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Monday 29 November 2021 – 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 **24** pages.

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

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Answer **all** the questions.

1 The exhaust gases from diesel car engines contain nitrogen oxides.

(a) Complete the sentences about nitrogen oxides.

Put a (ring) around the correct answers.

Nitrogen oxides form in the engine when nitrogen from the **air** / **fuel** reacts with oxygen.

This happens because in car engines the gases are very **concentrated** / **hot**.

Nitrogen oxides are harmful because they cause **acid rain** / **particulates**.

[2]

(b) Urea is used in the exhausts of some diesel cars to remove nitrogen oxides from the exhaust gases.

Urea reacts with nitrogen oxide (NO) and oxygen to make three new gases.

Substances used in the reaction		**New gases formed**
Urea		CO_2
Nitrogen oxide (NO)	----------→	H_2O
Oxygen		N_2

(i) Amir says that nitrogen oxides are reduced during the reaction.

Give **one** reason why Amir is correct.

.....

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

(ii) Jamal says that the reaction also involves oxidation.

Give **one** reason why Jamal is right.

.....

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

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(iii) Complete the table by giving the name of each new gas formed in the reaction.

Gas	Name
CO_2	
H_2O	
N_2	

[3]

(iv) Amir says that the three new gases formed are **not** harmful to health or to the environment.

Do you agree with Amir?
Explain your answer.

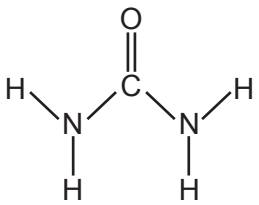
.....

.....

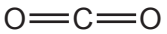
.....

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

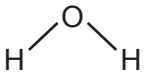
(c) Amir draws the structures of urea and of the gases involved in the reaction.



Urea



CO_2



H_2O

N_2

Amir looks at the number of bonds formed by carbon, oxygen, nitrogen and hydrogen atoms. He says that each type of atom has the same number of bonds in every molecule shown.

Do you agree with Amir?
Explain your answer.

.....

.....

.....

.....

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

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2 Layla heats a small piece of sodium. She then puts it in a jar of chlorine gas, as shown in **Fig. 2.1**.

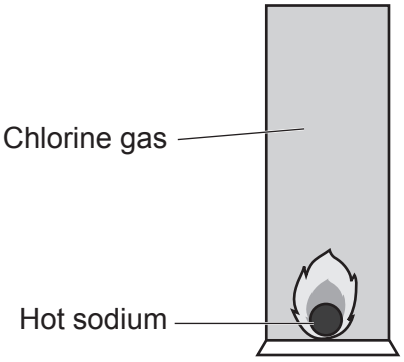

Fig. 2.1

Layla observes that the sodium burns quickly with a bright flame and forms a white solid.
The white solid is sodium chloride.

(a) Layla repeats the experiment. This time she uses lithium.

(i) What is the name of the salt that forms when lithium reacts with chlorine?

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

(ii) How would Layla's observations be different when she uses lithium?

Put a ring around the correct answer.

Reaction is slower **Reaction is faster** **Reaction takes same amount of time**
[1]

(iii) Give **one** reason for your answer to **(a)(ii)**.

.....

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

(b) Layla does experiments with other Group 1 and Group 7 elements.

Complete the table of information about each element.

Element	Group number	Solid, liquid or gas at room temperature?	Colour at room temperature
Sodium	1	Solid	Silver
Chlorine	7	.....	.....
Potassium	.....	.....	.....
Iodine	.....	Solid	.....

[3]

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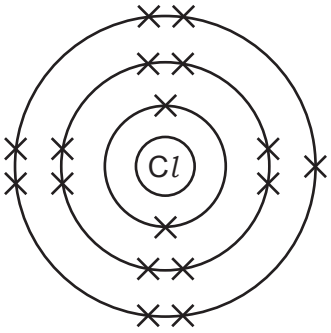
(c) **Fig. 2.2** shows the arrangement of electrons in a chlorine atom.



Chlorine (atomic number 17)

Fig. 2.2

(i) Complete **Fig. 2.3** to show the arrangement of electrons in a sodium atom.

