AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.4.1.3

# Extraction of metals and reduction

## Past-paper questions

| | |
|---|---|
| Tier | **Higher** |
| Question groups | **66** |
| 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.

**4.4.1.3 Extraction of metals and reduction**

**Question 01**

January 2007 | CHY1H | Original Q3 | Legacy

**3** Many everyday items are made from iron.

(a) Haematite is an *ore* of iron. Haematite contains iron oxide, $Fe_2O_3$.

(i) What is the meaning of the term *ore*?

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.....

*(1 mark)*

(ii) Iron can be produced by reacting iron oxide with carbon in a blast furnace.

What type of reaction produces the iron?

.....

.....

*(1 mark)*

(iii) The word equation for this reaction is:

iron oxide + carbon → iron + carbon dioxide

Complete and balance the symbol equation for this reaction.

.....$Fe_2O_3$ + .....C → ..... + .....

*(2 marks)*

**Question 3 continues on the next page**

**4.4.1.3 Extraction of metals and reduction**

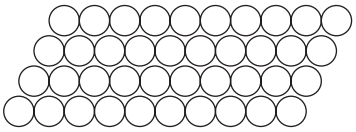
**Question 01 · continued**



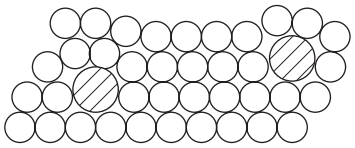
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(b) Pure iron is relatively soft and not very strong.

The iron from the blast furnace is very hard and brittle. It contains about 4 % carbon and is used as cast iron.



Pure iron



Cast iron

Explain the differences in the properties of pure iron and cast iron by referring to the diagrams.

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*(3 marks)*

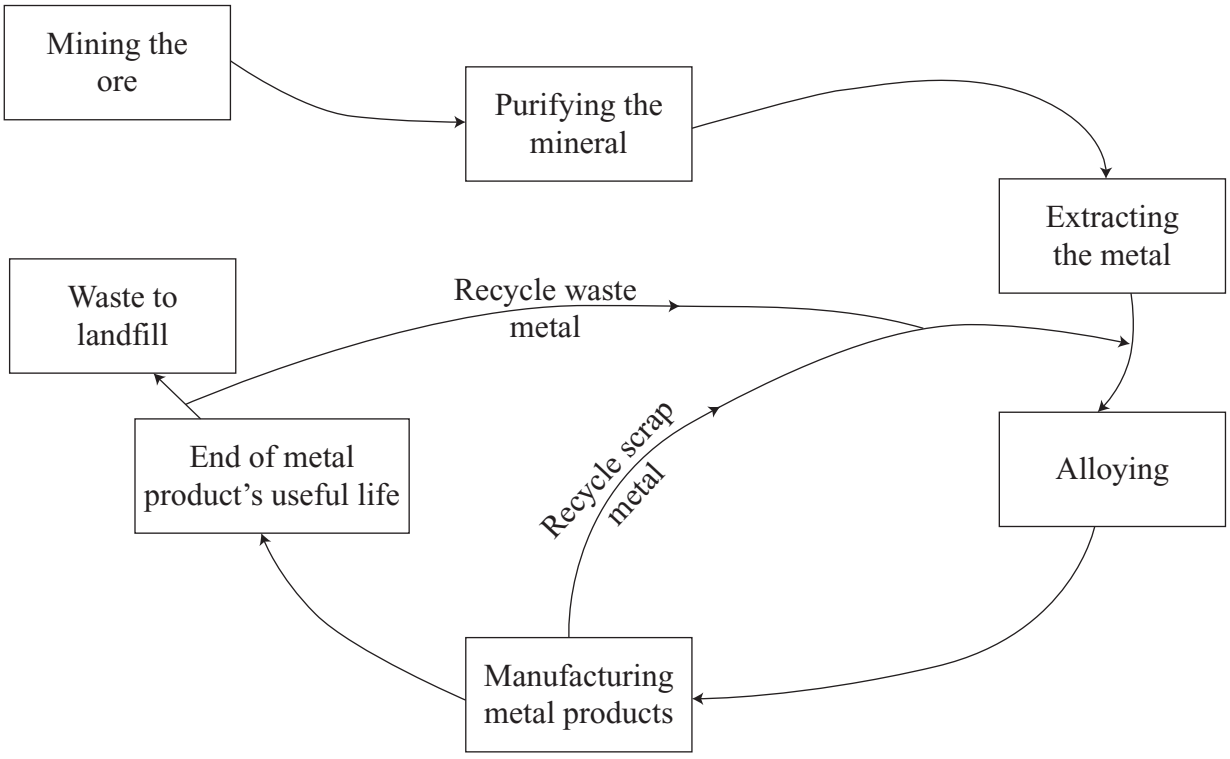
**4.4.1.3 Extraction of metals and reduction**

**Question 01 · continued**



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(c) The diagram shows the way in which iron is extracted, used and recycled.




Explain why the recycling of iron is necessary for sustainable development.

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*(3 marks)*

10

4.4.1.3 Extraction of metals and reduction

Question 02

March 2007 | CHY1A | Original Q6 | Legacy

## QUESTION SIX

Titanium is extracted from titanium oxide in this two-stage process.

**Stage 1**: titanium oxide + carbon + chlorine → titanium chloride + carbon dioxide

**Stage 2**: titanium chloride + sodium → titanium + sodium chloride

**Stage 2** takes place inside a furnace where the temperature needed is greater than 500 °C.
This procedure is a batch process which means that the furnace does not operate continuously but is cooled after each operation so that the titanium can be removed.

**6A** Titanium is not extracted in a blast furnace because . . .

**1** carbon is too dangerous to use.

**2** titanium cannot be extracted by reduction with carbon.

**3** titanium oxide is highly reactive.

**4** titanium is too valuable.

**6B** One of the products of **Stage 1** may increase . . .

**1** acid rain.

**2** global dimming.

**3** global warming.

**4** the ozone layer.

**6C** Titanium metal is produced in **Stage 2** because . . .

**1** chlorine is more reactive than titanium.

**2** sodium is more reactive than oxygen.

**3** sodium is more reactive than titanium.

**4** titanium is more reactive than carbon.

4.4.1.3 Extraction of metals and reduction

Question 02 · continued



**6D** Extraction of iron in the blast furnace is a continuous process.
One reason why the continuous process requires less energy than the batch process is that . . .

**1** iron ore is more plentiful than titanium ore.

**2** the furnace is maintained at a high temperature.

**3** iron ore contains fewer impurities than titanium ore.

**4** the continuous process is completed more quickly.

**Turn over for the next question**

### 4.4.1.3 Extraction of metals and reduction

**Question 03**

June 2007 | CHY1A | Original Q1 | Legacy

**QUESTION ONE**

This question is about iron and steel.

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

**A** hard

**B** resistant to corrosion

**C** easily shaped

**D** brittle

Iron from the blast furnace has few uses because it is . . . **1** . . . .

A low carbon steel is used to make wire because it is . . . **2** . . . .

A high carbon steel is used to make hammers and chisels because it is . . . **3** . . . .

A stainless steel is used to make cutlery because it is . . . **4** . . . .

4.4.1.3 Extraction of metals and reduction

Question 04

June 2007 | CHY1A | Original Q5 | Legacy

## QUESTION FIVE

This question is about the metals copper and zinc.

**5A** Copper and zinc can be extracted from their oxides by strongly heating the oxides with carbon.

In these reactions, the oxides are . . .

**1** oxidised.

**2** distilled.

**3** reduced.

**4** combined.

**5B** Copper can also be extracted by passing an electric current through . . .

**1** solid copper oxide.

**2** a solution of a copper compound.

**3** a copper-rich ore.

**4** impure copper.

**5C** There is a lot of research into new ways of extracting copper from low-grade ores.

One reason for this is . . .

**1** a significant rise in the price of copper.

**2** more copper ore is being found.

**3** a reduction in the use of copper.

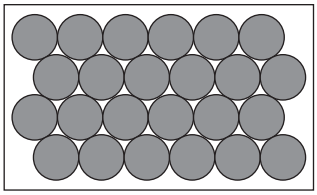
**4** low-grade ores contain more copper.

4.4.1.3 Extraction of metals and reduction

Question 04 · continued



**5D** The diagram shows the arrangement of the atoms in pure copper.



Pure copper is quite soft. It can be made harder by mixing it with zinc.

This is because . . .

**1** the copper atoms cannot now easily slide over each other.

**2** the zinc atoms attach themselves strongly to the copper atoms.

**3** the zinc atoms form strong bonds with the copper atoms.

**4** zinc is harder than copper.

4.4.1.3 Extraction of metals and reduction

Question 05

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.

4.4.1.3 Extraction of metals and reduction

Question 05 · 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**

4.4.1.3 Extraction of metals and reduction

Question 06

June 2007 | CHY1A | Original Q8 | Legacy

## QUESTION EIGHT

Exhaust fumes from petrol-driven cars contain harmful gases, particularly acidic nitrogen oxide, poisonous carbon monoxide and unburned hydrocarbons.

Catalytic converters are fitted to these cars to help to reduce the quantities of these gases released into the atmosphere. The reaction in the converter can be summarised by this equation:

carbon monoxide + nitrogen oxide → carbon dioxide + nitrogen

The catalysts in the converters usually contain a mixture of two transition metals, platinum and rhodium.

These metals occur in the Earth's crust mainly with copper and nickel sulfide ores.
To extract the metals, the ores are roasted in air which produces sulfur dioxide.

**8A** The balanced, symbol equation for the reaction between carbon monoxide and nitrogen oxide is . . .

**1** $2CO + 2NO \rightarrow 2CO_2 + N_2$

**2** $CO + NO \rightarrow CO_2 + N_2$

**3** $2CO + 2NO \rightarrow CO_2 + N_2$

**4** $2CO + 2NO \rightarrow CO_2 + 2N_2$

**8B** Which substance is reduced in this reaction?

**1** carbon monoxide

**2** carbon dioxide

**3** nitrogen oxide

**4** nitrogen

**8C** Why do some environmental organisations question the benefits of catalytic converters?

**1** They are expensive to manufacture and make cars more expensive.

**2** Polluting gases are released both in producing them and in using them.

**3** They do not remove any of the harmful gases from the exhaust fumes.

**4** Nitrogen is a poisonous gas.

4.4.1.3 Extraction of metals and reduction

Question 06 · continued



**8D** What conclusion about the use of catalytic converters can safely be made from the information in this question?

**1** Transition metals are good conductors of heat and electricity.

**2** There are no harmful gases in the exhaust fumes from a car fitted with a catalytic converter.

**3** A catalytic converter reduces the amount of carbon monoxide in the exhaust fumes from a petrol-driven car.

**4** Catalytic converters work equally well in both diesel-driven and petrol-driven cars.

**Turn over for the next question**

**4.4.1.3 Extraction of metals and reduction**

**Question 07**



**2** Copper is a widely used metal. The main ore of copper contains copper sulfide. Copper can be extracted from copper sulfide in a three stage process.

(a) In the first stage of extraction the copper sulfide is heated in air.

(i) Balance the symbol equation for the reaction.

$$Cu_2S + .....O_2 \rightarrow .....CuO + SO_2$$

*(1 mark)*

(ii) Explain why there would be an environmental problem if the gas from this reaction were allowed to escape into the atmosphere.

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*(2 marks)*

(b) In the second stage copper oxide, CuO, is reduced using carbon.

Describe and explain what happens during this reaction.

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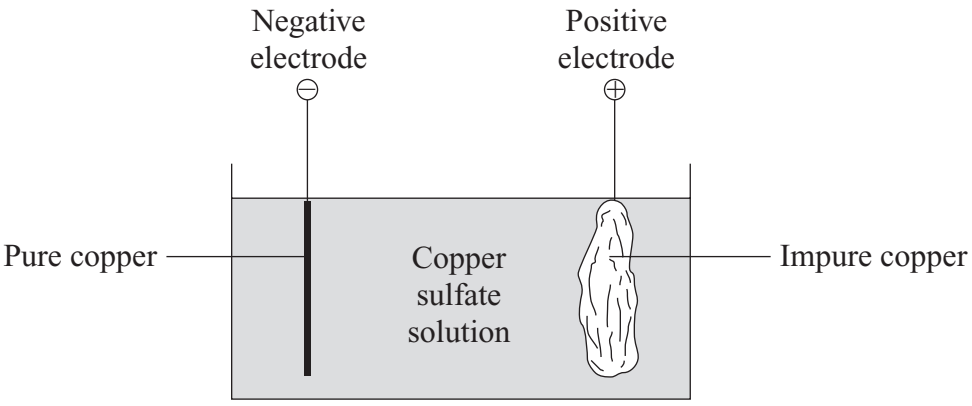
*(2 marks)*

**Question 07 · continued**



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(c) During the third stage the copper can be purified as shown in the diagram.




(i) What is the name of the type of process used for this purification?

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*(1 mark)*

(ii) Give **one** use of purified copper.

.....

*(1 mark)*

(d) Copper-rich ores are running out.

New ways of extracting copper from low grade ores are being researched.

Recycling of copper may be better than extracting copper from its ores.

Explain why.

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*(3 marks)*

10

4.4.1.3 Extraction of metals and reduction

Question 08

November 2007 | CHY1A | Original Q3 | Legacy

## QUESTION THREE

The table shows the emissions of sulfur dioxide, in the United Kingdom (UK), by different fuels in 1990 and in 2004.

| | Emissions of sulfur dioxide by different fuels in thousands of tonnes | | |
|---|---|---|---|
| **Fuel type** | **1990** | **2004** | **Percentage change between 1990 and 2004** |
| Coal | 2707 | 578 | –79 |
| Other solid fuels | 66 | 20 | –70 |
| Petroleum fuel oil | 605 | 78 | –87 |
| Other petroleum products (including petrol and diesel) | 193 | 83 | –57 |
| Gaseous fuels | 9 | 11 | +22 |
| Other emissions of sulfur dioxide | 118 | 58 | –51 |
| **TOTAL** | **3698** | **828** | **–78** |

- Since 1990, the amount of coal used in the generation of electricity at power stations has reduced by more than 60%.
- Since 1990, gaseous fuels have gradually been replacing fuel oil for electricity generation and in industry.
- The small amount of sulfur dioxide emitted from petrol and diesel fuel used in vehicles has decreased. It should decrease further with the increased use of low-sulfur petrol and diesel.

4.4.1.3 Extraction of metals and reduction

Question 08 · continued



**3A** Which fuel had the largest reduction in sulfur dioxide emissions, **in thousands of tonnes**, between 1990 and 2004?

**1** coal

**2** fuel oil

**3** other petroleum products

**4** gaseous fuels

**3B** This data suggests that emissions of sulfur dioxide between 1990 and 2004 . . .

**1** decreased for all fuels.

**2** decreased by more than 50% for all fuels.

**3** decreased by 78% for all fuels except gaseous fuels.

**4** decreased by more than 50% for all fuels except gaseous fuels.

**3C** Which reasonable prediction can be made from the evidence given at the beginning of this question?

**1** Sulfur dioxide emissions will begin to increase in the future as the number of vehicles on our roads increases.

**2** Overall, sulfur dioxide emissions are likely to continue to decrease.

**3** Supplies of fuel oil will be used up in another twenty years.

**4** Sulfur dioxide emissions from gaseous fuels will be greater than those from coal in the near future.

**3D** The data in the table was obtained by estimating the sulfur dioxide emissions from power stations, industrial plants, vehicles, etc.

Sulfur dioxide emissions in the UK could also be monitored by . . .

**1** providing each vehicle with a digital readout of sulfur dioxide emitted.

**2** measuring the sulfur dioxide concentrations in the air above the largest power stations and industrial plants.

**3** measuring the sulfur dioxide concentrations in the air at a large number of sites spread across the UK.

**4** measuring the sulfur content of all fuels before they are used.

4.4.1.3 Extraction of metals and reduction

Question 09

November 2007 | CHY1A | Original Q4 | Legacy

## QUESTION FOUR

### Jobs for bacteria – metal miners

Copper is found in the Earth's crust as the ore copper sulfide.

Traditionally, copper-rich ores are roasted and smelted to extract the metal.

Copper compounds can now be extracted from low-grade ores by bioleaching. In one type of bioleaching, the copper compounds are extracted from heaps of the crushed ore using bacteria.

- The bacteria live in the ore and gain their energy by slowly breaking down the copper compounds.
- The bacteria produce acidic solutions in which the copper compounds dissolve from the rocks and can be collected.
- The bacteria usually live at 35 °C to 40 °C. This means that breakdown of the compounds takes place only very slowly in the heaps of crushed ore.
- If these bacteria could work at a temperature 10 °C higher, then it is estimated that the rate of breakdown of the compounds would be twice as fast.

**4A** Which of the following is a disadvantage of extracting copper by bioleaching rather than by the traditional method?

**1** Bioleaching allows us to use low-grade ores.

**2** Bioleaching is more economical.

**3** Bioleaching is slower.

**4** Bioleaching uses less energy.

**4B** Copper compounds can be extracted more quickly from the ore in tanks at a temperature of 75 °C.

Where might bacteria able to work at this temperature be found?

**1** in rivers running through rainforests

**2** in polluted rivers

**3** in streams on the sides of active volcanoes

**4** in tropical seas

4.4.1.3 Extraction of metals and reduction

Question 09 · continued



**4C** About 20% of the world's copper is now extracted from low-grade ores by bioleaching.

Some scientists think that this figure will steadily increase in the next few years.

An increase in the use of bioleaching may **not** happen if . . .

**1** the price of copper increases dramatically.

**2** large new deposits of high-grade ore are discovered.

**3** the cost of energy rises quickly.

**4** sulfur dioxide levels in the atmosphere reach dangerous levels.

**4D** Copper can be obtained from solutions containing copper compounds by . . .

**1** electrolysis.

**2** oxidation.

**3** fractionation.

**4** combustion.

4.4.1.3 Extraction of metals and reduction

Question 10

November 2007 | CHY1A | Original Q7 | Legacy

## QUESTION SEVEN

Aluminium (7.85%) and iron (4.12%) are the two most abundant metals in the Earth's crust.

