Oxford Cambridge and RSA

Friday 13 June 2025 – 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

F

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 **28** pages.

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

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1 **Fig. 1.1** shows the names and formulae of some acids and alkalis.

Fig. 1.1

	Name of compound	**Formula**
Acids	Hydrochloric acid	HCl
	Sulfuric acid	H_2SO_4
Alkalis	Lithium hydroxide	LiOH
	Sodium hydroxide	NaOH
	Potassium hydroxide	KOH

(a) Write down the name of a compound from **Fig. 1.1** to answer the following questions.

(i) Which compound has a formula with 2 atoms?

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

(ii) Which **alkali** reacts with hydrochloric acid to make sodium chloride?

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

(iii) Which **alkali** has the highest relative formula mass?

Use the Periodic Table to help you.

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

(iv) Which **two** compounds can each react with magnesium metal to make hydrogen?

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

(v) Which compound gives a white precipitate when a few drops are added to dilute barium nitrate?

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

(b) Which statements are **true** and which are **false**?

Tick (✓) **one** box in each row.

	True	**False**
Acids form hydrogen ions when they dissolve in water.		
All neutralisation reactions make water.		
Copper does **not** react with dilute acid.		
Titrations give qualitative data.		

[3]

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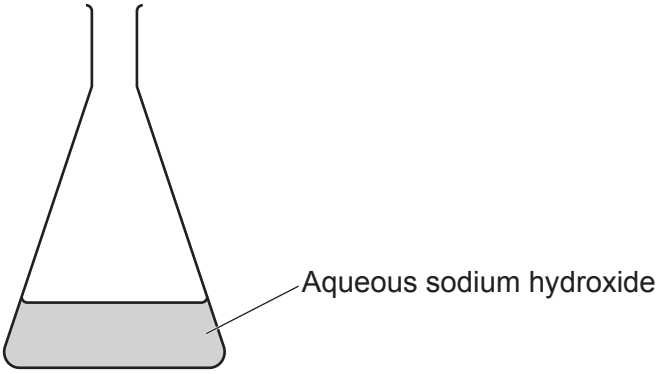
(c) A student does a titration to find out how much acid is needed to neutralise 25.0 cm^3 aqueous sodium hydroxide.

They add the aqueous sodium hydroxide to a conical flask.



(i) The student adds another substance to the conical flask so that they know when the aqueous sodium hydroxide is neutralised.

Name this substance.

Describe how the substance shows the student that the aqueous sodium hydroxide has been neutralised.

Name .....

Description .....

.....

[2]

(ii) Which other piece of apparatus does the student need to do the titration?

Tick (✓) **one** box.

Bunsen burner ☐

Burette ☐

Stop clock ☐

Test-tube ☐

Thermometer ☐

[1]

(iii) The student does the titration and then looks at the results of another student.

Explain why the student looks at the results of another student.

.....

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

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2 Several processes can be used to produce drinking water.

Each process has a purpose.

(a) Draw lines to connect each **water treatment process** with its correct **purpose**.

Water treatment process	**Purpose**
Aeration	Separates pure water from salt water.
Distillation	Uses oxygen to break down harmful waste.
Filtration	Removes solid impurities.

[2]

(b) Water for drinking is treated with chlorine.

What is the **test** and **expected result** for chlorine gas?

Tick (✓) **one** box in each column.

Test		**Expected result**	
Aqueous bromine	☐	goes blue	☐
Damp blue litmus paper	☐	goes green	☐
Lighted splint	☐	goes red then white	☐

[2]

