

**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	

**(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 _____ 2 _____
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?

\_\_\_\_\_  
\_\_\_\_\_

(1)

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

1 \_\_\_\_\_  
\_\_\_\_\_

2 \_\_\_\_\_  
\_\_\_\_\_

(2)

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

Tick (✓) **one** box.

Carbon dioxide

Hydrogen

Nitrogen	<input type="text"/>
Oxygen	<input type="text"/>

(1)

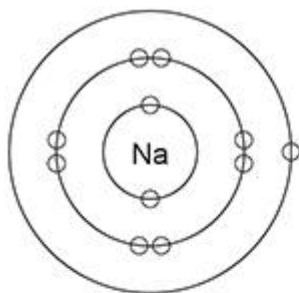
(h) Sodium fluoride is an ionic compound.

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

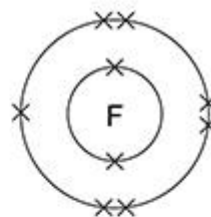
Complete the diagram below to show what happens when a sodium atom and a fluorine atom react to produce sodium fluoride.

You should:

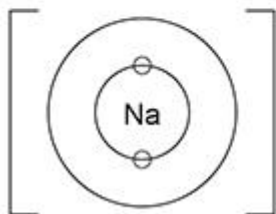
- complete the electronic structures of the sodium ion and the fluoride ion
- give the charges on the sodium ion and the fluoride ion.



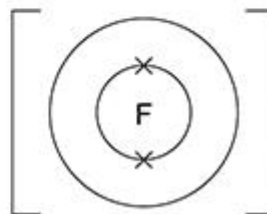
Sodium atom



Fluorine atom



Sodium ion



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<sup>3</sup> 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.

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$$X = \text{_____} \text{ } ^\circ\text{C}$$

(2)

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

Use the table above.

Most reactive \_\_\_\_\_

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Least reactive \_\_\_\_\_

(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  $18 \pm$  \_\_\_\_\_ °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.

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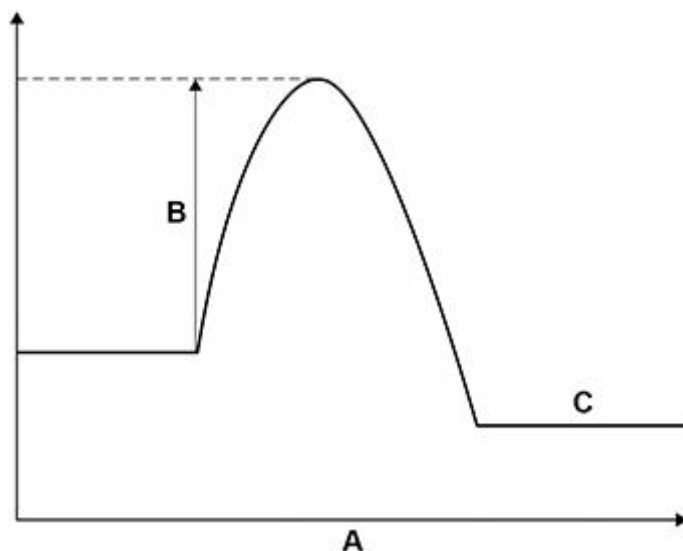
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(1)

- (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** \_\_\_\_\_

**B** \_\_\_\_\_

**C** \_\_\_\_\_

(3)

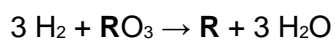
(Total 9 marks)

### 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:



- (a) The sum of the relative formula masses ( $M_r$ ) of the reactants ( $3 \text{H}_2 + \text{RO}_3$ ) is 150

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

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

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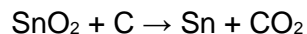
Relative atomic mass ( $A_r$ ) of **R** = \_\_\_\_\_**(2)**(b) Identify element **R**.

You should use:

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

Identity of **R** = \_\_\_\_\_**(1)**(c) Carbon is used to extract tin (Sn) from tin oxide ( $\text{SnO}_2$ ).

The equation for the reaction is:



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

Relative atomic masses ( $A_r$ ): C = 12 O = 16 Sn = 119

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Percentage atom economy = \_\_\_\_\_ %

**(3)**

(d) Tungsten (W) is a metal.

Tungsten is extracted from tungsten oxide ( $\text{WO}_3$ ).

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
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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.

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(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 \_\_\_\_\_

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2 \_\_\_\_\_

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(2)



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

You should balance the equation.



(2)

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

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(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.

**Diagram**

(4)

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

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(1)

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

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(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?
<b>A</b>	-117	79	No	No
<b>B</b>	801	1413	No	Yes
<b>C</b>	1535	2750	Yes	Yes
<b>D</b>	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.

