Surname		Centre Number	Candidate Number
First name(s)			0

GCSE

3410U10-1

S23-3410U10-1

FRIDAY, 16 JUNE 2023 – MORNING

CHEMISTRY – Unit 1:
Chemical Substances, Reactions and Essential Resources

FOUNDATION TIER

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**7**	
2.	**8**	
3.	**7**	
4.	**10**	
5.	**9**	
6.	**6**	
7.	**5**	
8.	**8**	
9.	**9**	
10.	**11**	
Total	**80**	

3410U101 01

ADDITIONAL MATERIALS

In addition to this examination paper you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in Question **5**(b).

The Periodic Table is printed on the back cover of this paper and the formulae for some common ions on the inside of the back cover.

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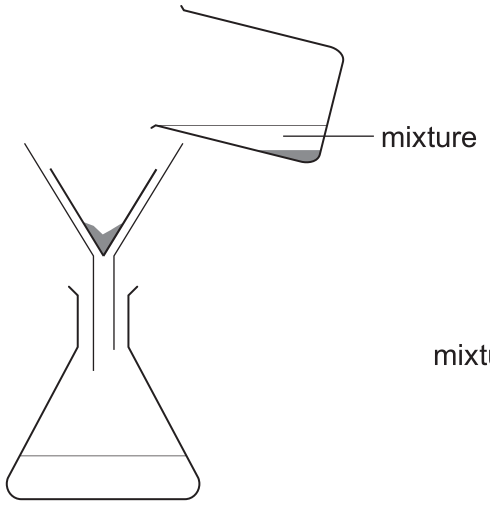
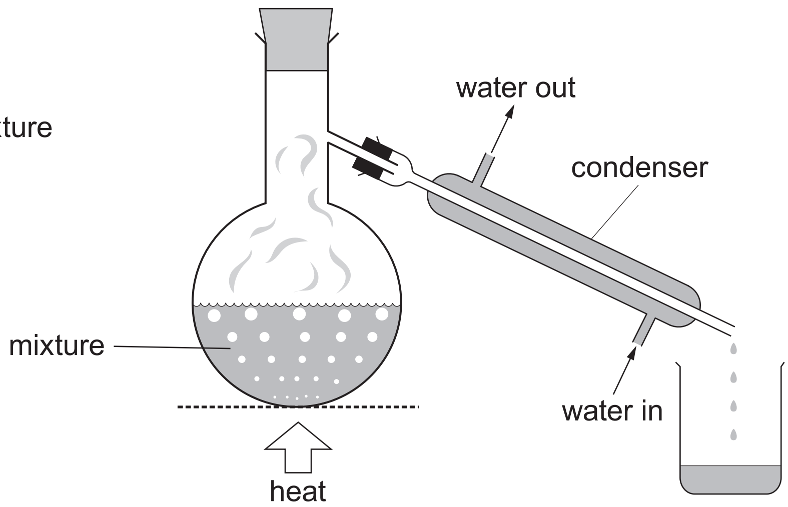
PJ*(S20-3410U10-1)

Answer **all** questions.

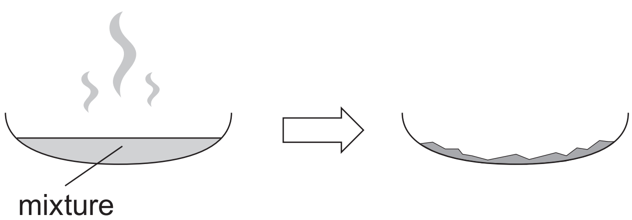
1. (a) The diagrams show four methods, **A**, **B**, **C** and **D**, used to separate different mixtures.



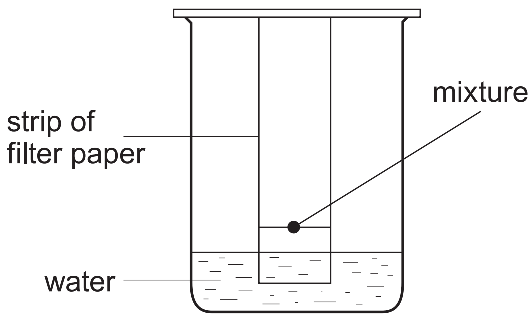
Method **A**



Method **B**



Method **C**



Method **D**

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(i) Choose from the box the names of methods **B** and **D**. [2]

distillation	**chromatography**	**filtration**	**evaporation**	**boiling**

Method **B** ....

Method **D** ....

(ii) Give the letter, **A**, **B**, **C** or **D**, of the method used to [3]

remove sand from water ....

obtain pure water from sea water ....

separate red and yellow dyes ....

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03

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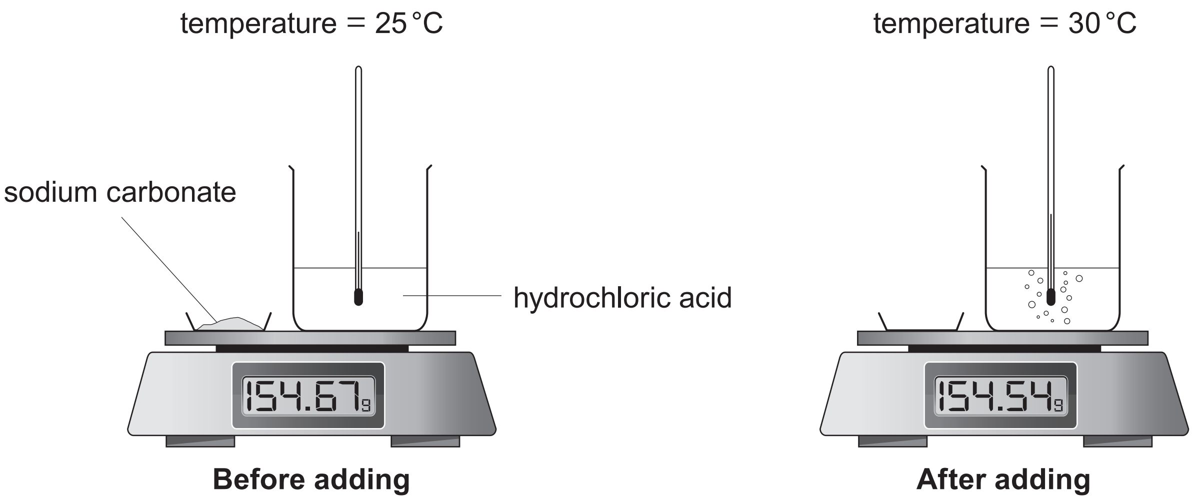
(b) Sodium carbonate reacts with dilute hydrochloric acid forming sodium chloride, water and carbon dioxide.

