C1: Atomic Structure and Periodic Table 1

ANSWER KEY

1.1	What is an atom?	The smallest part of an element that can exist
1.2	What is an element?	A pure substance made of only one type of atom
1.3.	What is a compound?	A pure substance made of two or more different atoms chemically bonded together
1.4	What is a molecule?	A substance made of more than one atom chemically bonded together, e.g. Cl_2, CH_4, O_2
1.5	What is a mixture?	A substance made of more than one substance, **not chemically bonded** together
1.6	How can we separate a mixture of sand and water?	Filtration
1.7	How can we separate a mixture of liquids with different boiling points?	Fractional distillation
1.8	How can we separate a mixture of coloured dyes?	Chromatography
1.9	Name the three subatomic particles	Protons, neutrons, electrons
1.10	**State the relative masses and charges of the subatomic particles**	**Mass: protons 1, neutrons 1, electrons 0** **Charge: protons +1, neutrons 0, electrons -1**
1.11	What is the plum pudding model of the atom?	A ball of positive charge with negative electrons embedded into it.
1.12	What did the gold foil experiment (alpha particle scattering) prove?	Atoms have a small, dense nucleus with a positive charge, and are mostly empty space
1.13	What did Chadwick discover?	The neutron
1.14	What did Bohr's experiments show?	Electrons are arranged in specific shells or energy levels

C1: Atomic Structure and Periodic Table 2

ANSWER KEY

2.1	**What is the atomic number of an atom?**	**The number of protons in an atom**
2.2	**What is the mass number of an atom?**	**The number of protons + the number of neutrons in an atom**
2.3.	How are the subatomic particles arranged in an atom?	Protons and neutrons in the nucleus, electrons orbiting the nucleus in shells
2.4	Why is the number of electrons in an atom equal to the number of protons?	Protons are positive, and electrons are negative, so their charges cancel out
2.5	How many electrons can go in the first shell?	2
2.6	How many electrons can go in the second and third shells?	8
2.7	What are groups in the periodic table?	The vertical columns, numbered 1,2,3,4,5,6,7,0
2.8	**What can the group tell you about the electrons in an atom?**	**The number of electrons in the outer shell. e.g. carbon is in group 4 so has 4 electrons in the outer shell.**
2.9	What are periods in the periodic table?	The horizontal rows in the periodic table
2.10	**What can the period tell you about the electrons in an atom?**	**The number of electron shells an atom has. e.g. carbon is in the second period so has two shells**
2.11	Why do atoms have no overall charge?	Protons are positive, and electrons are negative, and the number of electrons and protons are equal
2.12	**Approximately how large are atoms?**	**Radius is about 0.1nm (1×10^{-10} m)**
2.13	How large is the nucleus compared to the whole atom?	About 1/10,000 the size (1×10^{-14} m)

C1: Atomic Structure and Periodic Table 3

ANSWER KEY

3.1	**What are isotopes?**	• **Atoms of the same element with the same number of protons** • **but a different number of neutrons**
3.2	What is the relative atomic mass (A_r) of an element?	An average value for the mass number that takes into account the different isotopes of the element
3.3.	**In the modern periodic table, how are the elements arranged?**	**By increasing atomic (proton) number** (and in groups according to similar chemical properties)
3.4	Why do elements in the same group have similar chemical properties?	Because they have the same number of electrons in their outer shell
3.5	**Before the discovery of protons, neutrons and electrons how did scientists organise the elements?**	**By their atomic weight**
3.6	**Why did Mendeleev leave gaps in his periodic table?**	**For elements that had not yet been discovered**
3.7	Why did Mendeleev swap the order of some elements like tellurium and iodine	So they were in the same column as other elements with similar chemical properties
3.8	Where are metals on the periodic table found?	To the left of the periodic table
3.9	Where are non-metals on the periodic table found?	To the right of the periodic table
3.10	What is an ion?	A charged atom which has lost or gained electrons (to get a full outer shell)
3.11	**What kinds of ions do:** • **metals form?** • **non-metals form?**	• **Metals form positive ions** • **Non-metals form negative ions**
3.12	What is the charge on ions formed by: • group 1 atoms like Na? • group 2 atoms like Mg? • group 3 atoms like Al?	• Na^+ • Mg^{2+} • Al^{3+}
3.13	What is the charge on ions formed by: • group 7 atoms like Cl? • group 6 atoms like O?	• Cl^- • O^{2-}