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**(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.

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**(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.

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.

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(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.

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(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.

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Relative atomic mass (1 decimal place) = \_\_\_\_\_

(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'?

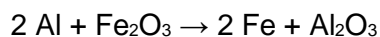
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(1)

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

The equation for the reaction is:



Show that aluminium is the limiting reactant.

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

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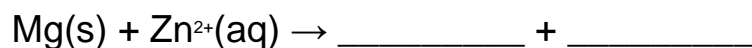
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(4)

Magnesium displaces zinc from zinc sulfate solution.

(c) Complete the ionic equation for the reaction.

You should include state symbols.



(2)

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

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(2)

(Total 9 marks)

**Q8.**

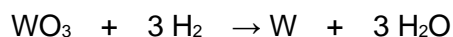
This question is about the extraction of metals.

- (a) Tungsten is a metal.

The symbol of tungsten is W

Tungsten is produced from tungsten oxide by reaction with hydrogen.

The equation for the reaction is:



Calculate the percentage atom economy when tungsten is produced in this reaction.

Use the equation:

$$\text{percentage atom economy} = \frac{184}{(M_r \text{ WO}_3) + (3 \times M_r \text{ H}_2)} \times 100$$

Relative formula masses ( $M_r$ ):  $\text{WO}_3 = 232$      $\text{H}_2 = 2$

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Percentage atom economy = \_\_\_\_\_%

(2)

Aluminium is extracted from aluminium oxide.

- (b) 38% of a rock sample is aluminium oxide.

Calculate the mass of aluminium oxide in 40 kg of the rock sample.

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Mass of aluminium oxide = \_\_\_\_\_ kg  
(2)

- (c) The formula of aluminium oxide is  $\text{Al}_2\text{O}_3$

Calculate the relative formula mass ( $M_r$ ) of aluminium oxide.

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

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Relative formula mass ( $M_r$ ) = \_\_\_\_\_  
(2)

- (d) 60.0 kg of aluminium oxide produces a maximum of 31.8 kg of aluminium.

In an extraction process only 28.4 kg of aluminium is produced from 60.0 kg of aluminium oxide.

Calculate the percentage yield.

Give your answer to 3 significant figures.

Use the equation:

$$\text{percentage yield} = \frac{\text{mass of product actually made}}{\text{maximum theoretical mass of product}} \times 100$$

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Percentage yield = \_\_\_\_\_ %  
(3)

- (e) Extracting metals by electrolysis is a very expensive process.

Explain why aluminium is extracted using electrolysis and not by reduction with carbon.



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(2)  
(Total 11 marks)

**Q9.**

A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

This is the method used.

1. Measure 50 cm<sup>3</sup> of the copper sulfate solution into a polystyrene cup.
  2. Record the starting temperature of the copper sulfate solution.
  3. Add the metal and stir the solution.
  4. Record the highest temperature the mixture reaches.
  5. Calculate the temperature increase for the reaction.
  6. Repeat steps 1-5 with different metals.
- (a) Draw **one** line from each type of variable to the name of the variable in the investigation.

Type of variable	Name of variable in the investigation
	Concentration of solution
Dependent variable	Particle size of solid
	Temperature change
Independent variable	Type of metal
	Volume of solution

(2)

(b) The student used a polystyrene cup and not a glass beaker.

Why did this make the investigation more accurate?

Tick **one** box.

Glass is breakable

Glass is transparent

Polystyrene is a better insulator

Polystyrene is less dense

(1)

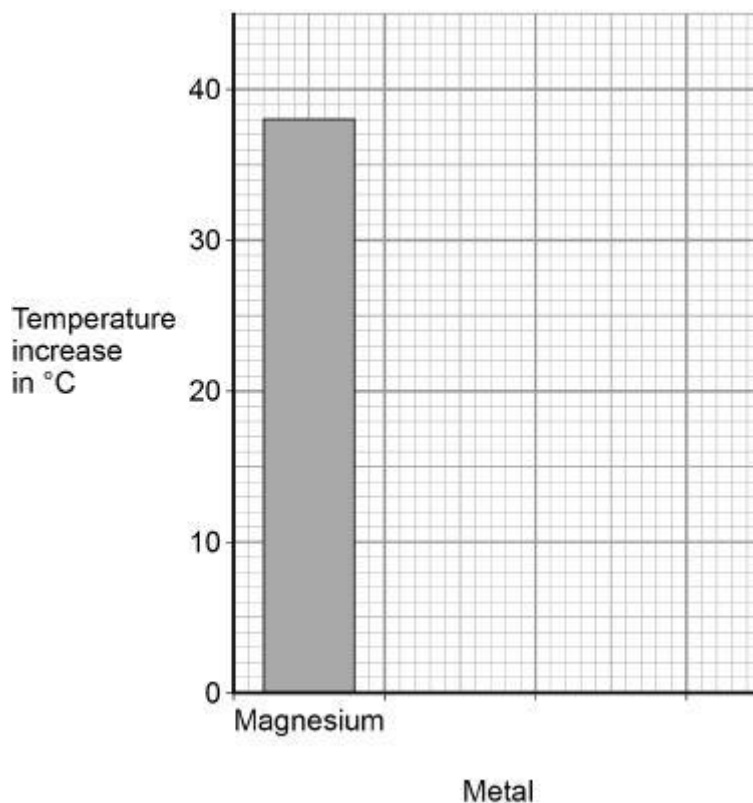
The table below shows the student's results.

