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**F**

# Monday 20 June 2022 – Morning

## GCSE (9–1) Chemistry B (Twenty First Century Science)

**J258/02** Depth in Chemistry (Foundation Tier)

**Time allowed: 1 hour 45 minutes**

**You must have:**
- a ruler (cm/mm)
- the Data Sheet for GCSE (9-1) Chemistry B (inside this document)

**You can use:**
- a scientific or graphical calculator
- an HB pencil

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

**INSTRUCTIONS**
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

**INFORMATION**
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **32** pages.

**ADVICE**
- Read each question carefully before you start your answer.

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Answer **all** the questions.

**1** **Fig. 1.1** shows a model for the arrangement of ions in an ionic compound when it is a solid and when it is a liquid.

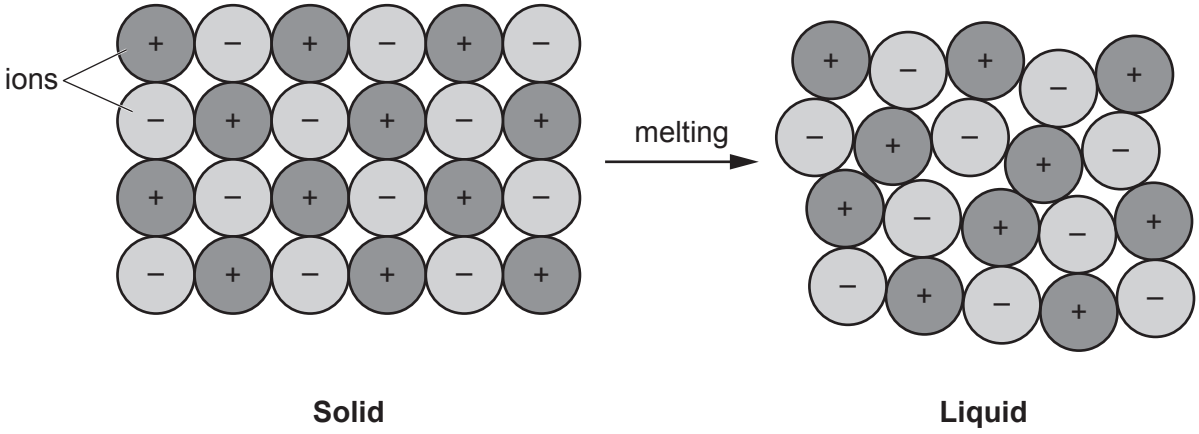


**Fig. 1.1**

**(a)** Which of the following statements are true only for the solid, which are true only for the liquid and which are true for both?

Tick (✓) **one** box in each row.

| | **True only for the solid** | **True only for the liquid** | **True for both** |
|---|---|---|---|
| The ions are close together. | | | |
| The ions are attracted by opposite charges. | | | |
| The ions are in a regular arrangement. | | | |
| The ions can move over each other. | | | |

**[2]**

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**(b)** Sodium chloride and magnesium chloride are ionic compounds.

The melting points of sodium chloride and magnesium chloride are shown in the table.

| | **Melting point (°C)** |
|---|---|
| Sodium chloride | 801 |
| Magnesium chloride | 714 |

**(i)** What is the state of sodium chloride and of magnesium chloride at 750 °C?

Put a ring around **one** word to complete each sentence.

At 750 °C, sodium chloride is a **solid / liquid / gas**.

At 750 °C, magnesium chloride is a **solid / liquid / gas**.

**[1]**

**(ii)** A limitation of the model shown in **Fig. 1.1** is that it does **not** show the reasons why different compounds have different melting points.

Which **two** statements describe the reasons why compounds have different melting points?

Tick (✓) **two** boxes.

Ions in different compounds have different chemical symbols. ☐

Ions in different compounds have different charges. ☐

Ions in different compounds have different colours. ☐

The force of attraction between ions is different in different compounds. ☐

**[2]**

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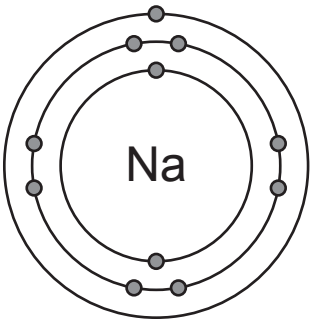
**(c)** Sodium chloride contains sodium ions, $Na^+$, with a single positive charge.

**Fig. 1.2** shows the arrangement of electrons in a sodium atom.




Electron arrangement: 2,8,1

**Fig. 1.2**

**(i)** Which information from the Periodic Table shows us that a sodium atom contains a total of 11 electrons?

Tick (✓) **one** box.

- the atomic number ☐
- the chemical symbol for the element ☐
- the group number ☐
- the relative atomic mass ☐

**[1]**

**(ii)** Use ideas about electrons to explain why sodium atoms form an ion with a +1 charge.

.....

.....

