Questions are for both separate science and combined science students unless indicated in the question

Q1.

This question is about Group 1 elements.

(a) Complete **Table 1** to show the electronic structure of a potassium atom.

Table 1

Atom	Number of electrons	Electronic structure
Sodium	11	2,8,1
Potassium	19	2,8,8,1

(1)

(b) Why do Group 1 elements have similar chemical properties?

Tick (✓) **one** box.

They have the same number of electron shells.	☐
They have the same number of outer shell electrons.	✓
They have two electrons in the first shell.	☐

(1)

(c) What is the type of bonding in sodium?

Tick (✓) **one** box.

Covalent	☐
Ionic	☐
Metallic	✓

(1)

Table 2 shows observations made when lithium, potassium and rubidium react with water.

Table 2

Element	Observations

Lithium	Bubbles slowly Floats Moves slowly
Sodium	1 Bubbles very quickly 2 Floats
Potassium	Bubbles very quickly Melts into a ball Floats Moves very quickly Flame
Rubidium	Sinks Melts into a ball Explodes with a flame

(d) Give **two** observations you could make when sodium reacts with water.

Write your answers in **Table 2**.

(2)

(e) How does the reactivity of the elements change going down Group 1?

Reactivity increases as you go down the group.

(1)

(f) Give **two** ways in which the observations in **Table 2** show the change in reactivity going down Group 1.

1 Increasing rate of bubble formation

2 Increasing speed of movement.

(2)

(g) Which gas is produced when Group 1 elements react with water?

Tick (✓) **one** box.

Carbon dioxide ☐

Hydrogen ☑

Nitrogen ☐

Oxygen ☐

(1)

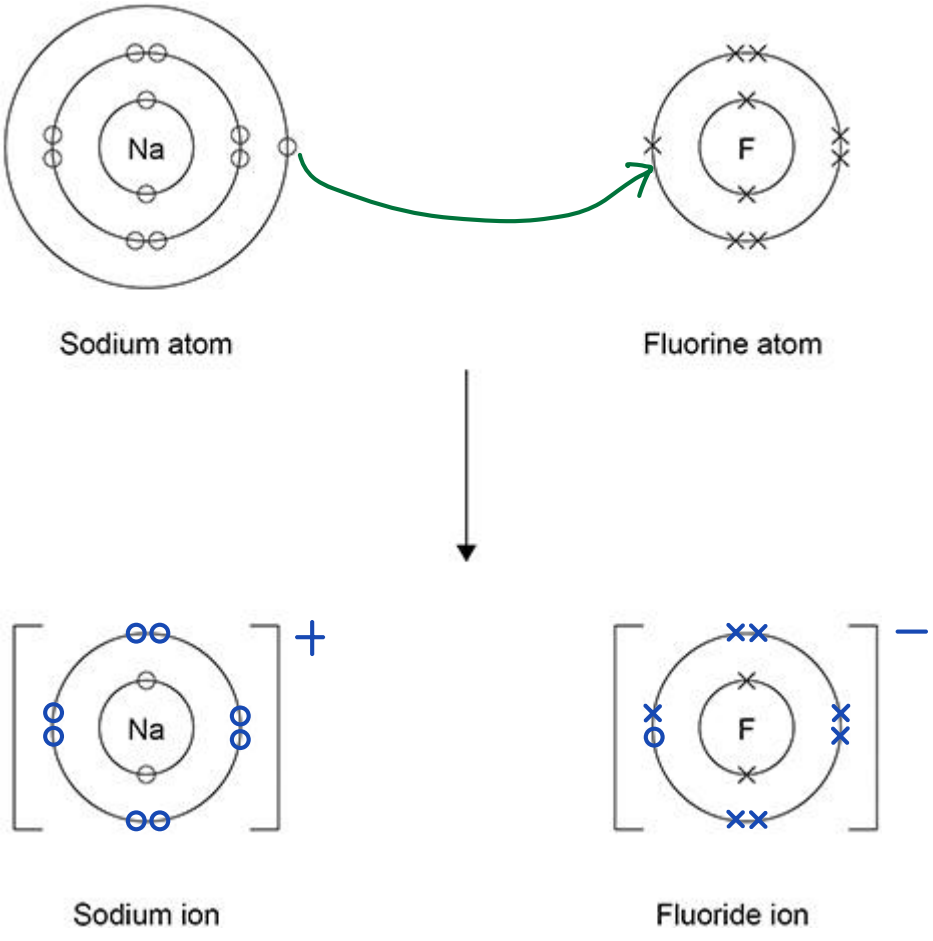
(h) Sodium fluoride is an ionic compound.

