Atomic Structure 6

Name: _____

Class: _____

Date: _____

Time: **85 minutes**

Marks: **82 marks**

Comments:

1. This question is about Group 1 elements.

(a) Sodium reacts with chlorine to produce sodium chloride.

Balance the equation for the reaction.

$$\_\_\_\_\_\ Na + Cl_2 \rightarrow \_\_\_\_\_\ NaCl$$

(1)

(b) 4.6 g of sodium reacts with chlorine to produce 11.7 g of sodium chloride.

What mass of chlorine reacted?

_____

_____

Mass of chlorine = _____ g

(1)

(c) A teacher puts hot sodium into a gas jar of chlorine.

The changes seen before, during and after this reaction were observed.

Complete the sentences.

Choose the answers from the box.

colourless	**green**	**lilac**	**silver**	**white**	**yellow**

Sodium is a _____ solid.

Chlorine is a _____ gas.

The hot sodium burns with a _____ flame.

The product sodium chloride is a _____ solid.

(4)

(d) Sodium chloride (NaCl) is an ionic compound.

Write the formulae of the ions in sodium chloride.

Sodium ion _____

Chloride ion _____

(2)

(e) Complete the sentence.

Choose the answer from the box.

an atom	**an electron**	**a neutron**	**a proton**

Potassium is more reactive than sodium.

This is because potassium loses _____ more easily than sodium.

(1)

(f) How does the size of a potassium atom compare with the size of a sodium atom?

Give a reason for your answer.

_____

Reason _____

_____

_____

(2)

(Total 11 marks)

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

(a) What order did scientists use to arrange elements in early periodic tables?

_____

_____

(1)

(b) In the early periodic tables some elements were placed in the wrong groups.

Mendeleev overcame this in his periodic table.

Give **one** way Mendeleev did this.

_____

_____

(1)

The table shows the boiling points of fluorine, chlorine and bromine.

Element	Boiling point in °C
Fluorine	−186
Chlorine	−34
Bromine	+59

(c) Explain why the boiling points in the table are low.

(2)

(d) Explain the trend in the boiling points in the table above.

(3)

(e) Explain why neon is unreactive.

Give the electronic structure of neon in your answer.

(2)

(f) How many atoms are there in 1 g of argon?

The Avogadro constant is 6.02×10^{23} per mole.

Relative atomic mass (A_r): Ar = 40

_____

_____

_____

_____

Number of atoms in 1 g = _____

(2)

(Total 11 marks)

3. This question is about sodium.

(a) Sodium reacts with chlorine.

What is the balanced equation for the reaction?

Tick (✓) **one** box.

$Na + Cl \longrightarrow NaCl$ ☐

$Na + Cl_2 \longrightarrow NaCl_2$ ☐

$2\ Na + Cl_2 \longrightarrow 2\ NaCl$ ☐

$2\ Na + Cl \longrightarrow Na_2Cl$ ☐

(1)

(b) Hot sodium is put in a gas jar of chlorine.

Describe the observations made before, during and after the reaction.

Before reaction _____

_____

During reaction _____

_____

After reaction _____

_____

(3)

(c) Explain why sodium is less reactive than potassium.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(d) Chlorine reacts with sodium and with hydrogen.

Compare the structure and bonding in sodium chloride and hydrogen chloride.

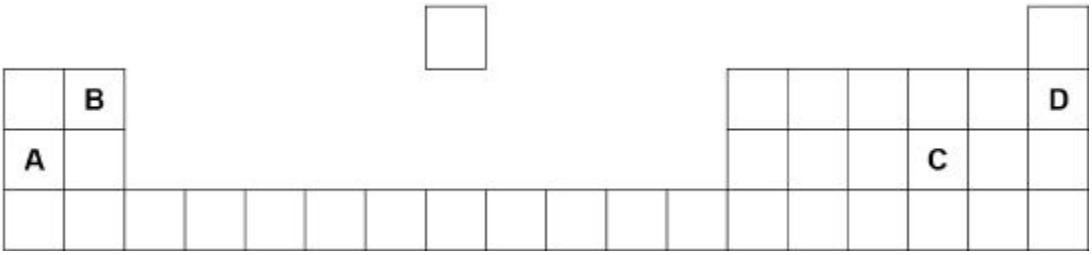
(6)

(Total 14 marks)

4. This question is about the elements in Group 2 of the periodic table.

(a) **Figure 1** shows the positions of four elements, **A**, **B**, **C**, and **D**, in the periodic table.

