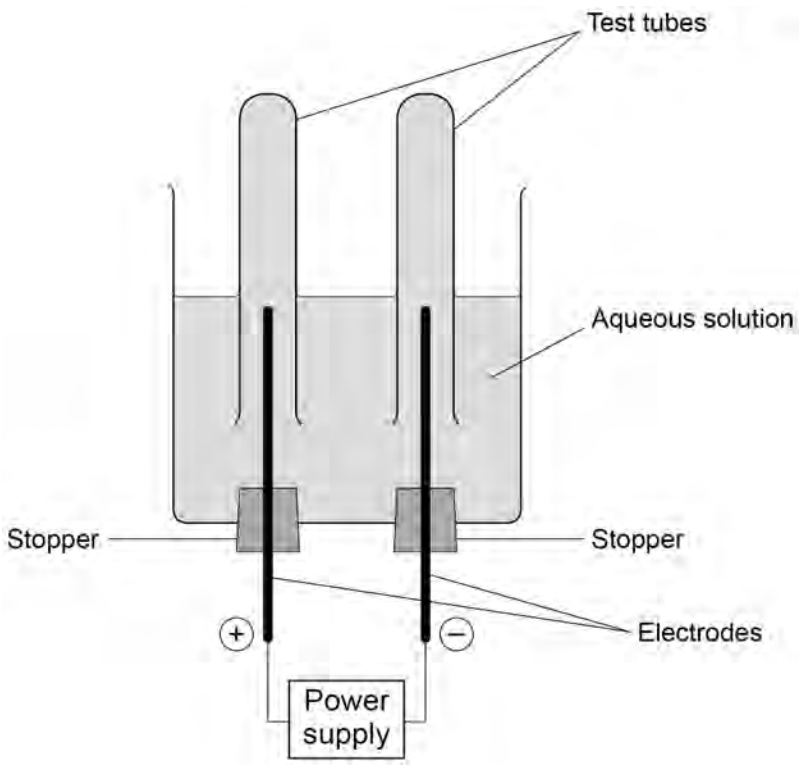
Question 36 · continued



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

**Figure 7** shows the apparatus.

**Figure 7**



Question 36 · 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

### 4.4.3.3 Using electrolysis to extract metals

**Question 37**

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]**

4.4.3.3 Using electrolysis to extract metals

Question 37 · 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]**

_____

_____

_____

_____

_____

_____

**11**