..... **[2]**

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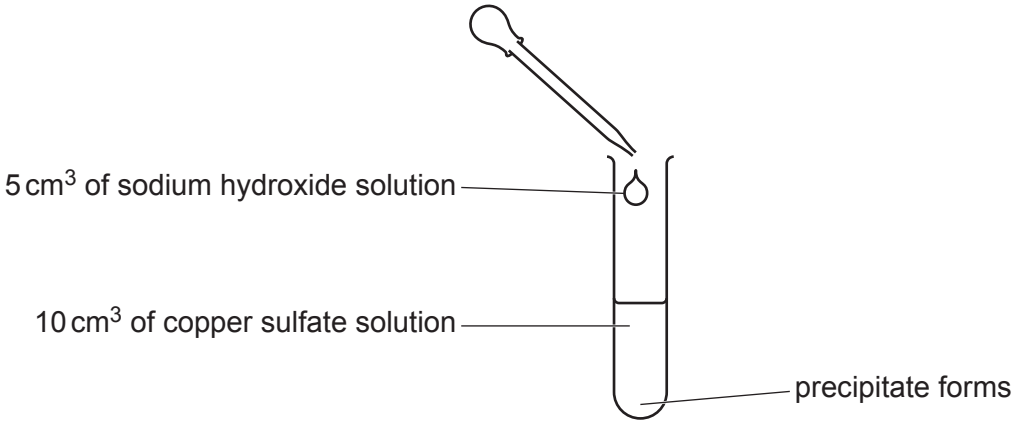
**2** Jane does an experiment.

She puts 10 $cm^3$ of copper sulfate solution in a boiling tube.

She adds 5 $cm^3$ of sodium hydroxide solution. A precipitate of copper hydroxide forms.




**(a)** What are the correct state symbols for copper sulfate and copper hydroxide in this experiment?

Tick (✓) **one** box in each row.

| **Substance** | **State symbol** | | |
|---|---|---|---|
| | **(s)** | **(aq)** | **(l)** |
| copper sulfate solution | | | |
| copper hydroxide precipitate | | | |

**[2]**

**(b)** At the end of the reaction, the boiling tube contains a mixture of a precipitate of copper hydroxide in a solution.

Describe how Jane can separate pure, dry copper hydroxide from this mixture.

.....

.....

.....

..... **[2]**

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**(c)** Jane does more experiments.

She adds a different volume of sodium hydroxide solution to 20 $cm^3$ of copper sulfate solution each time.

She records the mass of dry copper hydroxide that forms in each experiment.

**Table 2.1** shows her results.

| Volume of copper sulfate solution ($cm^3$) | Volume of sodium hydroxide solution added ($cm^3$) | Mass of dry copper hydroxide formed (g) |
|---|---|---|
| 20 | 5 | 0.18 |
| 20 | 10 | 0.52 |
| 20 | 15 | 0.58 |
| 20 | 20 | 0.78 |
| 20 | 25 | 0.98 |
| 20 | 30 | 0.98 |
| 20 | 35 | 0.98 |

**Table 2.1**

**(i)** Describe the pattern shown by the results in **Table 2.1**.

.....

.....

..... **[2]**

**(ii)** Jane wants to change her experiment to make more than 1.00 g of dry copper hydroxide.

Jane and Alex talk about the results.

Jane says, 'To make more copper hydroxide we need to add more than 35 $cm^3$ of sodium hydroxide solution.'

Alex says, 'To make more copper hydroxide we need to add more than 20 $cm^3$ of copper sulfate solution.'

Who is right?

Jane ☐

Alex ☐

Use information from **Table 2.1** to explain your choice.

.....

.....

.....

..... **[2]**

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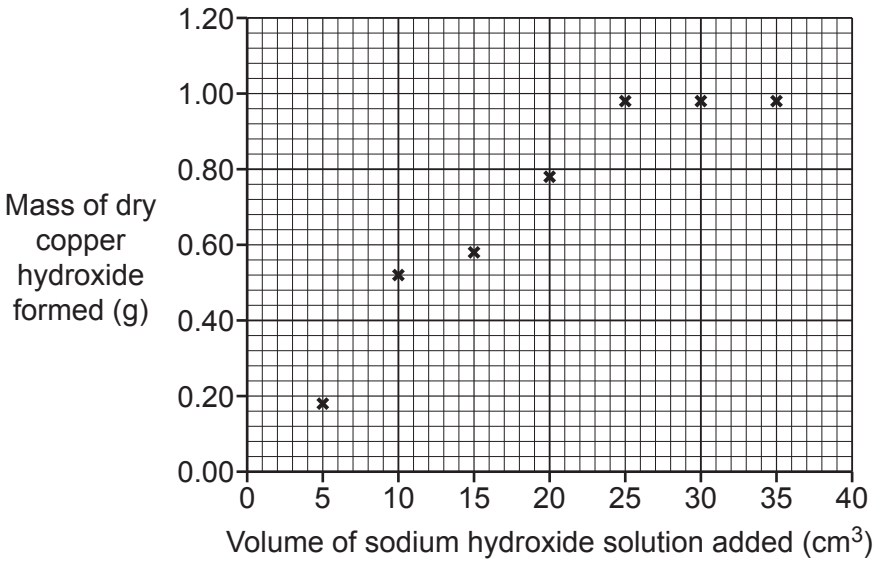
**(d)** Jane plots her results on a graph.




Jane thinks that one of her results is an outlier.