Figure 1



Which element is in Group 2?

Tick **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

Group 2 metal carbonates break down when heated to produce a metal oxide and a gas.

metal carbonate ⟶ metal oxide + gas

(b) Name the two products when calcium carbonate ($CaCO_3$) is heated.

_____ and _____

(2)

(c) What type of reaction happens when a compound breaks down?

Tick **one** box.

burning ☐

decomposition ☐

neutralisation ☐

reduction ☐

(1)

(d) The metal carbonate takes in energy from the surroundings to break down.

What type of reaction takes in energy from the surroundings?

Tick **one** box.

combustion ☐

electrolysis ☐

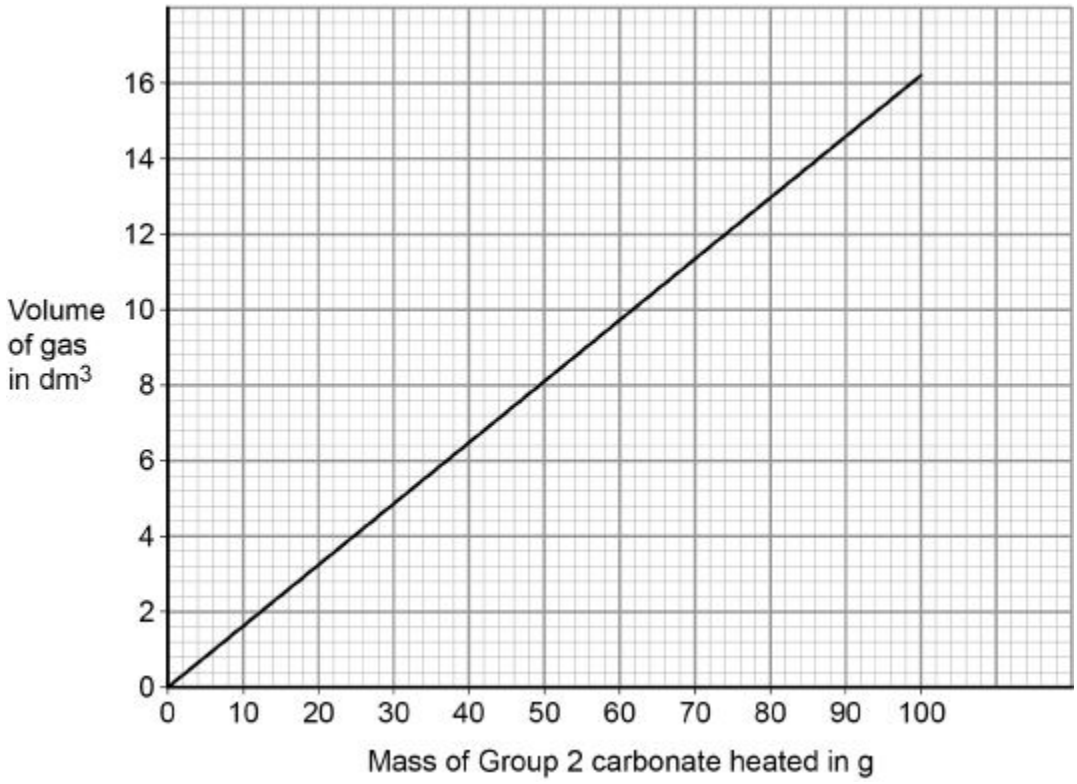
endothermic ☐

exothermic ☐

(1)

(e) **Figure 2** shows the volume of gas produced when a Group 2 metal carbonate is heated.

