Chemical patterns – 2021/20 GCSE 21st Chemistry B

1. Nov/2021/Paper_J258/01/No.1

In the early nineteenth century, a chemist called Dobereiner found sets of three elements with similar properties.

Table 1.1 shows an example:

Element	Relative atomic mass
Lithium	6.9
Sodium	23.0
Potassium	39.1

Table 1.1

(a) State the Group number of lithium, sodium and potassium in the modern Periodic Table.

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

(b) Which statements about lithium, sodium and potassium are **true** and which are **false**?

Tick (✓) **one** box in each row.

Statement	True	False
They all react with water.		
Lithium is the most reactive.		
They all react with chlorine.		
They are all metals.		

[2]

(c) **(i)** The elements nitrogen, phosphorus and arsenic have similar properties.

Complete **Table 1.2** by adding the symbols for these three elements.

	Element	Symbol	Relative atomic mass
1	Nitrogen	.....	14.0
2	Phosphorus	.....	31.0
3	Arsenic	.....	74.9

Table 1.2

[1]

(ii) Dobereiner called his sets of three elements 'triads'. He had this idea:

'The relative atomic mass of element 2 is approximately equal to the mean of the other two elements.'

Do the elements in **Table 1.2** fit Dobereiner's idea?

Yes ☐

No ☐

Use a calculation to help explain your answer.

.....

.....

.....

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

(d) Mendeleev arranged the elements in order of their relative atomic masses.

Mendeleev's work was peer reviewed.

Describe the peer review process.

.....

.....

.....

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

2. Nov/2021/Paper_J258/01/No.5(a, b)

Chemists use models to describe things that are too small to be seen.

Fig. 5.1 shows an atomic model proposed by a scientist over 100 years ago:

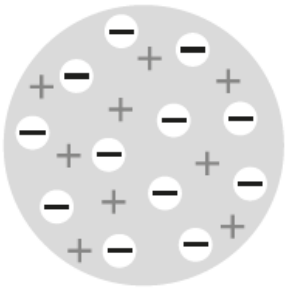


Fig. 5.1

(a) Which scientist suggested the atomic model in **Fig. 5.1**?

Put a (ring) around the correct answer.

Dalton **Thomson** **Rutherford** **Bohr**

[1]

(b) The modern model of the atom is different from the model in **Fig. 5.1**.

Complete the sentences about the modern model of the atom.

Use the words.

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

electrons **ions** **neutrons** **nucleus** **protons**

The centre of the atom is called the ..... .

This is made up of positively charged ..... and

neutral ..... .

The ..... are negatively charged.

In a neutral atom, there are equal numbers of .....

and ..... .

[3]

3. Nov/2021/Paper_J258/01/No.8(c _ e)

(c) Mia adds a solution of chlorine to a solution of sodium bromide.

This is the equation for the reaction that happens:

$Cl_2(aq) + 2NaBr(aq) \rightarrow Br_2(aq) + 2NaCl(aq)$

The solution changes colour.

(i) State the colour of the solution at the end of the experiment.

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

(ii) What causes the colour change?

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

(d) Potassium reacts with chlorine. Sodium also reacts with chlorine.

Is the reaction of sodium with chlorine **faster** or **slower** than the reaction of potassium with chlorine?

Faster ☐

Slower ☐

Explain why the rate of reaction is different.

.....

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

(e) Calcium also reacts with chlorine.
Calcium forms Ca^{2+} ions and chlorine forms Cl^- ions.

What is the correct formula of calcium chloride?

Put a (ring) around the correct answer.

CaCl **Ca_2Cl_2** **$CaCl_2$** **$ClCa_2$** **ClCa**

[1]

4. Nov/2021/Paper_J258/02/No.2

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

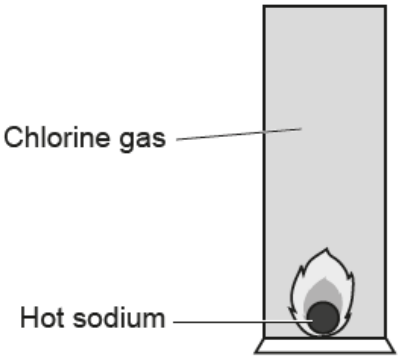


Fig. 2.1

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]**

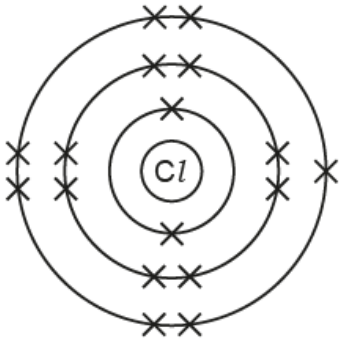
(b) Layla does experiments with other Group 1 and Group 7 elements.