Iron is extracted from iron oxide in a blast furnace.

The equations show two reactions that occur in the furnace.

$$FeO + C \rightarrow Fe + CO$$

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

**7A** Which substances are reduced and which substances cause the reduction in these two reactions?

| | Substances reduced | Substances causing the reduction |
|---|---|---|
| **1** | iron | carbon and carbon monoxide |
| **2** | iron oxides | carbon monoxide and carbon dioxide |
| **3** | carbon and carbon dioxide | iron oxides |
| **4** | iron oxides | carbon and carbon monoxide |

**7B** Aluminium **cannot** be extracted from its ores in a blast furnace because . . .

**1** it is more reactive than iron.

**2** too many stages are needed in the process.

**3** too much energy is required.

**4** it is more reactive than carbon.

**Question 10 · continued** November 2007 | CHY1A | Original Q7 | Legacy

**7C** 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.

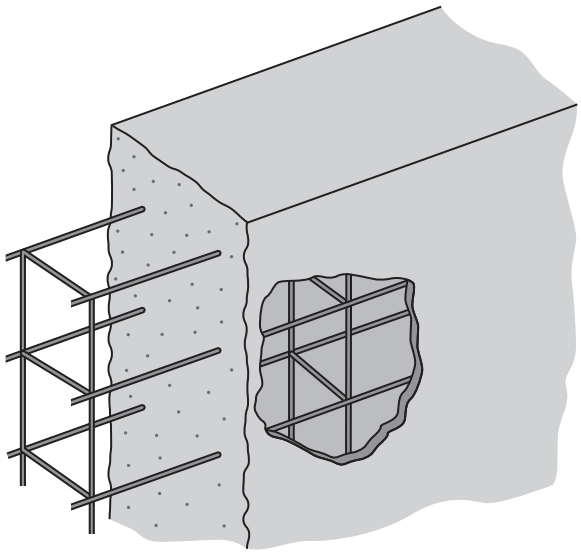
**1** **W** and **X**

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

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

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

**7D** The diagram shows some reinforced concrete.



Which one of the following is the best material to use to reinforce concrete?

**1** cast iron

**2** low carbon steel

**3** high carbon steel

**4** stainless steel

4.4.1.3 Extraction of metals and reduction

Question 11

November 2007 | CHY1A | Original Q9 | Legacy

## QUESTION NINE

In the 1980s, environmentalist Paul Ehrlich predicted that there would be a massive worldwide shortage of various natural resources. At the same time, economist Julian Simon said that natural resources were effectively infinite.

In 1988, the known resources of tin were estimated to last for 18 years. In 2006, there is still not a serious shortage of tin.

**9A** Which of the following is **not** a reason why Ehrlich's prediction of massive shortages has been proved wrong?

**1** Existing materials have been recycled.

**2** Existing resources have been used more efficiently.

**3** More material has been imported.

**4** New sources have been discovered.

**9B** The Coca-Cola company is a commercial organisation. Coke cans are now made from 80% less aluminium than 40 years ago.

What is the most probable reason for this?

**1** The company sells more Coca-Cola than 40 years ago.

**2** The price of aluminium has decreased.

**3** There is a serious shortage of aluminium.

**4** Thinner cans cut costs and increase profits.

**9C** The availability of metals has not decreased as fast as predicted 20 years ago. One reason for this is a reduction in the use of some metals.

Which of the following has **not** contributed to a reduction in the overall use of metals?

**1** Environmental concerns have caused more people to use energy saving lamps which has reduced the demand for tungsten.

**2** To reduce costs, 'tin' cans are now coated with plastic instead of tin.

**3** To reduce corrosion, aluminium has replaced iron in some of the body parts of cars.

**4** New technology has resulted in the use of more fibre optic cables and a reduced use of copper wire.

4.4.1.3 Extraction of metals and reduction

Question 11 · continued



**9D** The main source of tin is the ore tin sulfide. This is used to make tin oxide. The tin oxide is then heated with carbon to obtain the metal.

Why does it normally take less energy to obtain tin from scrap tin than to extract the tin from its ore?

**1** There are more impurities in scrap tin than in the tin ore.

**2** More waste materials are left from scrap tin than from tin ore.

**3** Scrap tin does not need to be reduced to tin.

**4** Tin sulfide contains the element sulfur.

**END OF TEST**

**4.4.1.3 Extraction of metals and reduction**

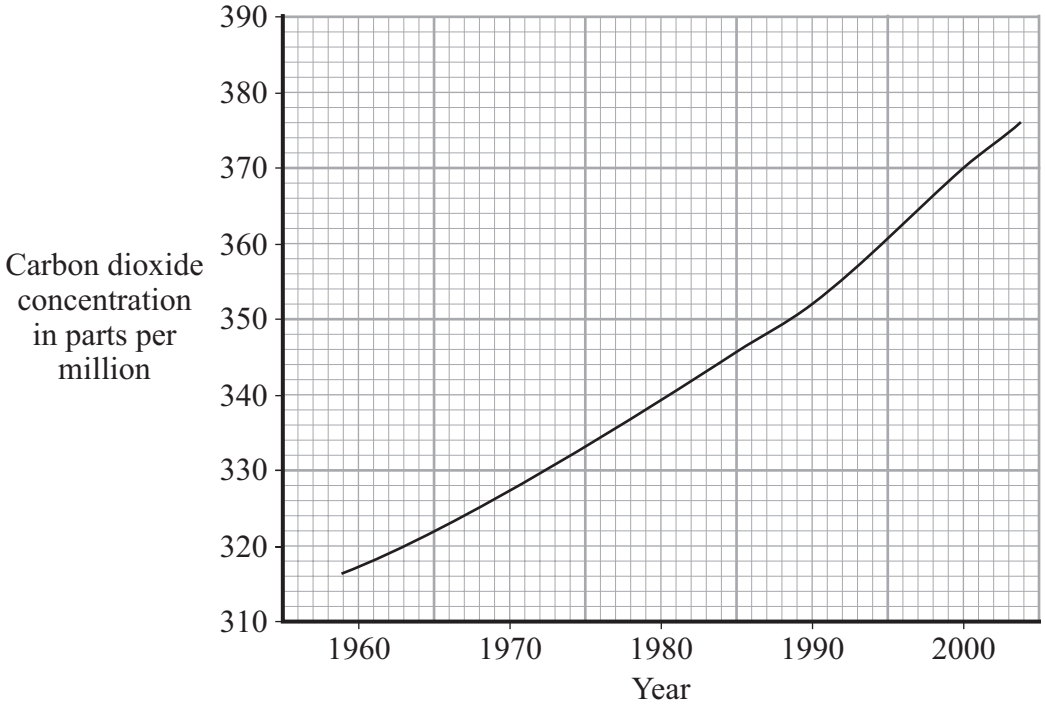
**Question 12**

November 2007 | CHY1B | Original Q4 | Legacy

## QUESTION FOUR

Measurements of carbon dioxide in the atmosphere have been made continuously for almost 50 years at the Mauna Loa Observatory, 4000 metres up a mountain in Hawaii.
This site is far enough away from any large carbon dioxide source to be a reliable measuring point.

**Atmospheric carbon dioxide levels measured at Mauna Loa, Hawaii**




**4A** What is the mean (average) rate of increase per year of carbon dioxide (in parts per million) in the atmosphere at Mauna Loa between 1990 and 2000?

**1** 1.8

**2** 18.0

**3** 352.0

**4** 370.0

**4B** The change in carbon dioxide concentration over the past 50 years is thought to be a result of . . .

**1** increased volcanic activity.

**2** an increase in the use of fossil fuels.

**3** variations in the Sun's energy output.

**4** an increase in ocean temperatures.

**4.4.1.3 Extraction of metals and reduction**

**Question 12 · continued**



**4C** Many scientists think that there is a close link between atmospheric carbon dioxide levels and global warming.
Some political leaders have taken no action to reduce carbon dioxide emissions.

One possible reason is that . . .

**1** restrictions on industrial development might result.

**2** their countries have few oil reserves.

**3** they do not think that scientists are qualified to make important judgements.

**4** they do not think that global warming will affect their country.

**4D** Concerns about carbon dioxide levels and global warming have increased research and technical development in some areas.

Which of these has **not** been part of this development?

**1** the use of ethanol as a fuel in cars

**2** the use of diesel oil instead of petrol in cars

**3** the use of vegetable oils as a fuel in cars

**4** the development of electric cars

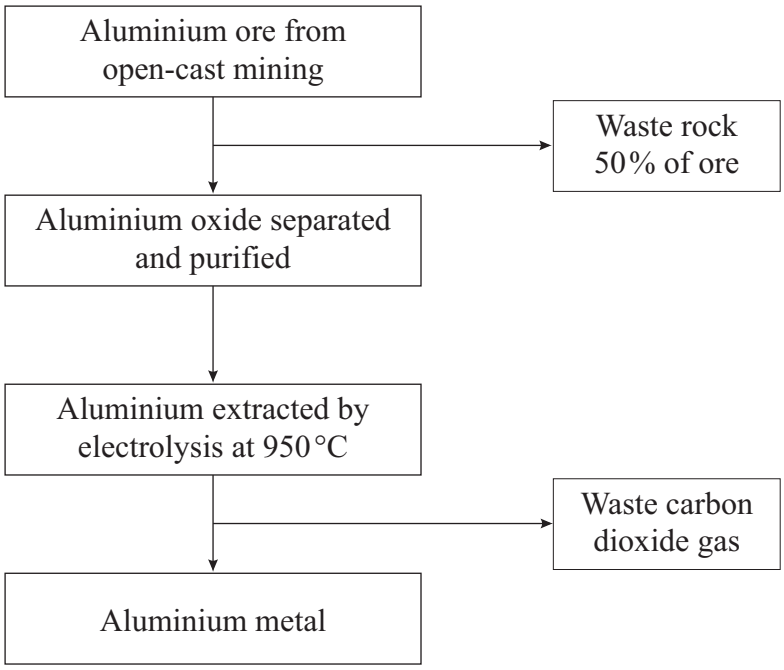
### 4.4.1.3 Extraction of metals and reduction

**Question 13**

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)*

**4.4.1.3 Extraction of metals and reduction**

**Question 13 · 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**

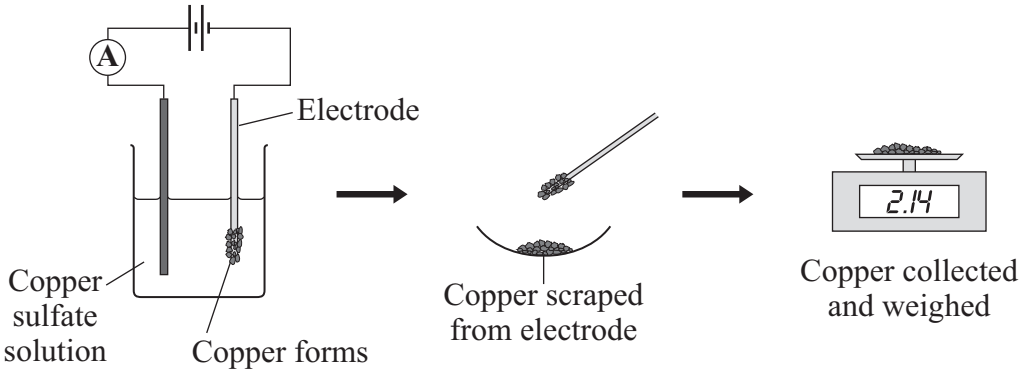
4.4.1.3 Extraction of metals and reduction

Question 14

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

4.4.1.3 Extraction of metals and reduction

Question 14 · 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.

**4.4.1.3 Extraction of metals and reduction**

**Question 15**

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.

- 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.

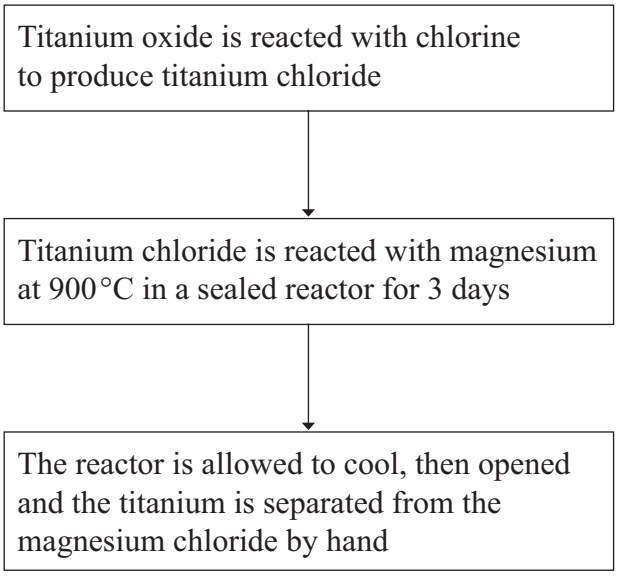
### 4.4.1.3 Extraction of metals and reduction

**Question 16**

June 2008 | CHY1H | Original Q4 | Legacy

**4** Titanium is used in aircraft, ships and hip replacement joints. Titanium is as strong as steel but 45 % lighter, and is more resistant to acids and alkalis.

Most titanium is produced from its ore, rutile (titanium oxide), by a batch process that takes up to 17 days.




Titanium reactors produce about 1 tonne of the metal per day.
Iron blast furnaces produce about 20 000 tonnes of the metal per hour.

**4** (a) Give **one** property of titanium that makes it more useful than steel for hip replacement joints.

.....

*(1 mark)*

**4** (b) In the reactor magnesium is used to produce titanium. If carbon were used instead of magnesium, no titanium would be produced.

What does this tell you about the relative reactivities of carbon, magnesium and titanium?

.....

.....

.....

.....

*(2 marks)*

**4.4.1.3 Extraction of metals and reduction**

**Question 16 · continued**



*for mark*

**4** (c) The use of titanium is limited because it is expensive.

Explain why titanium costs more than steel.

.....

.....

.....

.....

.....

.....

*(3 marks)*

6

**Turn over for the next question**

### 4.4.1.3 Extraction of metals and reduction

**Question 17**

November 2008 | CHY1AP | Original Q4 | Legacy

## QUESTION FOUR

The extraction of iron involves heating a mixture of iron ore, limestone and coke (carbon) at high temperatures in a blast furnace.

The limestone and iron ore are extracted from large quarries, some of which are found in areas of outstanding natural beauty.

**4A** Some people are against the development of these large quarries.

One reason is that the quarries . . .

**1** attract large numbers of tourists to visit the area.

**2** make unsightly scars on the landscape.

**3** are unnecessary because there are few uses for limestone.

**4** create a dangerous habitat for wildlife.

**4B** Some people support the development of these quarries.

One reason is that the working quarries . . .

**1** are always placed where the public cannot see them.

**2** conserve resources.

**3** provide employment for people who live in the area.

**4** provide an area for leisure activities.

**4C** Iron is produced continuously, sometimes for several years without shutting down the blast furnace.

This is done . . .

**1** because it is difficult to obtain large supplies of limestone.

**2** because it takes several years to reach the required temperature in the furnace.

**3** to minimise the energy costs.

**4** to ensure that the iron is of the highest quality.

**4D** Some iron is obtained by recycling scrap iron.

Why does it take less energy to make iron from scrap iron than to extract the iron from its ore?

**1** Scrap iron is an alloy.

**2** Scrap iron contains the element sulfur.

**3** Scrap iron does **not** have to be reduced using carbon.

**4** Corrosion of the scrap iron makes it easier to melt.

**Turn over for the next question**

### 4.4.1.3 Extraction of metals and reduction

**Question 18**

March 2009 | CHY1AP | Original Q2 | Legacy

## QUESTION TWO

This question is about the production of metals.

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

**A** decomposed

**B** acidified

**C** reduced

**D** extracted

Some metals are produced from their carbonate ores.

The ores are first . . . **1** . . . from the ground.

They are then heated until the metal carbonate is . . . **2** . . . .

When the ore is heated, sulfur impurities may react with air and eventually cause rainwater to be . . . **3** . . . .

Finally, the metal oxide can be reacted with carbon and so be . . . **4** . . . to the metal.

### 4.4.1.3 Extraction of metals and reduction

**Question 19**

March 2009 | CHY1AP | Original Q9 | Legacy

**QUESTION NINE**

A scientist investigated the chemistry of four metals, **W**, **X**, **Y** and **Z**.

These are the results.

- The oxides of **W** and **Y** were reduced to the metal when mixed with carbon and heated.
- The oxide of **Z** could not be reduced by heating with carbon.
- The oxide of **X** decomposed to the metal on heating alone.
- **Y** gave off hydrogen gas with dilute acid but **W** and **X** did not.

**9A** Starting with the most reactive, what is the order of reactivity for the four metals?

**1** **X**, **W**, **Y**, **Z**

**2** **Z**, **Y**, **W**, **X**

**3** **X**, **W**, **Z**, **Y**

**4** **Z**, **W**, **Y**, **X**

**9B** Which metal is most likely to be found in the ground as the pure metal?

**1** **W**

**2** **X**

**3** **Y**

**4** **Z**

**9C** How would metal **Z** be produced?

**1** by mixing the oxide of **Z** with carbon and heating

**2** by mixing an oxide of **Z** with the metal **W** and heating

**3** by electrolysis of a molten oxide of **Z**

**4** by heating the oxide of **Z** in a stream of hydrogen gas

**4.4.1.3 Extraction of metals and reduction**

**Question 19 · continued**



**9D** The equation for the reduction of the oxide of **W** to the metal **W** can be represented by the following equation:

$$2\mathbf{W}_2O_3 \quad + \quad \boldsymbol{q}C \quad = \quad 3CO_2 \quad + \quad \boldsymbol{r}\mathbf{W}$$

What values of ***q*** and ***r*** are needed to balance the equation?