Figure 2



The student collected 5.2 dm^3 of gas.

What mass of the Group 2 metal carbonate is heated?

Mass = _____ g

(1)

(f) Calculate the mass of the Group 2 carbonate needed to produce 24 dm^3 of gas.

Use your answer from part **(e)** to help you.

_____

_____

_____

_____

Mass = _____ g

(2)

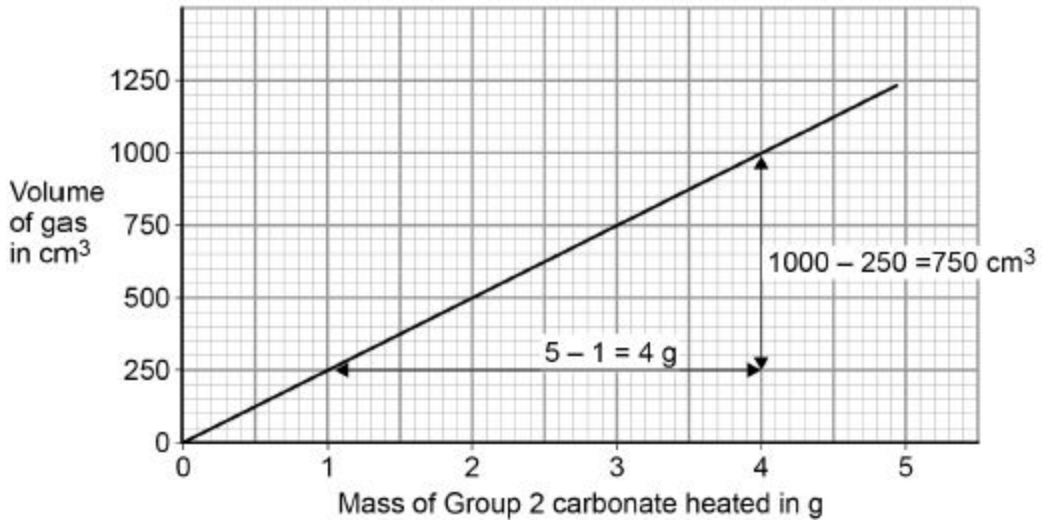
(g) A student heated different masses of a Group 2 carbonate. The student measured the volume of gas produced.

Figure 3 shows a graph of the student's results.

The student calculates the gradient of the line in **Figure 3**

The student makes **two** mistakes.

Figure 3



$$\text{Correct formula for gradient} = \frac{\text{Increase in volume of gas}}{\text{Increase in mass of Group 2 metal carbonate heated}}$$

$$\text{Student's calculation} = \frac{4}{750} = 0.00533 \text{ cm}^3 \text{ per g}$$

Identify the **two** mistakes the student makes.

Calculate the correct gradient of the line.

Mistake 1 _____

_____

Mistake 2 _____

_____

Calculation _____

_____

Gradient = _____ cm^3 per g

(4)

(h) A student repeated the experiment with a different Group 2 metal carbonate (**X**CO_3).

The relative formula mass (M_r) of **X**CO_3 is 84

Relative atomic masses (A_r): C = 12 O = 16

Calculate the relative atomic mass (A_r) of **X**.

Name metal **X**.

Use the periodic table.

_____

_____

_____

_____

Relative atomic mass (A_r) = _____

Metal **X** is _____

(4)

(Total 16 marks)

5. This question is about the halogens.

(a) Which group in the periodic table is known as the halogens?

Tick **one** box.