**(i)** Draw lines of best fit on the graph. **[1]**

**(ii)** Put a ring around the outlier on the graph. **[1]**

**(iii)** Suggest what the correct mass reading for the outlier should be.

correct mass reading = ..... g **[1]**

**(iv)** What is the most likely reason for the outlier?

Tick (✓) **one** box.

Jane did not add enough sodium hydroxide solution. ☐

Some of the copper hydroxide was lost before weighing. ☐

The copper hydroxide contained water when Jane weighed it. ☐

The reaction had not finished. ☐

**[1]**

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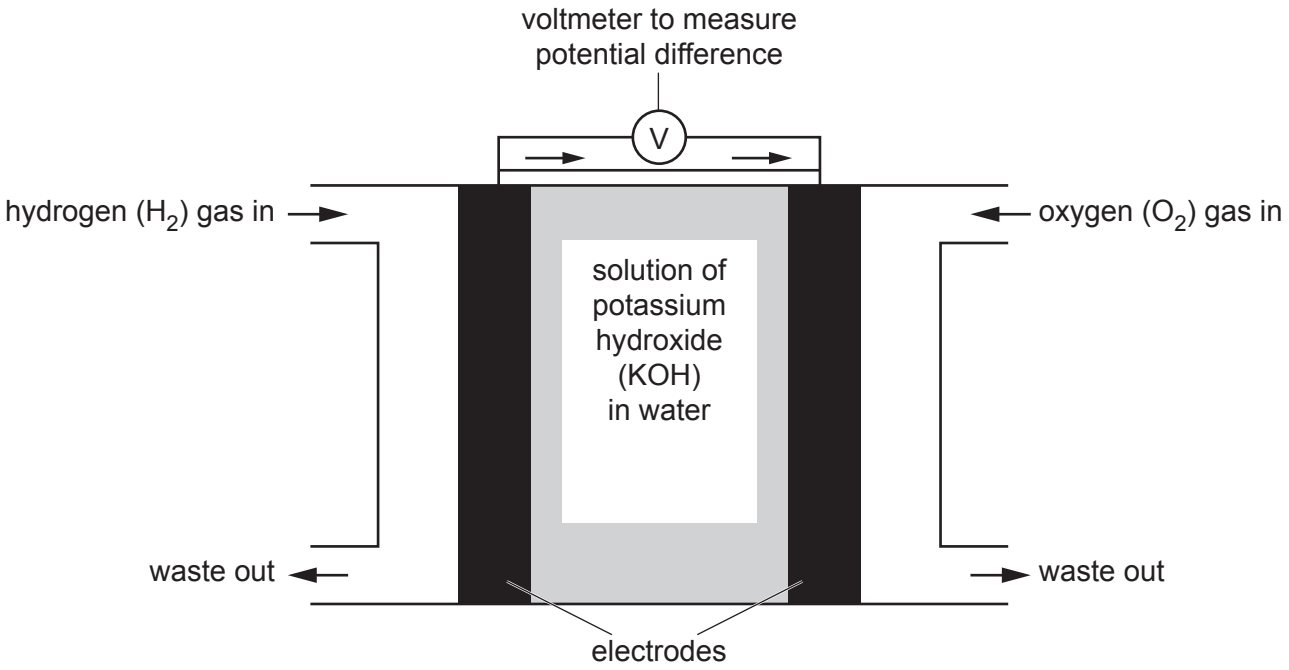
**3** Beth works for a company that makes hydrogen fuel cells.

She measures how much electrical energy a fuel cell produces by measuring its potential difference. She uses the cell shown.




**(a)** Before she sets up the cell, Beth tests each gas to check its identity.

Draw lines to connect each **gas** to its correct **test** and **result**.

| Gas | Test | Result |
|---|---|---|
| | lime water | pops |
| hydrogen | glowing splint | goes blue |
| oxygen | lighted splint | goes milky |
| | damp pH paper | relights |

**[2]**

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**(b)** The fuel cell is filled with potassium hydroxide solution rather than pure water.

This is because potassium hydroxide solution is a better electrical conductor than pure water.

Which statement explains why potassium hydroxide solution is a better electrical conductor than pure water?

Tick (✓) **one** box.

Potassium hydroxide is acidic. ☐

Potassium hydroxide is a metal. ☐

Potassium hydroxide is very soluble in water. ☐

Potassium hydroxide solution contains charged ions. ☐

**[1]**

**(c)** This equation shows the reaction that happens in the fuel cell:

$$2H_2 + O_2 \rightarrow 2H_2O$$

Beth does some experiments using different amounts of hydrogen in a fuel cell.

She records the masses of hydrogen and oxygen which are used and the mass of water made each time.

Her results are shown in **Table 3.1**.

| Experiment | Mass of hydrogen used (g) | Mass of oxygen used (g) | Mass of water made (g) |
|---|---|---|---|
| 1 | 0.1 | 0.8 | 0.9 |
| 2 | 0.4 | 3.2 | 3.6 |
| 3 | 0.5 | 4.0 | ..... |
| 4 | 1.0 | ..... | ..... |

**Table 3.1**

**(i)** Complete **Table 3.1** by predicting the missing amounts for experiments 3 and 4. **[2]**

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**(ii)** In each experiment, Beth notices that the potential difference of the cell decreases after a time.