The diagram below shows dot and cross diagrams for a sodium atom and a fluorine atom.

Complete the diagram below to show what happens when a sodium atom and a fluorine atom react to produce sodium fluoride.

You should:

- complete the electronic structures of the sodium ion and the fluoride ion
- give the charges on the sodium ion and the fluoride ion.



(3)

(Total 12 marks)

Q2.

A student investigated the reactivity of metals with hydrochloric acid.

This is the method used.

1. Measure 50 cm^3 of hydrochloric acid into a polystyrene cup.
2. Measure the temperature of the hydrochloric acid.
3. Add one spatula of metal powder to the hydrochloric acid and stir.
4. Measure the highest temperature the mixture reaches.
5. Calculate the temperature increase for the reaction.
6. Repeat steps 1 to 5 three more times.
7. Repeat steps 1 to 6 with different metals.

The table below shows the student's results.

Metal	**Temperature increase in °C**				**Mean temperature increase in °C**
	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	
Cobalt	6	7	5	9	7
Magnesium	54	50	37	55	**X**
Zinc	18	16	18	20	18

(a) Calculate the mean temperature increase **X** for magnesium in the table above.

Do **not** include the anomalous result in your calculation.

$\frac{54 + 50 + 55}{3} = 53$

X = 53 °C

(2)

(b) Determine the order of reactivity for the metals cobalt, magnesium and zinc.

Use the table above.

Most reactive Magnesium

Zinc

Least reactive Cobalt

(1)

(c) The range of measurements either side of the mean shows the uncertainty in the mean temperature increase.

Complete the sentence.

Use the table above.

The mean temperature increase for zinc is 18 ± 2 °C

(1)

(d) What type of variable is the volume of hydrochloric acid in this investigation?

Tick (✓) **one** box.

Control	✓
Dependent	
Independent	

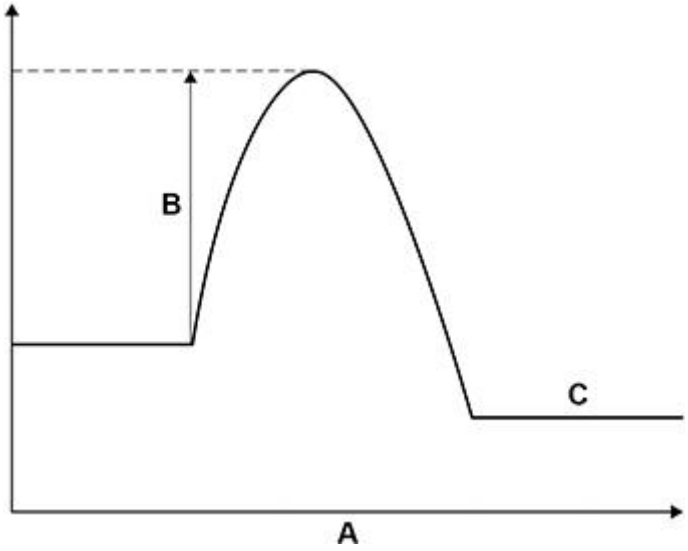
(1)

(e) Suggest **one** way of improving **step 3** in the method to give results which are more repeatable.

Use the same mass of metal powder

(1)

(f) The figure below shows a reaction profile for the reaction of magnesium with hydrochloric acid.



What do labels **A**, **B** and **C** represent on the figure above?

Choose answers from the box.

activation energy	**energy**	**overall energy change**
products	**progress of reaction**	**reactants**

A Progress of reaction

B Activation energy

C Products

(3)

(Total 9 marks)

Q3.

This question is about the extraction of metals.

Element **R** is extracted from its oxide by reduction with hydrogen.

The equation for the reaction is:

$$3\ H_2 + \mathbf{R}O_3 \rightarrow \mathbf{R} + 3\ H_2O$$

150 150

(a) The sum of the relative formula masses (M_r) of the reactants ($3\ H_2 + \mathbf{R}O_3$) is 150

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

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

$3H_2 + O_3 = (3\times2)+(3\times16) = 54$

$150 - 54 = 96$

Relative atomic mass (A_r) of **R** = 96

(2)

(b) Identify element **R**.