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]

(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

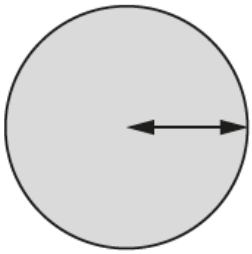
..... one electron to give a full outer shell.

[2]

5. Nov/2021/Paper_J258/02/No.8

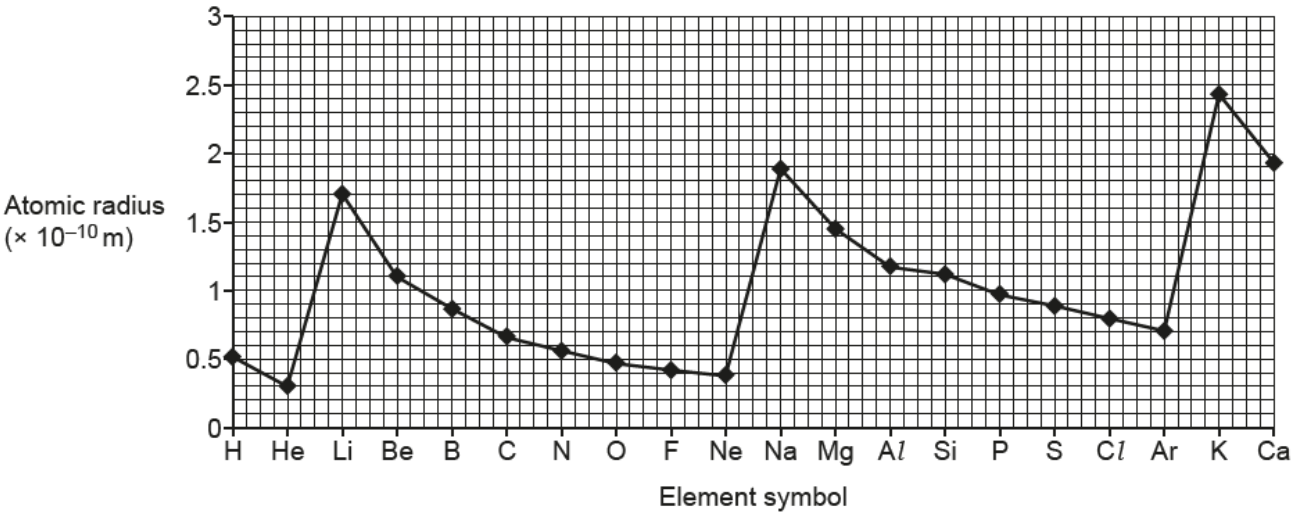
Kai wants to build scale models of atoms of the first 20 elements of the Periodic Table.

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]**

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

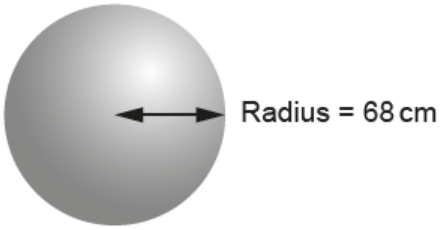
Tick **one** box (✓) in each row.
Use the graph.

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]**

(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]

6. Nov/2020/Paper_J258/01/No.5

Lithium-ion batteries are used in phones, tablets and electric cars.

(a) Lithium reacts with chlorine and with bromine.

(i) Lithium is in Group 1. Chlorine and bromine are in Group 17.

Draw lines to connect each element with **one** correct property.

Element	Property
Lithium (Group 1)	Conducts electricity
Chlorine (Group 17)	Unreactive
	Colourless gas
	Green gas

[2]

(ii) 14 g of lithium reacts with 71 g of chlorine.