Why does this happen?

Tick (✓) **one** box.

The concentration of potassium hydroxide solution increases. ☐

The hydrogen and oxygen are used up. ☐

The reaction takes in energy. ☐

Waste products are made. ☐

**[1]**

**(d)** Beth's company wants to use hydrogen fuel cells to provide power for a car.

Most cars use petrol as a fuel.

Beth looks at the information about hydrogen and petrol in **Table 3.2**.

| | **Hydrogen** | **Petrol** |
|---|---|---|
| Energy released by 1 kg of fuel (MJ) | 140 | 50 |
| State at room temperature and pressure | gas | liquid |
| Volume of 1 kg of fuel ($m^3$) | 12 | 0.001 |
| Waste products | water | carbon dioxide and water |
| Other points | usually produced from electrolysis of water which needs electricity | petrol engines also produce carbon monoxide and nitrogen oxides |

**Table 3.2**

**(i)** Use information from **Table 3.2** to explain **two** advantages of using hydrogen, rather than petrol, as a fuel for cars.

1 .....

.....

2 .....

.....

**[2]**

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**(ii)** Use information from **Table 3.2** to explain **two** reasons why hydrogen is more difficult to use as a fuel for cars than petrol.

1 .....

.....

2 .....

.....

**[2]**

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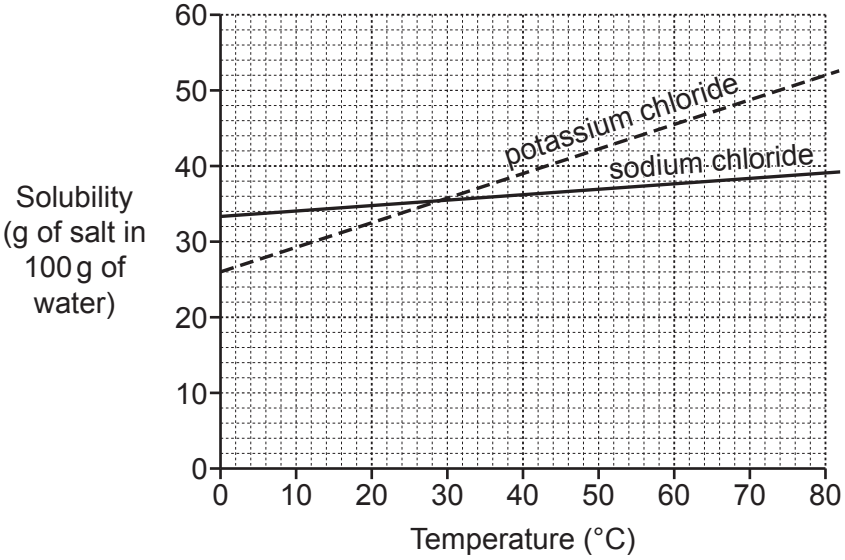
**4** The solubility of a salt shows how much salt dissolves in 100 g of water.

The graph shows the solubility of some Group 1 salts in water at different temperatures.




**(a)** Use the graph to describe how temperature affects the solubility of sodium chloride and potassium chloride.

Use values from the graph to support your answer.

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.....

.....

..... **[3]**

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**(b)** Jack works out a way to predict the solubility of potassium chloride.

He uses this formula:

solubility (g in 100 g of water) = 26 + (0.3 × temperature)

**(i)** Use Jack's formula to predict the solubility of potassium chloride at 80 °C.

predicted solubility of potassium chloride at 80 °C = ..... g in 100 g water **[2]**

**(ii)** Does this value agree with the solubility of potassium chloride at 80 °C shown on the graph?

Yes ☐

No ☐

Use data from the graph to explain your answer.

.....

.....

.....

..... **[2]**

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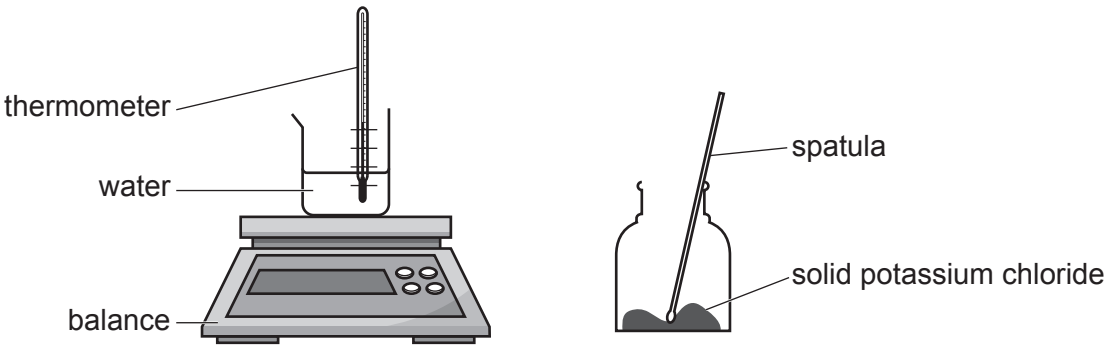
**(c)*** Jack decides to check the data given on the graph.