**1** ***q*** = 3 and ***r*** = 4

**2** ***q*** = 2 and ***r*** = 2

**3** ***q*** = 4 and ***r*** = 2

**4** ***q*** = 3 and ***r*** = 2

**END OF TEST**

4.4.1.3 Extraction of metals and reduction

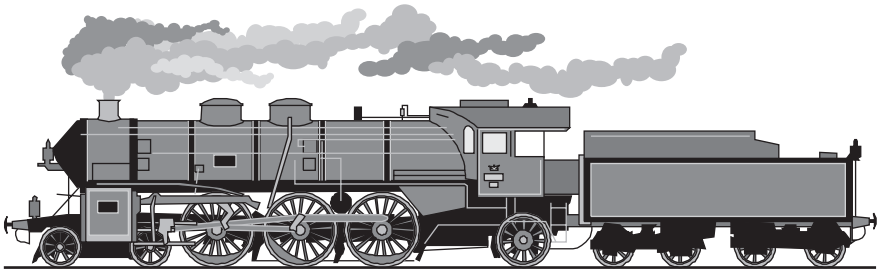
Question 20

June 2009 | CHY1AP | Original Q4 | Legacy

## QUESTION FOUR

Read the following newspaper extract.

### Copper shortage puts the brakes on Flying Scotsman renovation



A major overhaul of the steam locomotive Flying Scotsman has been delayed by more than a year because of the lack of copper for the engine's firebox.

Copper is at a record high price because of huge demand from China's rapidly growing economy. The price had been falling over the previous 30 years, which had discouraged exploration for new supplies.

Other users have been forced to switch to cheaper materials, with plumbers using plastic rather than copper pipes, and telecoms firms using fibre-optic cables rather than copper wire.

**4A** The firebox of a steam locomotive is where coal is burned to boil water.

Which of these properties is **not** important when using copper in the firebox of a steam locomotive?

**1** Copper is a good conductor of heat.

**2** Copper has a high melting point.

**3** Copper is a good conductor of electricity.

**4** Copper is easily hammered and bent into shape.

4.4.1.3 Extraction of metals and reduction

Question 20 · continued



**4B** Which row in the table explains why copper was important to plumbers and telecoms firms?

| | Plumbers | Telecoms firms |
|---|---|---|
| **1** | High melting point | Good heat conductor |
| **2** | Good electrical conductor | High melting point |
| **3** | Resistant to corrosion | Good electrical conductor |
| **4** | High boiling point | Good electrical conductor |

**4C** Which of the following would make the copper shortage in China and other countries worse?

**1** recycling scrap copper rather than burying it in landfill sites

**2** developing alternative materials to do the same job as copper

**3** extraction of copper from low-grade ores

**4** forcing suppliers to reduce the price of copper

**4D** Why is it environmentally important to recycle copper rather than mine fresh copper ore?

**1** Copper ores are non-renewable, and a lot of energy is needed to extract copper from its ore.

**2** There are enormous reserves of copper ore which are not expected to run out for hundreds of years.

**3** Copper ores are cheap, and scrap copper is easy to dispose of in landfill sites.

**4** Copper recycling is difficult and uses more energy when compared with processing new ores.

**4.4.1.3 Extraction of metals and reduction**

**Question 21**

June 2009 | CHY1AP | Original Q6 | Legacy

## QUESTION SIX

Two problems caused by the gases released when fossil fuels are burned are:

- acid rain, caused by sulfur dioxide and oxides of nitrogen
- global warming, caused by carbon dioxide.

Fuel manufacturers have introduced low-sulfur fuels to try to reduce the sulfur dioxide emissions.

**6A** Low-sulfur fuels were introduced in the UK in 2000. The amount of acid rain gases from transport increased from 2000 to 2004.

This increase could be due to . . .

**1** the partial combustion of low-sulfur fuels.

**2** an increasing number of vehicles on the UK's roads.

**3** increasing emissions of carbon monoxide.

**4** some sulfur dioxide not dissolving in rain water.

**6B** Carbon monoxide and oxides of nitrogen can be removed by a catalytic converter in the exhaust system of vehicles. The two gases, carbon monoxide (CO) and nitrogen dioxide ($NO_2$), react to produce carbon dioxide ($CO_2$) and nitrogen ($N_2$).

The balanced equation that correctly describes this reaction is . . .

**1** $CO + NO_2 \rightarrow CO_2 + N_2$

**2** $2CO + NO_2 \rightarrow 2CO_2 + N_2$

**3** $3CO + 2NO_2 \rightarrow 3CO_2 + N_2$

**4** $4CO + 2NO_2 \rightarrow 4CO_2 + N_2$

**6C** The conversion of carbon monoxide and nitrogen dioxide to carbon dioxide and nitrogen will . . .

**1** decrease acid rain and decrease global warming.

**2** decrease acid rain and increase global warming.

**3** increase acid rain and increase global warming.

**4** increase acid rain and decrease global warming.

4.4.1.3 Extraction of metals and reduction

Question 21 · continued



**6D** Environmentalists have encouraged the use of hydrogen as a fuel instead of petrol because . . .

**1** hydrogen is a renewable fuel obtained from sugar.

**2** carbon monoxide is the main product of combustion.

**3** no carbon dioxide is produced when hydrogen is burned.

**4** hydrogen produces only low levels of sulfur dioxide when burned.

**Turn over for the next question**

4.4.1.3 Extraction of metals and reduction

Question 22

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 22 · 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.

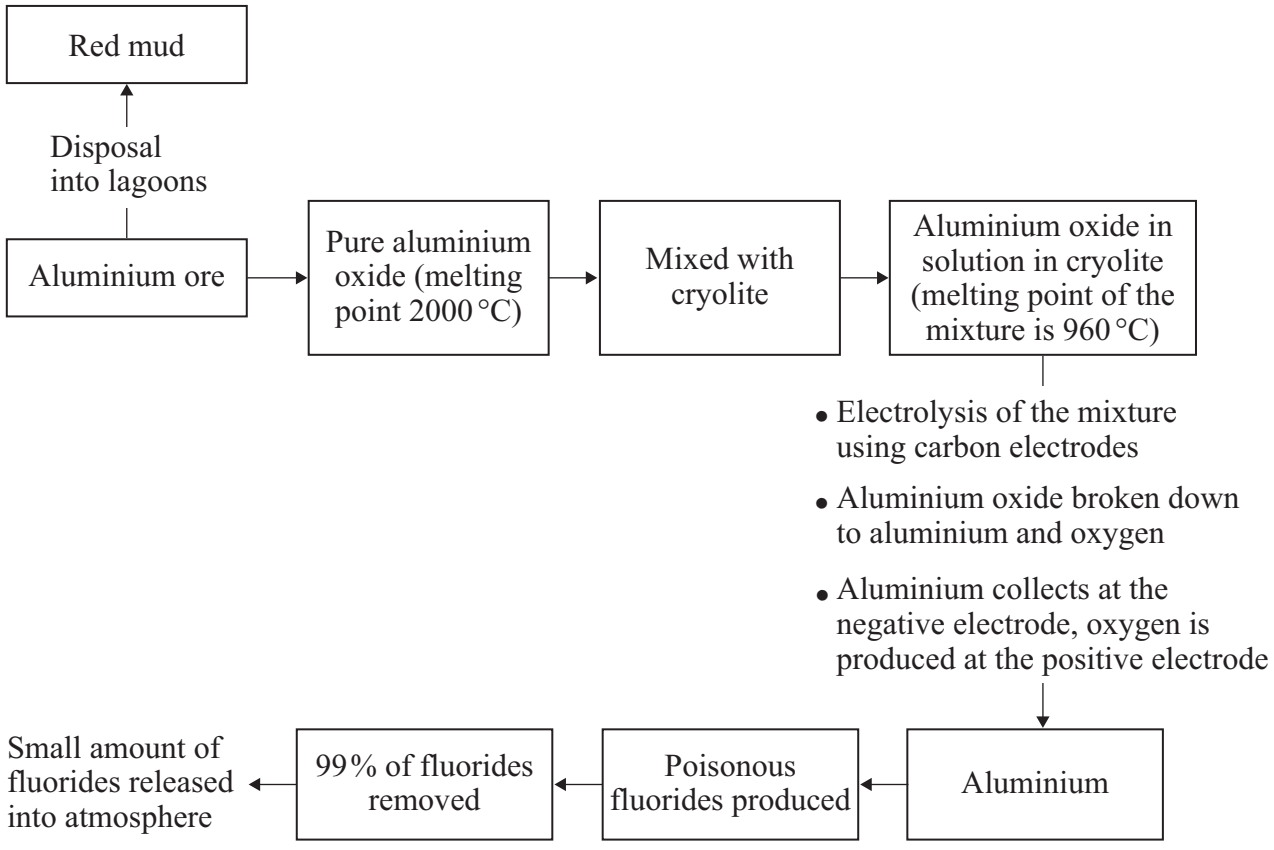
4.4.1.3 Extraction of metals and reduction

Question 23

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.

4.4.1.3 Extraction of metals and reduction

Question 23 · continued



**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**

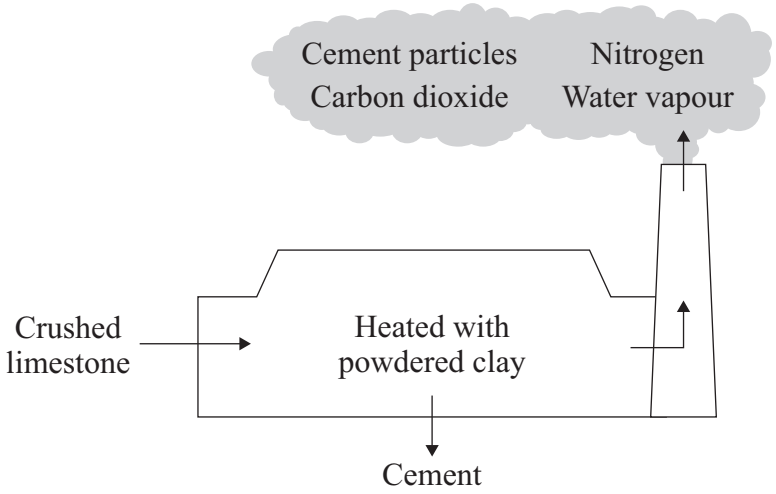
### 4.4.1.3 Extraction of metals and reduction

**Question 24**

June 2009 | CHY1H | Original Q1 | Legacy

**1** A limestone quarry is in an area of natural beauty and near several villages.
The company operating the quarry wants planning permission to build a new cement works in the quarry.

The diagram shows some of the substances used and produced at a cement works.




**1** (a) Limestone is mainly calcium carbonate, $CaCO_3$.
Write the correct number in the box to complete each sentence.

**1** (a) (i) The formula shows that calcium carbonate, $CaCO_3$,

contains ☐ different elements.

*(1 mark)*

**1** (a) (ii) Calcium carbonate, $CaCO_3$, contains a total number of ☐ atoms.

*(1 mark)*

**4.4.1.3 Extraction of metals and reduction**

**Question 24 · continued**



*for mark*

**1** (b) The company wants the new cement works because the nearest cement works is 100 km from the quarry. The company argues that a new cement works sited inside the quarry would reduce carbon dioxide emissions.

Suggest why the new cement works might reduce carbon dioxide emissions.

.....

.....

.....

*(1 mark)*

**1** (c) Residents from the villages near the quarry are concerned that there will be atmospheric pollution from the new cement works.

**1** (c) (i) Name and explain how **one** of the emissions from the chimney causes atmospheric pollution.

Name of emission: .....

Explanation: .....

.....

*(2 marks)*

**1** (c) (ii) Suggest what the company could do to reduce this atmospheric pollution.

.....

.....

*(1 mark)*

**6**

### 4.4.1.3 Extraction of metals and reduction

**Question 25**

June 2009 | CHY1H | Original Q4 | Legacy

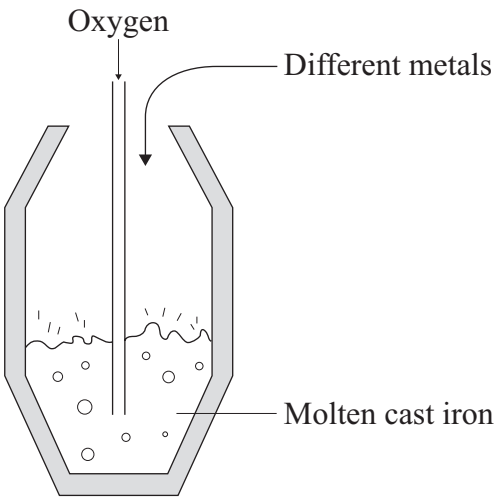
**4** The demand for iron and steel is high.

**4** (a) Iron that is extracted from its oxide by carbon reduction in a blast furnace is called cast iron. Cast iron contains about 4% carbon. This carbon makes cast iron very brittle.

Carbon steels can be made by the following processes.

- Blowing oxygen into molten cast iron to remove most of the carbon.
- Adding a calculated amount of carbon.

Sometimes different metals may also be added to the molten carbon steels.




**4** (a) (i) Suggest how blowing oxygen into molten cast iron removes most of the carbon.

.....

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*(2 marks)*

**4** (a) (ii) Why are different metals sometimes added to molten carbon steels?

.....

.....

*(1 mark)*

4.4.1.3 Extraction of metals and reduction

Question 25 · continued



*for mark*

**4** (b) The percentage of iron and steel recycled in the UK has been increasing.

| Year | % iron and steel recycled |
|---|---|
| 1998 | 25 |
| 2000 | 35 |
| 2002 | 42 |
| 2004 | 46 |
| 2006 | 57 |

The UK government has set targets for the percentage of iron and steel to be recycled. In 2006 the target was exceeded.

Suggest **two** reasons why the UK government wants to encourage recycling of iron and steel.

1 .....

.....

2 .....

.....

*(2 marks)*

5

**4.4.1.3 Extraction of metals and reduction**

**Question 26**

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)*

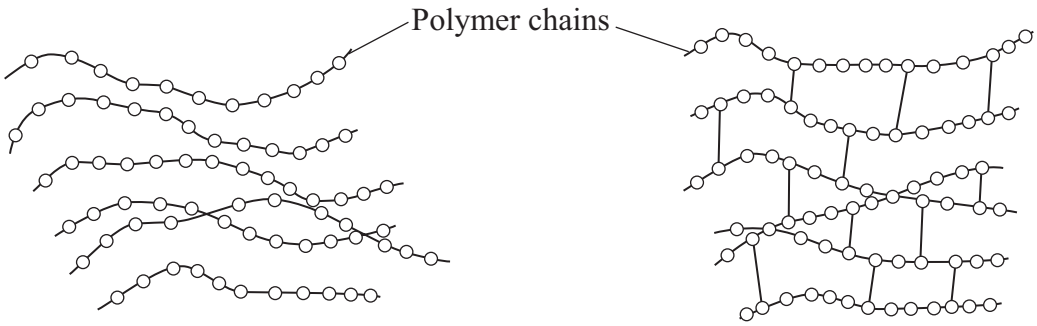
**6** (a) (ii) PEX is a shape memory polymer. What property does a shape memory polymer have?

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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.

.....

.....

.....

.....

.....

*(3 marks)*

**4.4.1.3 Extraction of metals and reduction**

**Question 26 · 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

4.4.1.3 Extraction of metals and reduction

Question 27

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.

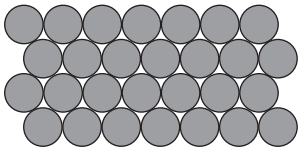
**4** the metal ores are very abundant.

4.4.1.3 Extraction of metals and reduction

Question 27 · 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. |

**4.4.1.3 Extraction of metals and reduction**

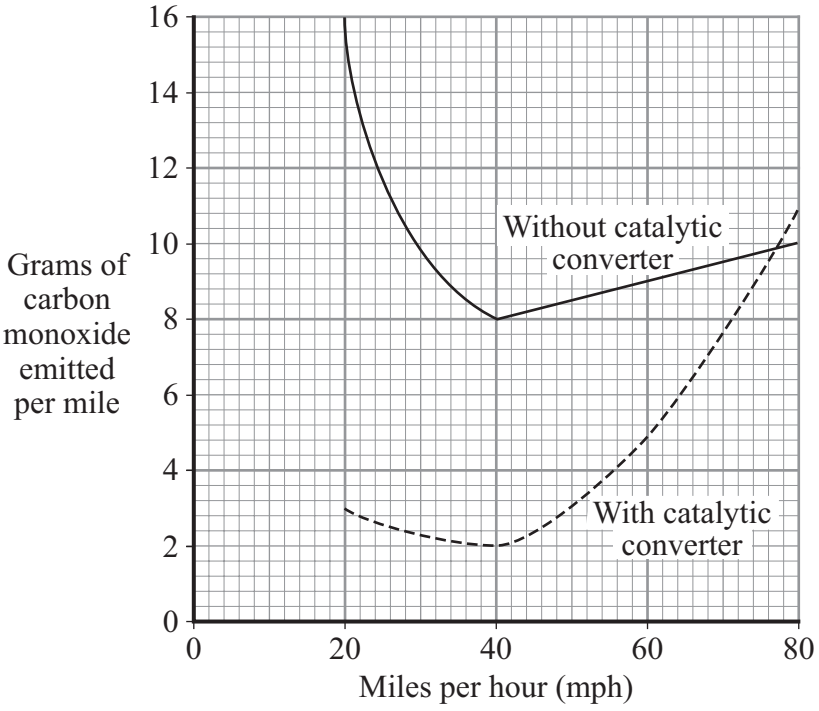
**Question 28**

November 2009 | CHY1AP | Original Q6 | Legacy

## QUESTION SIX

Catalytic converters are fitted to car exhausts to reduce harmful emissions from the car.
In a catalytic converter, carbon monoxide is converted into carbon dioxide. However, catalytic converters are not 100% efficient.

The graph shows the effect of a catalytic converter.




**6A** At 40 mph, a catalytic converter reduces carbon monoxide emissions by . . .

**1** 2 g per mile.

**2** 4 g per mile.

**3** 6 g per mile.

**4** 8 g per mile.

Question 28 · continued



**6B** At what speed does a car with a catalytic converter emit the same amount of carbon monoxide as a car without a catalytic converter?

