

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

Atomic Structure and the Periodic Table	R/A/G
Atoms, elements and compounds	
<p>All substances are made of atoms. An atom is the smallest part of an element that can exist.</p> <p>Atoms of each element are represented by a chemical symbol, e.g. O represents an atom of oxygen, Na represents an atom of sodium.</p> <p>There are about 100 different elements. Elements are shown in the periodic table.</p> <p>Compounds are formed from elements by chemical reactions.</p> <p>Chemical reactions always involve the formation of one or more new substances, and often involve a detectable energy change.</p> <p>Compounds contain two or more elements chemically combined in fixed proportions and can be represented by formulae using the symbols of the atoms from which they were formed.</p> <p>Compounds can only be separated into elements by chemical reactions.</p> <p>Chemical reactions can be represented by word equations or equations using symbols and formulae.</p>	
Mixtures	
<p>A mixture consists of two or more elements or compounds not chemically combined together.</p> <p>The chemical properties of each substance in the mixture are unchanged.</p> <p>Mixtures can be separated by physical processes such as filtration, crystallisation, simple distillation, fractional distillation and chromatography. These physical processes do not involve chemical reactions and no new substances are made.</p>	
The development of the model of the atom	
<p>New experimental evidence may lead to a scientific model being changed or replaced.</p> <p>Before the discovery of the electron, atoms were thought to be tiny spheres that could not be divided.</p> <p>The discovery of the electron led to the plum pudding model of the atom. The plum pudding model suggested that the atom is a ball of positive charge with negative electrons embedded in it.</p> <p>The results from the alpha particle scattering experiment led to the conclusion that the mass of an atom was concentrated at the centre (nucleus) and that the nucleus was charged. This nuclear model replaced the plum pudding model.</p> <p>Niels Bohr adapted the nuclear model by suggesting that electrons orbit the nucleus at specific distances. The theoretical calculations of Bohr agreed with experimental observations.</p> <p>Later experiments led to the idea that the positive charge of any nucleus could be subdivided into a whole number of smaller particles, each particle having the same amount of positive charge. The name proton was given to these particles.</p> <p>The experimental work of James Chadwick provided the evidence to show the existence of neutrons within the nucleus. This was about 20 years after the nucleus became an accepted scientific idea.</p>	
Relative charges of subatomic particles	
The relative electrical charges of the particles in atoms are:	

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

Name of particle	Relative charge
Proton	+1
Neutron	0
Electron	-1

- In an atom, the number of electrons is equal to the number of protons in the nucleus. Atoms have no overall electrical charge.
- The number of protons in an atom of an element is its atomic number.
- All atoms of a particular element have the same number of protons.
- Atoms of different elements have different numbers of protons.

Size and mass of atoms

Atoms are very small, having a radius of about 0.1 nm (1×10^{-10} m).

The radius of a nucleus is less than 1/10 000 of that of the atom (about 1×10^{-14} m).

Almost all of the mass of an atom is in the nucleus.

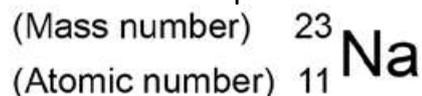
The relative masses of protons, neutrons and electrons are:

Name of particle	Relative mass
Proton	1
Neutron	1
Electron	Very small

The sum of the protons and neutrons in an atom is its mass number.

Atoms of the same element can have different numbers of neutrons; these atoms are called **isotopes** of that element.

Atoms can be represented as shown in this example:

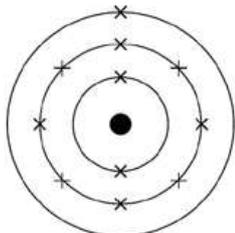


Relative atomic mass

The relative atomic mass of an element is an average value that takes account of the abundance of the isotopes of the element and is compared to the carbon-12 isotope.

Electronic structure

The electrons in an atom occupy the lowest available energy levels (innermost available shells). The electronic structure of an atom can be represented by numbers or by a diagram. For example, the electronic structure of sodium is 2,8,1 or showing two electrons in the lowest energy level, eight in the second energy level and one in the third energy level.



