AQA Chemistry Unit 1

Chemical changes

Crompton House Chemistry

		Learned it	Revised it
1	I understand displacement reactions and use the reactivity series to predict the outcome of a reaction		
2	I can use my knowledge of displacement reactions to explain the extraction of metals including using reduction with carbon		
3	I can predict salts produced in neutralisation of acids with alkalis, bases and carbonates including writing ionic equations for neutralisation.		
4	I can describe how to use universal indicator and the pH scale to identify acids and alkalis		
5	HT I can use and explain the terms dilute and concentrated (in terms of amount of substance) and weak and strong (in terms of the degree of ionisation) in relation to acids		
6	HT I can explain how the concentration of an aquesous solutions and strength of an acid affects the pH of the solution and how pH is related to the hydrogen ion concentration of a solution		
7	***Required practical 1:*** *preparation of a pure, dry sample of a soluble salt from an insoluble oxide or carbonate using a Bunsen burner to heat dilute acid and a water bath or electric heater to evaporate the solution*		

DODDLE QUIZZES

AQA Reactivity of metals: _____%

AQA Extraction of Metals : _____%

AQA The pH Scale: _____%

AQA Salt Production: _____%

Self Reflection

WWW:

EBI:

Checked by Teacher:

Date:

Chapter 5: Chemical changes 1

Knowledge organiser

Reactions of metals

The **reactivity** of a metal is how chemically reactive it is. When added to water, some metals react very vigorously – these metals have *high* reactivity. Other metals will barely react with water or acid, or won't react at all – these metals have *low* reactivity.

Reactivity series

The reactivity series places metals in order of their reactivity.

Sometimes, for example in the table below, hydrogen and carbon are included in the series, even though they are non-metals.

Reaction with water	Reaction with acid	Reactivity series: Metal	Reactivity	Extraction method
		potassium	high reactivity	
fizzes, gives off hydrogen gas	explodes	sodium		electrolysis
		lithium		
		calcium		
reacts very slowly	fizzes, gives off hydrogen gas	magnesium		
		aluminium		
		(carbon)		
		zinc	Decreasing reactivity	
		iron		reduction with carbon
	reacts slowly with warm acid	tin		
		lead		
no reaction		(hydrogen)		
	no reaction	copper		
		silver		mined from the Earth's crust
		gold	low reactivity	

Metal extraction

Some metals, like gold, are so unreactive that they are found as pure metals in the Earth's crust and can be mined.

Most metals exist as compounds in rock and have to be extracted from the rock. If there is enough metal compound in the rock to be worth extracting it is called an **ore**.

Metals that are less reactive than carbon can be extracted by reduction with carbon. For example:

iron oxide + carbon → iron + carbon dioxide

Metals that are more reactive than carbon can be extracted using a process called **electrolysis**.

Reduction and oxidation

If a substance gains oxygen in a reaction, it has been **oxidised**.

If a substance loses oxygen in a reaction, it has been **reduced**.

For example:

iron + oxygen → iron oxide

iron has been oxidised

iron oxide + carbon → iron + carbon dioxide

iron oxide has been reduced

Salts

When acids react with metals or metal compounds, they form salts. A salt is a compound where the hydrogen from an acid has been replaced by a metal. For example nitric acid, HNO_3, reacts with sodium to form $NaNO_3$. The H in nitric acid is replaced with Na.

The table shows how to name salts.

Acid	hydrochloric acid	sulfuric acid	nitric acid
Formula	HCl	H_2SO_4	HNO_3
Ions formed in solution	H^+ and Cl^-	$2H^+$ and SO_4^{2-}	H^+ and NO_3^-
Type of salt formed	metal chloride	metal sulfate	metal nitrate
Sodium salt example	sodium chloride, NaCl	sodium sulfate, Na_2SO_4	sodium nitrate, $NaNO_3$

Displacement reactions

In a **displacement** reaction a *more* reactive element takes the place of a *less* reactive element in a compound.

For example:

copper sulfate + iron → iron sulfate + copper

$CuSO_4(aq) + Fe(s) \rightarrow FeSO_4(aq) + Cu(s)$

Iron is more reactive than copper, so iron displaces the copper in copper sulfate.

Reactivity and ions

A metal's reactivity depends on how readily it forms an **ion** by losing electrons.

In the displacement reaction of copper sulfate and iron, iron forms an ion more easily than copper.

At the end of the reaction you are left with iron ions, not copper ions.