He adds small amounts of solid potassium chloride to water at room temperature (20 °C).

He stirs until the solid dissolves and then adds more.

He stops adding when no more solid dissolves.

The diagrams show **some** of the apparatus he uses.




Jack wants to find out how much solid potassium chloride dissolves in 100 g of water at different temperatures.

Describe the method Jack should use. Include what he needs to measure, what he needs to control, what he needs to change and what results he should expect.

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..... **[6]**

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**5** Some metals are extracted from their ores by heating with carbon.

Other metals are extracted from their ores by electrolysis.

**Fig. 5.1** shows the order of reactivity of some metals, compared to carbon.

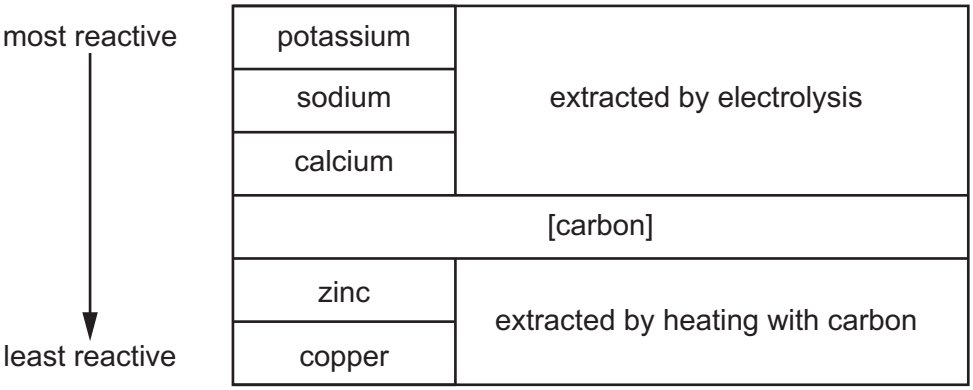


**Fig. 5.1**

**(a)** Which statement explains why calcium must be extracted from its ore by electrolysis?

Tick (✓) **one** box.

Calcium does not conduct electricity. ☐

Calcium is a non-metal. ☐

Calcium is more reactive than carbon. ☐

Calcium is too unreactive to be extracted using carbon. ☐

**[1]**

**(b)** **(i)** Which metal, not listed in **Fig. 5.1**, is less reactive than carbon?

Put a ring around the correct answer.

**lithium** **magnesium** **potassium** **silver**

**[1]**

**(ii)** Mia makes this statement:

'The information in **Fig. 5.1** shows that all metals which are more reactive than carbon are in Group 1.'

Use information from **Fig. 5.1** to help explain why Mia's statement is only partly correct.

.....

.....

..... **[2]**

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**(c)** **(i)** How are iron and aluminium extracted from their ores?

Tick (✓) **one** box in each row.

| Metal | Extracted by heating with carbon | Extracted by electrolysis |
|---|---|---|
| iron | | |
| aluminium | | |

**[1]**

**(ii)** After extraction, iron is mixed with other elements to make steel.

Complete the sentences about steel.

Use words from the list.

| | | | | | |
|---|---|---|---|---|---|
| **carbon** | **chlorine** | **sulfur** | **harder** | **softer** | **weaker** |

To make steel, iron is mixed with small amounts of ..... .

This makes the steel ..... . **[1]**

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**(d)** Copper is extracted from copper oxide by heating it with carbon.

This is the equation for the reaction that happens:

$2CuO(s) + C(s) \rightarrow 2Cu(s) + CO_2(g)$

**(i)** Write the **word** equation for the reaction between copper oxide and carbon.

**[2]**

**(ii)** What is oxidised and what is reduced during the reaction between copper oxide and carbon?

Explain your reasons.

oxidised .....

reduced .....

reasons .....

.....

**[2]**

**(iii)** What would you expect to happen to the total mass of solids during the reaction between copper oxide and carbon?

Tick (✓) **one** box.

mass of solids becomes zero ☐

mass of solids decreases ☐

mass of solids increases ☐

mass of solids stays the same ☐

**[1]**

**(iv)** Explain how you decided your answer to **(d)(iii)**.

.....

..... **[1]**

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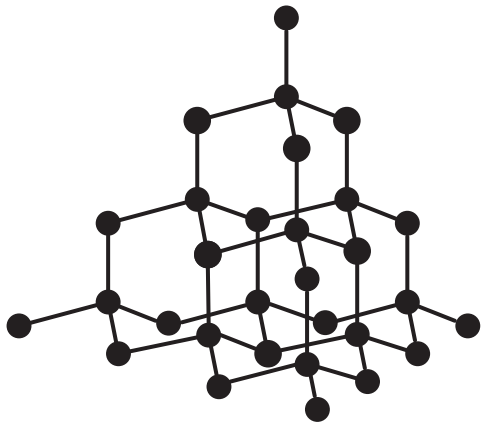
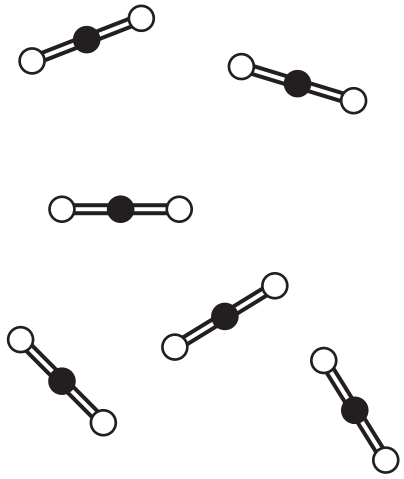
**6** The diagram shows the structures of diamond and carbon dioxide.