Revision Pack Topic 1 - Atomic Structure and the Periodic Table

The Periodic Table	
<p>The elements in the periodic table are arranged in order of atomic (proton) number and so that elements with similar properties are in columns, known as groups. The table is called a periodic table because similar properties occur at regular intervals. Elements in the same group of the periodic table have the same number of electrons in their outer shell (outer electrons) and this gives them similar chemical properties.</p>	
Development of the Periodic table	
<p>Before the discovery of protons, neutrons and electrons, scientists attempted to classify the elements by arranging them in order of their atomic weights. The early periodic tables were incomplete and some elements were placed in inappropriate groups if the strict order of atomic weights was followed. Mendeleev overcame some of the problems by leaving gaps for elements that he thought had not been discovered and in some places changed the order based on atomic weights. Elements with properties predicted by Mendeleev were discovered and the gaps were filled. Knowledge of isotopes made it possible to explain why the order based on atomic weights was not always correct.</p>	
Metals and non-metals	
<p>Elements that react to form positive ions are metals. Elements that do not form positive ions are non-metals. The majority of elements are metals. Metals are found to the left and towards the bottom of the periodic table. Non-metals are found towards the right and top of the periodic table.</p>	
Group 0 (or Group 8)	
<p>The elements in Group 0 of the periodic table are called the noble gases. They are unreactive and do not easily form molecules because their atoms have a stable arrangement of electrons. The noble gases have eight electrons in their outer shell, except for helium, which has only two electrons. The boiling points of the noble gases increase with increasing relative atomic mass (going down the group).</p>	
Group 1	
<p>The elements in Group 1 of the periodic table are known as the alkali metals and have characteristic properties because of the single electron in their outer shell. You should be able to describe the reactions of the first three alkali metals with oxygen, chlorine and water. In Group 1, the reactivity of the elements increases going down the group.</p>	
Group 7	
<p>The elements in Group 7 of the periodic table are known as the halogens and have similar reactions because they all have seven electrons in their outer shell. The halogens are non-metals and consist of molecules made of pairs of atoms. In Group 7, the further down the group an element is, the higher its relative molecular mass, melting point and boiling point.</p>	

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

In Group 7, the reactivity of the elements decreases going down the group. A more reactive halogen can displace a less reactive halogen from an aqueous solution of its salt.	
Properties of Transition metals (Chemistry only)	
Comparison with Group 1 metals	
The transition elements are metals with similar properties which are different from those of the elements in Group 1. There are differences compared with Group 1 in melting points, densities, strength, hardness and reactivity with oxygen, water and halogens (Cr, Mn, Fe, Co, Ni, Cu.)	
Typical Properties	
Many transition elements have ions with different charges, form coloured compounds and are useful as catalysts.	

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

Match up the correct term to the definition:

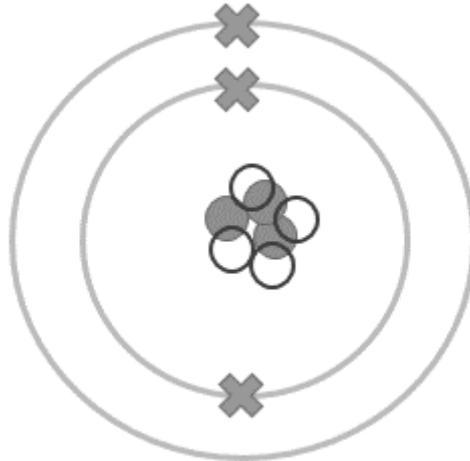
Atom	Positively charged subatomic particle
Ion	Formed from two or more elements by chemical reactions
Isotope	A substance which cannot be broken down chemically
Neutron	A charged particle
Proton	The smallest part of an element
Electron	Atom of an element with a different number of neutrons
Nucleus	Negatively charged subatomic particle
Element	Part of atom which contains neutrons and protons
Compound	Subatomic particle with no charge

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Label IT

Label the diagram of the atom below.

Using the periodic table to help you, write as much information about this atom as you can.