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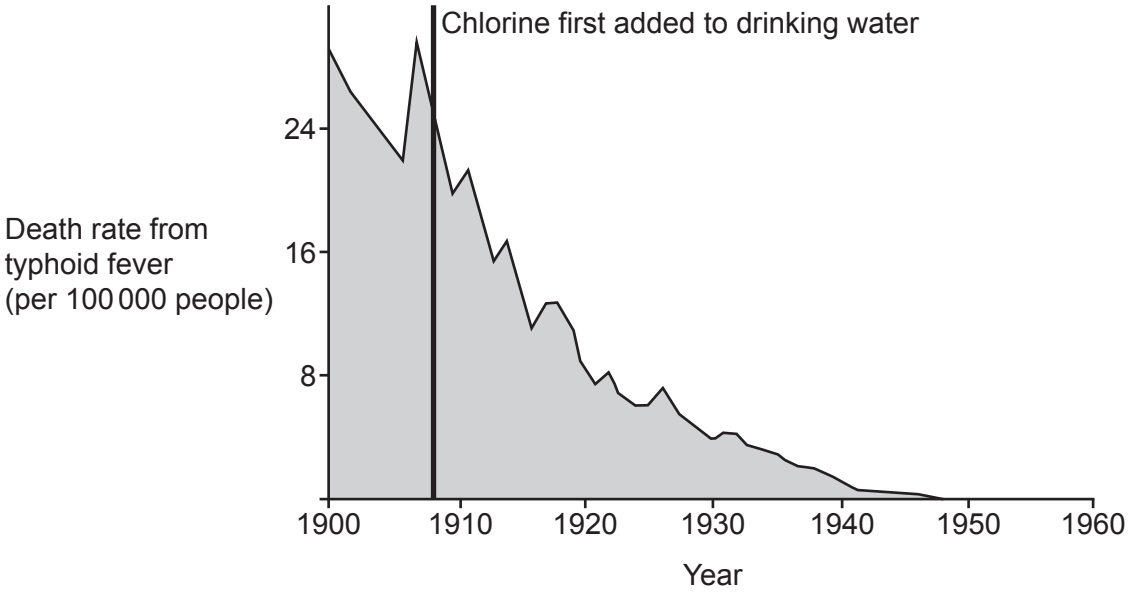
(c) Typhoid fever is a disease that causes death. It is caused by harmful microorganisms in water.

Chlorine was first added to drinking water in the United States in 1908.

The graph shows the death rate from typhoid fever in the United States before and after chlorine was first added to drinking water.



(i) Describe what the graph shows about the death rate from typhoid fever in the United States before and after chlorine was first added to drinking water.

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

(ii) A student looks at the graph and has this idea:

'The graph shows that everyone in the world has had water that is safe to drink since about 1948.'

Suggest **two** reasons why the student is **not** correct.

1 .....

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2 .....

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[2]

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(d) The effect of adding chlorine to drinking water was an important scientific discovery.

Today, information about important scientific discoveries is published for peer review.

Explain what happens during peer review.

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

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3 Pure iron corrodes easily and is **not** strong enough for some uses.

(a) When iron corrodes it reacts with oxygen to make iron(III) oxide.

Complete **Table 3.1** by filling in the missing formulae and state symbols.

Table 3.1

	Formula	**State symbol**
Iron	.....	(s)
Oxygen	.....	.....
Iron(III) oxide	Fe_2O_3	.....

[3]

(b) Steel is a mixture of iron with other elements.

Table 3.2 shows the percentages of other metals mixed with iron in two types of steel.

Table 3.2

Type of steel	**Percentage of other elements mixed with iron**
Steel 1	chromium 16.7% nickel 8.1% copper 3.6% carbon 0.1%
Steel 2	carbon 1.9%

(i) Calculate the percentage of iron in **Steel 1**.

Percentage of iron = ...%

[2]

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(ii)* Adding different elements to steel changes its properties.

Table 3.3 shows the effect on properties of steel of adding different elements.

Table 3.3

Element	Effect on properties of steel
Chromium	More corrosion resistance, especially at high temperatures.
Nickel	More corrosion resistance. Can be bent more without breaking.
Carbon	Increasing amounts increases hardness but also makes steel more easy to break. No effect on corrosion resistance.
Copper	Electrical conductivity increases. More corrosion resistance in sea water.

Steel 1 is used to make engine parts for ships.

Predict the properties of **Steel 1** and **Steel 2** and explain why **Steel 1** is suitable to make engine parts for ships but **Steel 2** is **not**.

Use the information in **Table 3.2** and **Table 3.3** in your answer.

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

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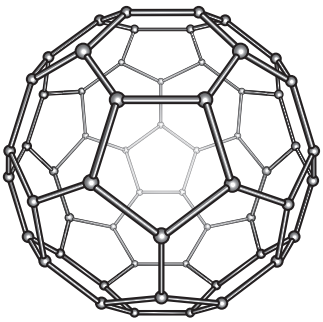
4 Carbon nanoparticles contain only carbon atoms.