Group 1 ☐

Group 2 ☐

Group 7 ☐

Group 0 ☐

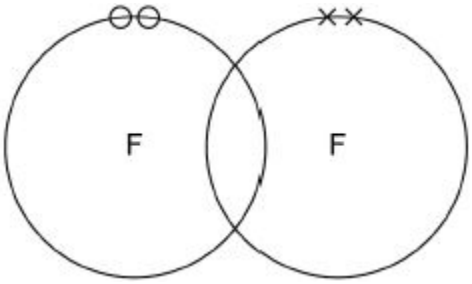
(1)

(b) A fluorine atom has 7 electrons in the outer shell.

The diagram below shows part of a dot and cross diagram to represent a molecule of fluorine (F_2).

Complete the dot and cross diagram.

You should show only the electrons in the outer shells.



(2)

(c) Chlorine reacts with potassium bromide solution.

Complete the word equation.

chlorine + potassium bromide ⟶ _____ + _____

(2)

(d) What type of reaction happens when chlorine reacts with potassium bromide solution?

Tick **one** box.

- decomposition ☐
- displacement ☐
- neutralisation ☐
- precipitation ☐

(1)

(e) Complete the sentence.

Choose the answer from the box.

an atom	**an electron**	**a neutron**	**a proton**

Chlorine is more reactive than bromine.

This is because chlorine gains _____ more easily.

(1)

(f) How does the size of a chlorine atom compare with the size of a bromine atom?

Complete the sentence.

Choose the answer from the box.

bigger than	**the same size as**	**smaller than**

A chlorine atom is _____ a bromine atom.

(1)

(g) Give a reason for your answer to part **(f)**

Reason _____

_____

(1)

(h) Fluorine reacts with chlorine to produce ClF_3

Balance the chemical equation for the reaction.

$$Cl_2 + \_\_\_\_\_F_2 \longrightarrow 2\ ClF_3$$

(1)

(i) Explain why fluorine is a gas at room temperature.

Use the following words in your answer:

energy **forces** **molecules** **weak**

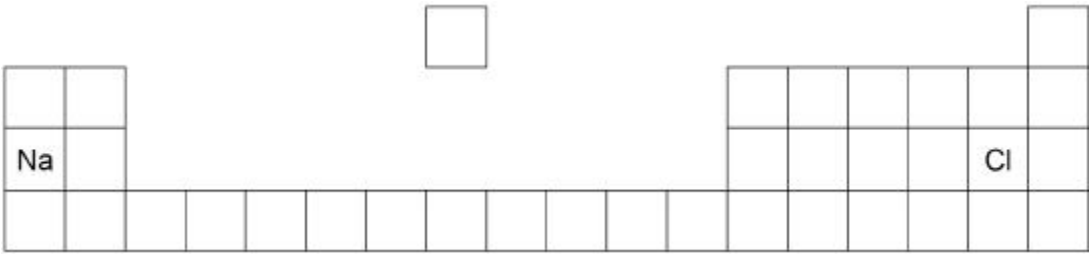
(3)

(Total 13 marks)

6. This question is about sodium and chlorine.

Figure 1 shows the positions of sodium and chlorine in the periodic table.

Figure 1



(a) State **one** difference and **one** similarity in the electronic structure of sodium and of chlorine.

Difference _____

_____

Similarity _____

_____

(2)

(b) Sodium atoms react with chlorine atoms to produce sodium chloride (NaCl).

Describe what happens when a sodium atom reacts with a chlorine atom.

Write about electron transfer in your answer.

_____

_____

_____

_____

_____

_____

_____

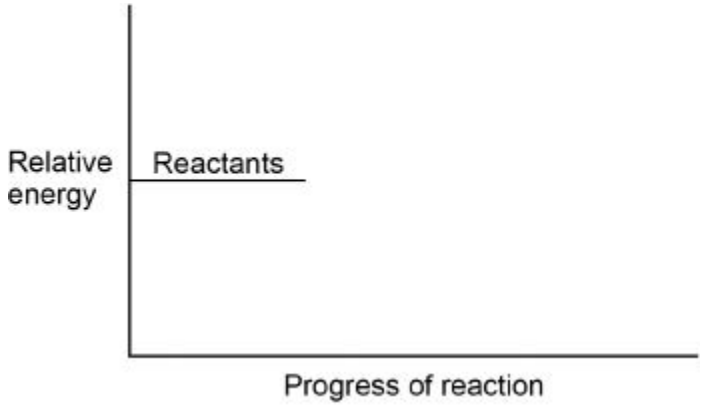
_____

(4)

(c) The reaction between sodium and chlorine is an exothermic reaction.