Sodium (atomic number 11)

Fig. 2.3

[2]

(ii) Chlorine forms chloride ions, Cl^-.

Complete the sentence to explain why chloride ions have a charge of –1.

Use the words.

You can use each word once, more than once, or not at all.

eight **gain** **lose** **seven** **two**

Chlorine has ..... electrons in the outer shell, so it needs to

..... one electron to give a full outer shell.

[2]

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3 Aluminium is extracted from molten aluminium oxide by electrolysis.

(a) Explain why molten aluminium oxide conducts electricity but solid aluminium oxide does not.

.....

.....

.....

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

(b) **Fig. 3.1** shows the tank used to electrolyse aluminium oxide.

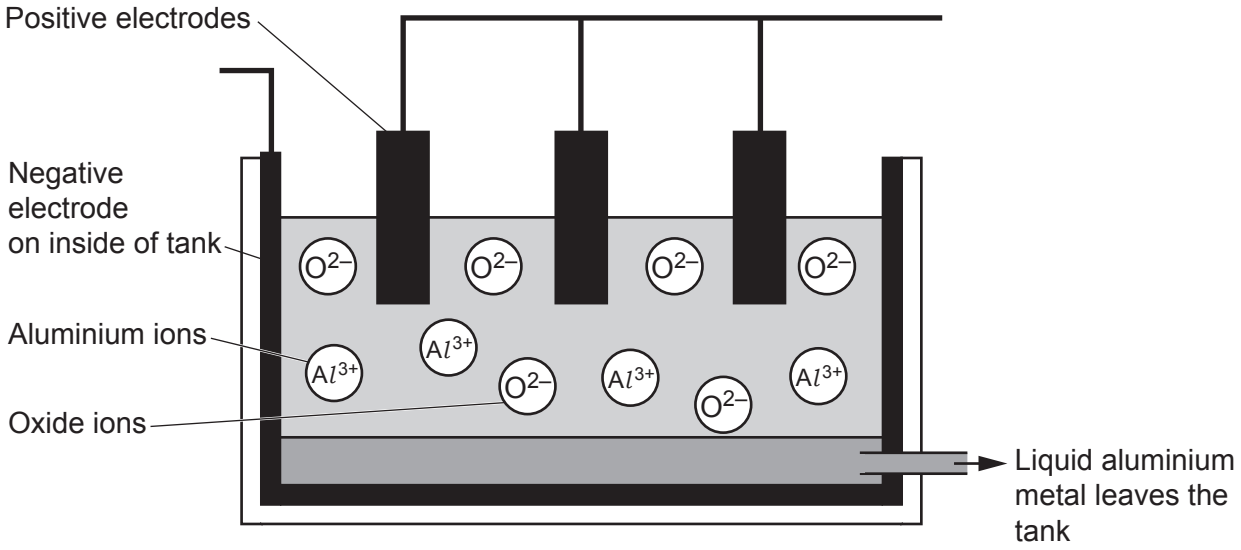

Fig. 3.1

(i) Give the name of the product formed at each electrode in **Fig. 3.1**.

Product at positive electrode .....

Product at negative electrode .....

[2]

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(ii) The temperature inside the tank is 900 °C. The aluminium metal leaves the tank as a liquid.

What does this tell you about aluminium metal?

Tick (✓) **one** box.

The boiling point of aluminium metal is below 900 °C. ☐

The melting point of aluminium metal is above 900 °C. ☐

The melting point of aluminium metal is below 900 °C. ☐

[1]

(c) Aluminium metal is used to make electrical cables.

Fig. 3.2 shows the bonding in a metal.

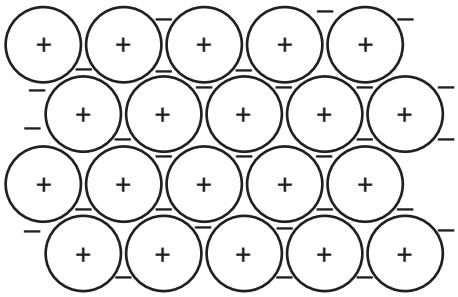

Fig. 3.2

(i) What does (+) in **Fig. 3.2** represent?