What mass of chlorine reacts with 5.6 g of lithium?

Mass of chlorine = ... g **[2]**

(iii) Jack reacts lithium with chlorine. He then reacts lithium with bromine.

Describe how the rates of these two reactions are different.

.....

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

(b) Lithium is made by the electrolysis of molten lithium chloride.

Which substance is formed at each electrode?

Put a (ring) around each correct answer.

Anode (positive electrode): **chloride** **chlorine** **hydride** **hydrogen**

Cathode (negative electrode): **oxide** **oxygen** **lithium**

[2]

(c) Lithium-ion batteries contain chemical cells.

Which statement is the correct definition for a chemical cell?

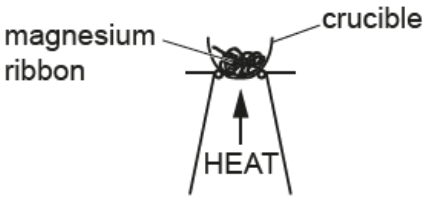
Tick (✓) **one** box.

- A chemical cell produces its full potential difference but the potential difference then quickly decreases. ☐
- A chemical cell takes a long time to get to its full potential difference. ☐
- A chemical cell produces a potential difference that lasts for a short time. ☐
- A chemical cell produces a potential difference until the reactants are used up. ☐

[1]

7. Nov/2020/Paper_J258/02/No.6

Eve heats magnesium ribbon in a crucible.



(a) Complete the word equation and balance the symbol equation for the reaction that happens in the crucible.

magnesium + ... → magnesium oxide

.....Mg + O_2 → .....MgO

[2]

(b) Eve writes down the mass of the empty crucible, and the mass of the crucible and magnesium oxide at the end of the experiment.

She also works out how much magnesium oxide she expects to make (her **theoretical yield**).

Mass of empty crucible (g)	17.9
Mass of crucible and magnesium oxide at the end of the experiment (g)	21.6
Mass of magnesium oxide formed (g)	.....
Theoretical yield of magnesium oxide (g)	4.0

Table 6.1

(i) Complete **Table 6.1** by calculating the mass of magnesium oxide formed in Eve's experiment.

[1]

(ii) Eve works out her percentage yield, using the equation:

$$\textbf{percentage yield} = \frac{\textbf{mass of magnesium oxide formed}}{\textbf{theoretical yield of magnesium oxide}} \times 100\ \%$$

Calculate the percentage yield in Eve's experiment.

Use the data in **Table 6.1**, and the equation provided.

Give your answer to **2** significant figures.

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

(c) Eve does some more experiments.

She measures the mass of magnesium oxide formed when different masses of magnesium are heated.