<b>Metal</b>	<b>Temperature increase in °C</b>
Magnesium	38
Nickel	8
Zinc	16

(c) Complete **Figure 1**.

Use data from the table above.

**Figure 1**



(2)

- (d) The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give **one** reason why this conclusion is **not** correct.

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(1)

- (e) The temperature increase depends on the reactivity of the metal.

Write the metals magnesium, nickel and zinc in order of reactivity.

Use the table above.

Most reactive \_\_\_\_\_

\_\_\_\_\_

Less reactive \_\_\_\_\_

(1)

- (f) **Y** is an unknown metal.

Describe a method to find the position of **Y** in the reactivity series in Question (e)

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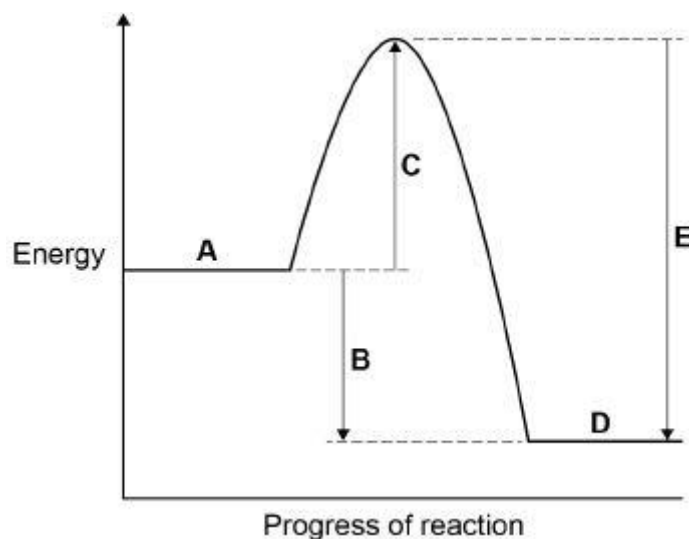


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(3)

**Figure 2** shows the reaction profile for the reaction between zinc and copper sulfate solution.

**Figure 2**



(g) Which letter represents the products of the reaction?

Tick **one** box.

A		B		C		D		E	
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(1)

(h) Which letter represents the activation energy?

Tick **one** box.

A		B		C		D		E	
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(1)

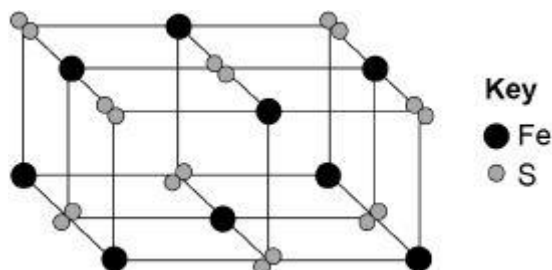
(Total 12 marks)

**Q10.**

This question is about metals and metal compounds.

- (a) Iron pyrites is an ionic compound.

The diagram below shows a structure for iron pyrites.



Determine the formula of iron pyrites.

Use the diagram above.

\_\_\_\_\_

**(1)**

- (b) An atom of iron is represented as  ${}^{56}_{26}\text{Fe}$

Give the number of protons, neutrons and electrons in this atom of iron.

Number of protons \_\_\_\_\_

Number of neutrons \_\_\_\_\_

Number of electrons \_\_\_\_\_

**(3)**

- (c) Iron is a transition metal.

Sodium is a Group 1 metal.

Give **two** differences between the properties of iron and sodium.

1. \_\_\_\_\_

\_\_\_\_\_

2. \_\_\_\_\_

\_\_\_\_\_

**(2)**

Nickel is extracted from nickel oxide by reduction with carbon.

- (d) Explain why carbon can be used to extract nickel from nickel oxide.