The diagrams show the apparatus before and after sodium carbonate is added to hydrochloric acid.



Tick (✓) **two** observations that show a chemical reaction is taking place. [2]

The solid stays the same	☐
A gas is formed	☐
A temperature change occurs	☐
The mass of the beaker and contents stays the same	☐

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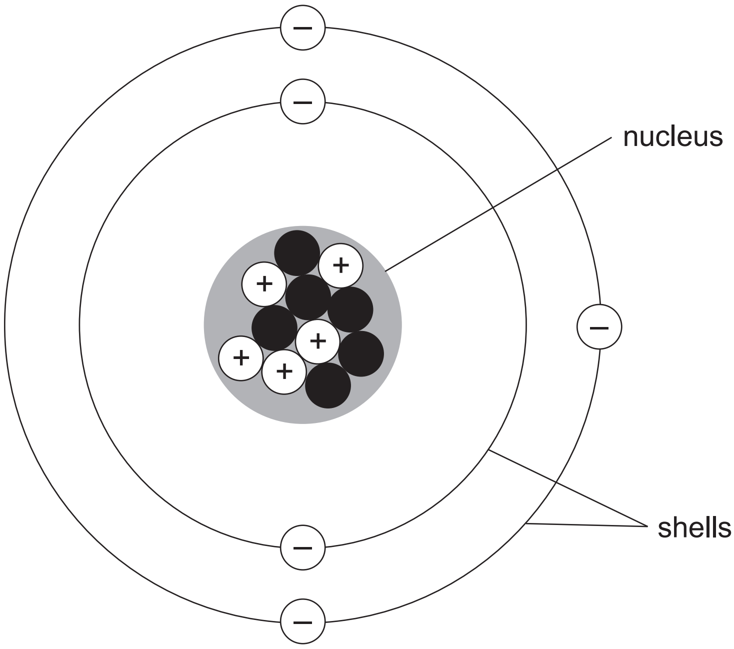
2. (a) Atoms contain particles called protons, neutrons and electrons. The diagram shows a model of an atom of boron.



State whether the statements in the table below are **true** or **false**. [4]

Statement	True or false?
Boron atoms contain the same number of protons and electrons	....
The particles found in the shells are called electrons	....
The nucleus contains five neutrons	....
The electronic structure of boron is 3,2	....

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(b) The formula of boron trioxide is B_2O_3.

Calculate the relative formula mass (M_r) of boron trioxide. [2]

$A_r(B) = 11 \qquad A_r(O) = 16$

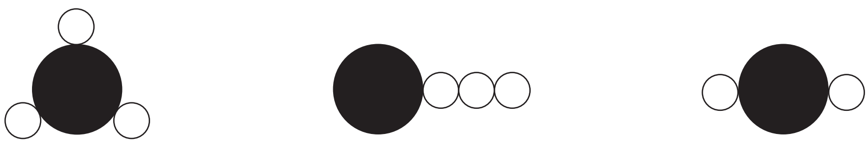
Relative formula mass = ...

(c) The diagrams below represent atoms of boron and fluorine.

boron, B fluorine, F

Boron trifluoride has the formula BF_3.

Choose the **letter** of the diagram that represents a molecule of boron trifluoride. [1]



A **B** **C**

Letter ....

(d) Magnesium fluoride contains the ions Mg^{2+} and F^-.

Underline the correct formula for magnesium fluoride. [1]

Mg2F **Mg_2F** **MgF^2** **MgF_2**

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3. (a) (i) The diagram below shows the position of the Earth's continents today.

In 1912 Alfred Wegener suggested that all the continents must once have been joined together as one big land mass.

Diagrams **A**, **B** and **C** show the position of the Earth's continents 50 million, 100 million and 150 million years ago, but not necessarily in that order.

A **B** **C**

Give the letter, **A**, **B** or **C**, of the diagram which shows the position of the Earth's continents 150 million years ago. [1]

Letter ....

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(ii) Wegener's theory of continental drift was not accepted by other scientists until several years after his death in 1930. The evidence to support his theory was found in 1960 when part of the ocean floor was surveyed around a plate boundary. The table shows data collected from the survey.