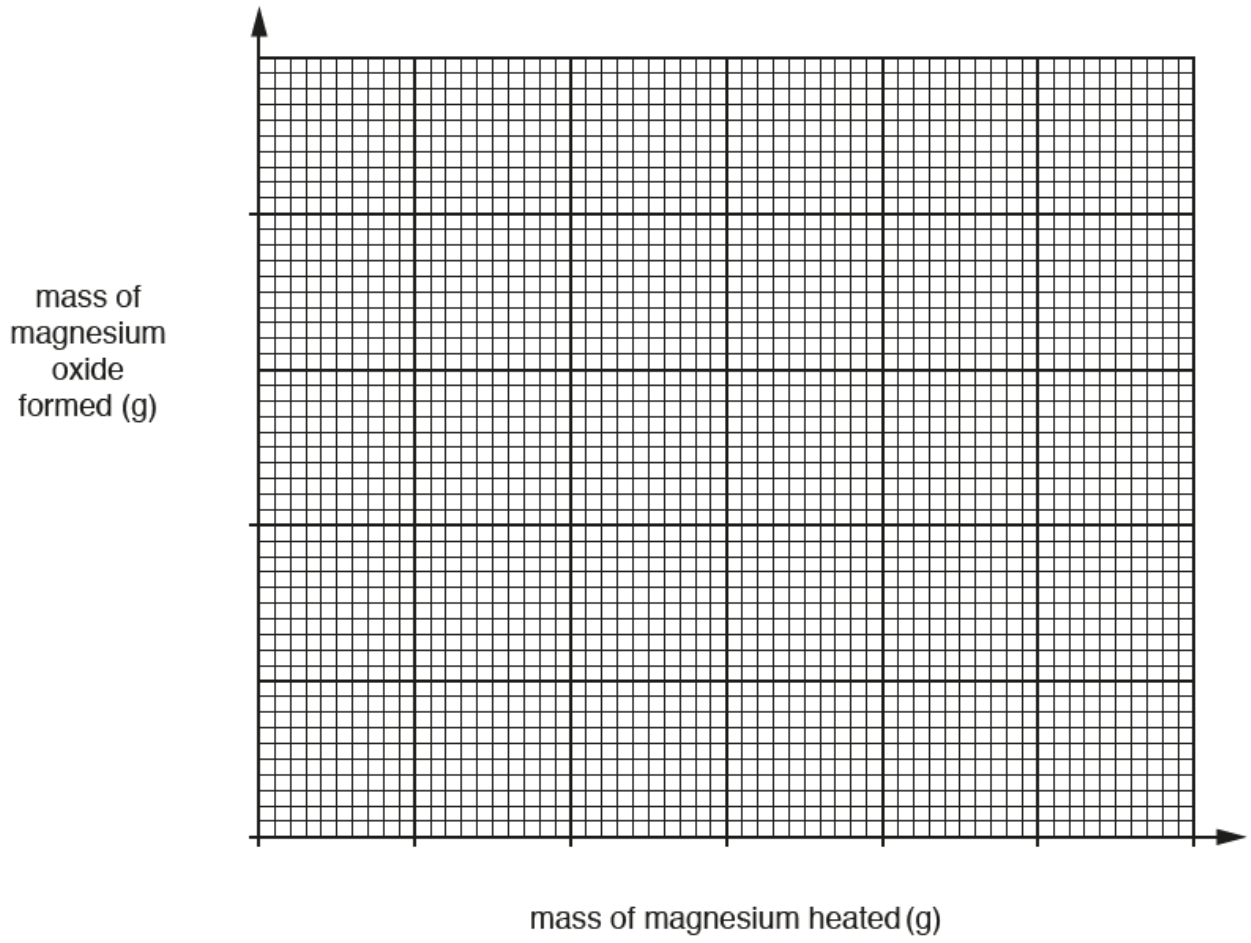
Experiment	Mass of magnesium heated (g)	Mass of magnesium oxide formed (g)
1	0.5	0.8
2	1.0	1.3
3	1.5	2.4
4	2.0	3.2
5	2.5	4.0

Table 6.2

(i) Plot a graph of magnesium oxide formed against mass of magnesium heated.

Use the data in **Table 6.2**.

You should include on your graph:
- an appropriate scale for your axes
- a line of best fit.



[4]

(ii) Eve thinks that she wrote down the results for one of her experiments before the reaction had fully finished.

Suggest which reaction had not fully finished.

Use your graph to explain your answer.

Reaction .....

Explanation .....

.....

[2]

8. Nov/2021/Paper_J258/03/No.1

Chlorine is used to make water safe to drink.

(a) How does chlorine make water safe to drink?

.....

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

(b) James has a solution of chlorine in water.

He tests the solution with **blue** litmus paper.

State **two** colour changes that James will see.

1 .....

2 .....

[2]

(c) Mia adds a solution of chlorine to a solution of sodium bromide.

This is the equation for the reaction that happens:

$Cl_2(aq) + 2NaBr(aq) \rightarrow Br_2(aq) + 2NaCl(aq)$

The solution changes colour.

(i) State the colour of the solution at the end of the experiment.

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

(ii) What causes the colour change?

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

(d) Potassium reacts with chlorine. Sodium also reacts with chlorine.

Is the reaction of sodium with chlorine **faster** or **slower** than the reaction of potassium with chlorine?

Faster ☐

Slower ☐

Explain why the rate of reaction is different.

.....

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

(e) Calcium also reacts with chlorine.
Calcium forms Ca^{2+} ions and chlorine forms Cl^- ions.

What is the correct formula of calcium chloride?

Put a (ring) around the correct answer.

CaCl **Ca_2Cl_2** **$CaCl_2$** **ClCa$_2$** **ClCa**

[1]

(f) The element astatine, At, is below iodine in Group 7 of the Periodic Table.