Buckyballs are a type of carbon nanoparticle that have carbon atoms joined together in a ball with a hollow centre.



(a) Which statements about buckyballs and other nanoparticles are **true** and which are **false**?

Tick (✓) **one** box in each row.

	True	**False**
Buckyballs are chemical compounds.		
Buckyballs are larger than carbon atoms.		
Diamond and graphite are examples of nanoparticles.		
Some nanoparticles are shaped as tubes.		

[3]

(b) The surface area to volume ratio of a buckyball can be calculated using this formula:

surface area to volume ratio = $\frac{3}{r}$ where r is the radius of the buckyball **in nm**.

Calculate the surface area to volume ratio of a buckyball that has a radius of 0.5 nm.

Surface area to volume ratio = ... **[2]**

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(c) Scientists are developing ways of using nanoparticles to carry medicines into the human body.

Some people think that using nanoparticles to carry medicines may cause risks.

Which **two** statements explain why using nanoparticles may cause risks?

Tick (✓) **two** boxes.

- Medicines can be carried in the hollow spaces in nanoparticles. ☐
- Nanoparticles are small enough to enter the brain. ☐
- Nanoparticles have a high surface area. ☐
- There is more data about uses of nanoparticles than about their effects on health. ☐

[2]

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5 Both natural fertilisers and synthetic fertilisers are used to grow food crops.

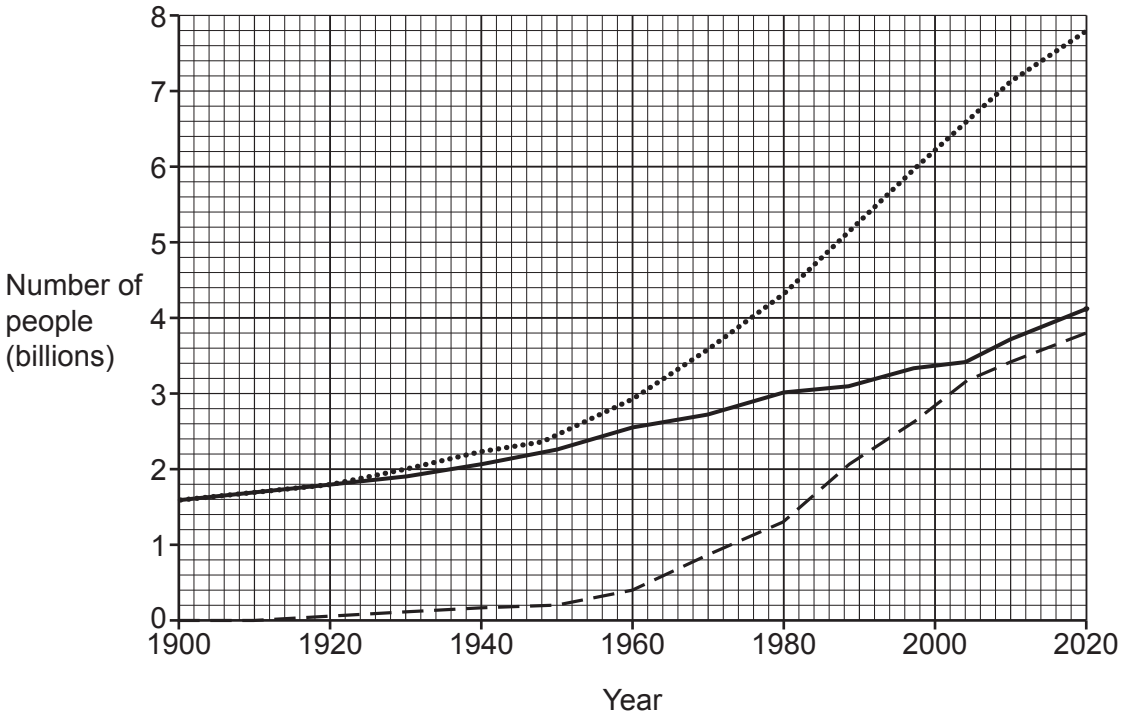
The graph shows data between 1900 and 2020 for:
- the world population
- the number of people that could be fed from food grown using only **natural** fertilisers
- the number of people that could be fed from food grown using only **synthetic** fertilisers.