Distance of ocean floor from plate boundary (km)	Approximate age of rock (million years)
2000	100

Calculate the mean speed at which the ocean floor is spreading. [1]

$$\text{mean speed (km/million years)} = \frac{\text{distance (km)}}{\text{time (million years)}}$$

Mean speed = ... km/million years

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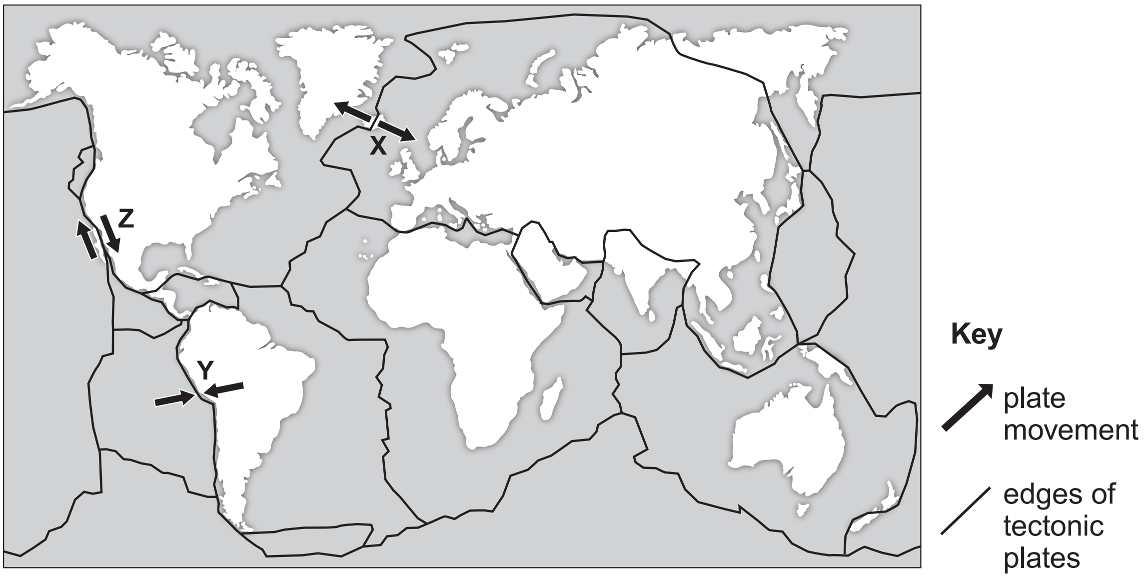
(iii) The map shows some information about tectonic plates and three locations **X**, **Y** and **Z**.



Give the **letter** of the location you would expect to have earthquakes but not volcanic eruptions. [1]

Letter ....

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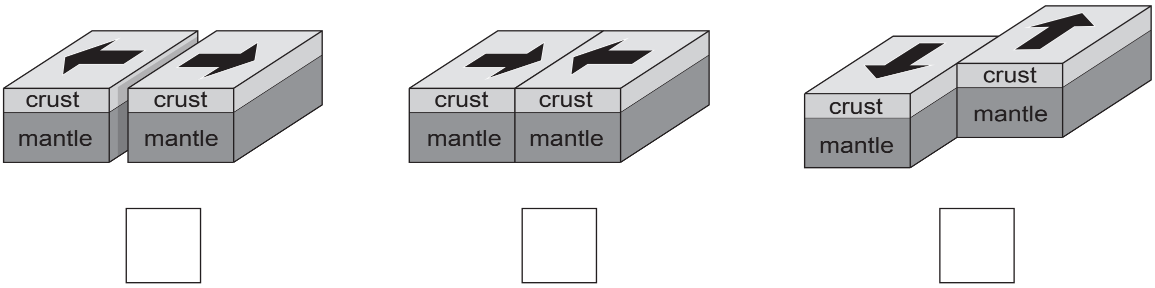
(b) The photograph below shows 'pillow lava' which was formed from volcanoes on the sea bed at a **constructive** plate boundary millions of years ago.

'pillow lava' on Llanddwyn Island, Anglesey

(i) Tick (✓) the box of the diagram that shows a constructive plate boundary where the pillow lava was formed. [1]



(ii) Complete the sentences by underlining the correct word(s) in the brackets. [2]

Pillow lava is formed at a constructive plate boundary when **(magma / sea water / crust)** rises and cools, forming new rock.

The movement of the Earth's tectonic plates is caused by **(electric currents / convection currents / ocean currents)** within the mantle.

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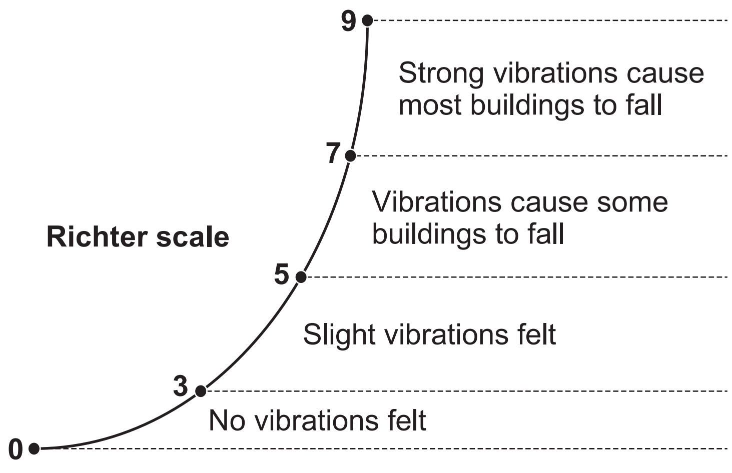
(c) Charles Richter developed the Richter Scale in 1935 to measure the strength of earthquakes.



In June 2018 an earthquake occurred in the Caernarfon area, with a minor tremor being felt.

Circle the number that best shows the size of the earthquake in Caernarfon. [1]

1 **4** **6** **8**

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4. Dilute hydrochloric acid reacts with magnesium forming magnesium chloride and hydrogen gas.