**1** 40 mph

**2** 70 mph

**3** 77 mph

**4** 80 mph

**6C** Which statement about the graph is true?

**1** Catalytic converters work best at speeds above 40 mph.

**2** The higher the speed, the higher the carbon monoxide emissions.

**3** There is no connection between speed and the amount of carbon monoxide emitted.

**4** Catalytic converters are more effective at lower speeds.

**6D** All the carbon monoxide emitted into the atmosphere eventually forms carbon dioxide.

Which of the following statements is true?

**1** Using catalytic converters reduces the amount of carbon dioxide put into the atmosphere by cars.

**2** The effect that car emissions have on global warming is not changed by using catalytic converters.

**3** Carbon dioxide levels are not affected by the use of cars.

**4** A car without a catalytic converter produces more carbon dioxide than a car fitted with one.

### 4.4.1.3 Extraction of metals and reduction

**Question 29**



**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.

.....

.....

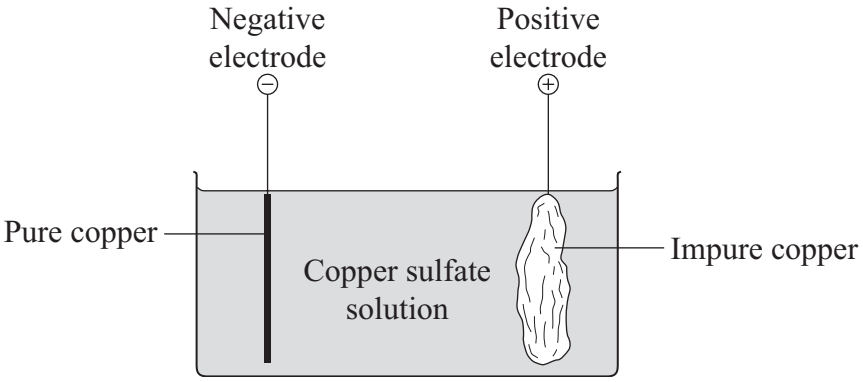
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*(2 marks)*

**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?

.....

*(1 mark)*

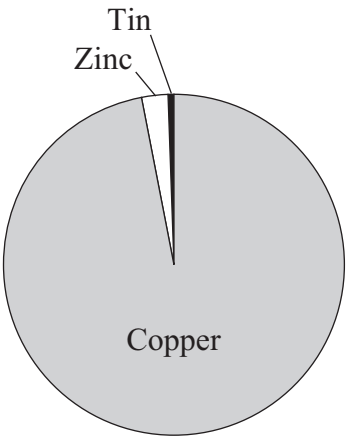
**4.4.1.3 Extraction of metals and reduction**

**Question 29 · continued**



*for mark*

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




The composition of a 2p coin in 1991

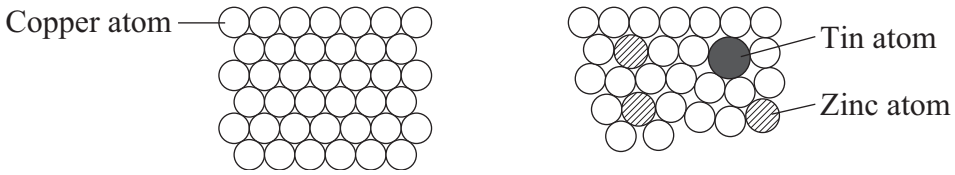
**5** (b) (i) How was copper made harder for use in 2p coins in 1991?

.....

.....

*(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.




.....

.....

.....

.....

.....

.....

*(2 marks)*

6

**4.4.1.3 Extraction of metals and reduction**

**Question 30**

March 2010 | CHY1AP | Original Q6 | Legacy

## QUESTION SIX

Titanium cannot be extracted by carbon reduction of its ore, which contains titanium dioxide, $TiO_2$

Titanium is obtained from titanium dioxide in two stages.

In **Stage 1**, the titanium dioxide is converted to titanium chloride ($TiCl_4$).

titanium dioxide + chlorine + carbon → titanium chloride + carbon dioxide

The possible escape of carbon dioxide and chlorine (a poisonous gas) can cause damage to the environment.

In **Stage 2**, the titanium chloride formed is reacted with sodium.

titanium chloride + sodium → titanium + sodium chloride

The sodium chloride formed is removed by washing the titanium with hydrochloric acid but the disposal of the acidic sodium chloride solution causes another environmental problem.

**6A** Which of the following is a correctly balanced equation for **Stage 2**?

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

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

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

**4** $TiC1_4 + 4Na \rightarrow Ti + 4NaCl$

**6B** Sodium, not carbon, is used to extract titanium from its compounds.

Which row in the table does this information suggest to be the order of reactivity for carbon, sodium and titanium?

| | **Most reactive** → | | **Least reactive** |
|---|---|---|---|
| **1** | Sodium | Titanium | Carbon |
| **2** | Sodium | Carbon | Titanium |
| **3** | Titanium | Sodium | Carbon |
| **4** | Carbon | Titanium | Sodium |

**4.4.1.3 Extraction of metals and reduction**

**Question 30 · continued** March 2010 | CHY1AP | Original Q6 | Legacy

**6C** In **Stage 1**, the gases carbon dioxide and chlorine should **not** be allowed to escape into the air because . . .

**1** both add to global dimming.

**2** both are poisonous gases.

**3** carbon dioxide adds to global warming and chlorine is toxic.

**4** carbon dioxide adds to global dimming and chlorine is expensive.

**6D** In **Stage 2**, the best way to dispose of the acidic sodium chloride solution is . . .

**1** to pump it into the ocean.

**2** to pump it into landfill sites.

**3** to boil the solution until all the acid has evaporated.

**4** to separate the acid from the salt so that both can be used in other chemical processes.

4.4.1.3 Extraction of metals and reduction

Question 31

March 2019 | CHY1AP | Original Q8 | Legacy

## QUESTION EIGHT

The table below gives the temperatures at which some metal carbonates decompose.

| Name of metal carbonate | Position of metal in periodic table | Temperature at which it decomposes |
|---|---|---|
| Sodium carbonate | Group 1 | Decomposes only above its melting point of 851 °C |
| Calcium carbonate | Third in Group 2 | 825 °C |
| Magnesium carbonate | Second in Group 2 | 350 °C |
| Zinc carbonate | In the transition metal block | 300 °C |

**8A** Which of the following pairs of carbonates would decompose at 750 °C?

**1** sodium carbonate and calcium carbonate

**2** calcium carbonate and magnesium carbonate

**3** sodium carbonate and zinc carbonate

**4** magnesium carbonate and zinc carbonate

**8B** A valid conclusion that can be drawn from the temperatures in the table is that . . .

**1** transition metal carbonates are the most thermally stable.

**2** Group 2 metal carbonates become less thermally stable down the group.

**3** zinc carbonate is the least thermally stable.

**4** Group 1 metal carbonates melt before they decompose.

Question 31 · continued

March 2010 | CHY1AP | Original Q8 | Legacy

**8C** Extracting metal carbonates, such as limestone, from the ground can cause environmental damage.

A mining company issued this statement:

> Our research shows that our method of mining for limestone causes very little environmental damage.

This statement is . . .

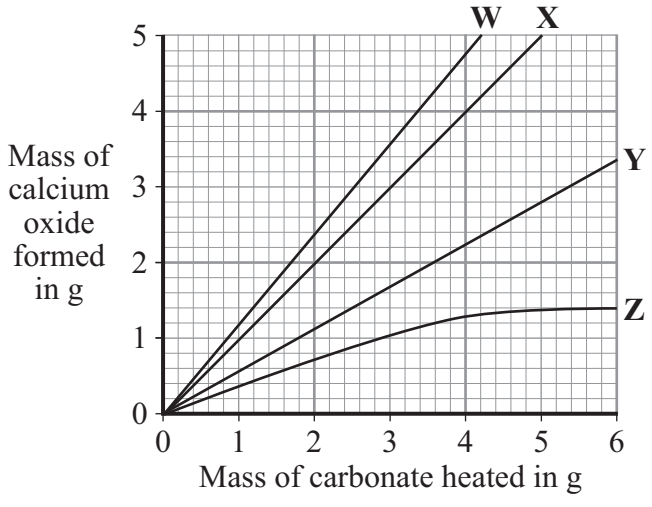
**1** given on invalid evidence.

**2** an invalid hypothesis.

**3** a biased conclusion.

**4** based on hearsay.

**8D** Assuming complete reaction, which of the following lines on the graph represents the mass of calcium oxide formed by heating different masses of calcium carbonate?




**1** **W**

**2** **X**

**3** **Y**

**4** **Z**

4.4.1.3 Extraction of metals and reduction

Question 32

March 2010 | CHY1BP | Original Q8 | Legacy

## QUESTION EIGHT

All the gases in the Earth's atmosphere can be separated by this method:

- remove the carbon dioxide
- cool the air down to a very low temperature so that it liquefies
- allow the liquefied gases to warm up
- collect the gases as they boil off at different temperatures.

The table below gives some information about the gases in the Earth's atmosphere.

| Gas | Melting point in °C | Boiling point in °C | Abundance in % |
|---|---|---|---|
| Oxygen | −223 | −183 | 21 |
| Nitrogen | −209 | −196 | 78 |
| Carbon dioxide | −57 | −57 | 0.03 |
| Helium | −272 | −269 | Less than 0.1 |
| Neon | −248 | −246 | Less than 0.1 |
| Argon | −189 | −186 | 0.9 |
| Krypton | −157 | −153 | Less than 0.1 |
| Xenon | −112 | −108 | Less than 0.1 |

**8A** In this method of separation, carbon dioxide is always removed from the air before it is liquefied because . . .

**1** it would react with the other gases present.

**2** it would solidify during cooling and block up the pipes.

**3** it is a greenhouse gas and would warm up the apparatus.

**4** it is a heavy gas and would not separate properly from the mixture.

4.4.1.3 Extraction of metals and reduction

Question 32 · continued



**8B** How many of the gases listed in the table (excluding carbon dioxide), would be liquid at –150 °C?

**1** None

**2** 1

**3** 2

**4** 3

**8C** Argon is the cheapest of the noble gases to produce because . . .

**1** there is high demand for it for use in light bulbs.

**2** it is the most abundant of the noble gases.

**3** it is the gas that vaporises most easily and so requires the least energy to remove it.

**4** it is an unreactive gas so it can easily be separated from the other gases in the air.

**8D** Earth's early atmosphere contained a high percentage (%) of carbon dioxide.

One reason for the reduction of the percentage of carbon dioxide is that carbon dioxide . . .

**1** has dissolved in the oceans.

**2** has been reduced to carbon monoxide.

**3** has decomposed to form carbon and oxygen.

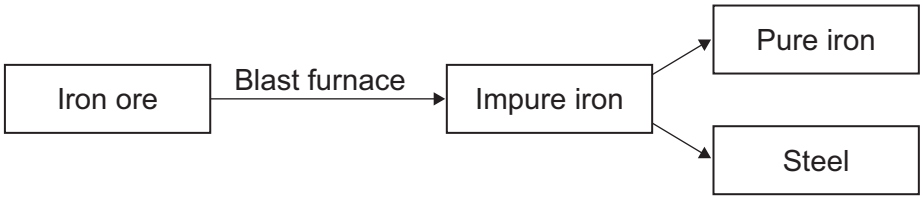
**4** has been released by plants.

### 4.4.1.3 Extraction of metals and reduction

**Question 33** June 2010 | CHY1AP | Original Q3 | Legacy

**QUESTION THREE**

The flow chart shows how iron ore can be changed into useful materials.




**3A** Iron ore is the starting material for making iron because . . .

**1** iron ore is magnetic.

**2** iron ore contains a reasonable amount of iron oxide.

**3** a lot of energy is needed to convert iron ore into iron.

**4** mining iron ore does not cause any environmental problems.

**3B** In the blast furnace, iron oxide is converted to iron using carbon. This is because . . .

**1** iron is less reactive than carbon.

**2** iron is more reactive than carbon.

**3** carbon is a cheap material to use.

**4** carbon combines with the metal impurities in the iron ore, leaving iron.

4.4.1.3 Extraction of metals and reduction

Question 33 · continued



**3C** Impure iron is hard and brittle. This is because in impure iron . . .

**1** the impurities distort the layers of atoms so they cannot slide over each other.

**2** the carbon breaks up the iron structure, allowing it to bend easily.

**3** its structure has been destroyed by heating to a very high temperature.

**4** all the atoms are the same and so remain in a regular arrangement.

**3D** When impure iron is converted into steel, . . .

**1** all the carbon is removed and not replaced.

**2** the amount of carbon is carefully controlled.

**3** all the metal impurities are removed and not replaced.

**4** chromium is always added to the iron.

**Turn over for the next question**

### 4.4.1.3 Extraction of metals and reduction

**Question 34**

June 2010 | CHY1AP | Original Q9 | Legacy

**QUESTION NINE**

This question is about metals.

**9A** A scientist investigated some reactions of three metals, **K**, **L** and **M**.

- Metal **L** can be extracted by mixing its oxide with carbon and heating.
- Metal **M** cannot be extracted by mixing its oxide with carbon and heating.
- Hydrogen will displace metal **K** from its oxide but will not displace metal **L** from its oxide.
- The oxide of metal **K** is decomposed to the metal on heating alone.

The order of reactivity for the three metals, with the most reactive first, is . . .

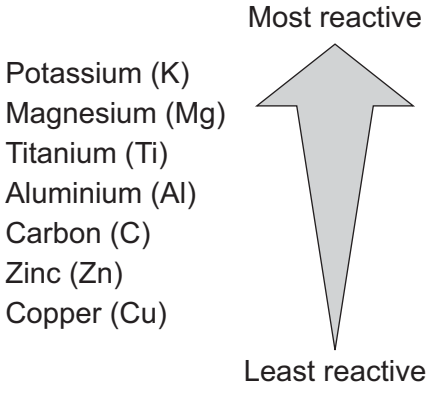
**1** **K, L, M.**

**2** **M, L, K.**

**3** **L, K, M.**

**4** **K, M, L.**

**9B** The order of reactivity for several metals and carbon is shown below.




Which of the following shows a correctly balanced equation for a possible reaction?

**1** $ZnO + C \rightarrow Zn + CO_2$

**2** $Cu + MgO \rightarrow CuO + Mg$

**3** $2Mg + K_2O \rightarrow 2MgO + 2K$

**4** $2Al + 3ZnO \rightarrow 3Zn + Al_2O_3$

4.4.1.3 Extraction of metals and reduction

Question 34 · continued



Titanium is extracted from titanium chloride by mixing the titanium chloride with sodium and heating the mixture. The reaction is carried out in a furnace above 500 °C.

It is a batch process; this means that the furnace does not operate continuously but is cooled after each operation so that the titanium can be removed.

**9C** Which row in the table correctly describes the reaction for the extraction of titanium?

| | Why the reaction occurs | Products of the reaction |
|---|---|---|
| **1** | Sodium is more reactive than titanium | Titanium, sodium and chlorine |
| **2** | Titanium is more reactive than sodium | Titanium and chlorine |
| **3** | Titanium is more reactive than sodium | Titanium and sodium chloride |
| **4** | Sodium is more reactive than titanium | Titanium and sodium chloride |

**9D** The extraction of iron in a blast furnace is a continuous process.

Over a period of 12 months, the batch method for extraction of titanium requires much more energy per tonne of metal than the continuous method for the extraction of iron.

This is because . . .

**1** the batch process is completed more quickly.

**2** iron is less reactive than titanium.

**3** the furnace is not maintained at a high temperature.

**4** titanium chloride is not as pure as iron oxide.

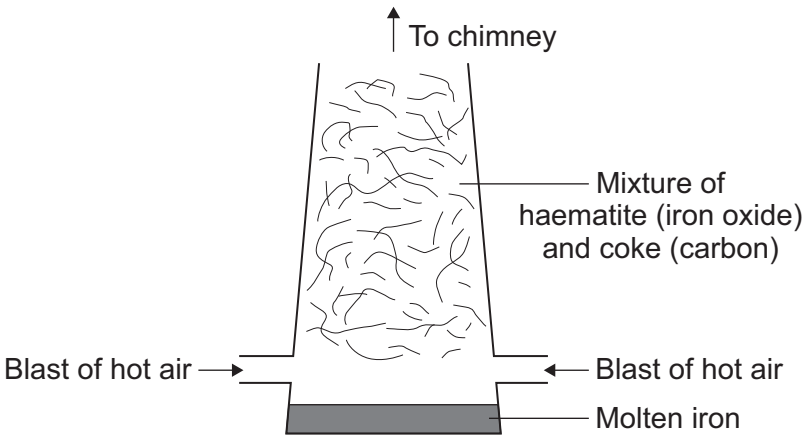
**END OF TEST**

### 4.4.1.3 Extraction of metals and reduction

**Question 35**

June 2010 | CHY1H | Original Q3 | Legacy

**3** Iron is produced by reacting a mixture of haematite and coke in a blast furnace.
Haematite is an ore of iron containing iron oxide ($Fe_2O_3$).
Coke is made from coal and is almost pure carbon.




**3 (a) (i)** The coke burns in air. This reaction heats the furnace to above 1300 °C.

Complete the chemical equation for carbon reacting with oxygen to form carbon dioxide.

..... + $O_2$ → $CO_2$

*(1 mark)*

**3 (a) (ii)** Carbon monoxide is also formed in the furnace. Carbon monoxide reacts with iron oxide to produce iron and carbon dioxide.

iron oxide + carbon monoxide → iron + carbon dioxide

Complete and balance the chemical equation for the production of iron.

$Fe_2O_3$ + 3CO → ..... + .....