Key Words to help you:

Shell Electron Proton Electron Neutron

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Complete the definitions table:

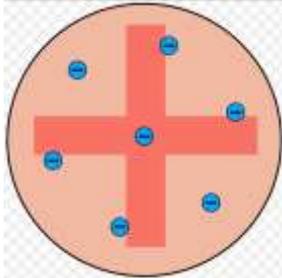
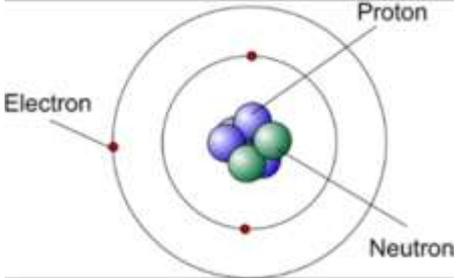
Key Word	Definition
Atom	
Element	
Compound	
Mixture	

Complete the table of sub-atomic particles:

Particle	Charge	Relative Mass	Location

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Models of the atom:

	Plum Pudding Model	Nuclear Model
Diagram		
Description		
Problems (things the model did not explain)		

Name of Scientist	Key contributions to the model of the atom
Rutherford	
Thompson	
Bohr	
Chadwick	

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The Periodic Table

Use the periodic table to complete the table below to show the numbers of protons, neutrons and electrons of each element.

Element	Atomic Number	Mass Number	Protons	Neutrons	Electrons
Lithium (Li)	3	7	3	4	3
Magnesium (Mg)					
Iodine (I)					
Aluminium (Al)					
Oxygen (O)					

1. How is the periodic table arranged (in terms of protons)?
2. What does the group number of an element tell you?
3. What can you say about the chemical properties of elements in the same group?

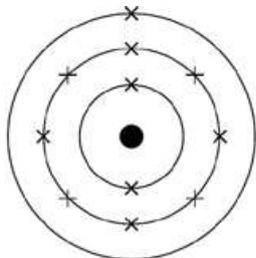
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4. Where are the metals on the periodic table?
5. Where are the non-metals on the periodic table?
6. What were Mendeleev's key contributions to the development of the Periodic Table?
7. How is the modern periodic table different from Mendeleev's periodic table?
8. Why is the mass number of chlorine 35.5?

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Electronic Structure

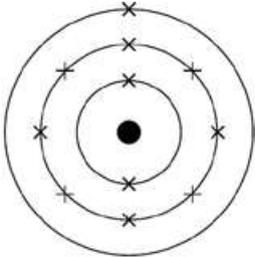
The diagram below shows the electronic structure of the element sodium. This can also be written as: 2,8,1.



1. How do you know that sodium has 11 electrons in total?
2. How many electrons go in the first shell?
3. How many electrons go in the second shell?
4. How many electrons are in the outside shell for sodium?
5. What group number is sodium in?
6. What will sodium do when it reacts?

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

Complete the table to show the electronic structures of these elements:

Element	Electronic Structure	Electron Configuration
Sodium		2,8,1
Nitrogen		
Magnesium		
Fluorine		
Aluminium		

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Complete the table to describe three of the important groups of elements in the Periodic Table:

Group Number	Name	Number of outer electrons	How the elements react	Trend in Reactivity
0	The Noble Gases	8 (except for He, which is 2)	Unreactive	Unreactive because they have a full outer shell of electrons.
1				
7				

Extension:

Explain the trend in reactivity as you go down Group 1.

Compare this with Group 7.

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

Practice Exam Questions:

Q1. This question is about atomic structure and elements.

(a) Complete the sentences.

(i) The atomic number of an atom is the number of (1)

(ii) The mass number of an atom is the number of
..... (1)

(b) Explain why an atom has no overall charge.

Use the relative electrical charges of sub-atomic particles in your explanation.

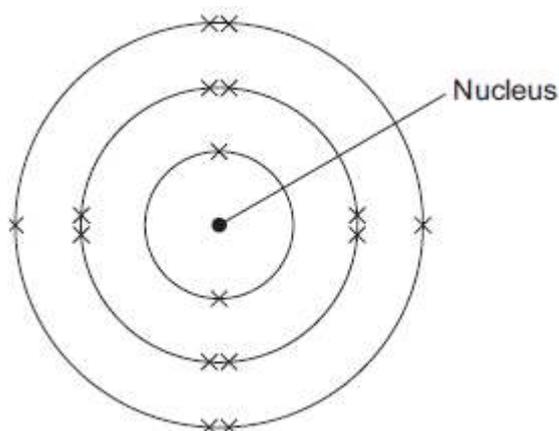
.....
.....
.....
..... (2)

(c) Explain why fluorine and chlorine are in the same group of the periodic table.