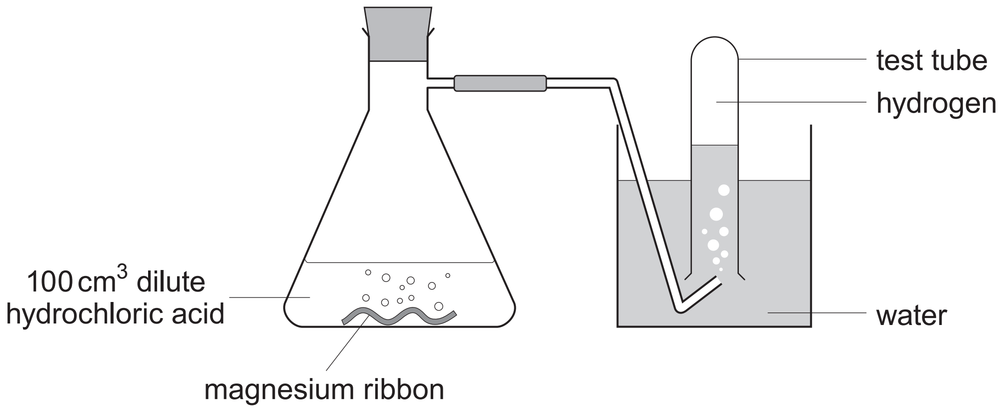
(a) Tick (✓) the box next to the correct equation for the reaction between magnesium and hydrochloric acid. [1]

$Mg + HCl \longrightarrow MgCl_2 + H$ ☐

$Mg + 2HCl \longrightarrow MgCl_2 + 2H$ ☐

$Mg + 2HCl \longrightarrow MgCl_2 + H_2$ ☐

(b) Osian wanted to find out how changing the concentration of the acid affects the rate of the reaction. He carried out five experiments at room temperature (20 °C). He added a 4 cm piece of magnesium ribbon to 100 cm^3 of hydrochloric acid of five different concentrations. He recorded the time it took to half-fill a test tube with gas.



His results are shown below.

Experiment	Acid concentration (%)	Time (s)
1	100	12
2	80	14
3	60	20
4	40	36
5	20	76

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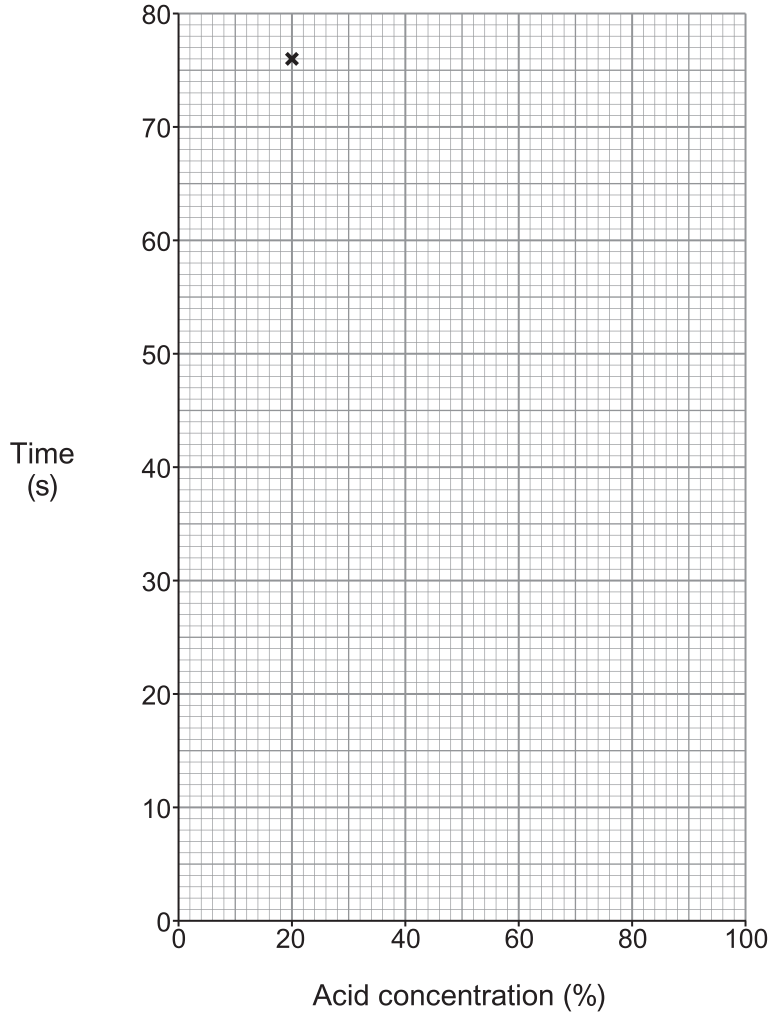
(i) Plot the acid concentration against time on the grid below and draw a suitable line.

One point has been plotted for you. [3]



(ii) Underline the correct word(s) in the brackets to complete the following sentences. [2]

As the acid concentration increases, the **time** to half-fill the test tube with gas **(increases / stays the same / decreases)**.

As the acid concentration increases, the **rate** of the reaction **(increases / stays the same / decreases)**.

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(iii) Using your knowledge of particle theory, underline the correct words in the brackets to complete the following sentence. [2]

At a higher concentration, there are **(more / less / the same number of)** particles present so there will be **(an equal / a smaller / a greater)** chance of collision.

(iv) There are other ways the rate of the reaction can be changed.

Tick (✓) the **two** statements that correctly describe other ways the rate of reaction can be increased. [2]

Increasing the temperature of the acid	☐
Using a lump of magnesium	☐
Using a different apparatus	☐
Using magnesium powder	☐
Decreasing the temperature of the acid	☐

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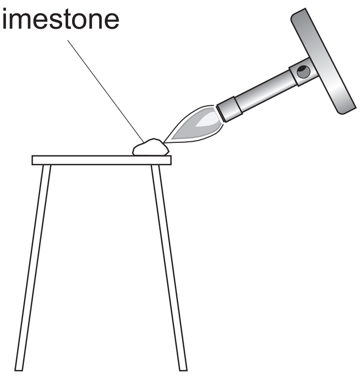
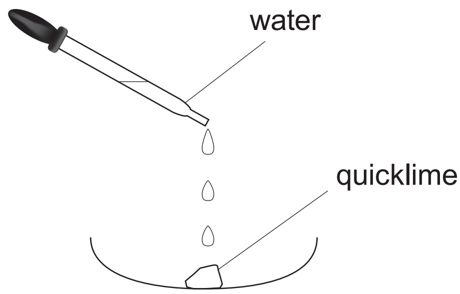
5. (a) A student carried out a two-stage experiment to change limestone (calcium carbonate) into slaked lime (calcium hydroxide).