Which **two** properties of astatine are correct?

Tick (✓) **two** boxes.

It reacts with Na^+ ions to form $NaAt_2$. ☐

Its atoms are larger than atoms of iodine. ☐

It is a solid at room temperature. ☐

It is colourless. ☐

It reacts with sodium iodide in solution to give iodine. ☐

[2]

9. Nov/2021/Paper_J258/03/No.4

In the early nineteenth century, a chemist called Dobereiner found some sets of three elements with similar properties.

The table shows an example:

Element	Relative atomic mass
Lithium	6.9
Sodium	23.0
Potassium	39.1

(a) Lithium, sodium and potassium react in a similar way with water.

(i) Balance the symbol equation for the reaction of lithium with water.

..... Li + ... H_2O → ..... LiOH + H_2 **[1]**

(ii) Potassium is more reactive with water than sodium and lithium.

State **two** observations that would prove this.

1 .....

2 .....

[2]

(b) Which property is used to arrange the elements in the modern Periodic Table?

Tick (✓) **one** box.

- Atomic number ☐
- Mass number ☐
- Neutron number ☐
- Relative atomic mass ☐

[1]

(c) Dobereiner called his sets of three elements, 'triads'. He had this idea:

'The relative atomic mass of the middle element is approximately equal to the mean of the other two elements.'

The elements nitrogen, phosphorus and arsenic:

- have similar properties
- are found in Group 5 of the modern Periodic Table.

Are nitrogen, phosphorus and arsenic a Dobereiner 'triad'?

Use the Data Sheet **and** a calculation to help explain your answer.

.....

.....

.....

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

10. Nov/2021/Paper_J258/03/No.6(a _ b)

Scientists use models to describe things that are too small to be seen.

Fig. 6.1 shows a model of an atom:

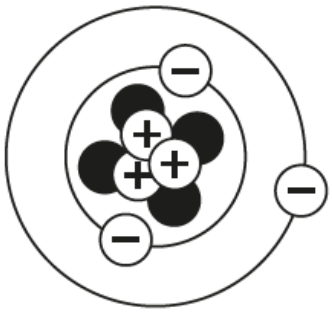


Fig. 6.1

(a) Name the particles represented by black circles in the model.

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

(b) **(i)** Identify the element in **Fig. 6.1**.

Use the Data Sheet.

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

(ii) How was the element in **Fig. 6.1** identified in **(b)(i)**?

.....

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

11. Nov/2021/Paper_J258/03/No.9

Blue copper sulfate crystals turn white when heated:

'blue copper sulfate' → 'white copper sulfate' + water

- Sarah weighs out five different samples of 'blue copper sulfate'.
- She puts each sample in a test tube.
- She heats each test tube.
- She weighs each test tube and its contents after heating.
- She then calculates the mass of 'white copper sulfate'.

(a) The graph shows the results:

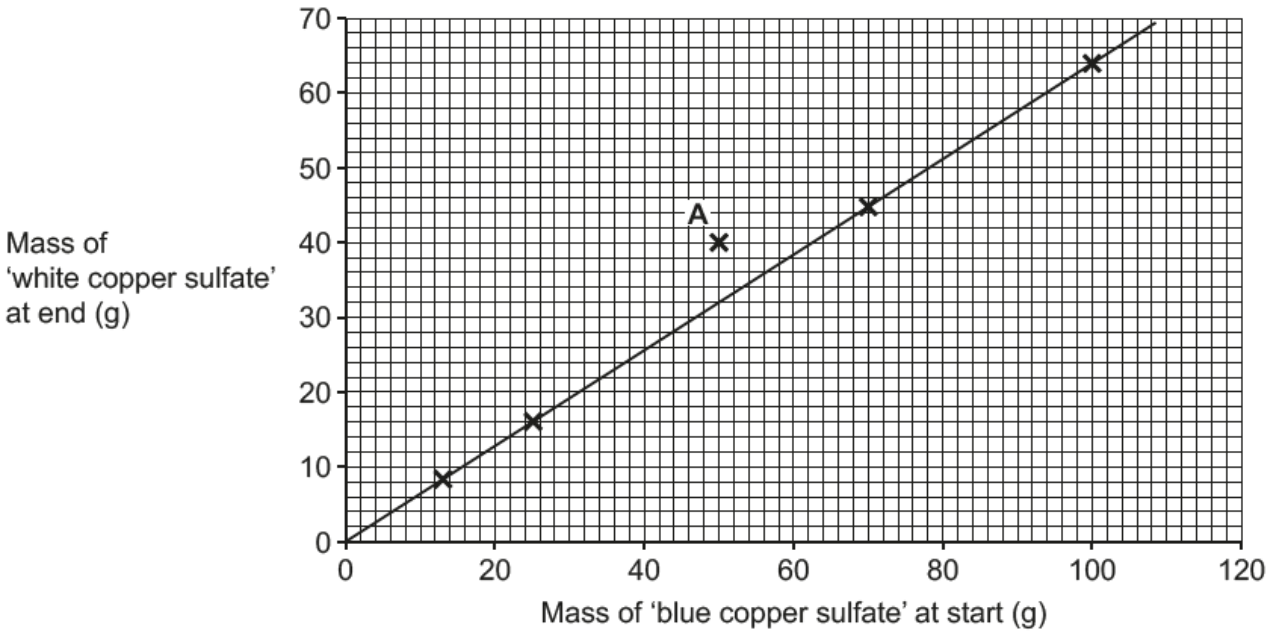


Fig. 9.1

(i) Result **A** does **not** fit the pattern.

Sarah says the test tube was not heated for long enough.

Is Sarah correct? Explain your answer.

.....

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

(ii) The equation for the line in **Fig. 9.1** is given by y = **m**x + **c**.

Calculate values for **m** and **c**, using **Fig. 9.1**.

m = ...

c = ... g
[3]

(b) (i) 25 g of 'blue copper sulfate' gives 16 g of 'white copper sulfate' when heated.

Calculate the number of moles of water that are made.

Use the equation: number of moles = $\frac{\text{mass of substance (g)}}{\text{relative formula mass (g)}}$

Number of moles of water = ... mol **[3]**

(ii) 'Blue copper sulfate' has the formula $CuSO_4 \cdot nH_2O$, where n is a whole number.

In one experiment, Sarah makes 2.0 mol of water and 0.4 mol of 'white copper sulfate'.

'White copper sulfate' has the formula $CuSO_4$.

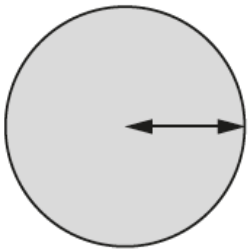
Calculate the value of n in 'blue copper sulfate', $CuSO_4 \cdot nH_2O$.

n = ... **[2]**

12. Nov/2020/Paper_J258/04/No.1

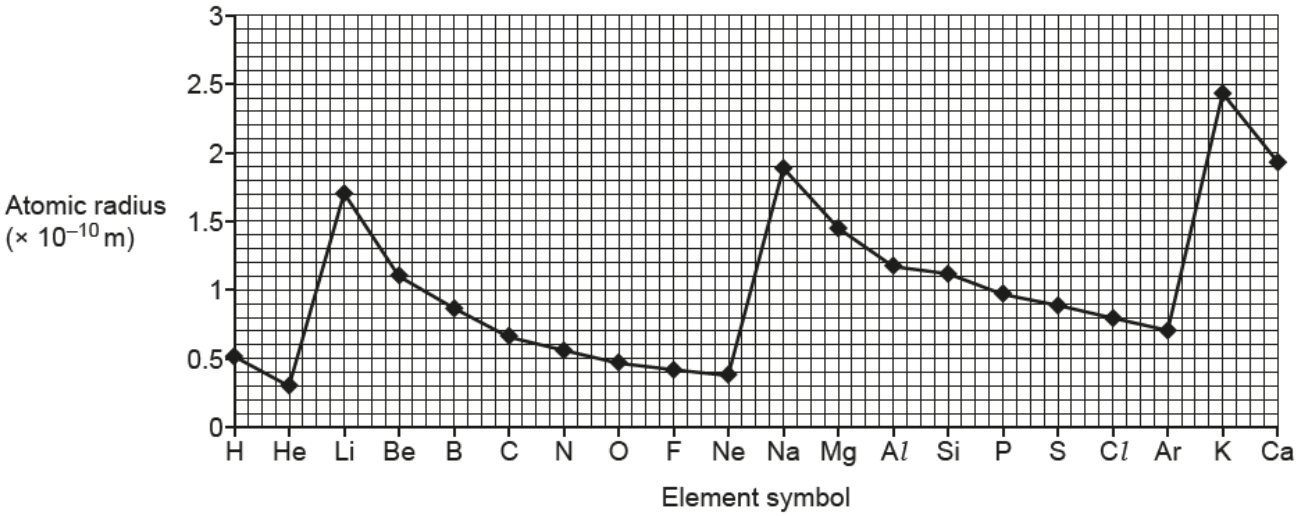
Kai wants to build scale models of atoms of the first 20 elements of the Periodic Table.