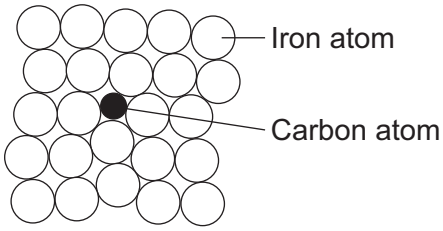
*(2 marks)*

4.4.1.3 Extraction of metals and reduction

Question 35 · continued



**3 (a) (iii)** Iron from a blast furnace is called cast iron and contains about 4% carbon.




Why is pure iron softer than cast iron?

.....

.....

.....

*(1 mark)*

**3 (b)** Steel is made by reducing the percentage of carbon in cast iron and then adding different metals to form the type of steel required.

In the UK we use about 1.8 billion steel cans every year but only 30% of these are recycled. Recycling reduces waste. Producing steel from recycled cans requires only 25% of the energy needed to make steel from iron ore.

Give **three** environmental benefits of recycling a higher percentage of used steel cans.

1 .....

.....

2 .....

.....

3 .....

.....

*(3 marks)*

7

### 4.4.1.3 Extraction of metals and reduction

**Question 36**

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. |

### 4.4.1.3 Extraction of metals and reduction

**Question 37**

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.

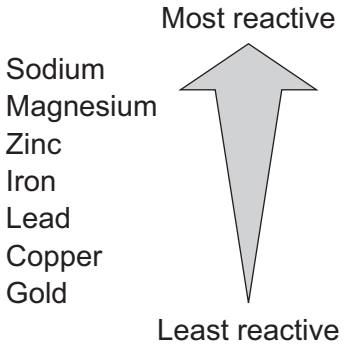
4.4.1.3 Extraction of metals and reduction

Question 38

November 2010 | CHY1AP | Original Q8 | Legacy

## QUESTION EIGHT

A metal will displace a less reactive metal from its compounds.




If a reaction occurs, it releases heat. The reactivity of metals can be investigated by measuring the temperature rise if a fair test is carried out between metals and metal compounds.

| Metal | Metal compound | Temperature rise in °C |
|---|---|---|
| Zinc | Lead nitrate | 10 |
| Iron | Lead nitrate | 6 |
| Zinc | Copper sulfate | 19 |
| Magnesium | Copper sulfate | 48 |
| Copper | Zinc sulfate | 0 |

**8A** The results in the table suggest that the largest rise in temperature occurs when . . .

**1** a metal reacts with a metal compound that is a sulfate.

**2** a transition metal is used with a metal compound.

**3** there is a large difference in reactivity between the metal used and the metal in the metal compound.

**4** a Group 1 metal reacts with a transition metal compound.

4.4.1.3 Extraction of metals and reduction

Question 38 · continued



**8B** Using copper and zinc sulfate does **not** cause a temperature rise.

This is because . . .

**1** not enough copper is used.

**2** zinc is more reactive than copper.

**3** copper corrodes easily.

**4** too much zinc sulfate is added.

**8C** Which of the following metals will cause the largest temperature rise when added to iron nitrate solution?

**1** gold

**2** sodium

**3** lead

**4** zinc

**8D**
- Carbon can reduce zinc oxide.
- Magnesium can react with carbon dioxide.
- Carbon can produce iron from iron oxide.

Where should carbon be placed in the reactivity series?

**1** above magnesium but below sodium

**2** above zinc but below magnesium

**3** below iron but above lead

**4** below lead but above copper

### 4.4.1.3 Extraction of metals and reduction

**Question 39**



**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.

.....

.....

.....

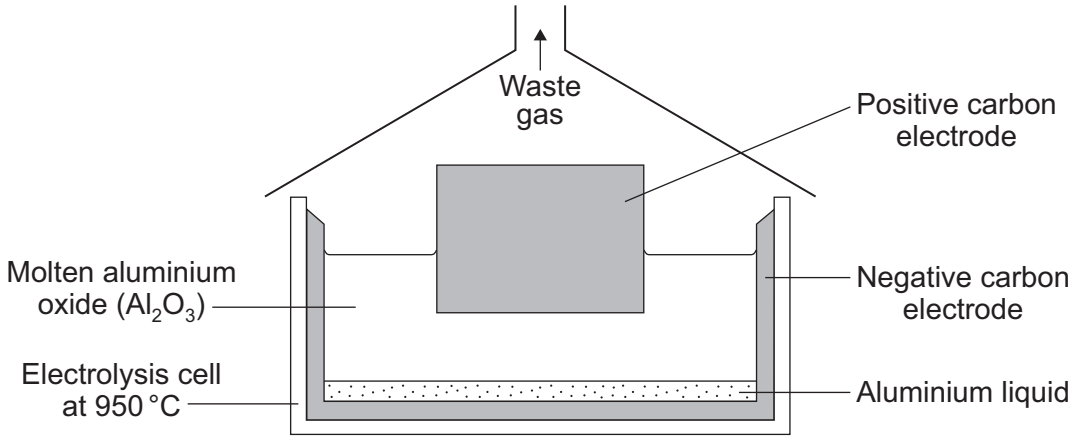
*(1 mark)*

4.4.1.3 Extraction of metals and reduction

Question 39 · 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

### 4.4.1.3 Extraction of metals and reduction

**Question 40**

January 2011 | CHY1H | Original Q4 | Legacy

**4** Titanium is used for replacement hip joints because it has a low density, is strong and does not corrode.
Titanium is extracted from titanium dioxide ($TiO_2$) in three stages.

**4 (a)** **Stage 1**
Titanium dioxide is converted into titanium chloride ($TiCl_4$) because the metal cannot be extracted from its oxide by *reduction* with carbon.

**4 (a) (i)** What does *reduction* mean?

.....

.....

*(1 mark)*

**4 (a) (ii)** Balance the chemical equation for the conversion of titanium dioxide to titanium chloride.

$TiO_2$ + $Cl_2$ + C → $TiCl_4$ + $CO_2$

*(1 mark)*

**4 (a) (iii)** Chemical equations are always balanced. Explain why.

.....

.....

.....

*(1 mark)*

**4 (b)** **Stage 2**
Titanium is extracted from the titanium chloride by reacting it with sodium at 1000 °C in a reactor.
The only other substance in the reactor is argon gas.

$TiCl_4$ + 4Na → Ti + 4NaCl

**4 (b) (i)** What does this tell you about the reactivity of sodium compared with titanium?

.....

.....

*(1 mark)*

**4 (b) (ii)** Suggest why the reactor contains argon and **not** air.

.....

.....

*(1 mark)*

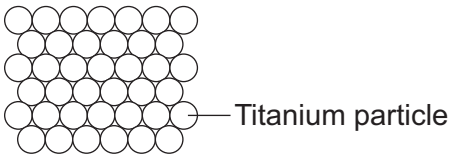
4.4.1.3 Extraction of metals and reduction

Question 40 · continued

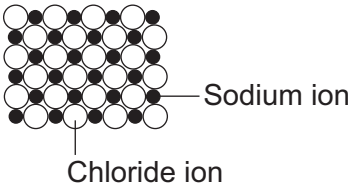


**4 (c)** **Stage 3**
After **Stage 2** the titanium is separated from the products by washing out the sodium chloride with water.
The diagrams show sections through the lattice of titanium metal and the lattice of sodium chloride.

**Titanium**




**Sodium chloride**




How do the diagrams show that:

**4 (c) (i)** titanium is an element

.....

.....

*(1 mark)*

**4 (c) (ii)** sodium chloride is a compound?

.....

.....

.....

.....

*(2 marks)*

8

### 4.4.1.3 Extraction of metals and reduction

**Question 41**

March 2011 | CHY1AP | Original Q2 | Legacy

**QUESTION TWO**

This question is about the positions of four metals in the reactivity series.

- Only metal **C** can be extracted by heating the metal oxide in hydrogen.
- Only metals **B** and **C** can be extracted by mixing their oxides with carbon and heating strongly.
- When the oxide of metal **A** is mixed with metal **D** and heated, metal **A** is produced.

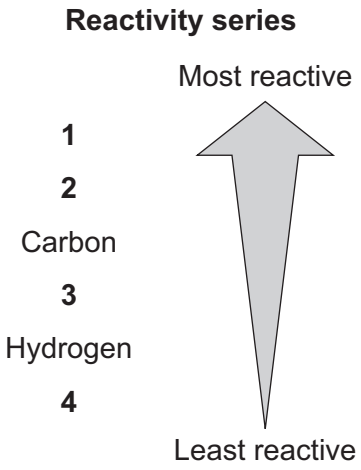
Match metals, **A**, **B**, **C** and **D**, with the numbers **1–4** in the reactivity series.

**A** Metal **A**

**B** Metal **B**

**C** Metal **C**

**D** Metal **D**



### 4.4.1.3 Extraction of metals and reduction

**Question 42**

March 2011 | CHY1AP | Original Q4 | Legacy

## QUESTION FOUR

This question is about the extraction and recycling of copper.

Copper is used in its pure form or mixed with other metals.
Large amounts of scrap copper metal from a variety of sources can easily be recycled by re-melting.

**4A** Pure copper can be extracted directly by . . .

**1** thermal decomposition of copper carbonate.

**2** thermal decomposition of copper oxide.

**3** carbon reduction of copper oxide in a blast furnace.

**4** electrolysis of copper compounds dissolved in water.

**4B** Small amounts of other metals are sometimes added to copper to produce . . .

**1** compounds that conduct electricity better.

**2** compounds that are softer.

**3** alloys that are harder.

**4** new elements that are harder.

**4C** The price of copper would increase if there was . . .

**1** a decrease in the demand for copper.

**2** an increase in energy costs.

**3** an increase in the amount of copper being recycled.

**4** a discovery of a low grade copper ore in a remote area of the world.

**4D** One **disadvantage** of recycling copper is that it . . .

**1** prevents heaps of scrap metal from building up.

**2** still requires the use of energy resources.

**3** will increase the price of copper.

**4** will contaminate the world's supplies of copper.

4.4.1.3 Extraction of metals and reduction

Question 43

March 2011 | CHY1AP | Original Q8 | Legacy

## QUESTION EIGHT

Zinc is a reactive metal that will react with oxygen at high temperatures. Its two main ores are zinc sulfide (ZnS) and zinc carbonate ($ZnCO_3$). The relative abundance of each ore is about the same throughout the world.

To extract zinc, the ores are first heated to produce zinc oxide:

$$2ZnS + 3O_2 \xrightarrow{\text{heat}} 2ZnO + 2SO_2$$

$$ZnCO_3 \xrightarrow{\text{heat}} ZnO + CO_2$$

The zinc oxide is mixed with carbon (C) and heated in a furnace.

In the furnace, these reactions occur:

$$C + O_2(air) \xrightarrow{\text{heat}} CO_2$$

$$CO_2 + C \longrightarrow 2CO$$

Zinc is extracted by the following reaction:

$$ZnO + CO \longrightarrow Zn + CO_2$$

**8A** An advantage of using zinc carbonate instead of zinc sulfide is that. . .

**1** zinc carbonate is more common and therefore cheaper.

**2** only one waste product is formed.

**3** less zinc is lost during the reaction.

**4** zinc is formed directly without another chemical being used.

**8B** The atmosphere inside the furnace is kept rich in carbon monoxide (CO).

This is to . . .

**1** prevent zinc oxide from reacting with carbon (C).

**2** stop the zinc from re-forming zinc oxide.

**3** remove carbon (C) from the furnace.

**4** make carbon dioxide ($CO_2$).

4.4.1.3 Extraction of metals and reduction

Question 43 · continued



**8C** Zinc ores also contain lead compounds. Lead is produced with the zinc in the furnace. The temperature inside the furnace is about 1500 °C.

| | Boiling point in °C | Density in g per $cm^3$ | Reactivity |
|---|---|---|---|
| **Lead** | 1749 | 11.3 | Low |
| **Zinc** | 907 | 7.1 | High |

Pure zinc is obtained from the furnace because . . .

**1** zinc leaves the furnace as vapour, and liquid lead remains in the furnace.

**2** liquid zinc floats on liquid lead in the furnace.

**3** lead leaves the furnace as vapour, and liquid zinc remains in the furnace.

**4** lead is more reactive than zinc and reacts with oxygen to form lead oxide.

**8D** Limestone is added to the furnace because . . .

**1** it provides energy for the reaction.

**2** it removes any acidic impurities.

**3** it is the only source of the carbon dioxide in the furnace.

**4** it is thermally stable.

### 4.4.1.3 Extraction of metals and reduction

**Question 44**

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 $CO_2$ |

### 4.4.1.3 Extraction of metals and reduction

**Question 44 · 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.

4.4.1.3 Extraction of metals and reduction

Question 45

June 2011 | CHY1AP | Original Q9 | Legacy

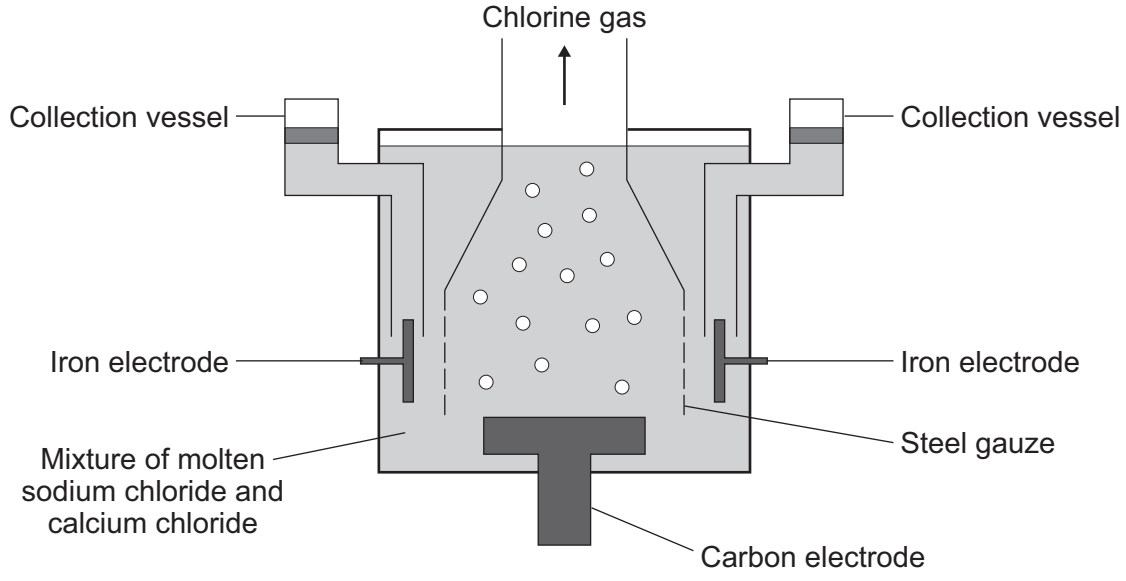
**QUESTION NINE**

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.

4.4.1.3 Extraction of metals and reduction

Question 45 · 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**

### 4.4.1.3 Extraction of metals and reduction

**Question 46**

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.

4.4.1.3 Extraction of metals and reduction

Question 46 · 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**

4.4.1.3 Extraction of metals and reduction

Question 47

November 2011 | CHY1AP | Original Q5 | Legacy

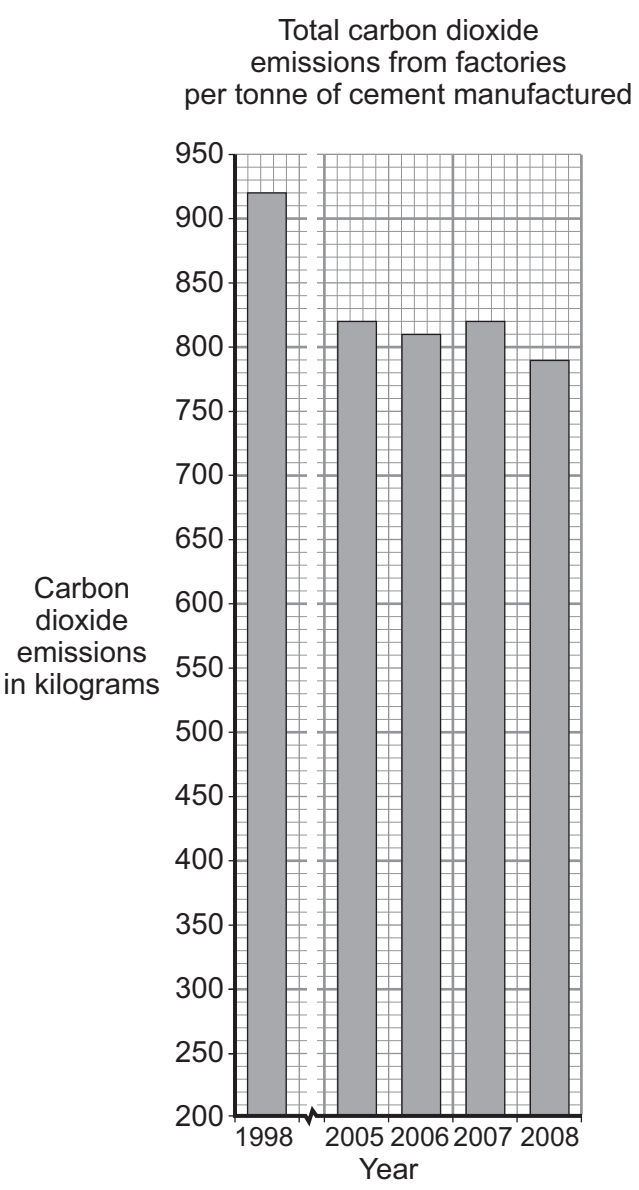
**QUESTION FIVE**

Cement is made in a rotary kiln, from a mixture of limestone and clay. The kiln is heated by burning a hydrocarbon fuel in air.