Stage **1**: Limestone (calcium carbonate) decomposes into quicklime (calcium oxide) and carbon dioxide



Stage **2**: Quicklime (calcium oxide) reacts with water forming slaked lime (calcium hydroxide)

(i) Write the formulae for calcium oxide and carbon dioxide to complete the equation for the reaction taking place in stage **1**. [2]

$CaCO_3 \longrightarrow$ .... + ...

(ii) Calcium hydroxide contains one Ca^{2+} ion for every two OH^{-} ions.

Write the chemical formula for calcium hydroxide. [1]

....

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(b)

Describe the economic benefits and environmental drawbacks of limestone quarrying. [6 QER]

....

....

....

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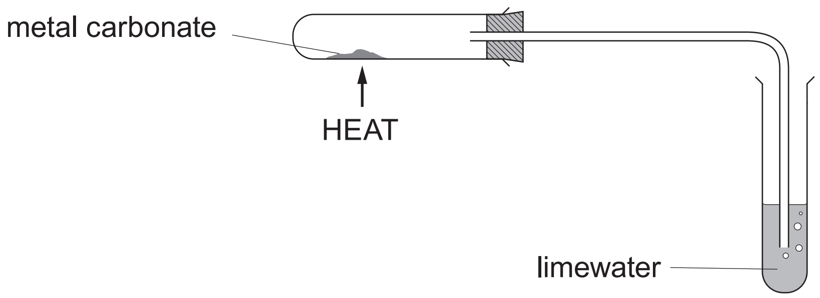
6. (a) Rhian investigated the decomposition of three different metal carbonates.

She measured the time taken for limewater to turn milky using the following apparatus.



Her results are shown in the table.

Metal carbonate	Time taken for limewater to turn milky (s)
copper(II) carbonate	18
zinc carbonate	27
lead carbonate	11

(i) Place the carbonates in order of stability. [1]

Most stable ....

....

Least stable ....

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(ii) If sodium carbonate was used in the investigation the limewater would not turn milky however long it was heated.

Tick (✓) the reason why the limewater would not turn milky. [1]

Sodium carbonate only decomposes a small amount on heating	☐
Sodium carbonate is very unstable	☐
Sodium carbonate does not decompose on heating	☐
Sodium carbonate decomposes too quickly	☐

(iii) On heating copper(II) carbonate, Rhian expected to make 5.0 g of copper(II) oxide. She actually made 3.5 g.

Use the formula below to calculate the percentage yield of copper(II) oxide in her experiment. [2]

$$\text{percentage yield} = \frac{\text{actual mass}}{\text{expected mass}} \times 100$$

Percentage yield = ... %

(iv) One of the ions present in copper(II) carbonate is CO_3^{2-}. [1]

Give the formula of the other ion present.

....

(b) Rhian carried out a flame test to show that sodium carbonate contains sodium ions.

Give the colour of the flame seen. [1]

....

6

7. Is it right to waste helium on party balloons?

Helium is a colourless inert gas found in Group 0 of the Periodic Table.

Helium is one of the commonest elements in the Universe, second only to hydrogen. However, on Earth it is relatively rare, as shown in **Table 1**.

Gases which have a density less than air can escape the Earth's gravity and leak away into space. The density of air is 1.2 g/m^3. **Bar chart 1** shows the densities of Group 0 gases.

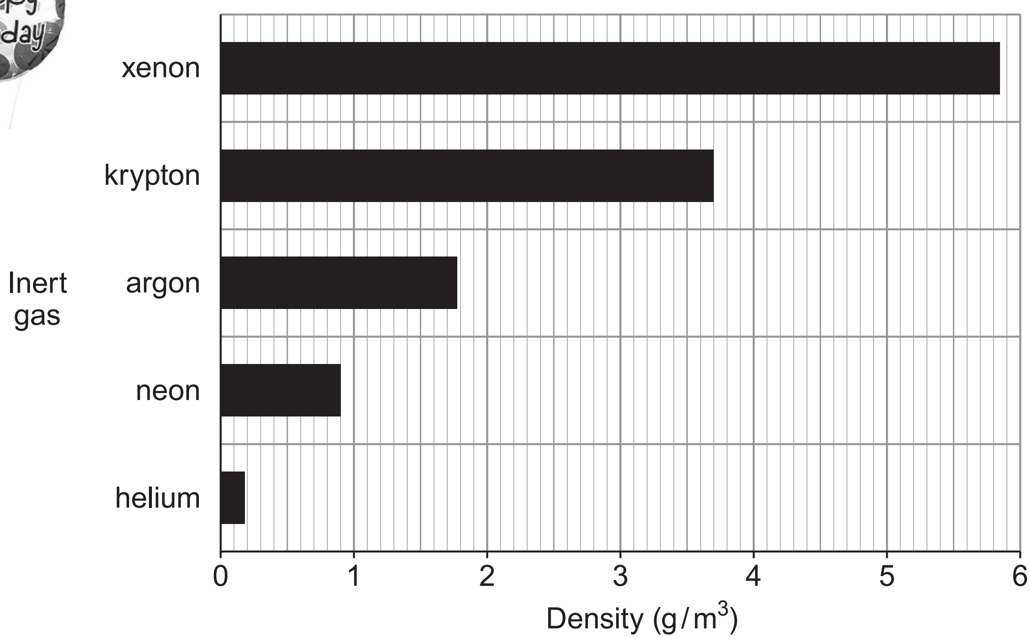
Helium has the lowest boiling point of any element. This makes it of key importance for magnets used in hospital MRI scanners, which must be super-cooled to generate the hugely powerful magnetic fields required.