Complete the reaction profile for the reaction between sodium and chlorine.

Figure 2



(2)

(Total 8 marks)

7. This question is about the halogens.

(a) Write the state symbol for chlorine at room temperature.

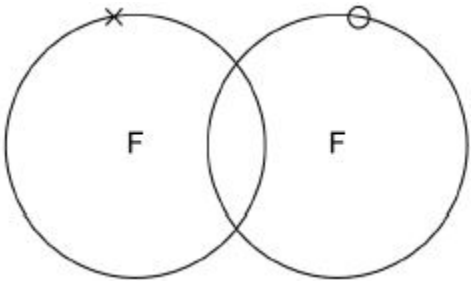
Cl_2 (_____)

(1)

(b) The diagram below represents one molecule of fluorine.

Complete the dot and cross diagram on the diagram above.

You should show only the electrons in the outer shells.



(2)

(c) A fluorine atom can be represented as $^{19}_{9}F$

What is the total number of electrons in a fluorine molecule (F_2)?

Tick **one** box.

9 ☐ 14 ☐ 18 ☐ 38 ☐

(1)

(d) Aluminium reacts with bromine to produce aluminium bromide.

Complete the balanced chemical equation for this reaction.

_____Al + _____Br_2 ⟶ 2_____

(2)

(e) When chlorine reacts with potassium bromide, chlorine displaces bromine.

$$Cl_2 + 2\ KBr \longrightarrow Br_2 + 2\ KCl$$

Explain why chlorine is more reactive than bromine.

(3)

(Total 9 marks)

Mark schemes

1.

(a) 2 Na + Cl2 ⟶ 2 NaCl

allow multiples

1

(b) 7.1 (g)

1

(c)

this order only

silver

1

green

allow yellow

1

yellow

allow white

1

white

1

(d) Na^+

1

Cl^-

1

*if no other mark awarded allow **1** mark for +(1) charge for sodium ion and –(1) charge for chloride ion*

(e) an electron

1

(f) potassium (atom) is larger

1

potassium (atom) has more energy levels (of electrons)
or
potassium (atom) has more shells (of electrons)

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

1

[11]

2.

(a) atomic weight

*do **not** accept atomic mass or A_r*

1

(b) left gaps / spaces

or

changed the order based on atomic weights

allow placed them in correct groups according to properties

*do **not** accept reference to atomic number*

1

(c) weak forces between the molecules

or

weak intermolecular forces

allow weak intermolecular bonds

*do **not** accept incorrect references to covalent bonds*

1

(so) little energy required to overcome / break the forces between molecules

or

(so) little energy required to overcome / break the intermolecular forces

allow (so) little energy required to separate the molecules

allow (so) little energy required to overcome / break the intermolecular bonds

ignore less energy

1

(d)

allow converse explanation in terms of boiling point

(the) molecules get larger going down the group

1

(so the) forces between the molecules increase

or

(so the) intermolecular forces increase

1

(so the) boiling points increase going down the group

or

(so the) boiling points increase with increasing relative atomic mass

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

1

(e) 2,8

allow diagram or description

1

(so) stable arrangement of electrons

or

(so) full outer shell

1

(f)

*an answer of 1.51 × 10^{22} scores **2** marks*

$\frac{1}{40} \times 6.02 \times 10^{23}$

or

$0.025 \times 6.02 \times 10^{23}$

1

1.51×10^{22}

allow 1.505 × 10^{22}

1

[11]