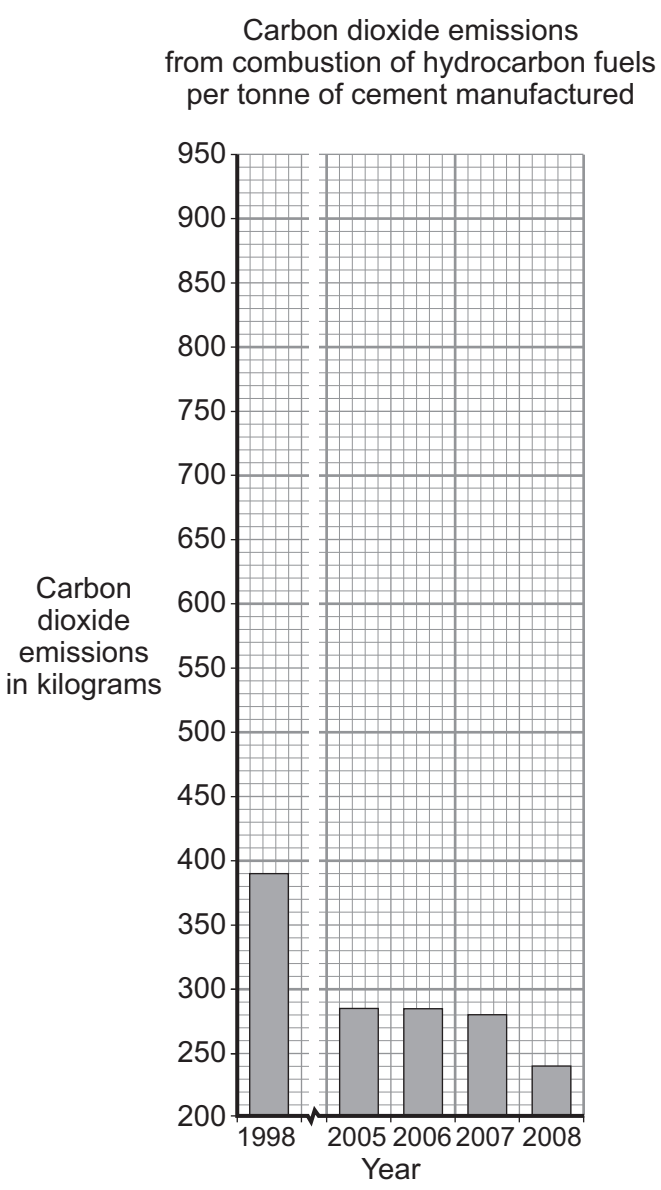
The cement industry needs to reduce carbon dioxide emissions.

**Graphs 1** and **2** show carbon dioxide emissions from cement manufacture in Britain, between 1998 and 2008.

**Graph 1**




**Graph 2**



4.4.1.3 Extraction of metals and reduction

Question 47 · continued



**5A** A correct conclusion from the information in the graphs is that . . .

**1** the largest reduction in total emissions of carbon dioxide was from 1998 to 1999.

**2** the largest reduction in emissions of carbon dioxide from combustion of hydrocarbon fuels was from 2007 to 2008.

**3** from 2007 to 2008, total emissions of carbon dioxide, per tonne of cement manufactured, reduced by 40 kilograms.

**4** from 2007 to 2008, emissions of carbon dioxide from combustion of hydrocarbon fuels, per tonne of cement manufactured, reduced by 40 kilograms.

**5B** What was the percentage reduction in emissions of carbon dioxide from combustion of hydrocarbon fuels at cement factories between 1998 and 2008?

**1** 16.2 %

**2** 38.5 %

**3** 61.5 %

**4** 84.4 %

**5C** What proportion of the carbon dioxide released during cement manufacture in 2006 came from combustion of hydrocarbon fuels?

**1** 0.23

**2** 0.35

**3** 0.61

**4** 0.85

**5D** Most of the carbon dioxide released during cement manufacture comes from . . .

**1** hydrocarbons.

**2** limestone.

**3** quicklime.

**4** slaked lime.

4.4.1.3 Extraction of metals and reduction

Question 48

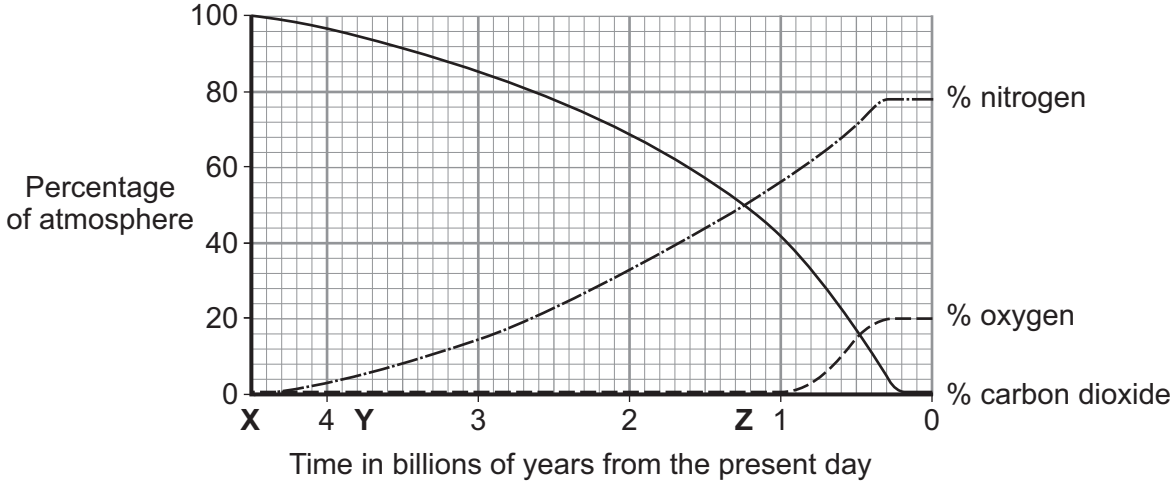
November 2011 | CHY1BP | Original Q7 | Legacy

**QUESTION SEVEN**

This question is about changes in the Earth's atmosphere that have occurred over time.

The Earth's early atmosphere was mainly carbon dioxide with small amounts of methane and ammonia.

The graph shows how the percentages of carbon dioxide, nitrogen and oxygen may have changed over time.




**7A** About how many years after the Earth was formed (**X**) did the percentage of carbon dioxide in the atmosphere fall to 60 %?

**1** 1.3 billion years

**2** 1.6 billion years

**3** 2.4 billion years

**4** 2.9 billion years

**7B** At a particular stage in the Earth's formation, some of the iron on its surface was oxidised.

What gas in the atmosphere could **not** have caused this change?

**1** nitrogen

**2** carbon dioxide

**3** oxygen

**4** water vapour

### 4.4.1.3 Extraction of metals and reduction

**Question 48 · continued**



**7C** Between times **Y** and **Z**, the amount of carbon dioxide in the atmosphere was reduced.

Which of the following statements could explain this reduction?

Most of the carbon dioxide . . .

**1** dissolved in the oceans.

**2** was absorbed by plants.

**3** was absorbed to form carbonate rocks in the mantle.

**4** became locked up in coal, oil and natural gas.

**7D** The graph showing the percentages of the various gases has . . .

**1** categoric variables plotted against a discrete variable.

**2** discrete variables plotted against a continuous variable.

**3** continuous variables plotted against a continuous variable.

**4** continuous variables plotted against a discrete variable.

### 4.4.1.3 Extraction of metals and reduction

**Question 49**

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.

.....

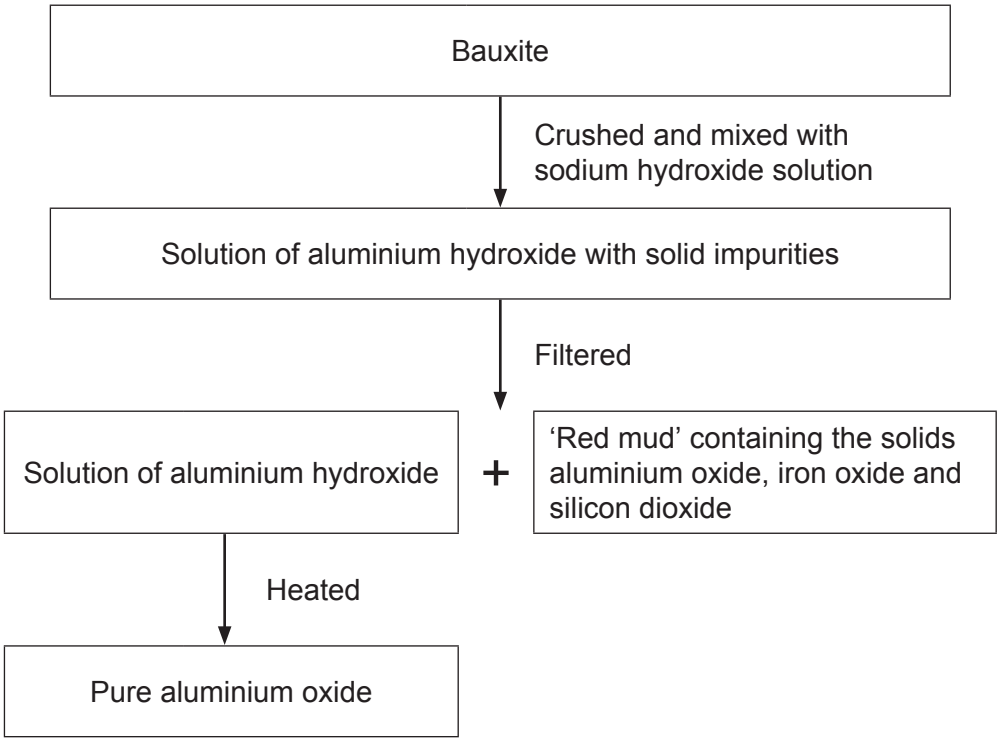
*(1 mark)*

**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.



4.4.1.3 Extraction of metals and reduction

Question 49 · 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)*

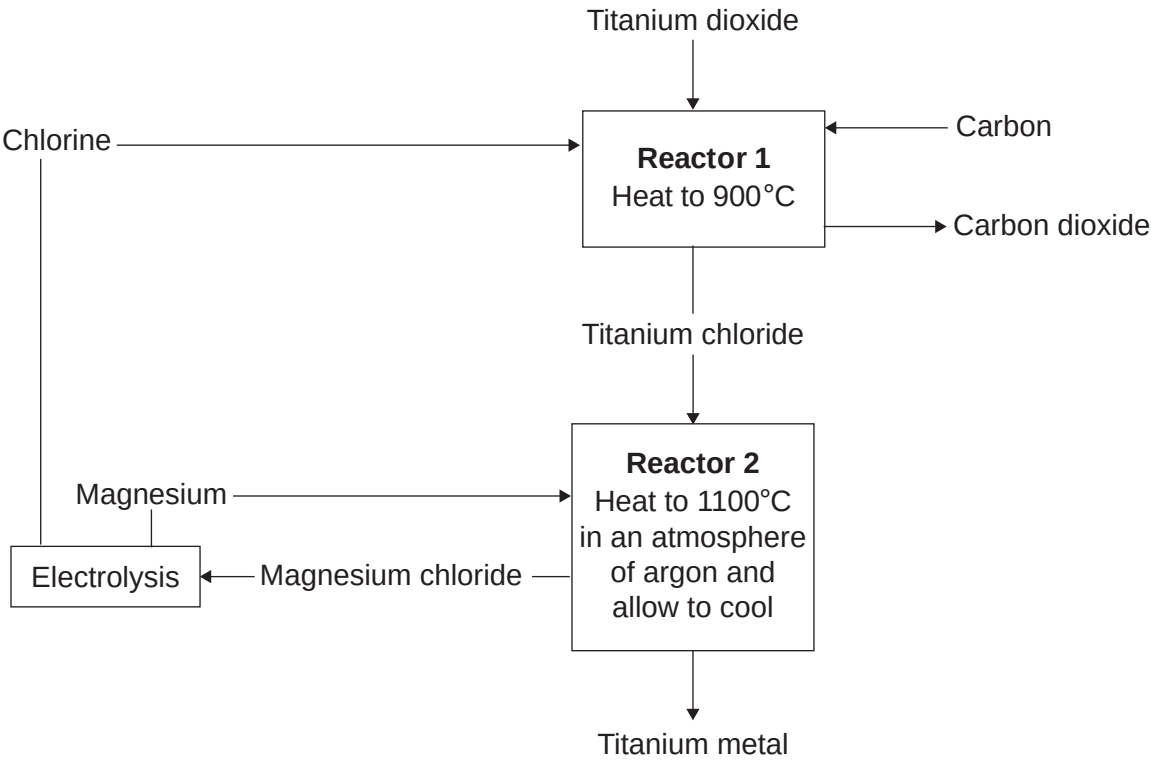
7

### 4.4.1.3 Extraction of metals and reduction

**Question 50**

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)*

4.4.1.3 Extraction of metals and reduction

Question 50 · continued



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

.....

.....

.....

.....

*(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.

.....

.....

.....

.....

*(2 marks)*

**Question 2 continues on the next page**

### 4.4.1.3 Extraction of metals and reduction

**Question 50 · 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.

.....

Mass = ..... kg

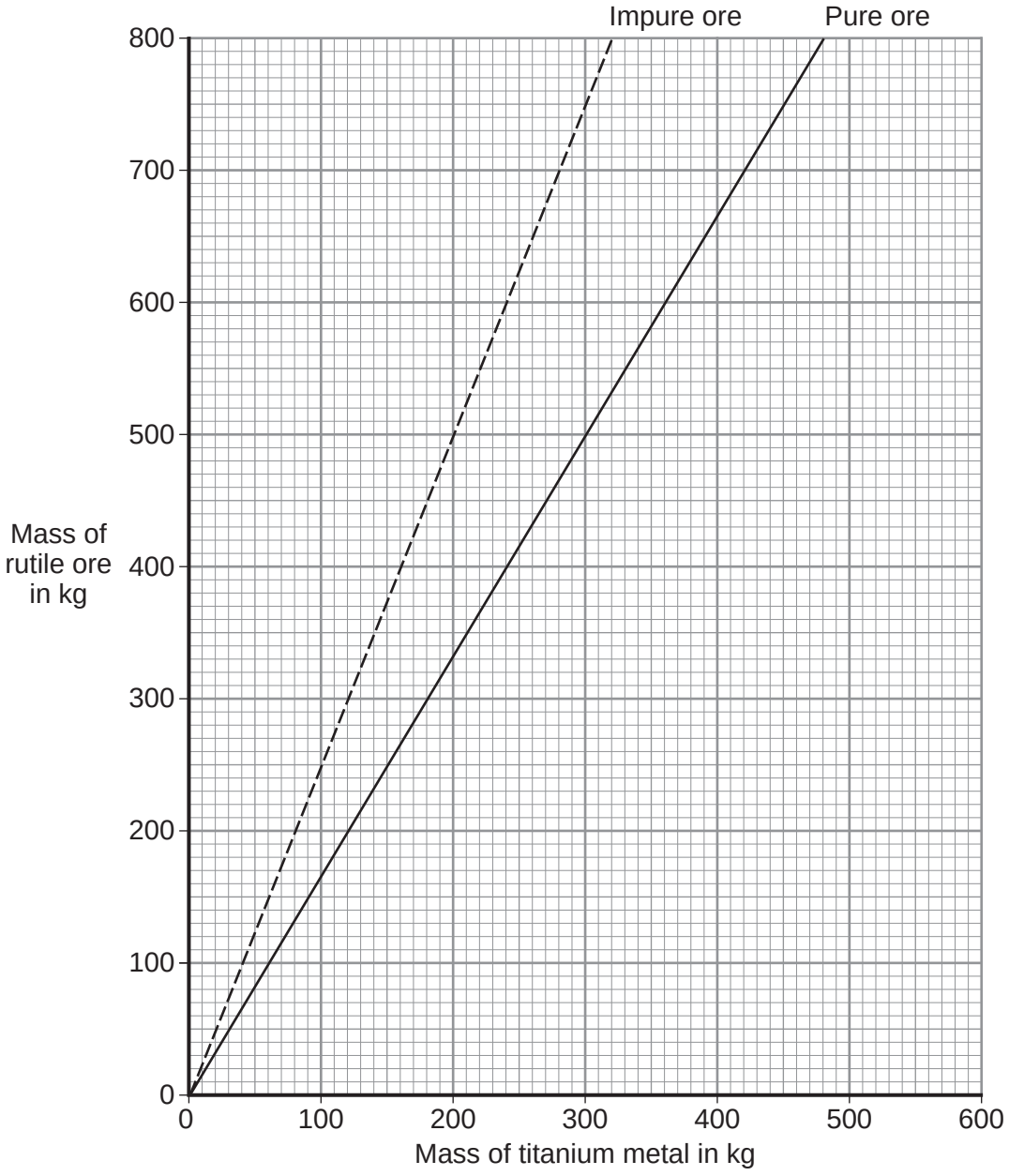
*(1 mark)*

4.4.1.3 Extraction of metals and reduction

Question 50 · 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

### 4.4.1.3 Extraction of metals and reduction

**Question 51**

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.

.....