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]**

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

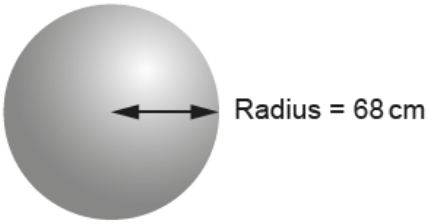
Tick **one** box (✓) in each row.
Use the graph.

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]**

(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	.....

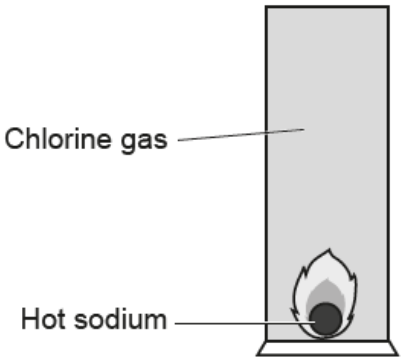
More information about the particles

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

[3]

13. Nov/2021/Paper_J258/04/No.4

Layla heats a small piece of sodium. She then puts it in a jar of chlorine gas, as shown:



The sodium burns with a bright flame. A white solid is formed.

She repeats the experiment using different Group 1 and Group 7 elements. She uses jars containing group 7 gases.

(a) Complete the table of information about the reactions between Group 1 and Group 7 elements.

Group 1 element	Group 7 element	Colour of Group 7 gas before the reaction	Name of product
Sodium	Chlorine	Green	Sodium chloride
Potassium	Iodine	.....	.....
Lithium	Chlorine	Green	Lithium chloride
Potassium	Chlorine	Green	Potassium chloride
Lithium	Iodine	.....	.....
Sodium	.....	Orange	Sodium bromide

[3]

(b) Which of the reactions from the table do you expect to be the fastest?

Explain your choice.

Reaction between ..... and .....

Explanation .....

.....

.....

[3]

(c) Layla tests some of the salts formed in the reactions. She collects samples of solid sodium chloride and solid sodium bromide.

She uses silver nitrate solution to test the salts, to show that they contain chloride and bromide ions.

Describe the steps she should follow to test each salt **and** state what results she should expect.

.....

.....

.....

.....

.....

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

14. Nov/2020/Paper_J258/03/No.10

Lithium-ion batteries are used in phones, tablets and electric cars.

(a) Lithium reacts with chlorine to form lithium chloride.

$2Li + Cl_2 \rightarrow 2LiCl$

What mass of chlorine reacts with 1 g of lithium?

Use the equation: number of moles = $\frac{\text{mass of substance (g)}}{\text{relative formula mass (g)}}$

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

Mass of chlorine = ... g **[3]**

(b) Lithium reacts with water to form lithium hydroxide (LiOH) and a gas.

Write a balanced symbol equation for this reaction.

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

(c) Lithium is made by the electrolysis of molten lithium chloride.

Name the product formed at each electrode.

Cathode .....

Anode .....

[2]

(d) Nina does some experiments with chlorine.

(i) Nina wants to use a displacement reaction to show chlorine is more reactive than bromine.

Describe what Nina needs to do and what she will see.

Nina needs to .....

Nina will see .....

[2]

(ii) Nina has to be careful when using chlorine in her experiments.

State **one** precaution she must take **and** why the precaution is needed.

Precaution

.....