Tick (✓) **one** box.

A metal ion ☐

A molecule ☐

A neutron ☐

A proton ☐

[1]

(ii) Describe what happens when a metal conducts electricity.

.....

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

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(d) Aluminium, copper and silver are all metals with high electrical conductivity.

The table shows information about each metal.

Metal	Electrical conductivity (MS / m)	Density (g / cm^3)	Price (£ / kg)
Copper	58	9.0	5
Silver	63	10.5	370
Aluminium	35	2.7	1

(i) Give **two** reasons why copper is a better choice than silver or aluminium for most electrical wiring.

Use the table to help.

1. .....

.....

2. .....

.....

[2]

(ii) Aluminium is used to make overhead power cables.

Give **one** advantage and **one** disadvantage of using aluminium rather than copper for overhead power cables.

Advantage

.....

.....

Disadvantage

.....

.....

[2]

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4 Many shops sell boxes of tablets to treat stomach upsets. Some of these tablets contain calcium carbonate, $CaCO_3$.

Jane does experiments to measure the mass of calcium carbonate in three different brands of tablets.

EasyCalm	**FeelRight**	**RumbleTum**
Pack size: 30 tablets	Pack size: 25 tablets	Pack size: 10 tablets

(a) Jane wants to make sure that the tablets she tests are representative of all the tablets in each brand.

What should Jane do to make sure her choice of tablets is **representative**?

Tick (✓) **two** boxes.

- Choose tablets at random from each box. ☐
- Choose tablets from more than one box of each brand. ☐
- Choose tablets that look the same. ☐
- Test every tablet from one box of each brand. ☐
- Test one tablet from each brand. ☐

[2]

(b) Jane reacts dilute hydrochloric acid with each tablet.
The equation shows the reaction that happens:

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Which **two** statements explain why this reaction is a neutralisation reaction?

Tick (✓) **two** boxes.

- Heat is given off. ☐
- Calcium carbonate is made. ☐
- A salt and water form. ☐
- The acid is used up. ☐
- Hydrogen gas is given off. ☐

[2]

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(c) Jane crushes each tablet and adds it to some water in a flask. She adds dilute hydrochloric acid from a burette until the solution is neutral.

The table shows the mean volume of dilute hydrochloric acid needed to neutralise one tablet from each brand.

Brand of tablet	**Mean volume of dilute hydrochloric acid needed (cm^3)**	**Mean mass of calcium carbonate in one tablet (mg)**
EasyCalm	10.5	1051
FeelRight	15.8	1582
RumbleTum	5.0	

(i) What else does Jane need to add to the flask before she starts her titration?

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

(ii) Give **one** reason for your answer to **(c)(i)**.

.....

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

(iii) Which brand of tablet contains the most calcium carbonate?

Put a (ring) around the correct answer.

EasyCalm **FeelRight** **RumbleTum**

[1]

(iv) Calculate the **relative formula mass** of calcium carbonate, $CaCO_3$.

Use the Data Sheet.

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

(v) Calculate the mean mass of calcium carbonate in **one RumbleTum** tablet.

Use the formula: mean mass of calcium carbonate (mg) = mean volume of hydrochloric acid (cm^3) × relative formula mass of $CaCO_3$

Use your answer to **(c)(iv)** and the information in the table.

Mean mass of calcium carbonate in one tablet = ... mg **[2]**

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(d) The label shows all of the ingredients in FeelRight tablets.

FeelRight Contains: calcium carbonate magnesium hydroxide

(i) How will magnesium hydroxide affect the volume of acid needed to neutralise each tablet of FeelRight?

.....

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

(ii) Give **one** reason for your answer to **(d)(i)**.

.....

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

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5 **Table 5.1** and **Table 5.2** show information about the structure, properties, and uses of graphite and graphene.