C1: Atomic Structure and Periodic Table 4

ANSWER KEY

4.1	**What name is given to elements in group 0?**	**Noble gases**
4.2	**Why are the group 0 elements unreactive?**	• **They have a full outer shell of electrons** • **don't need to lose or gain electrons**
4.3.	How does the boiling point of group 0 elements change down the group?	Increases down the group
4.4	**What name is given to elements in group 1?**	**Alkali metals**
4.5.	**List 3 observations when an alkali metal like sodium is placed into a basin of water containing universal indicator**	**Any 3 from:** • **metal floats** • **fizzing/bubbles** • **metal moves** • **metal dissolves/gets smaller** • **indicator turns blue/purple**
4.6	What are the products when an alkali metal reacts with: • oxygen • water • halogen?	• Oxygen → metal oxide • Water → metal hydroxide + hydrogen • Halogen → metal halide
4.7	**Explain why the group 1 elements get more reactive down the group**	• **Atoms get bigger so <u>outer</u> electrons further from nucleus** • **weaker attraction from the nucleus to the outer shell** • **easier to lose an electron**
4.8	**What name is given to elements in group 7?**	**Halogens**
4.9	Which is the most reactive element in group 7?	Fluorine (at the top)
4.10	**Explain why the group 7 elements get less reactive down the group** **(opposite trend to group 1)**	• **Atoms get bigger so <u>outer</u> electrons further from nucleus** • **weaker attraction from the nucleus to the outer shell** • **harder to gain an electron**
4.11	What is a displacement reaction?	Where a more reactive element displaces a less reactive one from a compound

C1: Transition Metals (Triple Content)

ANSWER KEY

1	Where are transition metals found in periodic table?	In the middle (between groups 2 and 3)
2	**How do the physical properties of transition metals compare to group 1 (alkali) metals?**	• **Harder** • **Stronger** • **Higher melting points** • **Higher density**
3	How does the reactivity of transition metals compare to group 1 (alkali) metals?	Less reactive
4	How are the ions formed by transition metals different to group 1 (alkali) metals?	Can form ions with different charges (variable oxidation states) e.g. iron can be Fe^{2+} and Fe^{3+} (group 1 metal ions are always 1+)
5	What is distinctive about the compounds formed from transition metals?	They are coloured (compounds of group 1 metals are always white solids or colourless solutions in comparison)
6	What can transition metals commonly be used as?	Catalysts e.g. iron (Fe) in manufacture of ammonia platinum (Pt) in catalytic converters

FOUNDATION TIER

Q1. Sodium and potassium are Group 1 elements.

(a) What is the name of Group 1 elements?

Tick (✓) **one** box.