3. (a) $2\ Na + Cl_2 \longrightarrow 2\ NaCl$

1

(b) (before)

silver solid / liquid / metal

allow grey solid / metal

or

green (gas)

allow yellow (gas)

1

(during)

yellow flame

allow orange / white flame

or

white smoke

or

green colour fades / disappears

allow vigorous reaction

1

(after)

white solid / powder

1

(c)

allow converse for potassium

(sodium has) fewer energy levels / shells

allow diagrams of electron structure

1

outer electron / shell is closer to nucleus

or

outer electron / shell is less shielded

1

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

1

(so) outer electron is less easily lost

allow (so) loses an / one electron less easily

allow (so) more energy needed to remove an / one electron

1

(d) **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.

4–6

Level 1: Relevant features are identified and differences noted.

1–3

No relevant content

0

Indicative content

	sodium chloride	hydrogen chloride
differences in bonding	ionic	covalent
	metal & non-metal	two **non**-metals
	transferring electrons	sharing electrons
	ions (Na^+ and Cl^-)	molecules
	charged particles	neutral **or** no overall charge
differences in structure	**giant** structure or lattice	**small / simple / discrete** molecules
	electrostatic	intermolecular forces
	(electrostatic forces) are **strong**	(intermolecular forces) are **weak**
	act in all directions	random **or** between the molecules
	regular	irregular / random
similarities in bonding	full shells **or** stability	full shells **or** stability
	(transferring) electrons	(sharing) electrons
	strong bonds	**strong** (covalent) bonds
	act in all directions	random **or** between the molecules
similarities in structure	(electrostatic) forces	(intermolecular) forces

ignore properties eg melting points, conduct electricity

to access level 2 there must be a comparison of the structure **and** bonding **and** magnitude of both sodium chloride **and** hydrogen chloride.

[14]

4. (a) B

1

(b) calcium oxide **or** CaO

1

carbon dioxide **or** CO_2

1

either order

(c) decomposition

1

(d) endothermic

1

(e) 32 (g)

allow 31−33 (g)

1

(f) $\frac{32}{5.2} \times 24$

1

148 (g)

allow a range 143−153 (g)

or

uses graph e.g. 12 dm^3 gives 74 (g) (1)

(then factors up so that 24 dm^3 gives) 148 (g) (1)

allow a range 143−153 (g)

1

*an answer of 148 (g) scores **2** marks*

*allow ecf from part **(e)***

(g) (mistakes)

increase in mass = 3 (not 4)

allow mistakes in either order

1

inserted numbers inversely into formula

allow numbers wrong way round

1

(calculation)

*an answer of 250 scores the **2** calculation marks*

1

$\text{gradient} = \frac{750}{3}$

allow $\frac{1000}{4}$

250 (cm^3 per g)

if no calculation marks awarded

allow $\frac{750}{4}$ ***or*** 187.5 ***or*** $\frac{3}{750}$

***or** 0.004 for **1** mark*

1

(h) 3 × 16 or 48

1

(48) + 12 or 60

allow their mass of oxygen + 12

1

84 − (60) **or** 24

allow 84 − their mass of carbonate

1

magnesium **or** Mg

*magnesium **or** Mg without working scores this mark*

1

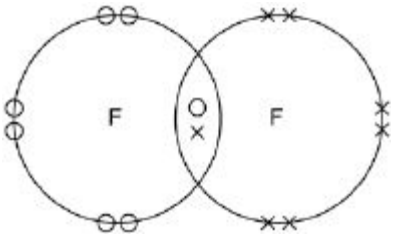
*an answer of 24 scores the **3** calculation marks*

[16]

5. (a) group 7

1

(b)