Key

····· World population

——— Number of people that could be fed from food grown using only **natural** fertilisers

— — — Number of people that could be fed from food grown using only **synthetic** fertilisers



(a) Predict when the first **synthetic** fertiliser became available.

Use the graph.

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

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(b)

(i) How many people could be fed with food grown using only **natural** fertilisers in 1900 and 2020.

Use the graph.

Number of people that could be fed using only **natural** fertilisers in 1900 .....

Number of people that could be fed using only **natural** fertilisers in 2020 .....

[2]

(ii) Calculate the percentage increase in the number of people that can be fed using only **natural** fertilisers between 1900 and 2020.

Give your answer to **1** decimal place.

Percentage increase = ... % **[3]**

(c) A student looks at the graph and has this idea:

'The total amount of food that can be grown using both natural and synthetic fertilisers in 2020 is enough to feed everybody in the world.'

Is the student correct?

Use data from the graph to explain your answer.

.....

.....

.....

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

(d) Making and using synthetic fertilisers has both costs and benefits.

Which statements about making and using synthetic fertilisers are a **benefit** and which are a **cost**?

Tick (✓) **one** box in each row.

	Benefit	**Cost**
Synthetic fertilisers are used to increase the rate of growth of food crops.		
The manufacture of synthetic fertilisers uses energy from fossil fuels.		
Using synthetic fertilisers causes eutrophication.		

[2]

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(e) Most synthetic fertilisers contain three essential elements.

One essential element is nitrogen.

Which **two other** essential elements do fertilisers contain?

Tick (✓) **two** boxes.

Carbon ☐

Hydrogen ☐

Oxygen ☐

Phosphorus ☐

Potassium ☐

[2]

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6 Hydrogen is made when methane reacts with steam.

The equation shows the reaction.

$CH_4 + 2H_2O \rightleftharpoons 4H_2 + CO_2$

(a) Which **two** statements explain why this reaction does **not** give a 100% yield?

Tick (✓) **two** boxes.

At the end of the reaction there will be some unreacted methane. ☐

Carbon dioxide cannot be used as a fuel. ☐

Carbon dioxide is a waste product. ☐

The equation has a reversible symbol. ☐

[2]

(b) The table shows information about the masses of some of the substances in the equation.

$CH_4 + 2H_2O \rightleftharpoons 4H_2 + CO_2$

	Relative formula mass	**Total mass in equation**
CH_4	16	16
H_2O	18	2 × 18 = 36
H_2	2	4 × 2 = 8

(i) Explain why the total mass of hydrogen in the equation is given by 4 × 2 = 8.

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.....

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

(ii) Calculate the atom economy of the reaction.

Use:
- data from the table above
- the formula: atom economy = $\frac{\text{total mass of hydrogen in equation}}{\text{total mass of all reactants in equation}} \times 100$

Atom economy = ...%
[2]

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(iii) Calculate the relative formula mass of carbon dioxide, CO_2.

Use the Periodic Table.

Relative formula mass = ... **[2]**

(c) The carbon dioxide is separated from the hydrogen and used in another process to make methanol (CH_3OH) to be used as a fuel.

(i) Which **two** statements give benefits of using the carbon dioxide in another process?

Tick (✓) **two** boxes.

Hydrogen and carbon dioxide are easy to separate.	☐
Less energy needs to be used to make hydrogen.	☐
The carbon dioxide is a by-product and **not** a waste product.	☐
The carbon dioxide is **not** released into the air.	☐

[2]

(ii) When hydrogen and methanol (CH_3OH) are burned as fuels they form products.

Draw lines to connect each **fuel burned** to the correct **products**.