\_\_\_\_\_

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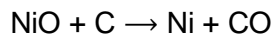
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(2)

(e) An equation for the reaction is:



Calculate the percentage atom economy for the reaction to produce nickel.

Relative atomic masses ( $A_r$ ): C = 12 Ni = 59Relative formula mass ( $M_r$ ): NiO = 75

Give your answer to 3 significant figures.

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Percentage atom economy = \_\_\_\_\_ %

(3)

(Total 11 marks)

**Q11.**

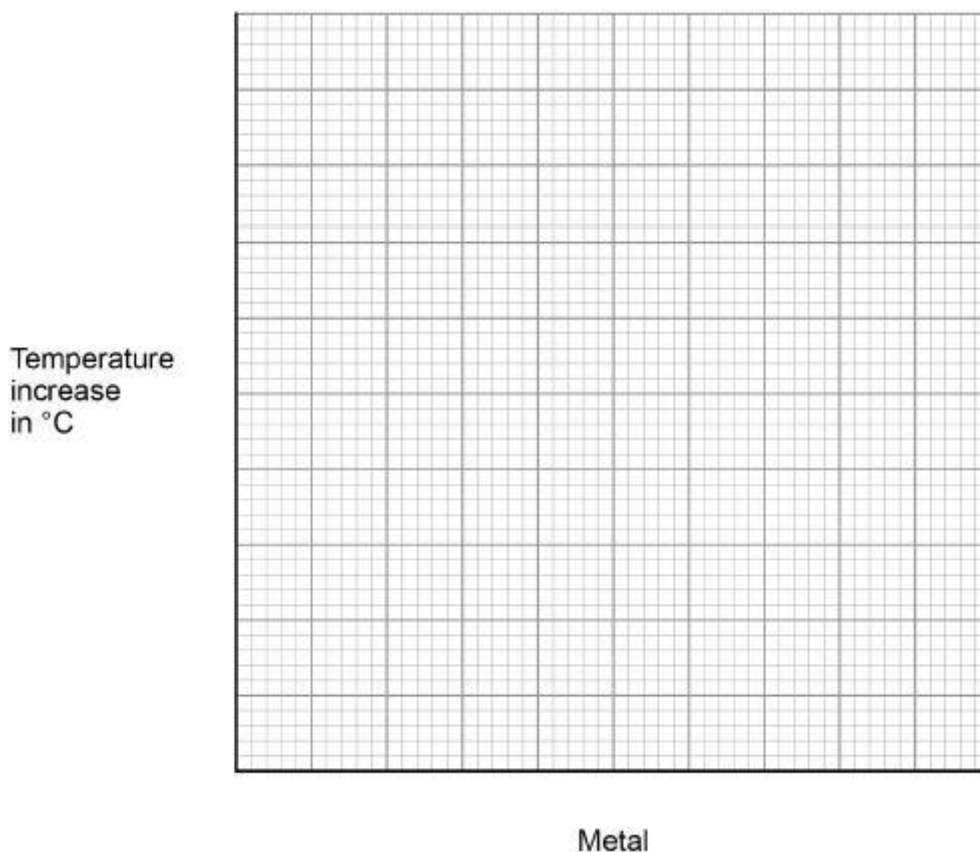
A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

The table below shows the student's results.

Metal	Temperature increase in °C
Copper	0
Iron	13
Magnesium	43
Zinc	17

(a) Plot the data from the table above on **Figure 1** as a bar chart.

Figure 1



(2)

- (b) The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give **one** reason why this conclusion is **not** correct.

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(1)

- (c) The temperature change depends on the reactivity of the metal.

The student's results are used to place copper, iron, magnesium and zinc in order of their reactivity.

Describe a method to find the position of an unknown metal in this reactivity series.

Your method should give valid results.

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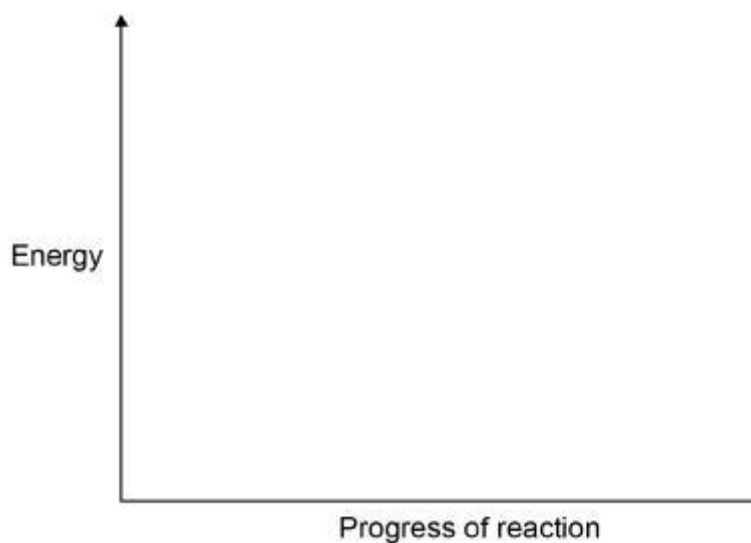
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(4)

- (d) Draw a fully labelled reaction profile for the reaction between zinc and copper sulfate solution on **Figure 2**.