*one shared pair anywhere in overlap between two circles **or** on intersection*

6 other electrons on each atom

*allow dots **or** crosses **or** mixture for all marks*

ignore any inner shell electrons

1

1

(c) bromine

1

potassium chloride

1

either order

allow correct chemical formulae

(d) displacement

1

(e) (an) electron

1

(f) smaller than

1

(g) (chlorine has) fewer levels / shells (of electrons)

allow converse for bromine

allow (chlorine has) fewer electrons

allow Cl has 3 levels / shells and Br has 4 levels / shells

ignore atomic number
or *mass number*
or *number of protons*

1

*mark independent of answer to part **(f)***

(h) 3

allow multiples

1

(i) there are weak forces

*do **not** accept weak bonds*

1

between molecules

1

*allow weak intermolecular forces for the first **2** marks*

which require little energy to overcome / break

allow does not need much energy to boil

1

[13]

6. (a) (difference)
sodium has one and chlorine has seven electrons in outer level / shell
or
number of electrons

number of electrons must be correct if quoted

1

(similarity)
both have three / same number of levels / shells
or
have electrons in third level / shell
or
both have incomplete (outer) levels / shells

allow both have 2 electrons in inner shell
or
both have 8 electrons in second shell
or
both are one electron away from full outer level / shell

1

(b) sodium (atom) loses

allow moves / transfers for loses

*do **not** accept sodium ion loses*

1

one (outer shell electron)

1

chlorine (atom) gains

*do **not** accept chloride*

1

one (electron)

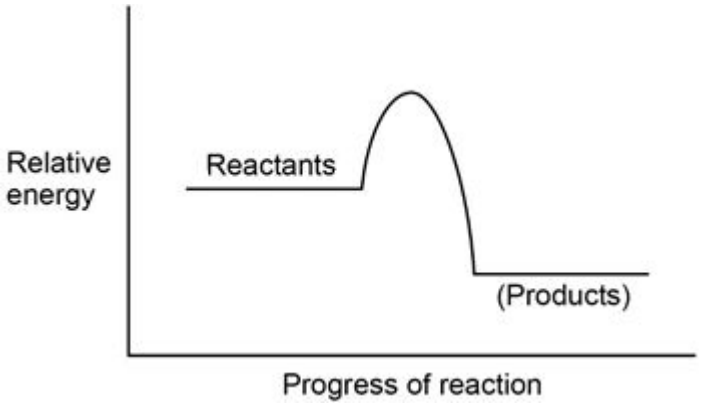
1

*transfer of 1 electron from chlorine to sodium **max 2** marks*

*reference to sharing or covalent bonding **max 3** marks*

allow marks from suitable diagram(s)

(c)



ignore labels

any curve / line going up and then down

products line below reactants

allow curve to start / finish anywhere along reactant / product lines

1

1

[8]

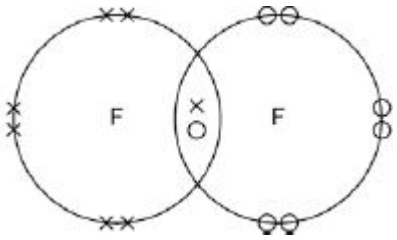
7. (a) g

*do **not** accept upper case (G)*

*do **not** accept gas*

1

(b)



*one shared pair anywhere in overlap between two circles **or** on intersection*

1

6 other electrons on each atom

1

*allow dots **or** crosses **or** mixture for all marks*

ignore any inner shell electrons

(c) 18

1

(d) $AlBr_3$

1

2 Al + 3 Br_2 (⟶ 2 $AlBr_2$)

1

*allow **1** mark for balancing their equation with an incorrect product*

(e) chlorine is a smaller atom
or has fewer energy levels
or outer shell closer to nucleus

ignore chlorine has fewer electrons

1

chlorine has less shielding
or
has the greater attraction between the nucleus and the outer shell **or** incoming electron

1

therefore chlorine can gain an electron (into the outer shell) more easily

1

*if no other marks awarded allow **1** mark for correct trend in reactivity in Group 7*

*do **not** accept reference to incorrect particles e.g. chloride atom*

***max 2** if outer shell / level not mentioned*
'it' refers to chlorine
allow converse reasons for bromine being less reactive

[9]