Some scientists believe that because helium is a finite resource it should not be used for party balloons.

Table 1

Inert gas	Percentage in the atmosphere (%)	Melting point (°C)	Boiling point (°C)
helium	0.00052	−272	−269
neon	0.0018	−246	−246
argon	0.93	−186	−186
krypton	0.0001	−152	−152
xenon	0.000009	−111	−106

Bar chart 1



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(a) Answer the following questions using the information given.

(i) Tick (✓) the box next to the **most** important property that makes helium a suitable material to fill **floating** party balloons. [1]

Helium is a gas ☐

Helium is the second most common element in the Universe ☐

Helium is less dense than air ☐

Helium is colourless ☐

(ii) Tick (✓) the box next to the correct statement. [1]

The Earth's atmosphere contains more helium than argon ☐

The Earth's atmosphere contains more xenon than helium ☐

The Earth's atmosphere contains more helium than krypton ☐

(iii) Tick (✓) the box next to the **best** reason for not using helium to fill party balloons. [1]

There isn't much helium in the Earth's atmosphere ☐

Scientists say helium shouldn't be used to fill balloons ☐

Helium is a finite resource ☐

(iv) Tick (✓) the box next to the correct statement. [1]

Only helium gas can leak away into space ☐

Helium and neon gases can leak away into space ☐

Only argon can leak away into space ☐

All inert gases can leak away into space ☐

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(b) The table below shows the electronic structure of three Group 0 elements.

Group 0 element	Electronic structure
helium	2
neon	2,8
argon	2,8,8

Tick (✓) the box next to the statement that **best** explains why Group 0 elements are unreactive. [1]

All Group 0 elements have 2 electrons in their inner shell ☐

All Group 0 elements have 8 electrons in their outer shell ☐

All Group 0 elements have full outer shells ☐

All Group 0 elements have some full shells ☐

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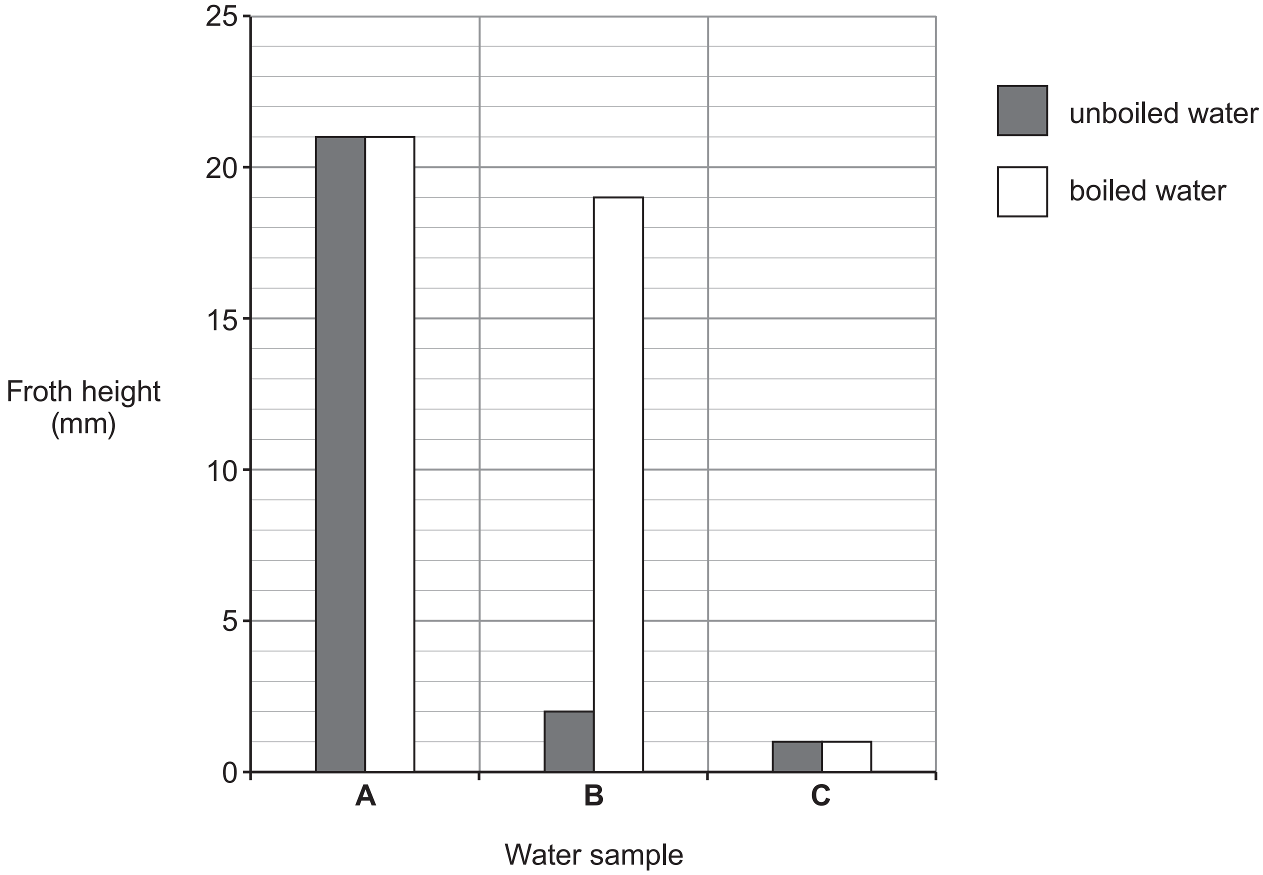
8. (a) Three samples of water, **A**, **B** and **C**, from different parts of the UK were tested in a laboratory.