Why the precaution is needed

.....

[2]

15. Nov/2020/Paper_J258/03/No.11(a _ b)

Titanium is used for hip replacements.

(a) Titanium's strength comes from its metallic structure as shown in **Fig. 11.1**.

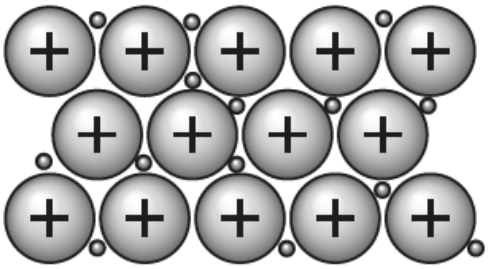


Fig. 11.1

Use **Fig. 11.1** to explain why the metallic bonds in titanium are very strong.

.....

.....

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

(b) Titanium is a transition metal. Calcium is **not** a transition metal.

Which **two** statements are correct about both calcium and titanium?

Tick (✓) **two** boxes.

They both conduct electricity. ☐

They both form cations. ☐

They both form coloured ions in solution. ☐

They both form ions with several different charges. ☐

They both react with cold water. ☐

[2]

16. Nov/2020/Paper_J258/04/No.6

Eve investigates the reaction between magnesium and oxygen to make magnesium oxide.
This is part of her method:

- Weigh the empty crucible.
- Put some magnesium ribbon into the crucible and weigh it again.
- Heat the magnesium ribbon in the crucible.

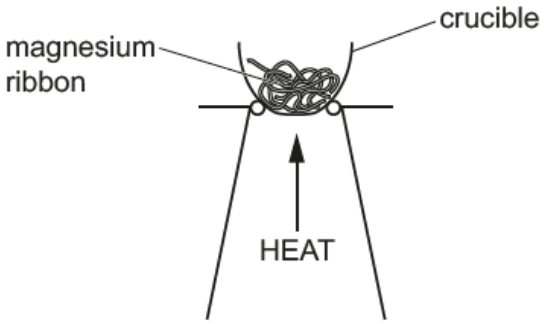


Table 6.1 shows Eve's results.

Mass of empty crucible (g)	20.0
Mass of crucible and magnesium ribbon before heating (g)	21.2
Mass of crucible and magnesium oxide after heating (g)	22.0

Table 6.1

(a) Eve weighs the crucible after heating. She heats it again and reweighs it.
She does this until the mass does **not** change.

Why does she do this?

.....

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

(b) Eve writes a word equation for the reaction.

magnesium + oxygen → magnesium oxide

Which reactant limits the amount of magnesium oxide that can be formed?

Explain your answer.

.....

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

(c) Use Eve's results in **Table 6.1** to calculate the mass of magnesium and oxygen used and the mass of magnesium oxide formed in the experiment.

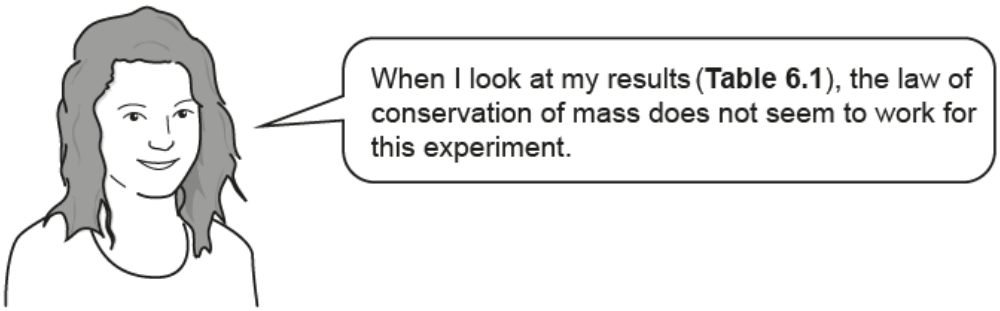
Write your answers in **Table 6.2**.

Mass of magnesium used (g)	.....
Mass of oxygen used (g)	.....
Mass of magnesium oxide formed (g)	.....

Table 6.2

[3]

(d) Eve thinks about her results.



Do you agree with Eve?

Yes ☐

No ☐

Explain your answer.

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.....

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