Alkali metals ☐

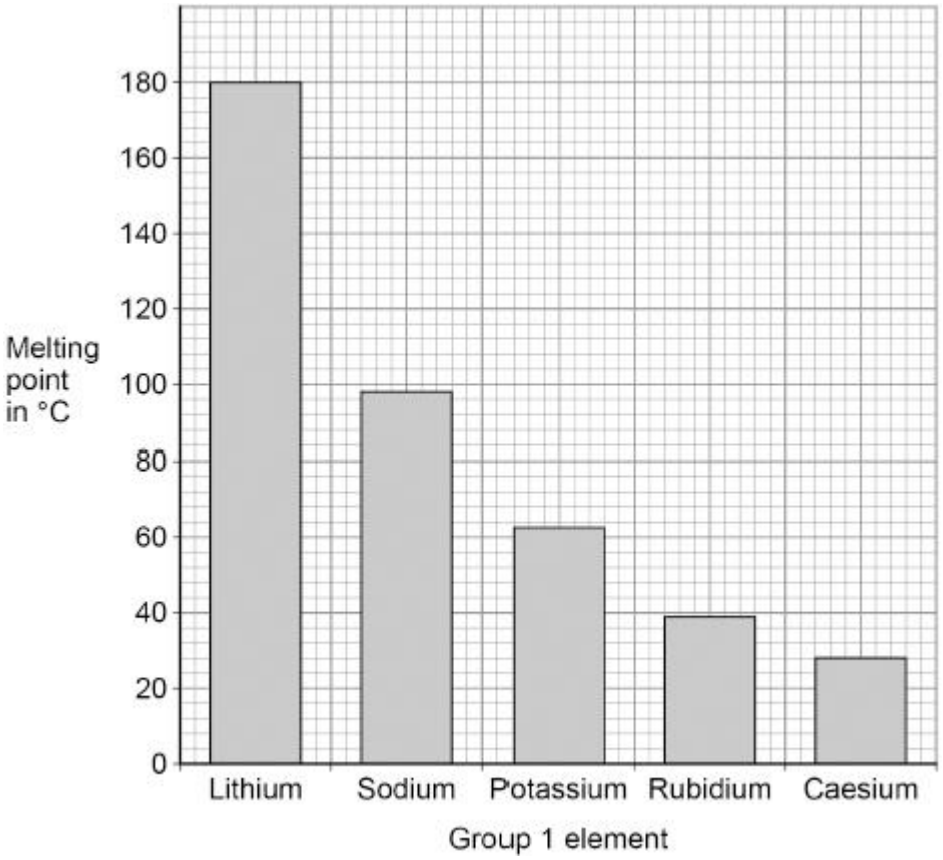
Halogens ☐

Noble gases ☐

(1)

(b) **Figure 1** represents the melting points of Group 1 elements.

Figure 1



What is the melting point of sodium?

Melting point of sodium = _____ °C

(1)

(c) Sodium reacts with water to produce sodium hydroxide and hydrogen.

Balance the equation for the reaction.

$$\_\_\_\_\_\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$$

(1)

(d) Calculate the relative formula mass (M_r) of sodium hydroxide (NaOH).

Relative atomic masses (A_r): H = 1 O = 16 Na = 23

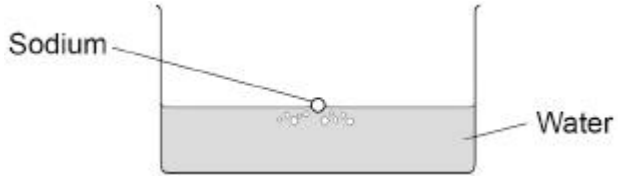
Relative formula mass (M_r) = _____

(2)

(e) Sodium and potassium both react with water.

Figure 2 shows sodium reacting with water.

Figure 2



Compare what is seen when sodium reacts with water and when potassium reacts with water.

(4)

(Total 9 marks)

Q2. This question is about elements in the periodic table.

(a) What property was used to arrange elements in early periodic tables?

Tick (✓) **one** box.

Atomic number ☐

Atomic weight ☐

Mass number ☐

(1)

(b) In early periodic tables, iodine (I) was placed before tellurium (Te).

Mendeleev placed iodine after tellurium.

Figure 1 shows part of Mendeleev's periodic table.

Figure 1

16 **O**	19 **F**
32 **S**	35.5 **Cl**
79 **Se**	80 **Br**
128 **Te**	127 **I**

Suggest **one** reason why Mendeleev placed iodine in the column shown in **Figure 1**.

_____

_____

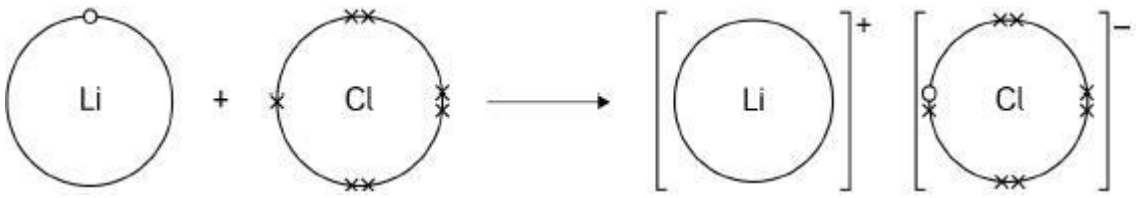
(1)

(c) Lithium reacts with chlorine to produce lithium chloride.