1 cm^3 of soap solution was added to 25 cm^3 of the three different water samples. Each sample was shaken for 1 minute. The height of the froth was measured.

The experiment was repeated using new samples of water, **A**, **B** and **C**, that had been boiled.



Give the **letter** of the water sample which is [2]

temporary hard water ....

permanent hard water ....

soft water ....

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(b) There are advantages and disadvantages of living in a hard water area.

Give **two** disadvantages of living in a hard water area. [2]

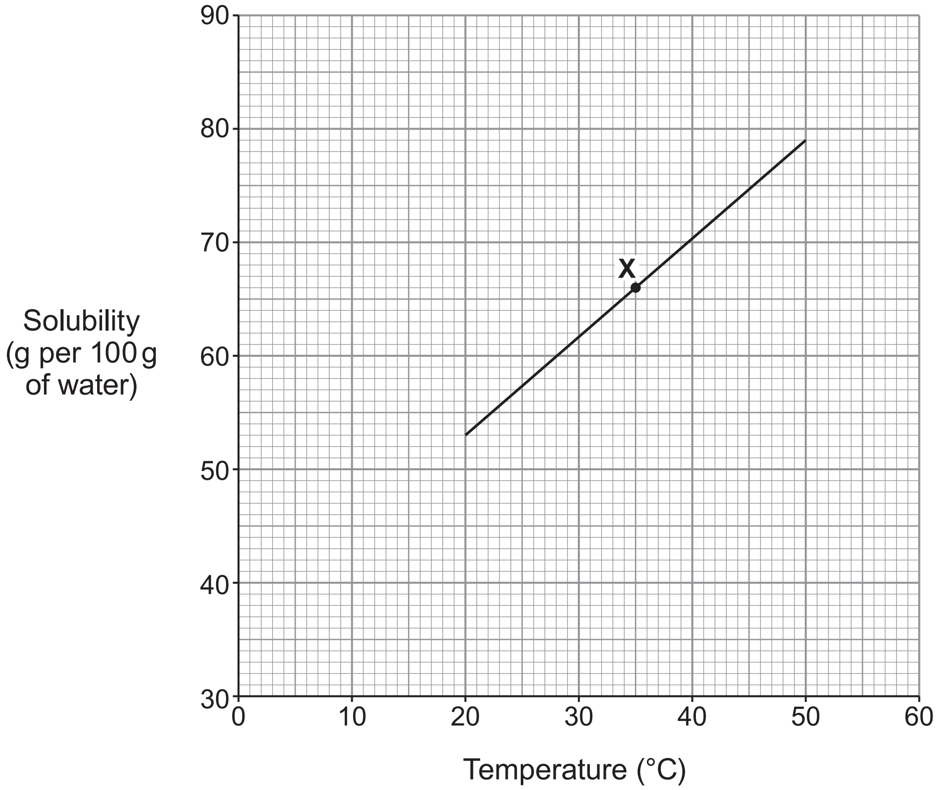
1 ....

....

2 ....

....

(c) The graph below shows the solubility of lead nitrate in water at different temperatures.



(i) State what point **X** on the graph tells you about lead nitrate. [1]

....

....

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(ii) The solubility of lead nitrate at 20 °C is 53 g per 100 g of water.

Use the graph to find its solubility at 50 °C and hence calculate the mass of lead nitrate crystals that form when a saturated solution containing 100 g of water cools from 50 °C to 20 °C. [2]

Mass = ... g

(iii) Use the graph to find the solubility of lead nitrate at 5 °C. [1]

.... g per 100 g of water

8

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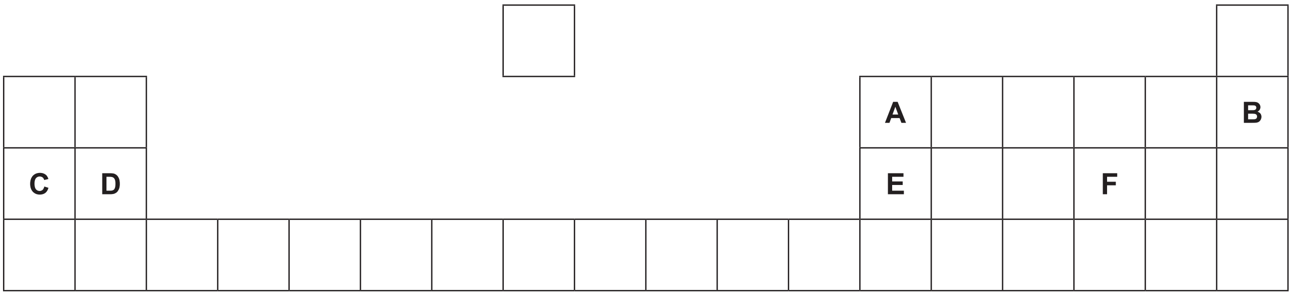
9. (a) The following diagram shows an outline of part of the Periodic Table.

The letters shown are NOT the chemical symbols of the elements.



Choose **letters** from the diagram to complete the table below. [4]

	Letter
The element in Group 3 and Period 2	…………………………….
The element which has 10 protons in its nucleus	…………………………….
The element with the electronic structure 2,8,6	…………………………….
The element which forms a 2+ ion	…………………………….