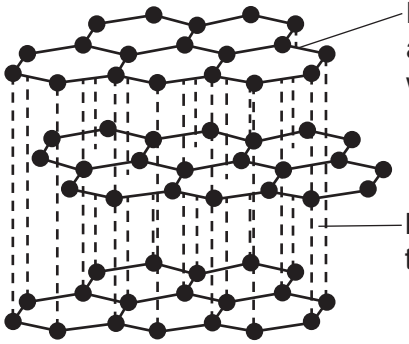
	Graphite
Structure	 Many layers of carbon atoms. Carbon atoms in each layer are bonded together with covalent bonds. Delocalised electrons hold the layers together with weak bonds.
Properties	Soft, flakes easily. High melting point. Good conductor of electricity. Brittle, breaks easily.
Uses	Making pencils.

Table 5.1

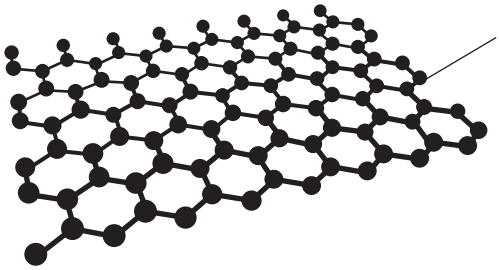
	Graphene
Structure	 Graphene sheets are nanoparticles. Each sheet contains a single layer of carbon atoms bonded together with covalent bonds. Structure contains delocalised electrons.
Properties	Thinnest material known. Harder and stronger than steel. High melting point. Excellent conductor of electricity. Very flexible.
Uses	Making micro-scale electronic components and batteries.

Table 5.2

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(a)* Explain the similarities and differences between graphite and graphene.

Use ideas about structure in your answer.

Use information from **Table 5.1** and **Table 5.2** in your answer.

.....

.....

.....

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.....

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

(b) Which **two** materials also contain only carbon atoms?

Put a ring around the **two** correct answers.

Crude oil **Diamond** **Fullerenes** **Methane** **Polymers**

[2]

(c) New types of batteries that contain nanoparticles of graphene have been available for less than 10 years. New products need to have a life cycle assessment.

Suggest **two** factors that need to be considered in a life cycle assessment for a new graphene battery.

1. .....

2. .....

[2]

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6 **Table 6.1** shows the concentration and the pH of some dilute acids.

Name of acid	Concentration of dilute acid (mol/dm^3)		pH
Hydrochloric acid	**Concentration gets lower** ↓	0.1	1.0
		0.01	2.0
		0.001	3.0
Sulfuric acid	**Concentration gets lower** ↓	0.1	0.7
		0.01	1.7

Table 6.1

(a) All of the acids in the table react with magnesium metal.

Which acid gives the **fastest** reaction?

Tick (✓) **one** box.

0.1 mol/dm^3 hydrochloric acid ☐

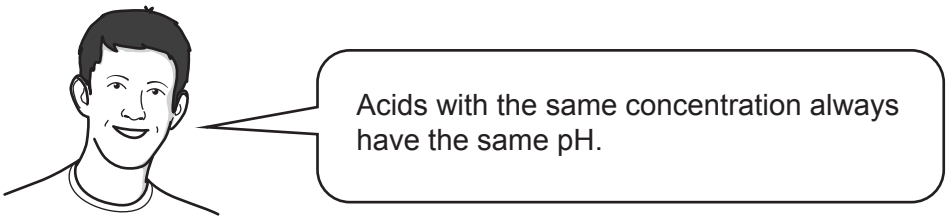
0.01 mol/dm^3 hydrochloric acid ☐

0.1 mol/dm^3 sulfuric acid ☐

0.01 mol/dm^3 sulfuric acid ☐

[1]

(b) Alex has an idea about pH.



Does the data in **Table 6.1** agree with Alex's idea?

Yes ☐

No ☐

Use data from **Table 6.1** to explain your answer.

.....

.....

.....

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

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(c) Alex tests the pH of some samples of dilute nitric acid. He uses Universal Indicator and a pH meter.

Table 6.2 shows his results.

Concentration of dilute nitric acid (mol/dm^3)		pH using Universal Indicator	pH using pH meter
Concentration gets lower ↓	0.1	1	1.0
	0.05	1	1.3
	0.01	2	3.5
	0.001	3	3.0

Table 6.2

(i) Describe how Alex uses Universal Indicator to measure the pH of the acids.