| Diamond | Carbon dioxide |
|---|---|
|  |  |
| giant covalent | simple molecules |

**(a)** The atoms in diamond are held together by single covalent bonds.

How is a single covalent bond formed?

Use ideas about electrons in your answer.

.....

..... **[2]**

**(b)** Which of these statements are only true for diamond, which are only true for carbon dioxide and which are true for both?

Tick (✓) **one** box in each row.

| | Only true for diamond | Only true for carbon dioxide | True for both |
|---|---|---|---|
| It is a compound. | | | |
| Each carbon atom has four bonds. | | | |
| It is an allotrope of carbon. | | | |
| It is found in the air. | | | |

**[2]**

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**(c)*** The melting point is the temperature at which a solid changes to a liquid.

**Table 6.1** shows the structures and melting points of diamond and carbon dioxide.

| | **Structure** | **Melting point (°C)** |
|---|---|---|
| **Diamond** | giant covalent | 4700 |
| **Carbon dioxide** | simple molecules | –57 |

**Table 6.1**

Explain why diamond and carbon dioxide change from a solid to a liquid at different temperatures.

Use ideas about energy, bonds and forces between molecules in your answer.

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..... **[6]**

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**7** **Fig. 7.1** shows the change in carbon dioxide concentration in the Earth's atmosphere over the last 575 million years.

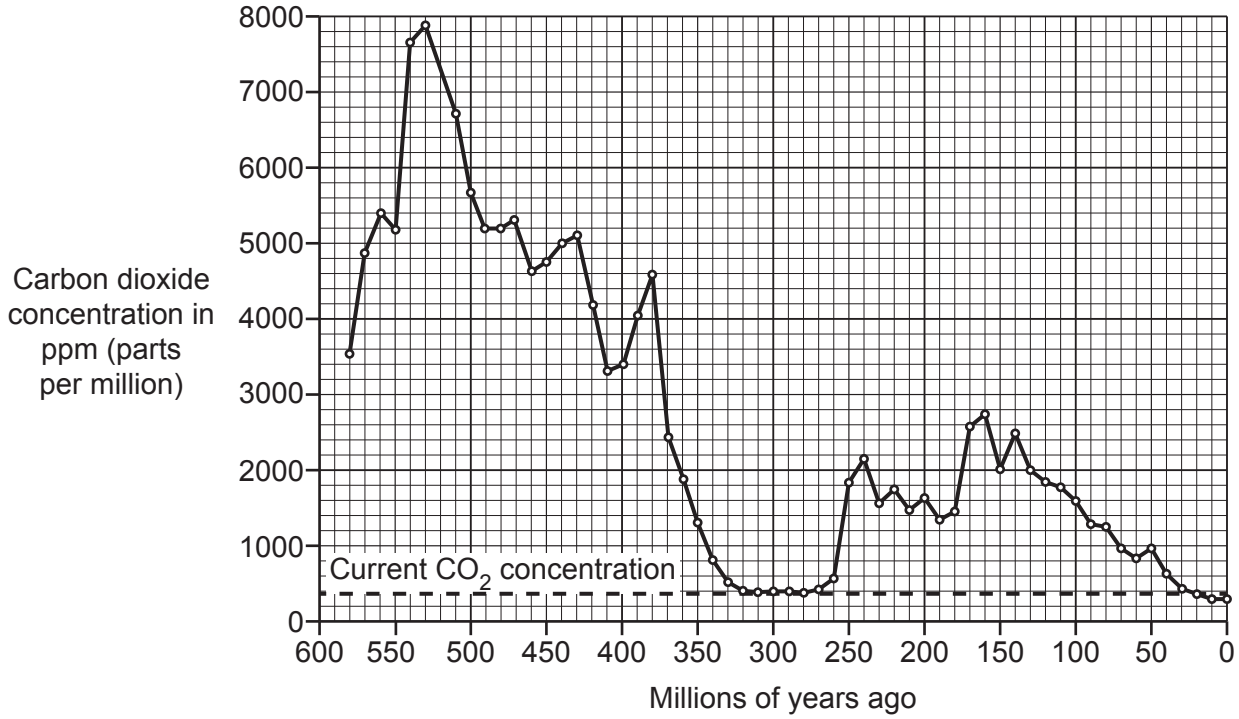


**Fig. 7.1**

**(a)** Carbon dioxide concentration was at its highest about 530 million years ago.

What was the value of the concentration of carbon dioxide 530 million years ago?

concentration of carbon dioxide = ..... ppm (parts per million) **[1]**

**(b)** During what period was the concentration of carbon dioxide similar to its concentration today?

from ..... to ..... millions of years ago **[1]**

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**(c)** **Fig. 7.1** shows the most recent value for the concentration of carbon dioxide to be 380 parts per million (ppm).