Figure 2 shows what happens to the electrons in the outer shells when a lithium atom reacts with a chlorine atom.

The dots (o) and crosses (x) represent electrons.

Figure 2



Describe what happens to a lithium atom and to a chlorine atom when they react.

Use **Figure 2** to answer in terms of electrons.

_____

_____

_____

_____

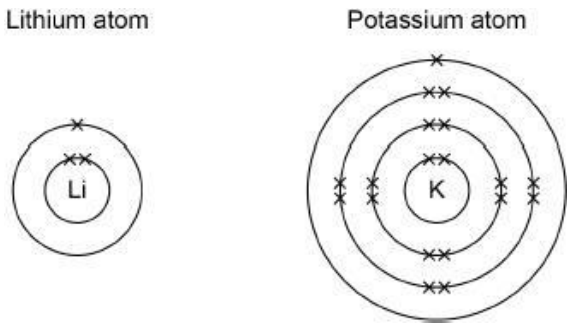
_____

(3)

(d) Lithium and potassium are in the same group of the periodic table.

Figure 3 represents the electronic structures of a lithium atom and of a potassium atom.

Figure 3



Give **two** reasons why potassium is more reactive than lithium.

1. _____

_____

2. _____

_____

(2)

(Total 7 marks)

Q3. This question is about calcium.

(a) Ionic compounds, such as calcium oxide, have high melting points.

Complete the sentences. Use words from the box.

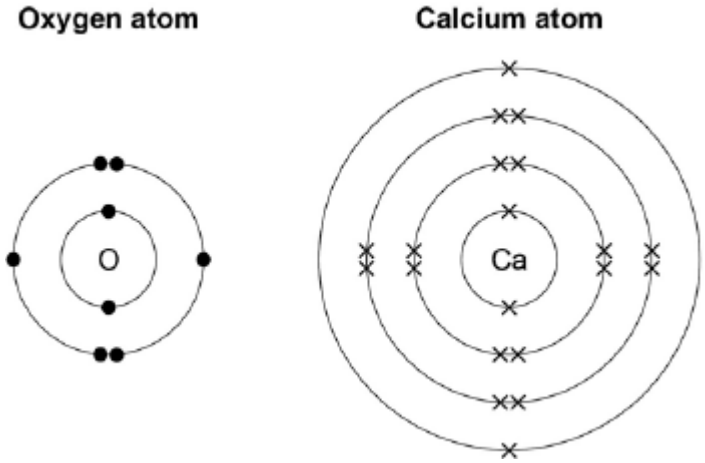
bonds	forces	ions	layers

Calcium oxide has a giant ionic lattice in which there are strong electrostatic

_____ of attraction in all directions.

(1)

(b) The figure below shows the electronic structure of an oxygen atom and a calcium atom.



Describe, as fully as you can, what happens when a calcium atom and an oxygen atom react to form calcium oxide.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 5 marks)

Q4. The model of the atom has changed over time.

Scientists investigated the structure of the atom.