Fuel burned	**Products**
Hydrogen	Only water
	Only carbon dioxide
Methanol (CH_3OH)	Carbon dioxide and water

[2]

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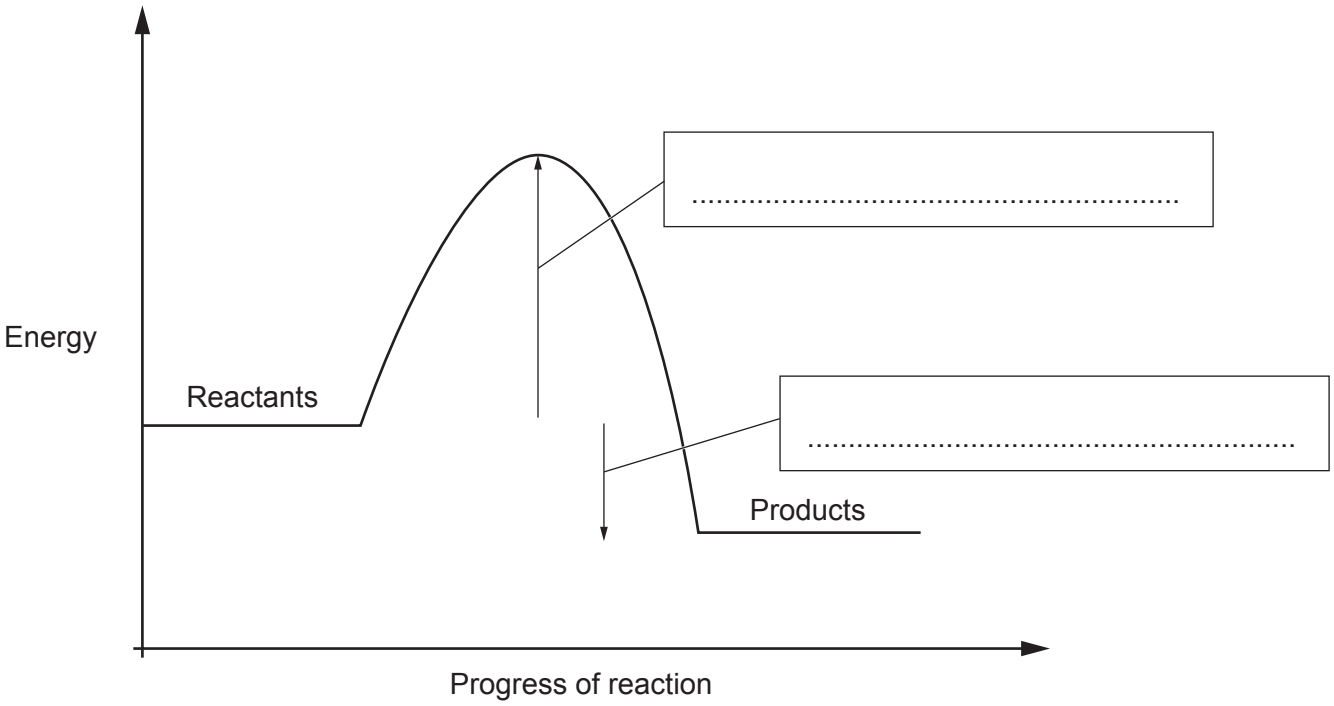
7

(a) **Fig. 7.1** shows a reaction profile diagram for a reaction.

Complete **Fig. 7.1** by filling in the labels.

Fig. 7.1



[2]

(b)* **Fig. 7.2** shows the trend in energy changes when some compounds dissolve in water.

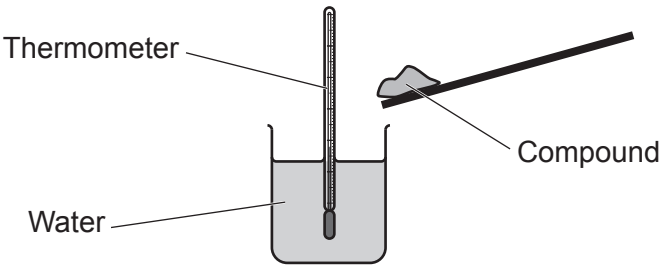
Fig. 7.2

Compound	**Trend**
Potassium chloride	Energy change becomes more endothermic when compound dissolves in water.
Potassium bromide	
Potassium iodide	

A student wants to show that the trend in **Fig. 7.2** is correct.

Fig. 7.3 shows the apparatus they set up.