.....

.....

.....

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

(ii) Alex says that the results in **Table 6.2** contain an outlier.

Put a ring around the result that is an outlier in **Table 6.2**. **[1]**

(iii) Explain your answer to **(c)(ii)**.

.....

.....

.....

.....
[2]

(iv) Alex says that using a pH meter rather than Universal Indicator to measure pH improves the quality of the data.

Suggest **one** reason why this is true.

.....

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

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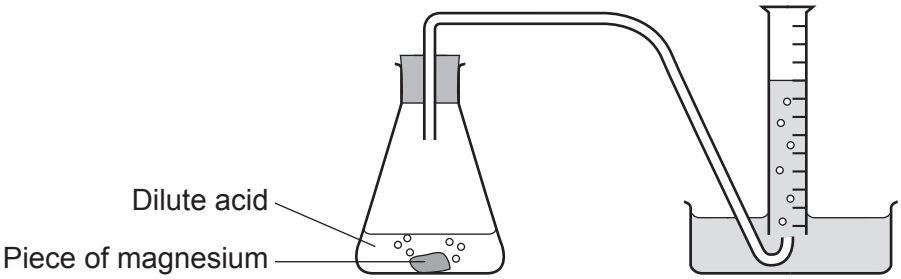
7* Kareem finds this table of information about the reactivity of some metals with dilute acids.

Metal	**Reactivity with dilute acids**
Copper	Does not react
Zinc	Metals become more reactive ↓
Magnesium	
Calcium	

He does some experiments to show that the reactivity of these metals is correct.

He uses the apparatus shown in the diagram.



Kareem finds that it takes **45 seconds** for magnesium to make 10 cm^3 gas.

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Describe how Kareem should use the same apparatus to do experiments to show that the reactivity of the metals shown in the table is correct.

Include in your answer what he should control and what results he should expect.

.....

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

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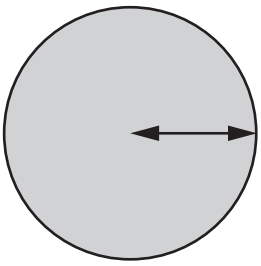
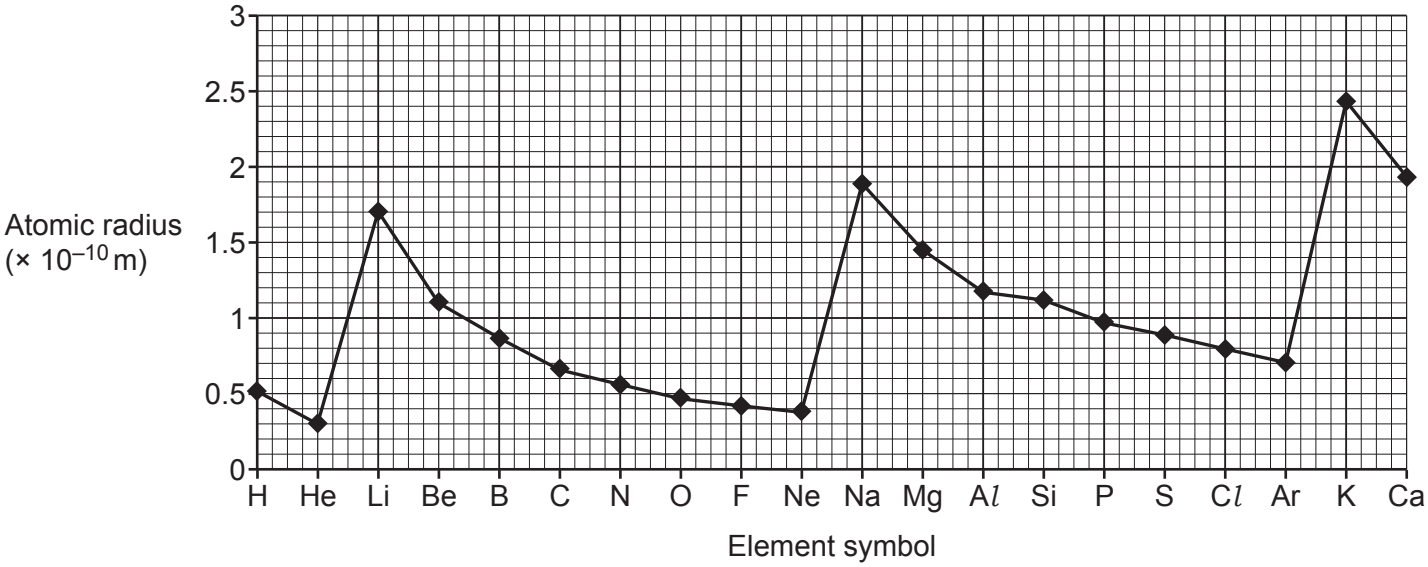
8 Kai wants to build scale models of atoms of the first 20 elements of the Periodic Table.