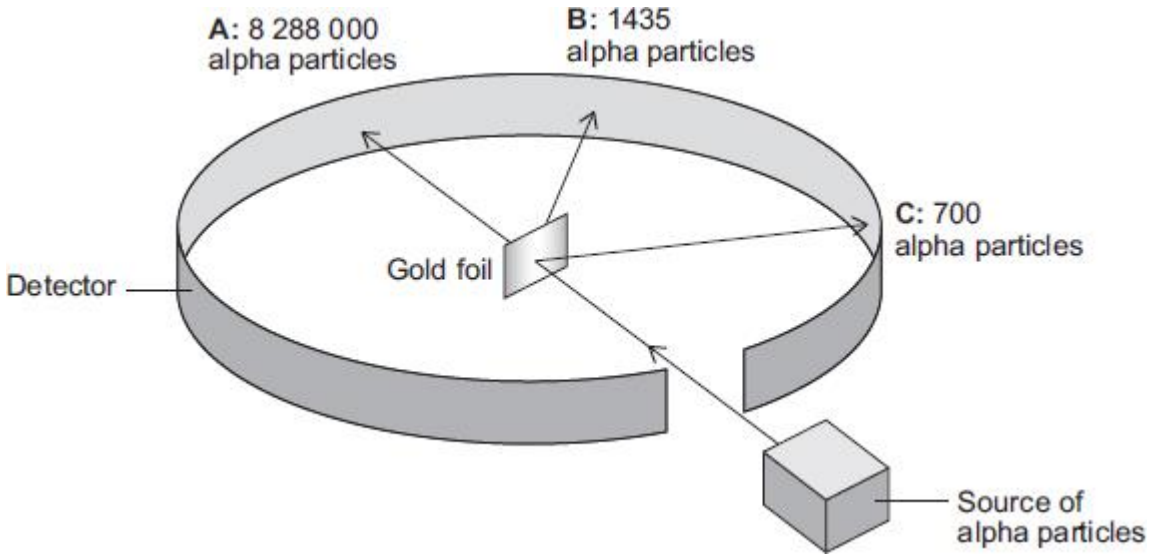
The scientists directed alpha particles at a thin sheet of gold foil.

(a) What is an alpha particle the same as? Tick (✓) **one** box.

A fast-moving electron	☐
A helium nucleus	☐
A radioactive isotope	☐
Electromagnetic radiation	☐

(1)

The diagram below shows:
- three of the pathways the alpha particles take
- the number of alpha particles detected at positions **A**, **B** and **C**.



The scientists concluded that a gold atom:
- is mostly empty space
- has a charged nucleus at its centre.

(b) How do the results in the diagram above show that a gold atom is mostly empty space?

_____

_____

(1)

(c) Explain how the results in the diagram above show that a gold atom contains a charged nucleus.

(2)

(d) A gold atom can be represented as:

$$^{197}_{79}Au$$

Describe the atomic structure of this gold atom.

You should include the numbers of each type of sub-atomic particle.

(5)

(Total 9 marks)

Q5. This question is about the periodic table.

(a) **Figure 1** shows part of Mendeleev's version of the periodic table.

Figure 1

H							
Li	Be	B	C	N	O	F	
Na	Mg	Al	Si	P	S	Cl	
K Cu	Ca Zn		Ti	V As	Cr Se	Mn Br	Fe Co Ni
Rb Ag	Sr Cd	Y In	Zr Sn	Nb Sb	Mo Te	I	Ru Rh Pd

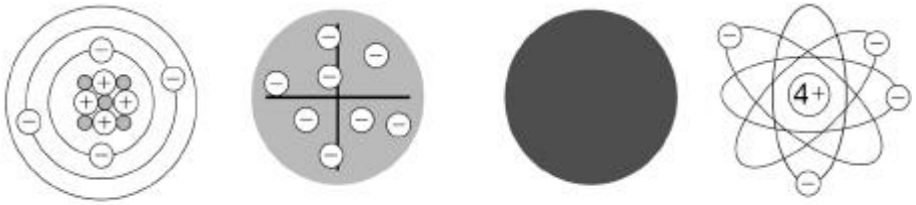
Which group of elements had **not** been discovered when Mendeleev's version of the periodic table was published?

_____

(1)

Figure 2 represents different models of the atom.

Figure 2



A **B** **C** **D**

(b) Which model represents the plum pudding model?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(c) Which model resulted from Chadwick's experimental work?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

Potassium has different isotopes.

(d) What is meant by 'isotopes'?

You should refer to subatomic particles.

_____

_____

_____

_____

(2)

(e) The table below shows the mass numbers and the percentage abundance of two isotopes of potassium.

Mass number	Percentage abundance
39	93.1
41	6.9

Calculate the relative atomic mass (A_r) of potassium.

Give your answer to 1 decimal place.

_____

_____

_____

_____

_____

Relative atomic mass (1 decimal place) = _____

(3)

(Total 8 marks)

HIGHER TIER

Q6. This question is about elements.