Do a calculation to convert 380 ppm into a percentage.

Use this formula:

$$\text{concentration in \%} = \frac{\text{concentration in ppm}}{10\,000}$$

..... % **[2]**

**(d)** **Fig. 7.2** shows the amount of oil burned and the change in the Earth's temperature between 1850 and 2010.

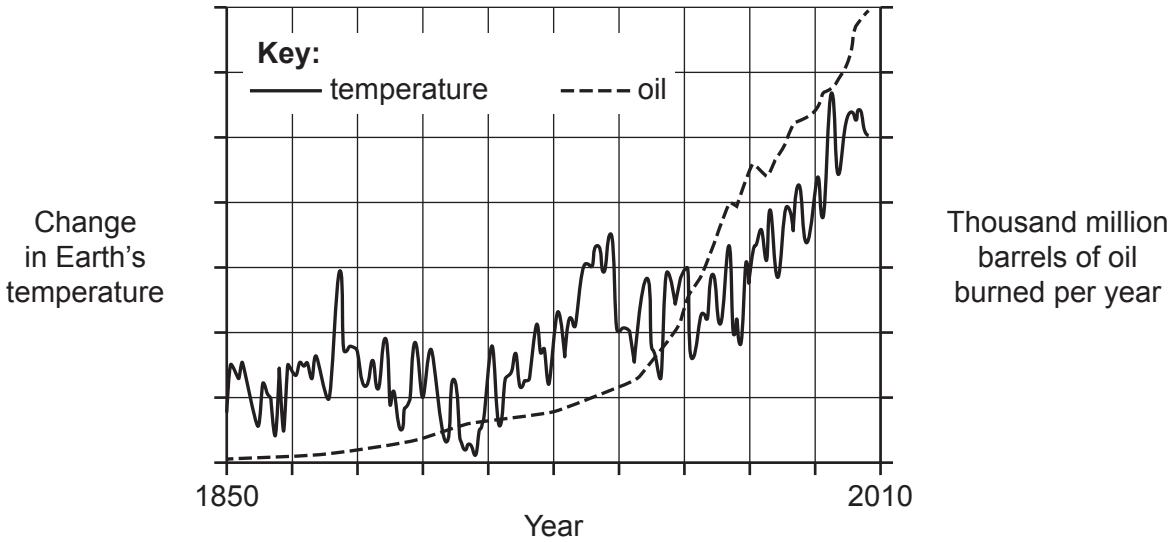


**Fig. 7.2**

Ben says that the graph shows a correlation between the total amount of oil burned per year and the change in global temperature.

Explain why Ben is right.

.....

..... **[1]**

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**(e)** Some scientists fear that climate change may cause other long-term environmental problems.

Describe **two** other long-term environmental problems caused by climate change.

1 .....

.....

2 .....

.....

**[2]**

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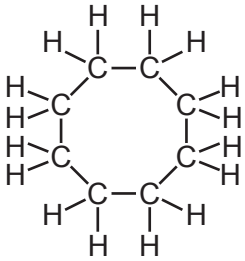
**8** **Fig. 8.1** shows the uses, properties and structure of some substances which contain carbon atoms.

**Cyclo-octane**

Added to petrol

Very flammable

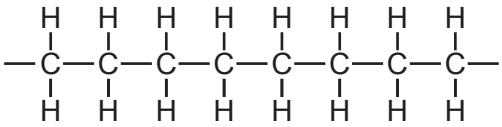


Carbon atoms bonded to other carbon atoms in rings and to hydrogen atoms

**Polyethene**

Used to make carrier bags

Flexible, softens at 1200 °C, stretches and breaks easily

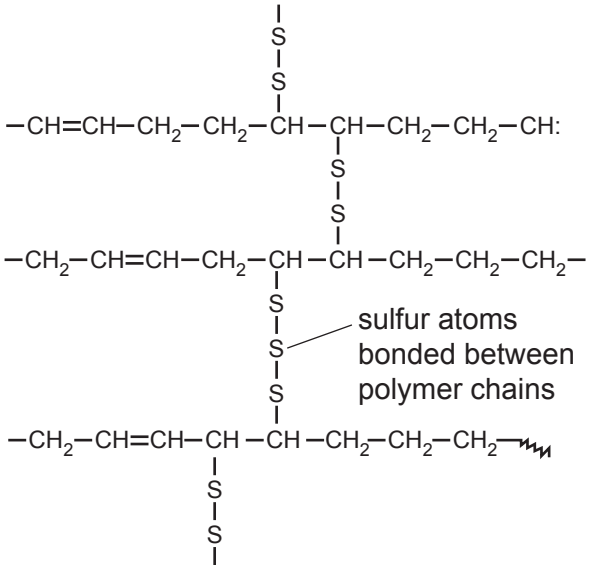


Carbon atoms bonded to other carbon atoms in long chains and to hydrogen atoms

**Synthetic rubber**

Used to make car tyres

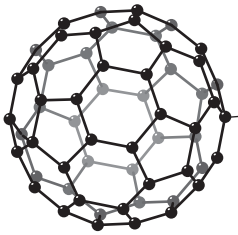
Stronger and harder than most polymers and has a higher melting point

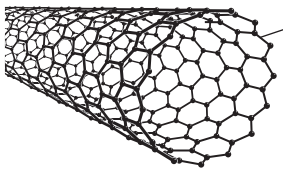



Carbon atoms bonded to other carbon atoms in long chains with sulfur atoms bonded between the polymer chains

**Nanoparticles**

Used to carry medicine molecules into the body




Carbon atoms bonded to other carbon atoms to form balls and tubes

**Fig. 8.1**

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**(a)** Petrol contains cyclo-octane.