He finds out that the atomic radius of an atom is the distance from the centre of the atom to its outer shell of electrons.



Radius of atom

He finds this graph, which shows the atomic radius of the first 20 elements.



(a) Lithium (Li), sodium (Na) and potassium (K) are in Group 1 of the Periodic Table.

How does the atomic radius change down Group 1?
Use the graph.

.....

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

(b) **(i)** Give the symbols of the **two** elements which have the **smallest** atoms.
Use the graph.

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

(ii) Which group of the Periodic Table do the elements in **(b)(i)** belong to?
Use the Data Sheet.

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

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(c) Which statements in the table are **true** and which are **false**?

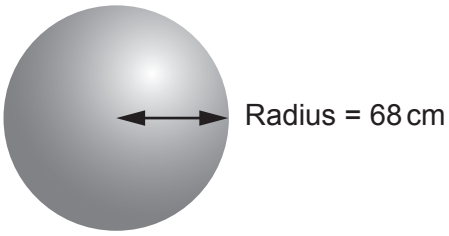
Tick **one** box (✓) in each row.
Use the graph.

Statement	**True (✓)**	**False (✓)**
Potassium (K) is the largest atom.		
Atomic radius gets smaller across every period of the Periodic Table.		
As proton number increases, atomic radius always decreases.		

[2]

(d) Kai makes a scale model of a lithium (Li) atom.

(i) The diagram shows the radius of his model of a lithium atom.



Model of a lithium (Li) atom

Kai makes a model of a **sodium (Na)** atom to the same scale.

Calculate the radius of the sodium atom model, in **cm**.

Use the graph.

Radius = ... cm **[3]**

(ii) Kai makes his lithium model red to match the flame test colour of lithium.

What colour should he make his sodium model?

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

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(e) Kai designs a sign to tell people about the particles inside a sodium atom.

Complete the missing information on the sign.

Particles inside a sodium atom

11
Na
sodium
23.0

Number of protons	.....
Number of neutrons	.....
Number of electrons	.....

More information about the particles

Type of particle	Charge	Relative Mass
Proton	+1	.....
Neutron	.....	1
Electron	.....	0

[3]