Fig. 7.3



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Describe how the student can use samples of the compounds in **Fig. 7.2** and the apparatus shown in **Fig. 7.3** to show that the trend in **Fig. 7.2** is **correct**.

Include in your answer:
- their method
- what they need to keep constant
- the results expected if the trend in energy changes shown in **Fig. 7.2** is correct.

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

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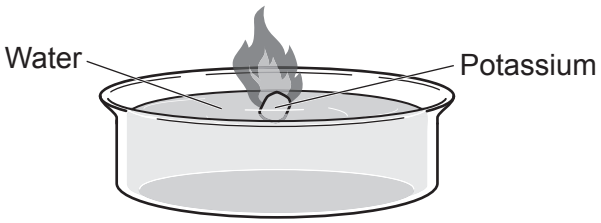
8 Potassium, sodium and lithium are metals in Group 1 of the Periodic Table.

A student watches a video of the reaction of potassium with water.

Fig. 8.1 shows a diagram of the experiment.

Fig. 8.1



The table shows information about this reaction.

Metal	**Products of the reaction**	**Observations**
Potassium	Potassium hydroxide Hydrogen gas	Potassium moves quickly on the surface of the water and fizzes violently. Potassium burns with a pale purple flame.

(a) The student then watches a video of the reaction of **sodium** with water.

Predict the products of the reaction of sodium with water and describe the observations you expect.

Products ..... and .....

Observations .....

.....

.....

.....

[3]

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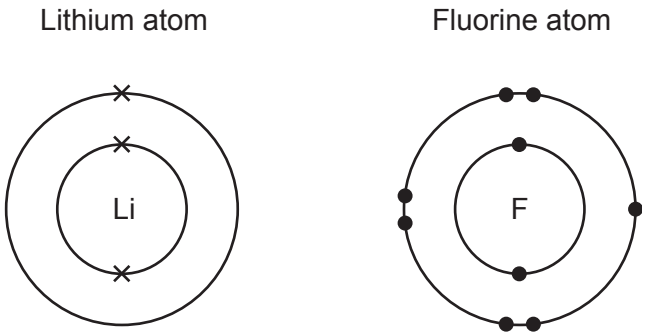
(b) **Fig. 8.2** shows the arrangement of electrons in a lithium atom and a fluorine atom.

Fig. 8.2



(i) Lithium and fluorine belong to different groups of the Periodic Table.

Explain how the arrangement of electrons in lithium and fluorine is related to their **groups** in the Periodic Table.

.....

.....

.....

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

(ii) Explain how **Fig. 8.2** shows that lithium and fluorine are in the same **period** of the Periodic Table.

.....

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

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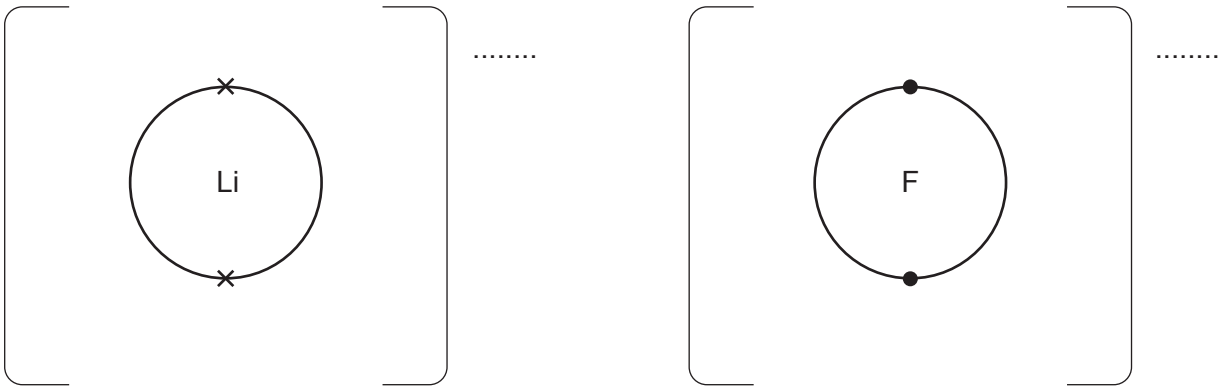
(iii) Lithium fluoride is an ionic compound that has lithium ions and fluoride ions.