Caesium is in Group 1 of the periodic table.

(a) Explain what happens to caesium atoms and to oxygen atoms when caesium reacts with oxygen to produce caesium oxide.

You should answer in terms of electrons.

(4)

(b) Explain why caesium is more reactive than sodium.

You should answer in terms of electrons.

(4)

(c) The diagram below shows part of Mendeleev's periodic table.

16 **O**	19 **F**
32 **S**	35.5 **Cl**
79 **Se**	80 **Br**
128 **Te**	127 **I**

Explain why the early periodic tables placed iodine (I) before tellurium (Te), but then Mendeleev placed tellurium before iodine.

(3)

(Total 11 marks)

Q7. This question is about halogens.

Bromine reacts with sodium to produce sodium bromide.

(a) Describe the structure of and bonding in sodium bromide.

(2)

(b) The equation for the reaction is:

$$2\ Na + Br_2 \rightarrow 2\ NaBr$$

1 g of bromine reacts with sodium.

Calculate the number of bromine molecules in 1 g of bromine.

1 mole of bromine contains 6.02×10^{23} bromine molecules.

Relative formula mass (M_r) of bromine = 160

Number of bromine molecules = _____

(3)

(c) The table below shows the boiling points of some halogens.

Halogen	**Boiling point in °C**
Fluorine	−188
Chlorine	−34
Bromine	60

Explain the trend in the boiling points of the halogens.

(4)

(Total 9 marks)

SEPARATE SCIENCE

Q8. In the periodic table, the transition elements and Group 1 elements are metals.

Some of the properties of two transition elements and two Group 1 elements are shown in the table below.

	Transition elements		**Group 1 elements**	
	Chromium	Iron	Sodium	Caesium
Melting point in °C	1857	1535	98	29
Formula of oxides	CrO Cr_2O_3 CrO_2 CrO_3	FeO Fe_2O_3 Fe_3O_4	Na_2O	Cs_2O

Use your own knowledge **and** the data in the table above to compare the chemical and physical properties of transition elements and Group 1 elements.

(6)
(Total 6 marks)

Q1.

(a) alkali metals

1

(b) 98 (°C)

allow a <u>value</u> in the range 97–99 (°C)

1

(c) $2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$

allow multiples

1

(d) (M_r =) 23 + 16 + 1

1

= 40

1

(e) **Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar / different is made clear and (where appropriate) the magnitude of the similarity / difference is noted.

3–4

Level 1: Relevant features are identified and differences noted.

1–2

No relevant content

0

Indicative Content:

<u>Similarities – sodium and potassium both:</u>

- float
- move
- bubble / effervesce / fizz
- melt
- form a ball
- get smaller **or** disappear

<u>Differences – potassium:</u>

- moves faster
- bubbles faster
- reacts faster
- disappears faster

- catches fire
- lilac flame

[9]

Q2.

(a) atomic weight

1

(b) (because) properties were similar
or
(because) iodine has similar / same properties as bromine / chlorine / fluorine
allow symbols

1

(c) lithium (atom) loses one electron

1

chlorine (atom) gains one electron

1

any **one** from:
- ions are formed
  allow ionic bonding
- lithium forms positive ion
- chlorine forms negative ion
- form a full outer shell(s) / level(s)
  allow noble gas structure is formed

1

allow energy levels for shells
allow converse for lithium

(d) any **two** from:

- reactivity of elements increases going down the group
- potassium has more shells
- potassium can lose an (outer) electron more easily
- potassium has an outer shell / electron further away from the nucleus
- potassium has more shielding (of the outer shell / electron)
- potassium has a weaker attraction between nucleus and outer shell / electron

2

[7]

Q3.

(a) base

1

(b) forces

1

(c) calcium loses electrons

1

oxygen gains electrons

1

two electrons are transferred

1

both get full outer shell of electrons

1

[6]

Q4.