Give the electronic structures of fluorine and chlorine in your explanation.

.....
.....
.....
..... (2)

(d) The diagram shows the electronic structure of an atom of a non-metal.



Revision Pack Topic 1 - Atomic Structure and the Periodic Table

What is the chemical symbol of this non-metal?

Tick (✓) **one** box.

Ar

O

S

Si

(1)

(e) When elements react, their atoms join with other atoms to form compounds.

Complete the sentences.

(i) Compounds formed when non-metals react with metals consist of particles called

(1)

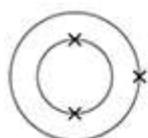
(ii) Compounds formed from only non-metals consist of particles called

(1)

(Total 9 marks)

Q2. The electronic structure of the atoms of five elements are shown in the figure below.

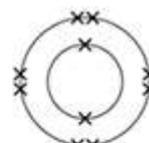
The letters are **not** the symbols of the elements.



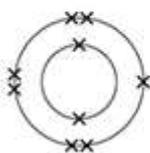
Element A



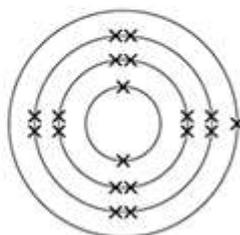
Element B



Element C



Element D



Element E

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

Choose the element to answer the question. Each element can be used once, more than once or not at all.

Use the periodic table to help you.

(a) Which element is hydrogen?

Tick **one** box.

A B C D E

(1)

(b) Which element is a halogen?

Tick **one** box.

A B C D E

(1)

(c) Which element is a metal in the same group of the periodic table as element **A**?

Tick **one** box.

A B C D E

(1)

(d) Which element exists as single atoms?

Tick **one** box.

A B C D E

(1)

(e) There are two isotopes of element **A**. Information about the two isotopes is shown in the table below.

Mass number of the isotope	6	7
Percentage abundance	92.5	7.5

Use the information in the table above to calculate the relative atomic mass of element **A**.

Give your answer to 2 decimal places.

.....
.....

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

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.....
.....
.....

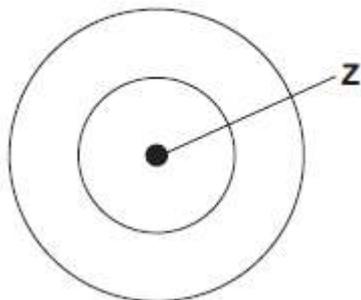
Relative atomic mass =

(4)
(Total 8 marks)

Q3. There are eight elements in the second row (lithium to neon) of the periodic table.

(a) **Figure 1** shows an atom with two energy levels (shells).

Figure 1



(i) Complete **Figure 1** to show the electronic structure of a boron atom.

(1)

(ii) What does the central part labelled **Z** represent in **Figure 1**?

.....

(1)

(iii) Name the sub-atomic particles in part **Z** of a boron atom.

Give the relative charges of these sub-atomic particles.

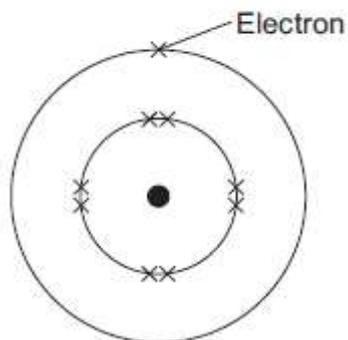
.....
.....
.....

(3)

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

(b) The electronic structure of a neon atom shown in **Figure 2** is **not** correct.

Figure 2



Explain what is wrong with the electronic structure shown in **Figure 2**.

.....

.....

.....

.....

.....

.....

(3)
(Total 8 marks)

Q4. This question is about the halogens (Group 7).