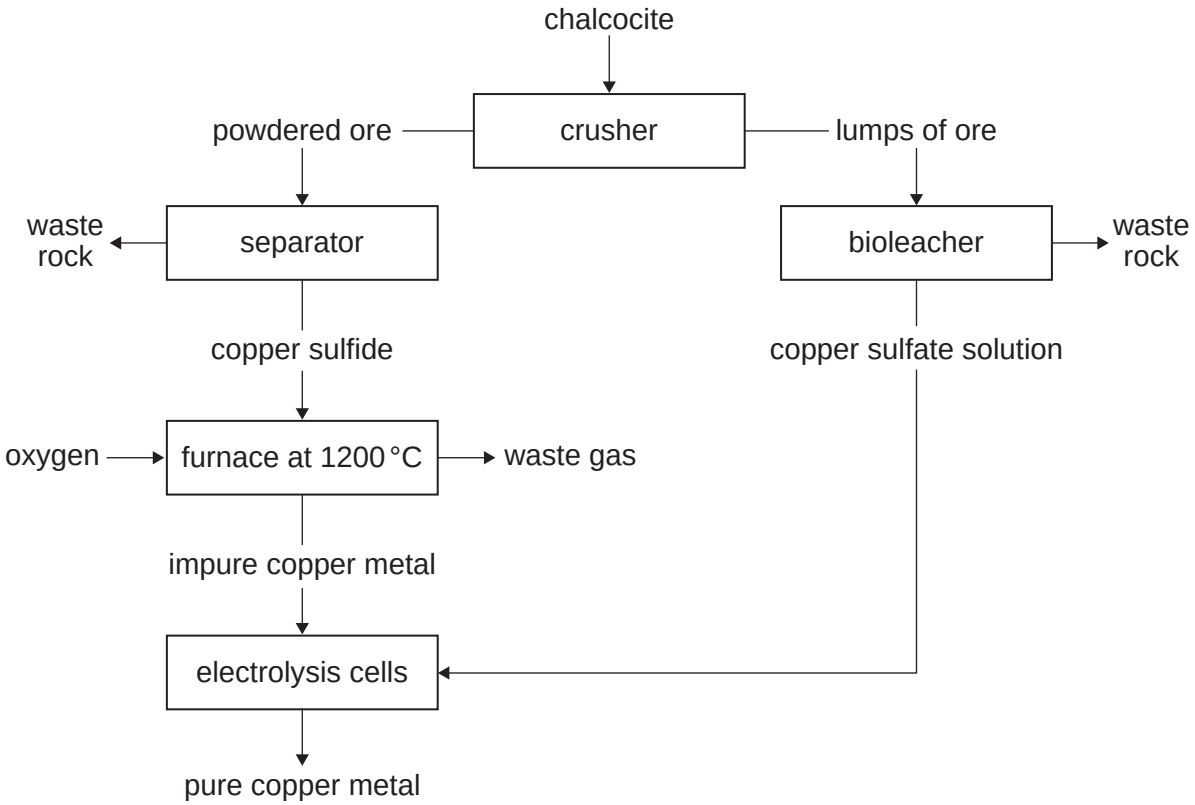
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.....

.....

*(2 marks)*

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



4.4.1.3 Extraction of metals and reduction

Question 51 · 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

### 4.4.1.3 Extraction of metals and reduction

**Question 52**

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.

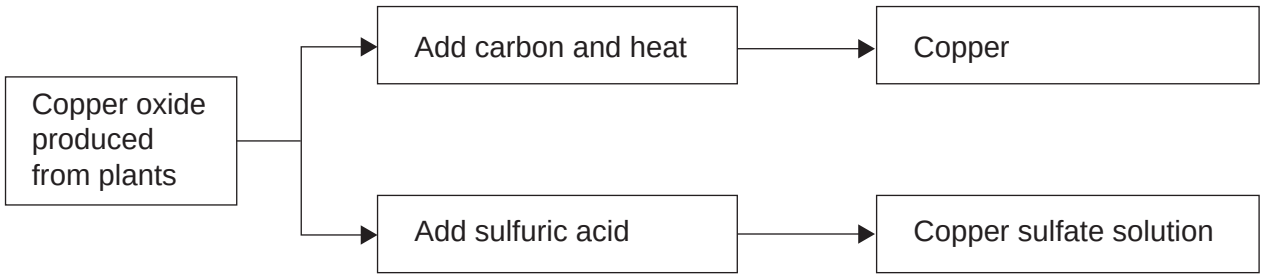
One way to extract the copper is to grow plants on the land.

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 ⟶ ..... + $CO_2$

4.4.1.3 Extraction of metals and reduction

Question 52 · 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]**

.....

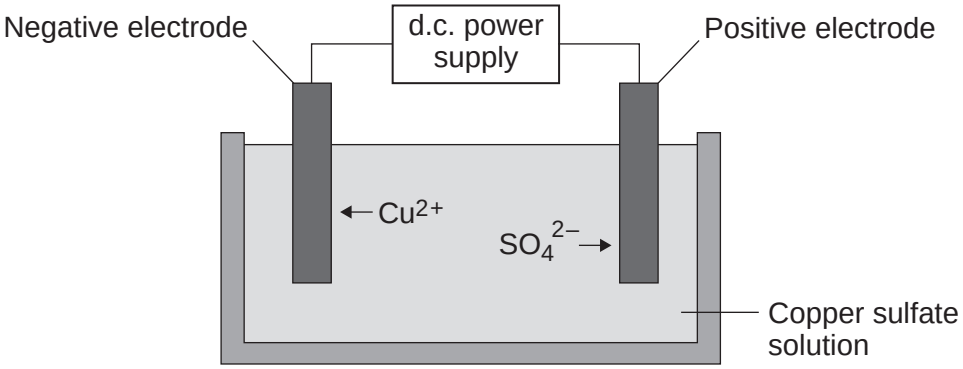
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**4 (b) (ii)** **Figure 4** shows the electrolysis of copper sulfate solution.

**Figure 4**




Describe what happens to the copper ions during electrolysis.

**[2 marks]**

.....

.....

.....

.....

9

### 4.4.1.3 Extraction of metals and reduction

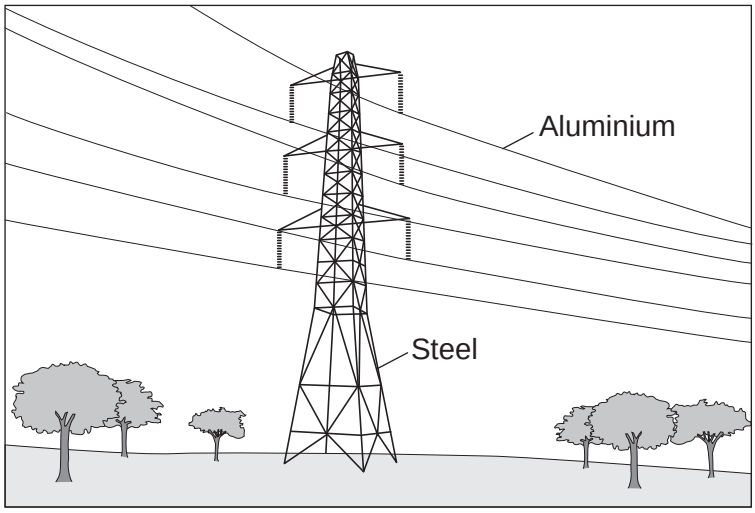
**Question 53**

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.

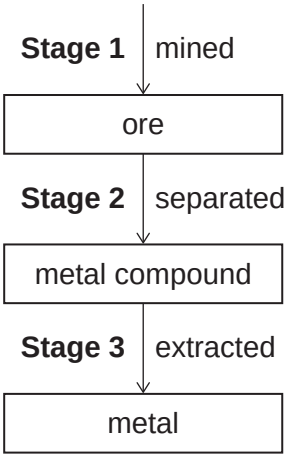
**Figure 4**




**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]**

.....

.....

.....

.....

4.4.1.3 Extraction of metals and reduction

Question 53 · 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.

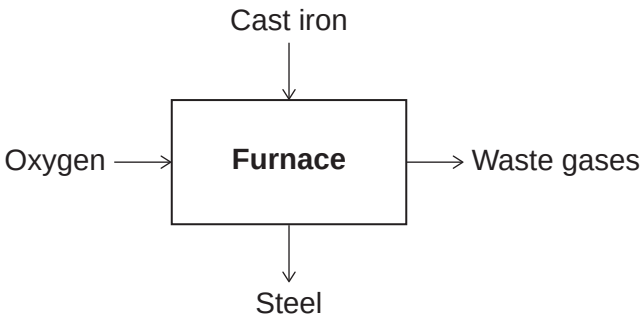
**[1 mark]**

.....

.....

**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**

4.4.1.3 Extraction of metals and reduction

Question 53 · 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

### 4.4.1.3 Extraction of metals and reduction

**Question 54**

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]**

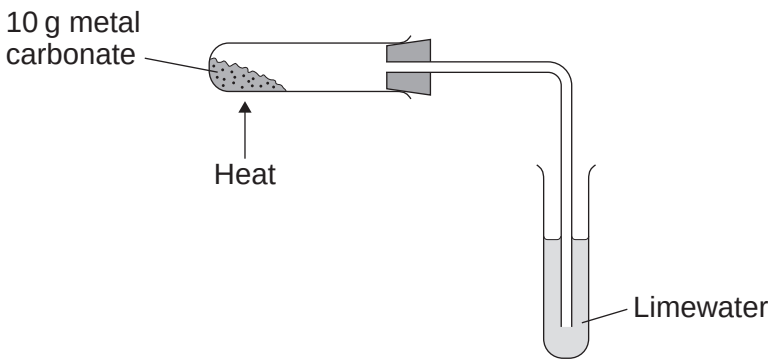
Tick (✓) **one** box.

- 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 54 · 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**

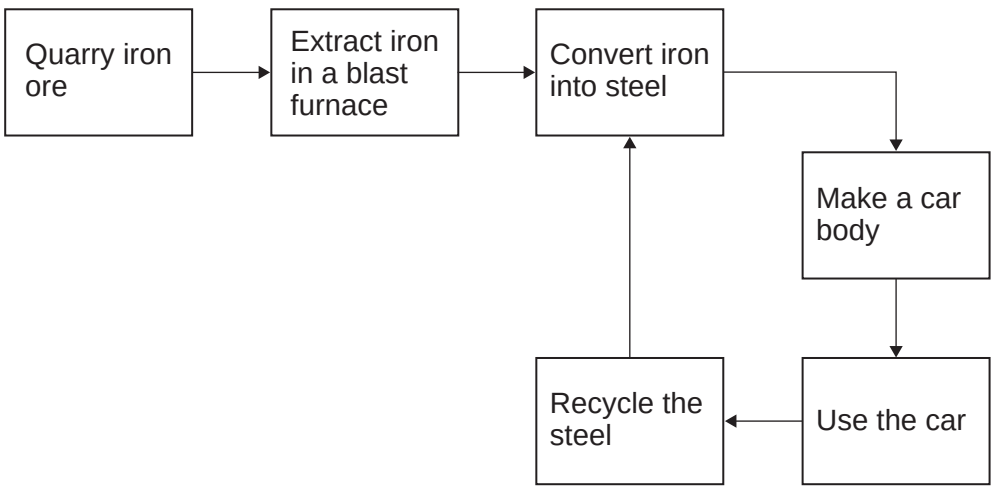
4.4.1.3 Extraction of metals and reduction

Question 54 · 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]**

_____

_____

_____

_____

4.4.1.3 Extraction of metals and reduction

Question 54 · 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

### 4.4.1.3 Extraction of metals and reduction

**Question 55**

June 2017 | CH1HP | Original Q5 | Legacy

**5** This question is about the Earth's atmosphere.

**5 (a)** The Earth's early atmosphere was a mixture of gases.

One theory is that the Earth's early atmosphere had the composition shown in **Table 4**.

**Table 4**

| Gas | Percentage in Earth's early atmosphere (%) |
|---|---|
| Carbon dioxide | 96 |
| Nitrogen | 3.5 |
| Oxygen | a trace |
| Other gases including methane, ammonia, hydrogen and water vapour | 0.5 |

**5 (a) (i)** Amino acids are at the basis of all life processes.
The simplest amino acid is glycine, $NH_2CH_2COOH$

Two scientists, Miller and Urey, showed that they could produce glycine from a mixture of methane, ammonia, hydrogen and water.
Miller and Urey concluded that this is how life was formed on Earth.

Suggest **one** reason why this conclusion may **not** be correct.

**[1 mark]**

**5 (a) (ii)** Give **three** reasons why the percentage of carbon dioxide in the Earth's atmosphere today is less than the percentage of carbon dioxide in the Earth's early atmosphere.

**[3 marks]**

Question 55 · continued



**5 (b)** **Table 5** shows the boiling points of some gases in the air.

**Table 5**

| Gas | Boiling point in °C |
|---|---|
| Nitrogen | –196 |
| Oxygen | –183 |
| Carbon dioxide | –79* |
| Helium | –269 |
| Neon | –246 |
| Argon | –186 |

*freezes at this temperature

Oxygen from the air is separated by fractional distillation. To do this separation the air is cooled to –200 °C. Most of the gases condense.

**5 (b) (i)** Name the two gases that would **not** condense at –200 °C.

**[1 mark]**

_____ and _____

**5 (b) (ii)** Suggest why carbon dioxide is removed before the air is cooled.

**[1 mark]**

_____

_____

**5 (b) (iii)** The liquid at –200 °C is passed into a fractionating column.

Explain why one of the fractions is a mixture of oxygen and one other gas.

**[2 marks]**

_____

_____

_____

_____

4.4.1.3 Extraction of metals and reduction

Question 55 · continued



**5 (c)** Oxygen is used in the production of steel.

Cast iron from a blast furnace contains 96% iron and 4% carbon.

The stages for the production of steel from cast iron are:

**Stage 1** pass oxygen into molten cast iron

**Stage 2** add small amounts of other metals.

Explain why each stage is needed in the production of steel.

**[4 marks]**

12

### 4.4.1.3 Extraction of metals and reduction

**Question 56**

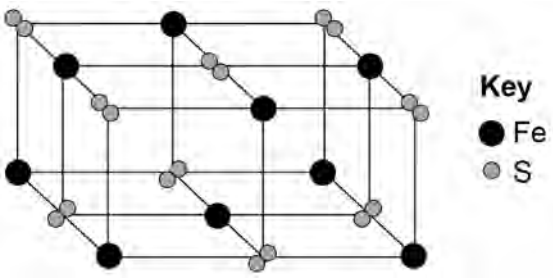
June 2018 | 8462/1H | Original Q2

**0 2** This question is about metals and metal compounds.

**0 2 . 1** Iron pyrites is an ionic compound.

**Figure 1** shows a structure for iron pyrites.

**Figure 1**




Determine the formula of iron pyrites.

Use **Figure 1**.

**[1 mark]**

**0 2 . 2** An atom of iron is represented as $^{56}_{26}Fe$

Give the number of protons, neutrons and electrons in this atom of iron.

**[3 marks]**

Number of protons _____

Number of neutrons _____

Number of electrons _____

**0 2 . 3** Iron is a transition metal.

Sodium is a Group 1 metal.

Give **two** differences between the properties of iron and sodium.

**[2 marks]**

1 _____

_____

2 _____

_____

4.4.1.3 Extraction of metals and reduction

Question 56 · continued



Nickel is extracted from nickel oxide by reduction with carbon.

**0 2 . 4** Explain why carbon can be used to extract nickel from nickel oxide.

**[2 marks]**

**0 2 . 5** An equation for the reaction is:

$$NiO + C \rightarrow Ni + CO$$

Calculate the percentage atom economy for the reaction to produce nickel.

Relative atomic masses ($A_r$): C = 12 Ni = 59

Relative formula mass ($M_r$): NiO = 75

Give your answer to 3 significant figures.

**[3 marks]**

Percentage atom economy = _____ %

11

### 4.4.1.3 Extraction of metals and reduction

**Question 57**

June 2018 | 8462/1H | Original Q8

**0 8** Titanium is a transition metal.

Titanium is extracted from titanium dioxide in a two stage industrial process.

**Stage 1** $TiO_2 + 2\,C + 2\,Cl_2 \rightarrow TiCl_4 + 2\,CO$

**Stage 2** $TiCl_4 + 4\,Na \rightarrow Ti + 4\,NaCl$

**0 8 . 1** Suggest **one** hazard associated with **Stage 1**.

**[1 mark]**

**0 8 . 2** Water must be kept away from the reaction in **Stage 2**.

Give **one** reason why it would be hazardous if water came into contact with sodium.

**[1 mark]**

**0 8 . 3** Suggest why the reaction in **Stage 2** is carried out in an atmosphere of argon and **not** in air.

**[2 marks]**

4.4.1.3 Extraction of metals and reduction

Question 57 · continued



**0 8 . 4** Titanium chloride is a liquid at room temperature.

Explain why you would **not** expect titanium chloride to be a liquid at room temperature.

**[3 marks]**

In **Stage 2**, sodium displaces titanium from titanium chloride.

**0 8 . 5** Sodium atoms are oxidised to sodium ions in this reaction.

Why is this an oxidation reaction?

**[1 mark]**

**0 8 . 6** Complete the half equation for the oxidation reaction.

**[1 mark]**

Na → _____ + _____

4.4.1.3 Extraction of metals and reduction

Question 57 · continued



**0 8 . 7** In **Stage 2**, 40 kg of titanium chloride was added to 20 kg of sodium.

The equation for the reaction is:

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

Relative atomic masses ($A_r$): Na = 23 Cl = 35.5 Ti = 48

Explain why titanium chloride is the limiting reactant.

You **must** show your working.

**[4 marks]**

**0 8 . 8** For a **Stage 2** reaction the percentage yield was 92.3%

The theoretical maximum mass of titanium produced in this batch was 13.5 kg.

Calculate the actual mass of titanium produced.

**[2 marks]**

Mass of titanium = _____ kg

**15**

### 4.4.1.3 Extraction of metals and reduction

**Question 58**

November 2020 | 8462/1H | Original Q2

**0 2** This question is about metals and the reactivity series.

**0 2 . 1** Which **two** statements are properties of most transition metals?

**[2 marks]**

Tick (✓) **two** boxes.

- They are soft metals. ☐
- They form colourless compounds. ☐
- They form ions with different charges. ☐
- They have high melting points. ☐
- They have low densities. ☐

**0 2 . 2** A student added copper metal to colourless silver nitrate solution.

The student observed:

- pale grey crystals forming
- the solution turning blue.

Explain how these observations show that silver is less reactive than copper.

**[3 marks]**

4.4.1.3 Extraction of metals and reduction

Question 58 · continued



**0 2 . 3** A student is given three metals, **X**, **Y** and **Z** to identify.

The metals are magnesium, iron and copper.

Plan an investigation to identify the three metals by comparing their reactions with dilute hydrochloric acid.

Your plan should give valid results.