(a) a helium nucleus

1

(b) most of the (alpha) particles pass straight through

*allow most of the (alpha) particles are **not** deflected / repelled / bounced back*

1

(c) some of the (alpha) particles bounce back
or
some of the (alpha) particles are deflected

1

(because the charged) alpha particles were repelled (by the charged nucleus)

1

(d) 79 protons **and** 79 electrons

1

118 neutrons

1

protons in the nucleus

1

neutrons in the nucleus

1

electrons are arranged in energy levels (around the nucleus)

allow electrons are arranged in shells (around the nucleus)

1

[9]

Q5.

(a) (Group) 0
or
noble gases

1

(b) B

1

(c) A

1

(d) (atoms with the) same number of protons

allow atoms with the same atomic number

allow atoms of the same element

ignore the same number of electrons

1

(but with) different numbers of neutrons

ignore (but with) different mass numbers

*do **not** accept (but with) different relative atomic mass*

1

(e) $\frac{(39 \times 93.1) + (41 \times 6.9)}{100}$

1

= 39.138

1

= 39.1

*allow correctly rounded answer to **1** decimal place from an incorrect calculation using all the values given in the question*

1

[8]

Q6.

(a) caesium atom loses one electron

1

(and) oxygen atom gains two electrons

1

(so) two caesium atoms react with one oxygen atom

allow (to produce) Cs_2O

*max **3** marks if reference to incorrect particles / bonding / structure*

1

any **one** from:

- (to form) Cs^+ and O^{2-}
- (to form) caesium ion(s) and oxide ion(s)
- (to form) ions with full outer shells / levels

1

(b) (caesium has) more energy levels
or
(caesium has) more shells

allow converse for sodium

1

(so the) outer electron / shell is further from nucleus
or

outer electron / shell is more shielded

1

(so) weaker attraction between nucleus and outer electron / shell

1

(so) outer electron is more easily lost

allow (so) less energy needed to remove outer electron

1

(c) early periodic tables were arranged with elements in order of their atomic weights

ignore atomic mass

1

iodine has a lower atomic weight than tellurium

allow converse for tellurium

1

(so) Mendeleev placed iodine with elements with same / similar properties

allow F / Cl / Br for elements

or

(so) Mendeleev placed tellurium with elements with same / similar properties

allow O / S / Se for elements

1

[11]

Q7.

(a) giant structure/repeating structure/lattice of ions

1

with strong electrostatic forces of attraction/strong attraction between oppositely charged ions

*if no other mark awarded allow **1** mark for ionic bonding*

1

(b) (moles bromine = $\frac{1}{160}$)
0.00625

1

(molecules of bromine =)
$0.00625 \times 6.02 \times 10^{23}$

allow correct use of an incorrectly calculated value for moles of bromine

1

(molecules of bromine =)
3.76×10^{21} (molecules)

allow 3.7625×10^{21} (molecules)

1

allow converse

(c) boiling point increases down the group

allow boiling point decreases up the table

1

(because) the relative formula / molecular mass increases
or
(because) the size of the molecule increases

1

(so) the intermolecular forces increase (in strength)

allow (so) the forces <u>between molecules</u> increase (in strength)

1

(so) more energy is needed to overcome the intermolecular forces

allow (so) more energy is needed to separate the molecules

*do **not** accept a reference to breaking bonds unless specifically between molecules*

1

[9]

Q8.

Level 3 (5–6 marks):
A detailed and coherent comparison is given, which demonstrates a broad knowledge and understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links.

Level 2 (3–4 marks):
A description is given which demonstrates a reasonable knowledge and understanding of the key scientific ideas. Comparisons are made but may not be fully articulated and / or precise.

Level 1 (1–2 marks):
Simple statements are made which demonstrate a basic knowledge of some of the relevant ideas. The response may fail to make comparisons between the points raised.

0 marks:
No relevant content.

Indicative content

Physical
Transition elements

- high melting points
- high densities
- strong
- hard

Group 1

- low melting points
- low densities
- soft

Chemical
Transition elements

- low reactivity / react slowly (with water or oxygen)
- used as catalysts
- ions with different charges
- coloured compounds

Group 1

- very reactive / react (quickly) with water / non-metals
- not used as catalysts
- white / colourless compounds
- only forms a +1 ion

6

[6]