You should use:

- your answer to part (a)
- the periodic table.

Identity of **R** = Molybdenum Mo

(1)

(c) Carbon is used to extract tin (Sn) from tin oxide (SnO_2).

The equation for the reaction is:

$$SnO_2 + C \rightarrow Sn + CO_2$$

Calculate the percentage atom economy for extracting tin in this reaction.

Relative atomic masses (A_r): C = 12 O = 16 Sn = 119 **(separate only)**

Atom economy = $\frac{\text{Mass of desired product}}{\text{Mass of all reactants}} \times 100\%$

$= \frac{Sn}{SnO_2 + C} = \frac{119}{(119 + (16 \times 2)) + 12} \times 100\%$

$= 73$

Percentage atom economy = 73 %

(3)

(d) Tungsten (W) is a metal.

Tungsten is extracted from tungsten oxide (WO_3).

All other solid products from the extraction method must be separated from the tungsten.

The table below shows information about three possible methods to extract tungsten from tungsten oxide.

Method	Reactant	Relative cost of reactant	Products

1	Carbon	Low	Tungsten solid Carbon dioxide gas Tungsten carbide solid
2	Hydrogen	High	Tungsten solid Water vapour
3	Iron	Low	Tungsten solid Iron oxide solid

Evaluate the three possible methods for extracting tungsten from tungsten oxide.

Carbon and Iron are the cheapest

Hydrogen is the most expensive

Separating solid products is expensive + time consuming

Method 1: W must be separated from WC

Some W is lost as WC,

CO_2 emitted

Method 2: No separation of solids needed

H_2O vapour produced

Method 3: W needs to be separated from Fe_2O_3

(4)

(Total 10 marks)

Q4.

This question is about Group 1 elements.

(a) Give **two** observations you could make when a small piece of potassium is added to water.

1 Effervescence, bubbling

2 Potassium floats

(2)

(b) Complete the equation for the reaction of potassium with water.

You should balance the equation.

$$2K + 2H_2O \rightarrow 2KOH + H_2$$

(2)

(c) Explain why the reactivity of elements changes going down Group 1.

Reactivity increases going down the group

Because the outer electron is further from the nucleus so there is less attraction between the nucleus and outer shell electron.
So the atom loses an electron more easily

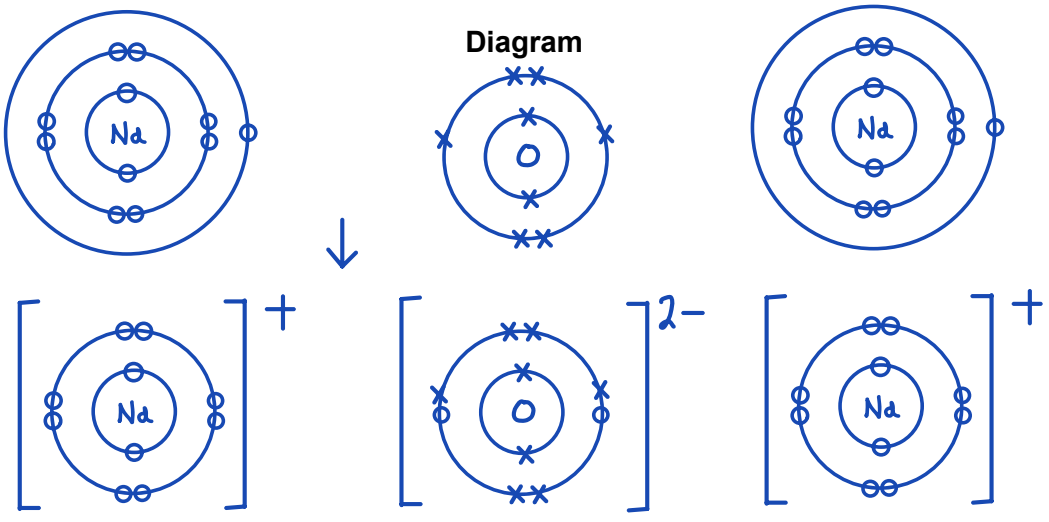
Reactivity related to ease of losing outer electron.

(4)

Sodium reacts with oxygen to produce the ionic compound sodium oxide.

Oxygen is a Group 6 element.

(d) Draw a dot and cross diagram to show what happens when atoms of sodium and oxygen react to produce sodium oxide.



(4)

(e) Why is oxygen described as being reduced in the reaction between sodium and oxygen?