**Figure 2**

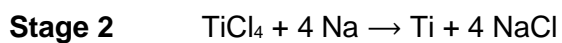
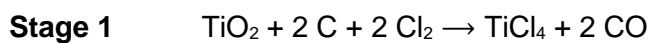
(3)

(Total 10 marks)

**Q12.**

Titanium is a transition metal.

Titanium is extracted from titanium dioxide in a two-stage industrial process.



- (a) Suggest **one** hazard associated with **Stage 1**.

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(1)

- (b) Water must be kept away from the reaction in **Stage 2**.

Give **one** reason why it would be hazardous if water came into contact with



sodium.

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(1)

- (c) Suggest why the reaction in **Stage 2** is carried out in an atmosphere of argon and **not** in air.

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(2)

- (d) Titanium chloride is a liquid at room temperature.

Explain why you would **not** expect titanium chloride to be a liquid at room temperature.

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(3)

In **Stage 2**, sodium displaces titanium from titanium chloride.

- (e) Sodium atoms are oxidised to sodium ions in this reaction.

Why is this an oxidation reaction?

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(1)

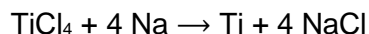
- (f) Complete the half equation for the oxidation reaction.



(1)

- (g) In Stage 2, 40 kg of titanium chloride was added to 20 kg of sodium.

The equation for the reaction is:



Relative atomic masses ( $A_r$ ): Na = 23 Cl = 35.5 Ti = 48

Explain why titanium chloride is the limiting reactant.

You **must** show your working.

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(4)

- (h) For a **Stage 2** reaction the percentage yield was 92.3%

The theoretical maximum mass of titanium produced in this batch was 13.5 kg.

Calculate the actual mass of titanium produced.

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Mass of titanium = \_\_\_\_\_ kg

(2)

(Total 15 marks)

### Q13.

A student investigated the reactivity of three different metals.

This is the method used.

1. Place 1 g of metal powder in a test tube.
2. Add 10 cm<sup>3</sup> of metal sulfate.
3. Wait 1 minute and observe.

4. Repeat using the other metals and metal sulfates.

The student placed a tick in the table below if there was a reaction and a cross if there was no reaction.

	Zinc	Copper	Magnesium
Copper sulfate	✓	x	✓
Magnesium sulfate	x	x	x
Zinc sulfate	x	x	✓

(a) What is the dependent variable in the investigation?

Tick **one** box.

Time taken

Type of metal

Volume of metal sulfate

Whether there was a reaction or not

(1)

(b) Give **one** observation the student could make that shows there is a reaction between zinc and copper sulfate.

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(1)

(c) The student used measuring instruments to measure some of the variables.

Draw **one** line from each variable to the measuring instrument used to measure the variable.

**Variable**

**Measuring instrument**

Balance

Measuring cylinder

Mass of metal powder

	Ruler
	Burette
Volume of metal sulfate	Thermometer
	Test tube

(2)

- (d) Use the results shown in table above to place zinc, copper and magnesium in order of reactivity.

Most reactive \_\_\_\_\_  
↕  
Least reactive \_\_\_\_\_

(1)

- (e) Suggest **one** reason why the student should **not** use sodium in this investigation.

\_\_\_\_\_  
\_\_\_\_\_

(1)

- (f) Which metal is found in the Earth as the metal itself?

Tick **one** box.

Calcium

Gold

Lithium

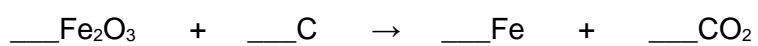
Potassium

(1)

- (g) Iron is found in the Earth as iron oxide ( $\text{Fe}_2\text{O}_3$ ).

Iron oxide is reduced to produce iron.

Balance the equation for the reaction.



(1)

(h) Name the element used to reduce iron oxide.

\_\_\_\_\_

(1)

(i) What is meant by reduction?

Tick **one** box.

Gain of iron

Gain of oxide

Loss of iron

Loss of oxygen

(1)

(Total 10 marks)