(a) How do the boiling points of the halogens change down the group from fluorine to iodine?

.....

.....

(1)

(b) Sodium bromide is produced by reacting sodium with bromine.

Sodium bromide is an ionic compound.

(i) Write down the symbols of the **two** ions in sodium bromide.

.....

(1)

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

(ii) Chlorine reacts with sodium bromide solution to produce bromine and one other product.

Complete the word equation for the reaction.

chlorine + sodium bromide \longrightarrow bromine +

(1)

(iii) Why does chlorine displace bromine from sodium bromide?

.....

(1)

(iv) Use the Chemistry Data Sheet to help you to answer this question.

Suggest which halogen could react with sodium chloride solution to produce chlorine.

.....

(1)

(Total 5 marks)

Q5. By 1869, about 60 elements had been discovered. Mendeleev arranged these elements in a table, in order of their atomic weight. He also put elements with similar chemical properties in the same columns. Mendeleev and part of his table are shown below.



	Group							
	1	2	3	4	5	6	7	8
Period 1	H							
Period 2	Li	Be	B	C	N	O	F	
Period 3	Na	Mg	Al	Si	P	S	Cl	
Period 4	Cu	K Zn	Ca -	-	Ti As	V Se	Cr Br	Mn Fe Co Ni

(a) (i) Name **one** element in Group 1 of Mendeleev's table that is not in Group 1 of the periodic table on the Data Sheet. Give a reason why this element should not be in Group 1.

Name of element

Reason

.....

(2)

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

(ii) Which group of the periodic table on the Data Sheet is missing from Mendeleev's table?

.....

(1)

(b) The gaps (–) in Mendeleev's table were for elements that had not been discovered.

(i) Compare Mendeleev's table with the periodic table on the Data Sheet.

Name **one** of the elements in Period 4 that had not been discovered by 1869.

.....

(1)

(ii) Mendeleev was able to make predictions about the undiscovered elements. This eventually led most scientists to accept his table.

Suggest what predictions Mendeleev was able to make about these undiscovered elements.

.....
.....
.....
.....
.....

(2)

(c) In terms of their electronic structure:

(i) state why lithium and sodium are both in Group 1

.....
.....
..... (1)

(ii) explain why sodium is more reactive than lithium.

.....
.....
.....
.....

.....(3) (Total 10 marks)

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

(iv) Which **two** statements are correct?

Tick (✓) **two** boxes.

Iron has a higher density than potassium.

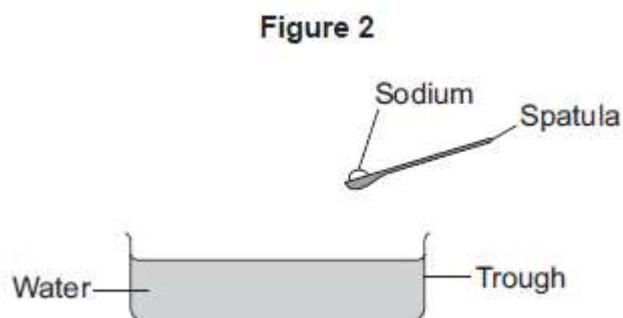
Iron is softer than potassium.

Iron reacts vigorously with water.

Iron forms ions that have different charges.

(2)

(c) **Figure 2** shows sodium being put into water.



Describe **three** observations that can be seen when sodium is put into water.

1

.....

2

.....

3

.....

(3)
(Total 11 marks)

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

Practice Exam Questions - MARK SCHEME

- M1.(a) (i) protons
allow "protons or electrons", but do not allow "protons and electrons" 1
- (ii) protons plus / and neutrons 1
- (b) (because the relative electrical charges are) $-(1)$ for an electron and $+(1)$ for a proton
allow electrons are negative and protons are positive 1
- and the number of electrons is equal to the number of protons
if no other mark awarded, allow 1 mark for the charges cancel out 1
- (c) (the electronic structure of) fluorine is 2,7 and chlorine is 2,8,7
allow diagrams for the first marking point 1
- (so fluorine and chlorine are in the same group) because they have the same number of or 7 electrons in their highest energy level or outer shell
if no other mark awarded, allow 1 mark for have the same / similar properties 1
- (d) S 1
- (e) (i) ions 1
- (ii) molecules 1
- [9]
- M2.(a) B 1
- (b) D 1
- (c) E 1