Oxygen gains electrons

(1)

(f) Explain why sodium oxide has a high melting point.

Na_2O forms a giant ionic lattice with strong electrostatic forces of attraction between oppositely charged ions. So large amounts of energy needed to break these bonds

(3)

(Total 16 marks)

Q5.

This question is about metals.

(a) The table below shows information about four substances.

Substance	Melting point in °C	Boiling point in °C	Does it conduct electricity in the solid state?	Does it conduct electricity in the liquid state?
A	–117	79	No	No
B	801	1413	No	Yes
C	1535	2750	Yes	Yes
D	1610	2230	No	No

Which substance could be a metal?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☑ **D** ☐

(1)

(b) Explain why alloys are harder than pure metals.

In an alloy, the atoms are of different sizes, so the layers are distorted and slide over each other less easily than in a pure metal.

(3)

(c) A student wants to compare the reactivity of an unknown metal, **Q**, with that of zinc.

Both metals are more reactive than silver.

The student is provided with:

- silver nitrate solution
- metal **Q** powder
- zinc powder
- a thermometer
- normal laboratory equipment.

No other chemicals are available.

Describe a method the student could use to compare the reactivity of metal **Q** with that of zinc.

Your method should give valid results.

- Measure temperature change when each metal is added to the silver nitrate solution.

The greater the temperature change, the more reactive.

(4)

(Total 8 marks)

Q6.

This question is about metals and the reactivity series.

(a) Which **two** statements are properties of most transition metals?

Tick (✓) **two** boxes. **(separate only)**

They are soft metals.	☐
They form colourless compounds.	☐
They form ions with different charges.	✓
They have high melting points.	✓
They have low densities.	☐

(2)

(b) A student added copper metal to colourless silver nitrate solution.

The student observed:

- pale grey crystals forming
- the solution turning blue.

Explain how these observations show that silver is less reactive than copper.

The grey crystals are silver.
The copper ions produced are blue.
Since copper displaces silver.

(3)

(c) A student is given three metals, **X**, **Y** and **Z** to identify.

The metals are magnesium, iron and copper.

Plan an investigation to identify the three metals by comparing their reactions with dilute hydrochloric acid.

Your plan should give valid results.

. Add the metals to the dilute hydrochloric acid

Measure temperature change

For Cu: No reaction - shown by temp. change

For Mg and Fe: Mg increases temp. more than Fe

Control variables: same conc^n of HCl
same mass / moles of metal
same particle size of metal
same temp. of acid.

(4)

(d) Metal **M** has two isotopes.

The table below shows the mass numbers and percentage abundances of the isotopes.

Mass number	Percentage abundance (%)
203	30
205	70

Calculate the relative atomic mass (A_r) of metal **M**.

Give your answer to 1 decimal place.

$\frac{(203 \times 30) + (205 \times 70)}{100} = 204.4$

Relative atomic mass (1 decimal place) = 204.4

(2)

(Total 11 marks)

Q7.

This question is about displacement reactions.

(a) The displacement reaction between aluminium and iron oxide has a high activation energy.

What is meant by 'activation energy'?

Minimum energy needed for particles to react

(1)

(b) A mixture contains 1.00 kg of aluminium and 3.00 kg of iron oxide.

The equation for the reaction is:

$$2\,Al + Fe_2O_3 \rightarrow 2\,Fe + Al_2O_3$$

2 1

Show that aluminium is the limiting reactant.

Relative atomic masses (A_r): O = 16 Al = 27 Fe = 56

M_r of Fe_2O_3 = (2×56) + (3×16) = 160

n moles Fe_2O_3 = $\frac{3000\ g}{160\ g\ mol^{-1}}$ = 18.75 mol

n° moles Al needed = 2 × 18.75 mol

= 37.5 mol

Mass of Al needed = 37.5 mol × 27 g mol^{-1}

= 1012.5 g

= 1.0125 kg

∴ 1 kg of Al is not enough.

(4)

Magnesium displaces zinc from zinc sulfate solution.

(c) Complete the ionic equation for the reaction.

You should include state symbols.

$$Mg(s) + Zn^{2+}(aq) \rightarrow Mg^{2+}(aq) + Zn(s)$$

(2)

(d) Explain why the reaction between magnesium atoms and zinc ions is both oxidation and reduction.

Mg atoms are oxidised as they lose electrons

Zn atoms are reduced because they gain electrons