**(i)** Which symbol should be used to warn people of the main hazard when handling cyclo-octane?

Tick (✓) **one** box.

☐

☐

☐

☐

**[1]**

**(ii)** Write down **two** safety precautions people should take when filling their cars with petrol.

1 .....

.....

2 .....

.....

**[2]**

**(b)** Carbon makes a much bigger range of different types of molecules than any other element.

Give **one** reason why carbon atoms can form so many different types of molecules.

Use **Fig. 8.1** to help you to answer.

.....

..... **[1]**

**(c)** Explain why polyethene and synthetic rubber have different properties.

Use ideas about structure from **Fig. 8.1** to help you to answer.

.....

.....

.....

..... **[2]**

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**(d)** **(i)** How are nanoparticles different to the other substances in **Fig. 8.1**?

.....

..... **[1]**

**(ii)** Explain why the structure of carbon nanoparticles helps them to carry medicine molecules into the body.

.....

..... **[2]**

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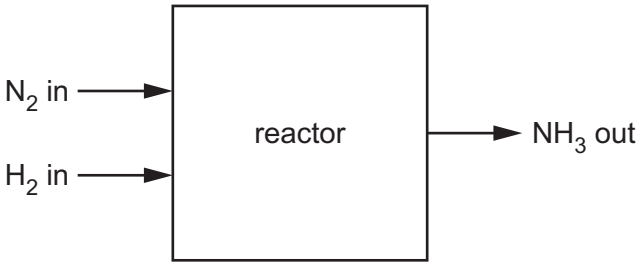
**9** Ammonia is used to make fertilisers. It is produced in a large-scale process.

The equation shows the reaction that happens in the process:

$$N_2 + 3H_2 \rightleftharpoons \underset{\text{ammonia}}{2NH_3}$$

The process happens in a reactor.




**(a)** The percentage yield of ammonia is usually between 10% and 20%.

**(i)** Use the equation to explain why it is not possible to get 100% yield of ammonia.

.....

..... **[1]**

**(ii)** The gas that leaves the reactor contains ammonia mixed with two other gases.

Use the equation to help you to give the names of the other **two** gases.

..... **and** ..... **[1]**

**(b)** An ammonia factory tests a new reactor.

The table shows the theoretical yield and actual yield for a process in the new reactor.

| | |
|---|---|
| Theoretical yield (tonnes) | 150 |
| Actual yield (tonnes) | 19.5 |

Calculate the percentage yield for the process in the new reactor.

Use the equation: $\text{percentage yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$

percentage yield = ..... % **[2]**

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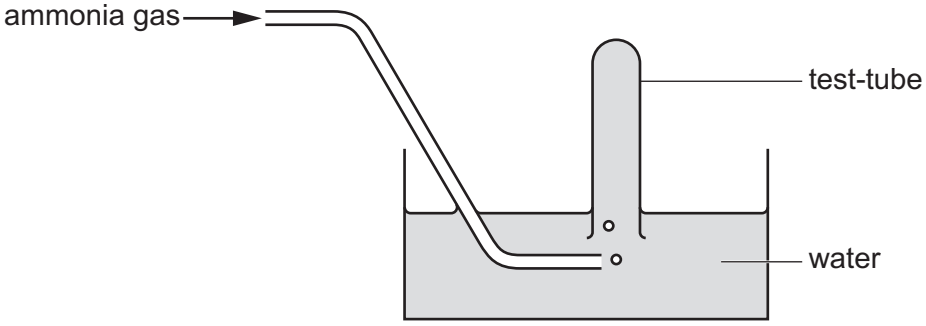
**(c)** Ammonia is very soluble in water.

Kofi does an experiment to make some ammonia.

He tries to collect it using the apparatus shown.




**(i)** Bubbles of ammonia gas enter the water but no gas collects in the test-tube.

What happens to the ammonia gas when it enters the water?

.....

..... **[1]**

**(ii)** Which apparatus should Kofi use to collect ammonia?

Tick (✓) **one** box.

burette ☐

gas syringe ☐

measuring cylinder ☐

volumetric flask ☐

**[1]**

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**(d)** Ammonia is an alkaline gas.

The pH of ammonia solution can be measured using a pH meter.

**(i)** Predict the pH of ammonia.

pH ..... **[1]**

**(ii)** Describe another method you could use to measure the pH of ammonia solution.

.....

.....

..... **[2]**

**END OF QUESTION PAPER**

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## ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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