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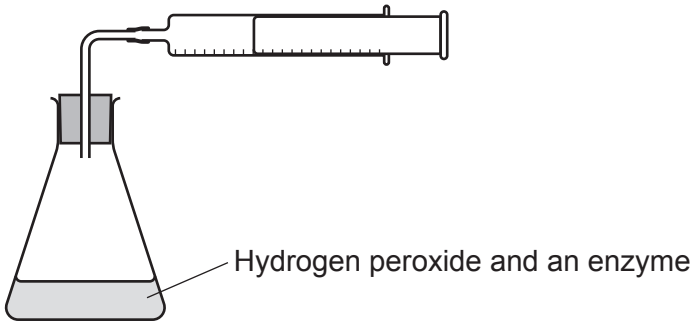
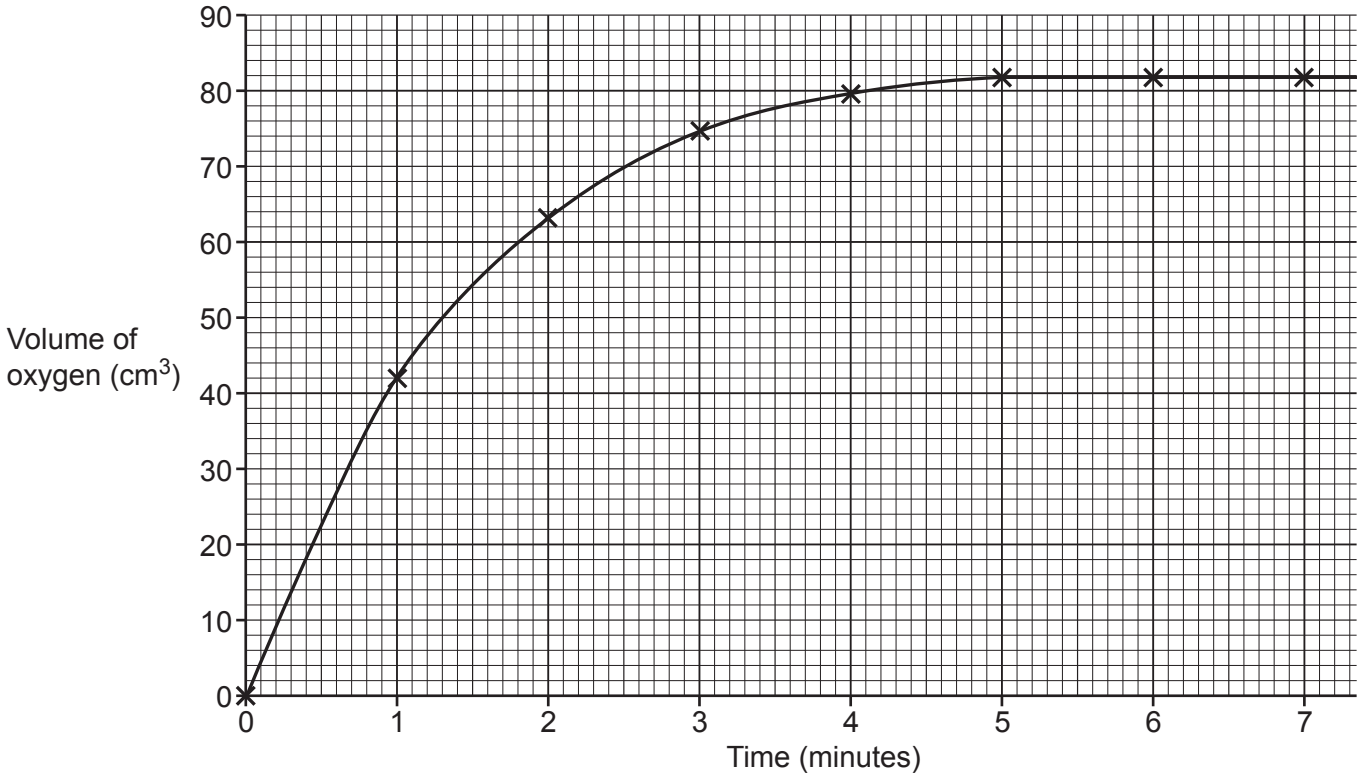
9 Hydrogen peroxide is a waste product produced by cells in our bodies. Hydrogen peroxide is broken down by an enzyme to form water and oxygen.

Beth adds a small amount of an enzyme to some hydrogen peroxide. She collects the oxygen given off in a gas syringe. She records the total volume of oxygen every minute.



The graph shows her results.



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(a) Use the graph to help you answer **(a)**.

(i) How long does it take for the reaction to finish?

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

(ii) How much oxygen is given off by the end of the reaction?

..... cm^3 **[1]**

(iii) Calculate the average volume of oxygen given off **per second**.

..... cm^3/s **[2]**

(b) The reaction that breaks down hydrogen peroxide does not start until the enzyme is added. When the enzyme is added, oxygen is given off quickly.

Explain this statement.

Use ideas about rates of reaction in your answer.

.....

.....

.....

..... **[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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