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

(d) C 1

(e) 92.5×6 and
 7×7.5 1

$\frac{607.5}{100}$ 1

6.075 1

6.08 1

allow 6.08 with no working shown for 4 marks

[8]

M3.(a) (i) electronic structure 2,3 drawn
*allow any representation of electrons, such as, dots,
crosses, or numbers (2,3)* 1

(ii) nucleus 1

(iii) protons and neutrons
*do **not** allow electrons in nucleus* 1

(relative charge of proton) +1
allow positive 1

(relative charge of neutron) 0
allow no charge/neutral
ignore number of particles 1

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

- (b) too many electrons in the first energy level or inner shell
allow inner shell can only have a maximum of 2 electrons 1
- too few electrons in the second energy level or outer shell
allow neon has 8 electrons in its outer shell or neon does not have 1 electron in its outer shell
allow neon has a stable arrangement of electrons or a full outer shell 1
- neon does not have 9 electrons **or** neon has 10 electrons
allow one electron missing
allow fluorine has 9 electrons 1
- ignore second shell can hold (maximum) 8 electrons or 2,8,8 rule or is a noble gas or in Group 0*
max 2 marks if the wrong particle, such as atoms instead of electrons
if no other mark awarded allow 1 mark for the electronic structure of neon is 2,8 [8]
- M4.(a)** increase 1
- (b) (i) Na^+ **and** Br^-
both required 1
- (ii) sodium chloride
allow NaCl
*do **not** allow sodium chlorine* 1
- (iii) chlorine is more reactive than bromine
allow converse argument
allow symbols Cl, Cl_2 , Br and Br_2
allow chlorine / it is more reactive
*do **not** allow chloride **or** bromide* 1

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

- (iv) fluorine
allow F / F₂
do not allow fluoride. 1 [5]
- M5.** (a) (i) *incorrect or no element = 0 marks*
- hydrogen
allow H / H₂ 1
- all the other elements are metals
allow hydrogen is a not an (alkali / group 1) metal
ignore hydrogen is a gas
- OR**
- copper (1)
allow Cu
- (copper) is not an alkali metal (1)
allow Cu is a transition element / metal
allow any valid specific chemical property eg Cu does not react with water
ignore references to electronic structure
ignore physical properties 1
- (ii) Group 0 / noble gases
ignore Group 8 1
- (b) (i) scandium / gallium / germanium
accept Sc / Ga / Ge
allow Krypton / Kr 1
- (ii) predicted they were metals
allow atomic mass / weight
ignore atomic structure 1

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

predicted their (chemical/physical) properties / reactivity

accept any chemical / physical property

allow similar properties if mentioned in context of a group

1

(c) (i) (both) have one / an electron in the outer energy level / shell

ignore form single plus ions

1

(ii) *accept shell for energy level*

accept converse explanation for lithium

if 'outer' not mentioned, max 2 marks

ignore sodium reacts more easily

sodium loses one outer electron more easily (than lithium)

1

because outer electrons/energy level further from the nucleus in sodium

or because sodium has more shells (than lithium)

*do **not** accept 'more outer shells'*

allow sodium (atom) is larger

1

because forces/attraction to hold outer electron are weaker in sodium
(than lithium)

accept more shielding in sodium (than lithium)

1

[10]

M6.(a) atomic weights

must be in this order

1

electrons

1

proton numbers

1

(b) (i) H/hydrogen

allow H₂ or h

1

(ii) one / 1

allow alkali metals

1

Revision Pack Topic 1 - Atomic Structure and the Periodic Table

(iii) Potassium (K) 1

(iv) Iron has a higher density than potassium 1

Iron forms ions that have different charges 1

(c) any **three** from:

- melts
- fizzes / bubbles / effervesces
allow gas produced
- sodium floats
- size of the sodium decreases
allow dissolves / disappears
- sodium moves
allow two marks for moves around on the surface of the water

3
[11]