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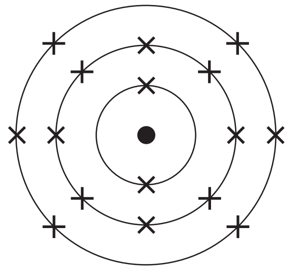
(b) The diagram below shows the electronic structure of an element in the Periodic Table.



In the space below, draw a diagram to show the electronic structure of the element which lies directly **above** it. [1]

(c) The table shows information about atoms **X**, **Y** and **Z**.

Atom	Symbol	Number of protons	Number of neutrons	Number of electrons
X	$^{31}_{15}\mathbf{X}$	....	16	15
Y	$^{39}_{19}\mathbf{Y}$	19	....	19
Z	$^{40}_{19}\mathbf{Z}$	19	21	....

(i) Complete the table. [3]

(ii) Underline the term used to describe atoms **Y** and **Z**. [1]

ions **inert** **insoluble** **isotopes**

9

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10. (a) The table shows information about some Group 1 elements.

Element	Relative atomic mass	Number of electrons in the outer shell	Melting point (°C)	Boiling point (°C)	Density (g/cm^3)
lithium	7	1	180	1342	0.53
sodium	23	1	98	883	0.97
potassium	39	1	63	759	0.89
rubidium	85	1	39	688	1.53
caesium	134	1	29	671	1.93

Use the information in the table to answer parts (i) and (ii).

(i) State the information which explains why the elements have similar chemical properties. [1]

....

(ii) State which **property** has a value which does **not** fit the trend down the group. [1]

....

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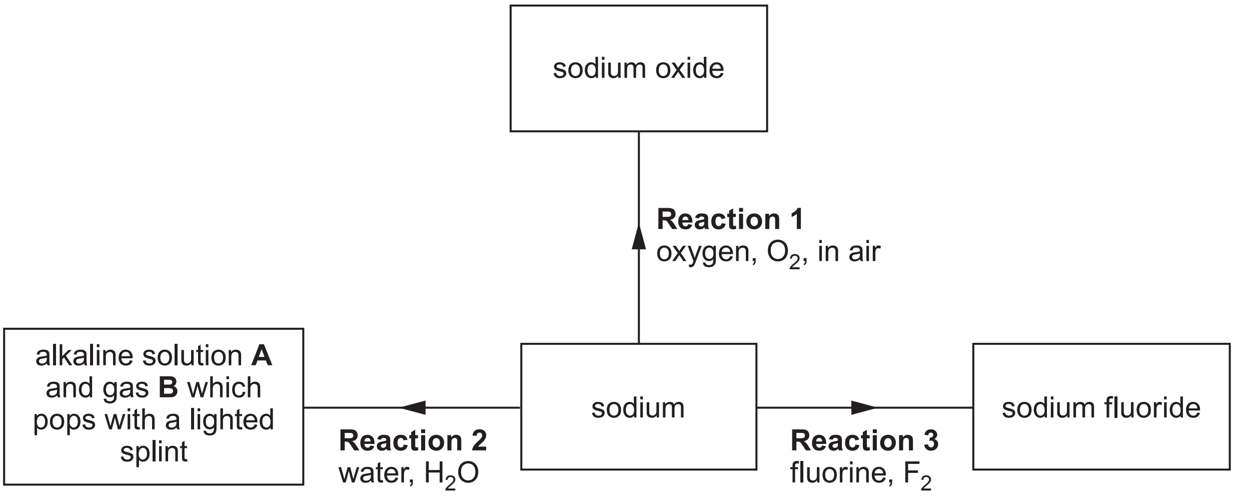
(b) The flow diagram shows some reactions of sodium.



(i) State how **Reaction 1** is prevented when storing sodium in the laboratory. [1]

....

(ii) Give the names of alkaline solution **A** and gas **B**. [2]

.... and ....

(iii) Name the Group 1 metal which would react **least** violently with water. [1]

....

(iv) Complete the symbol equation for **Reaction 3**. [1]

$$2Na + F_2 \longrightarrow 2 \text{...}$$

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(c) Sodium fluoride is added to some UK public water supplies to reduce tooth decay in children.

In America sodium hexafluorosilicate, Na_2SiF_6, is more commonly used. The relative formula mass of sodium hexafluorosilicate is 188.

(i) Calculate the percentage of fluorine in sodium hexafluorosilicate. [2]

$A_r(F) = 19$ $M_r(Na_2SiF_6) = 188$

Percentage = ... %

(ii) State an **ethical** reason why some people oppose the fluoridation of water supplies. [1]

....

....

(iii) Apart from water supplies, state the most commonly used source of fluoride to reduce tooth decay. [1]

....

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END OF PAPER

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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FORMULAE FOR SOME COMMON IONS

POSITIVE IONS		NEGATIVE IONS	
Name	Formula	Name	Formula
aluminium	Al^{3+}	bromide	Br^{-}
ammonium	NH_4^{+}	carbonate	CO_3^{2-}
barium	Ba^{2+}	chloride	Cl^{-}
calcium	Ca^{2+}	fluoride	F^{-}
copper(II)	Cu^{2+}	hydroxide	OH^{-}
hydrogen	H^{+}	iodide	I^{-}
iron(II)	Fe^{2+}	nitrate	NO_3^{-}
iron(III)	Fe^{3+}	oxide	O^{2-}
lithium	Li^{+}	sulfate	SO_4^{2-}
magnesium	Mg^{2+}		
nickel	Ni^{2+}		
potassium	K^{+}		
silver	Ag^{+}		
sodium	Na^{+}		
zinc	Zn^{2+}		

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THE PERIODIC TABLE

1	2					Group						3	4	5	6	7	0
						1 H Hydrogen 1											4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	63.5 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
86 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Key

A_r — relative atomic mass
Symbol
Name
Z — atomic number

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