Fig. 8.3 shows a dot and cross diagram of these ions.
The diagram is **not** complete.

Fig. 8.3



Complete **Fig. 8.3**.

You need to:
- show the arrangement of electrons in the **fluoride** ion
- show the charges on **both** ions. **[3]**

(iv) Which statement gives a correct limitation of using a complete dot and cross diagram to represent ionic bonding?

Tick (✓) **one** box.

It does **not** show that the ions are different sizes. ☐

It does **not** show the correct ratio of numbers of ions. ☐

It does **not** show the total number of electrons. ☐

It only shows shared electrons. ☐

[1]

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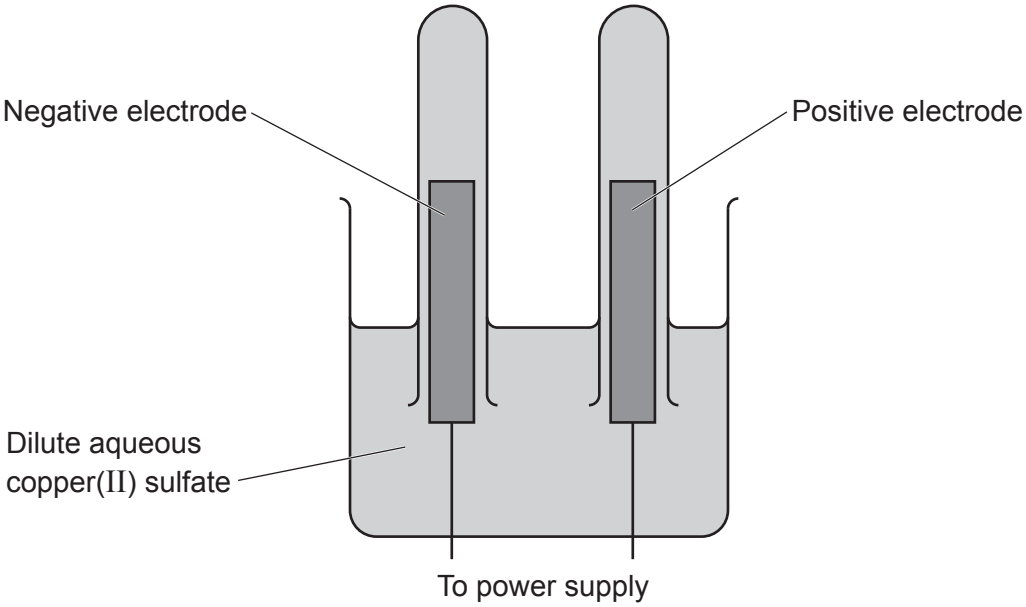
9 A student does an electrolysis experiment.

They pass electricity through dilute aqueous copper(II) sulfate using inert electrodes.

The diagram shows the apparatus they set up.



(a) Oxygen gas forms at the positive electrode.

Which **two** statements give correct reasons why oxygen forms at the positive electrode?

Tick (✓) **two** boxes.

Copper reacts with water to form oxygen. ☐

Hydroxide ions from water react to form oxygen. ☐

Non-metals usually form at the positive electrode. ☐

The electricity causes water to evaporate around the electrode. ☐

[2]

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(b) The student wants to find the rate that oxygen gas forms by measuring the volume of gas produced.

(i) Suggest **one** change to the apparatus so that the volume of oxygen gas can be measured.

.....

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

(ii) Describe how the student uses the new apparatus and a stop watch to find the rate that oxygen gas forms.

Include in your answer:
- what results they need to collect
- how they use their results to find the rate.

.....

.....

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.....

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

(c) The student measures the mass of the electrodes before and after the electrolysis.

The table shows their results.

	Negative electrode	**Positive electrode**
Mass before electrolysis (g)	10.2	10.4
Mass after electrolysis (g)	10.9	10.4

Explain what happens to the mass of each electrode during the experiment.

Positive electrode .....

.....

.....

Negative electrode .....

.....

.....
[3]

END OF QUESTION PAPER

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EXTRA ANSWER SPACE

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