**[4 marks]**

**Question 2 continues on the next page**

4.4.1.3 Extraction of metals and reduction

Question 58 · continued



**0 2 . 4** Metal **M** has two isotopes.

**Table 2** shows the mass numbers and percentage abundances of the isotopes.

**Table 2**

| Mass number | Percentage abundance (%) |
|---|---|
| 203 | 30 |
| 205 | 70 |

Calculate the relative atomic mass ($A_r$) of metal **M**.

Give your answer to 1 decimal place.

**[2 marks]**

Relative atomic mass (1 decimal place) = _____

11

4.4.1.3 Extraction of metals and reduction

Question 59

November 2020 | 8462/2H | Original Q6

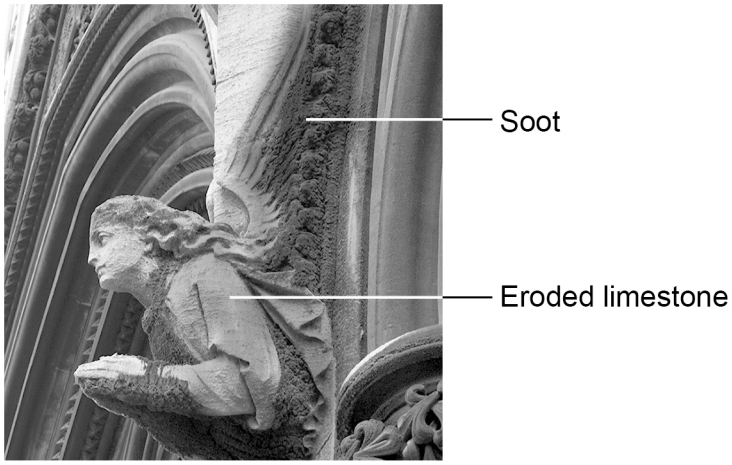
**0 6** This question is about atmospheric pollution.

**Figure 3** shows a limestone carving which has been damaged by atmospheric pollution.

The carving has been:

- blackened by soot
- eroded where the limestone has reacted with atmospheric pollutants.

**Figure 3**




**0 6 . 1** Explain why soot is formed when some fossil fuels are burned.

**[2 marks]**

4.4.1.3 Extraction of metals and reduction

Question 59 · continued



**0 6 . 2** Fossil fuels are burned in car engines.

Explain how reducing the amount of sulfur in fossil fuels reduces the erosion of limestone.

**[4 marks]**

**0 6 . 3** Oxides of nitrogen are atmospheric pollutants which are formed in car engines.

Explain why oxides of nitrogen are formed in car engines.

**[2 marks]**

8

### 4.4.1.3 Extraction of metals and reduction

**Question 60**

November 2021 | 8462/1H | Original Q3

**0 3** This question is about the extraction of metals.

Element **R** is extracted from its oxide by reduction with hydrogen.

The equation for the reaction is:

$$3\,H_2 + \mathbf{R}O_3 \rightarrow \mathbf{R} + 3\,H_2O$$

**0 3 . 1** The sum of the relative formula masses ($M_r$) of the reactants ($3\,H_2$ + $\mathbf{R}O_3$) is 150

Calculate the relative atomic mass ($A_r$) of **R**.

Relative atomic masses ($A_r$): H = 1 O = 16

**[2 marks]**

Relative atomic mass ($A_r$) of **R** = _____

**0 3 . 2** Identify element **R**.

You should use:

- your answer to **question 03.1**
- the periodic table.

**[1 mark]**

Identity of **R** = _____

4.4.1.3 Extraction of metals and reduction

Question 60 · continued



**0 3 . 3** Carbon is used to extract tin (Sn) from tin oxide ($SnO_2$).

The equation for the reaction is:

$$SnO_2 + C \rightarrow Sn + CO_2$$

Calculate the percentage atom economy for extracting tin in this reaction.

Relative atomic masses ($A_r$): C = 12 O = 16 Sn = 119

**[3 marks]**

Percentage atom economy = _____ %

**Question 3 continues on the next page**

4.4.1.3 Extraction of metals and reduction

Question 60 · continued



**0 3 . 4** Tungsten (W) is a metal.

Tungsten is extracted from tungsten oxide ($WO_3$).

All other solid products from the extraction method must be separated from the tungsten.

**Table 2** shows information about three possible methods to extract tungsten from tungsten oxide.

**Table 2**

| Method | Reactant | Relative cost of reactant | Products |
|---|---|---|---|
| 1 | Carbon | Low | Tungsten solid<br>Carbon dioxide gas<br>Tungsten carbide solid |
| 2 | Hydrogen | High | Tungsten solid<br>Water vapour |
| 3 | Iron | Low | Tungsten solid<br>Iron oxide solid |

Evaluate the three possible methods for extracting tungsten from tungsten oxide.

**[4 marks]**

10

4.4.1.3 Extraction of metals and reduction

Question 61

November 2021 | 8462/2H | Original Q8

**0 8** This question is about copper and alloys of copper.

Solders are alloys used to join metals together.

Some solders contain copper.

**Table 4** shows information about three solders, **A**, **B** and **C**.

**Table 4**

| Solder | Melting point in °C | Metals in solder |
|---|---|---|
| **A** | 183 | tin, copper, lead |
| **B** | 228 | tin, copper, silver |
| **C** | 217 | tin, copper, silver |

**0 8 . 1** Solder **B** and solder **C** are now used more frequently than solder **A** for health reasons.

Suggest **one** reason why.

Use **Table 4**.

**[1 mark]**

**0 8 . 2** Suggest **one** reason why solders **B** and **C** have different melting points.

Use **Table 4.**

**[1 mark]**

4.4.1.3 Extraction of metals and reduction

Question 61 · continued



Copper can be obtained by:

- processing copper ores
- recycling scrap copper.

**0 8 . 3** Suggest **three** reasons why recycling scrap copper is a more sustainable way of obtaining copper than processing copper ores.

**[3 marks]**

1 _____

_____

2 _____

_____

3 _____

_____

**Question 8 continues on the next page**

4.4.1.3 Extraction of metals and reduction

Question 61 · continued



Copper is extracted from low-grade ores by phytomining.

**0 8 . 4** Describe how copper is extracted from low-grade ores by phytomining.

**[4 marks]**

**0 8 . 5** Phytomining has **not** been widely used to extract copper.

Suggest **two** reasons why.

**[2 marks]**

1

2

11

### 4.4.1.3 Extraction of metals and reduction

**Question 62**

June 2022 | 8462/1H | Original Q7

**0 7** This question is about silicon and compounds of silicon.

**0 7 . 1** The reactivity series sometimes includes non-metals such as carbon, hydrogen and silicon.

Silicon can be extracted by reducing silicon dioxide with different substances.

The equation for one possible reaction is:

$$2\,C(s) + SiO_2(s) \rightarrow Si(s) + 2\,CO(g)$$

Explain what this reaction shows about the position of silicon in the reactivity series.

**[2 marks]**

**0 7 . 2** Aluminium also reduces silicon dioxide.

Carbon is used rather than aluminium to reduce silicon dioxide because carbon is cheaper than aluminium.

Carbon can be obtained by heating coal.

Aluminium is obtained from aluminium oxide.

Explain why aluminium is more expensive than carbon.

**[2 marks]**

4.4.1.3 Extraction of metals and reduction

Question 62 · continued



Magnesium also reduces silicon dioxide.

The equation for the reaction is:

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

**0 7 . 3** Give **one** reason why the products are difficult to separate if magnesium is used to reduce silicon dioxide.

**[1 mark]**

**0 7 . 4** Calculate the minimum mass in grams of magnesium needed to completely reduce 1.2 kg of silicon dioxide.

Relative atomic masses ($A_r$): O = 16 Mg = 24 Si = 28

**[5 marks]**

Minimum mass of magnesium = _____ g

4.4.1.3 Extraction of metals and reduction

Question 62 · continued

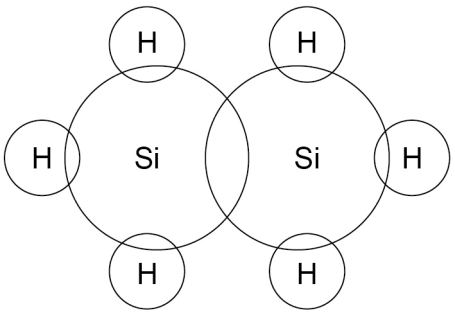


$Si_2H_6$ is a covalent compound of silicon and hydrogen.

**0 7 . 5** Complete **Figure 9** to show the outer shell electrons in a molecule of $Si_2H_6$

**[1 mark]**

**Figure 9**




**0 7 . 6** $Si_2H_6$ reacts with oxygen.

The equation for the reaction is:

$$2\,Si_2H_6(g) + 7\,O_2(g) \rightarrow 4\,SiO_2(s) + 6\,H_2O(g)$$

30 $cm^3$ of $Si_2H_6$ is reacted with 150 $cm^3$ (an excess) of oxygen.

Calculate the total volume of gases present after the reaction.

All volumes of gases are measured at the same temperature and pressure.

**[4 marks]**

Volume of gases = _____ $cm^3$

15

4.4.1.3 Extraction of metals and reduction

Question 63

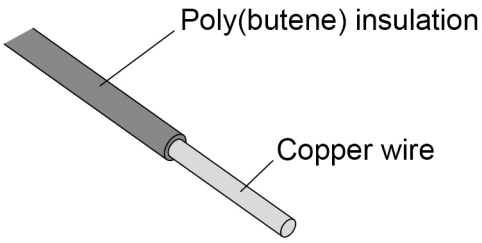


**0 1** This question is about copper wire and copper compounds.

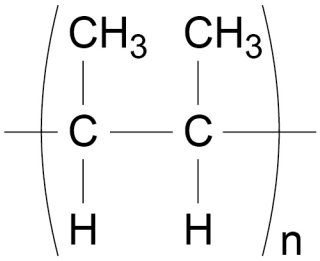
Copper is used to make electrical wires.

**Figure 1** shows how copper electrical wire is insulated using an addition polymer called poly(butene).

**Figure 1**




**0 1 . 1** The addition polymer poly(butene) has the displayed structural formula:

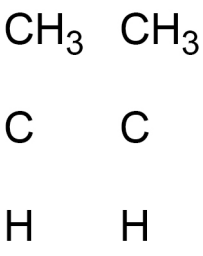



Poly(butene) is produced from the monomer butene.

Complete **Figure 2** to show the displayed structural formula of butene.

**[2 marks]**

**Figure 2**



4.4.1.3 Extraction of metals and reduction

Question 63 · continued



Copper can be obtained by recycling scrap copper wire.

**0 1 . 2** Suggest why poly(butene) insulation must be removed from scrap copper wire before the copper is recycled.

**[1 mark]**

**0 1 . 3** Describe how scrap copper wire can be recycled to make new copper water pipes.

**[2 marks]**

**0 1 . 4** Suggest **two** reasons why recycling scrap copper is more sustainable than extracting copper from copper ores.

**[2 marks]**

1

2

**Question 1 continues on the next page**

4.4.1.3 Extraction of metals and reduction

Question 63 · continued



Copper sulfate is a compound of copper.

Copper sulfate solution contains copper(II) ions and sulfate ions.

**0 1 . 5** A solution can be added to copper sulfate solution to show the presence of copper(II) ions.

Name the solution added.

Give the result of the test.

**[2 marks]**

Name of solution added _____

_____

Result _____

_____

**0 1 . 6** Describe **one** test to show the presence of sulfate ions in copper sulfate solution.

Give the result of the test.

**[2 marks]**

Test _____

_____

Result _____

_____

**11**

### 4.4.1.3 Extraction of metals and reduction

**Question 64**

June 2023 | 8462/1H | Original Q9

**0 9** This question is about displacement reactions.

Iron is extracted from iron oxide by a displacement reaction with carbon.

The equation for the reaction is:

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

**0 9 . 1** Which substance in the equation is reduced?

Give **one** reason for your answer.

Answer in terms of oxygen.

**[2 marks]**

Substance reduced _____

Reason _____

_____

**0 9 . 2** Which expression shows how to calculate the mass of carbon needed to produce 1 mole of iron from iron oxide?

Relative atomic mass ($A_r$): C = 12

**[1 mark]**

Tick (✓) **one** box.

$\frac{1}{3} \times 12$ g ☐

$\frac{3}{2} \times 12$ g ☐

$1 \times 12$ g ☐

$3 \times 12$ g ☐

**Question 9 continues on the next page**

Question 64 · continued



A student investigated displacement reactions of four different metals represented by **A**, **B**, **C** and **D**.

**A**, **B**, **C** and **D** are **not** the actual chemical symbols for the metals.

The student:

- added each metal to aqueous solutions of the metal nitrates
- observed whether a reaction took place.

**Table 6** shows information about three of the reaction mixtures.

**Table 6**

| Reaction | Metal | Metal nitrate solution | Equation |
|---|---|---|---|
| 1 | **A** | **B**$NO_3$ | **A** + 2**B**$NO_3$ → 2**B** + **A**$(NO_3)_2$ |
| 2 | **C** | **A**$(NO_3)_2$ | 2**C** + 3**A**$(NO_3)_2$ → 3**A** + 2**C**$(NO_3)_3$ |
| 3 | **C** | **D**$(NO_3)_2$ | no reaction |

**0 9 . 3** The ionic equation for **Reaction 1** is:

$$\mathbf{A} + 2\mathbf{B}^{+} \rightarrow 2\mathbf{B} + \mathbf{A}^{2+}$$

Why is this a redox reaction?

**[1 mark]**

Tick (✓) **one** box.

**A** gains electrons and $\mathbf{B}^{+}$ loses electrons. ☐

**A** loses electrons and $\mathbf{B}^{+}$ gains electrons. ☐

Both **A** and $\mathbf{B}^{+}$ gain electrons. ☐

Both **A** and $\mathbf{B}^{+}$ lose electrons. ☐

4.4.1.3 Extraction of metals and reduction

Question 64 · continued



**0 9 . 4** Which of the four metals has the greatest tendency to form positive ions?

Use **Table 6**.

**[1 mark]**

Tick (✓) **one** box.

**A** ☐ **B** ☐ **C** ☐ **D** ☐

**0 9 . 5** The nitrate ion has the formula $NO_3^-$

Which of the four metals could be aluminium?

Explain your answer.

Use **Table 6**.

**[3 marks]**

Metal _____

Explanation _____

_____

_____

_____

**Question 9 continues on the next page**

4.4.1.3 Extraction of metals and reduction

Question 64 · continued



**0 9 . 6** Metal **X** is extracted from an oxide of metal **X** by reaction with hydrogen.

The equation for the reaction is:

$$\mathbf{X}O_3 + 3H_2 \rightarrow \mathbf{X} + 3H_2O$$

The percentage atom economy for obtaining metal **X** by this method is 77.3%.

Calculate the relative atomic mass ($A_r$) of metal **X**.

Relative atomic masses ($A_r$): H = 1 O = 16

**[4 marks]**

Relative atomic mass ($A_r$) = _____

12

### 4.4.1.3 Extraction of metals and reduction

**Question 65**

June 2023 | 8462/2H | Original Q5

**0 5** Copper is extracted from metal ores.

Chalcopyrite is a metal ore containing a compound with the formula $CuFeS_2$

**0 5 . 1** $CuFeS_2$ reacts with oxygen to produce copper(II) sulfate and iron(II) sulfate.

Complete the equation for this reaction.

You should balance the equation.

**[2 marks]**

$$CuFeS_2 + _____ \rightarrow CuSO_4 + FeSO_4$$

**0 5 . 2** Calculate the percentage by mass of copper in $CuFeS_2$

Relative atomic masses ($A_r$): S = 32 Fe = 56 Cu = 63.5

**[3 marks]**

Percentage by mass = _____ %

**0 5 . 3** Describe a test to show the presence of copper(II) ions in a solution of copper(II) sulfate.

Give the result of the test.

**[2 marks]**

Test _____

Result _____

4.4.1.3 Extraction of metals and reduction

Question 65 · continued



**0 5 . 4** Copper can be extracted from low-grade ores by bioleaching.

Describe what is meant by bioleaching.

**[2 marks]**

9

**Turn over for the next question**

4.4.1.3 Extraction of metals and reduction

Question 66

June 2025 | 8462/1H | Original Q3

**0 3** This question is about metals and metal oxides.

Tin (Sn) is extracted from tin oxide using carbon.

The equation for the reaction is:

$$SnO_2 + C \longrightarrow Sn + CO_2$$

**0 3 . 1** Which substance is reduced in this reaction?

Give **one** reason for your answer.

Answer in terms of oxygen.

**[2 marks]**

Substance reduced _____

Reason _____

_____

**0 3 . 2** Why can carbon be used to extract tin from tin oxide?

**[1 mark]**

_____

_____

**Question 3 continues on the next page**

Question 66 · continued



**0 3 . 3** Cadmium (Cd) can be extracted by the reaction of cadmium oxide with carbon.

The equation for the reaction is:

$$CdO + C \longrightarrow Cd + CO$$

Calculate the percentage atom economy for the production of cadmium in this reaction.

Relative atomic masses ($A_r$): C = 12 Cd = 112

Relative formula mass ($M_r$): CdO = 128

**[3 marks]**

Percentage atom economy = _____ %

**0 3 . 4** Tungsten is a transition metal.

Potassium is a Group 1 metal.

Give **two** differences between the properties of tungsten and the properties of potassium.

**[2 marks]**

1 _____

2 _____

4.4.1.3 Extraction of metals and reduction

Question 66 · continued



Tungsten oxide reacts with hydrogen to give tungsten (W) and water.

**0 3 . 5** The equation for the reaction is:

$$WO_3 + 3\,H_2 \longrightarrow W + 3\,H_2O$$

The law of conservation of mass states:

'The mass of the products equals the mass of the reactants during a chemical reaction.'

Show that the equation obeys the law of conservation of mass.

Relative atomic mass ($A_r$): W = 184

Relative formula masses ($M_r$): $H_2$ = 2 $WO_3$ = 232 $H_2O$ = 18

**[2 marks]**

**0 3 . 6** The reaction producing tungsten has a high atom economy.

Why is it important to use reactions with a high atom economy in industry?

**[1 mark]**

11