Ionic equations (HT only)

When an ionic compound is dissolved in a solution, we can write the compound as its separate ions. For example, $CuSO_4(aq)$ can be written as $Cu^{2+}(aq)$ and $SO_4^{2-}(aq)$.

The displacement reaction of copper sulfate and iron can be written as:

$$Fe(s) + Cu^{2+}(aq) + SO_4^{2-}(aq) \rightarrow Fe^{2+}(aq) + SO_4^{2-}(aq) + Cu(s)$$

The SO_4^{2-} is unchanged in the reaction – it is a **spectator ion**. Spectator ions are removed from the equation to give an **ionic equation**:

$$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$$

Metals, covalent substances, and solid ionic substances do not split into ions in the ionic equation.

Steps for writing an ionic equation (HT only)

1. check symbol equation is balanced
2. identify all aqueous ionic compounds
3. write those compounds out as ions
4. remove spectator ions.

Half equations (HT only)

In the displacement reaction, an iron atom loses two electrons to form a iron ion:

$$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$$

A copper ion gains two electrons to form a copper atom:

$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$$

These two equations are called **half equations** – they each show half of the ionic equation.

Reduction and oxidation: electrons (HT only)

Oxidation and reduction (**redox** reactions) can be defined in terms of oxygen, but can also be defined as the loss or gain of electrons.

Oxidation is the *loss* of electrons, and reduction is the *gain* of electrons.

In the example displacement reaction:

- iron atoms have been oxidised
- copper ions have been reduced.

Acids and alkalis

Acids are compounds that, when dissolved in water, release H^+ ions. There are three main acids: sulfuric acid H_2SO_4, nitric acid HNO_3, and hydrochloric acid HCl.

Alkalis are compounds that, when dissolved in water, release OH^- ions.

The **pH** scale is a measure of acidity and alkalinity. It runs from 1 to 14.

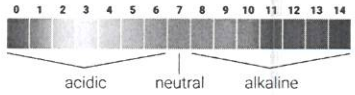
- Aqueous solutions with pH < 7 are acidic.
- Aqueous solutions with pH > 7 are alkaline.
- Aqueous solutions with pH = 7 are neutral.

Indicators

Indicators can show if something is an acid or an alkali.

- **Universal indicator** can also tell us the approximate pH of a solution.
- Electronic pH probes can give us the exact pH of a solution.

The pH scale



Chapter 5: Chemical changes 2

Knowledge organiser

Reactions of acids

Reactions of acids with metals

Acids react with some metals to form salts and hydrogen gas.

magnesium + hydrochloric acid → sodium chloride + hydrogen

Neutralisation reactions

Reactions of acids with metal hydroxides

Acids react with metal hydroxides to form salts and water.

hydrochloric acid + sodium hydroxide → sodium chloride + water

The ionic equation for this reaction is always:

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

Reactions of acids with metal oxides

Acids react with metal oxides to form salts and water.

hydrochloric acid + sodium oxide → sodium chloride + water

Reactions of acids with metal carbonates

Acids react with metal carbonates to form a salt, water, and carbon dioxide.

hydrochloric acid + sodium carbonate → sodium chloride + water + carbon dioxide

Alkalis and bases

Bases neutralise acids to form water in **neutralisation** reactions. Some metal hydroxides dissolve in water to form alkaline solutions, called alkalis.

Some metal oxides and metal hydroxide do not dissolve in water. They are **bases**, but are not alkalis.

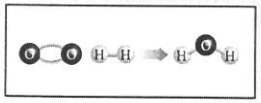
Balancing symbol equations

When writing symbol equations you need to ensure that the number of each atom on each side is equal.

$H_2 + O_2 \rightarrow H_2O$

unbalanced

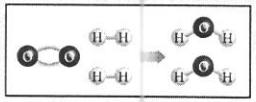
there are 2 hydrogen atoms on each side, but 2 oxygen atoms in the reactants and 1 in the product



$2H_2 + O_2 \rightarrow 2H_2O$

balanced

there are 4 hydrogen atoms on each side, and 2 oxygen atoms on each side



State symbols

A balanced symbol equation should also include state symbols.

State	Symbol
solid	(s)
liquid	(l)
gas	(g)
aqueous or dissolved in water	(aq)

Strong and weak acids

Sulfuric acid, nitric acid, and hydrochloric acid, are all **strong acids**. This means that, when dissolved in water, every molecule splits up into ions – they are completely ionised:

- $H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$
- $HNO_3(aq) \rightarrow H^+(aq) + NO_3^-(aq)$
- $HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$

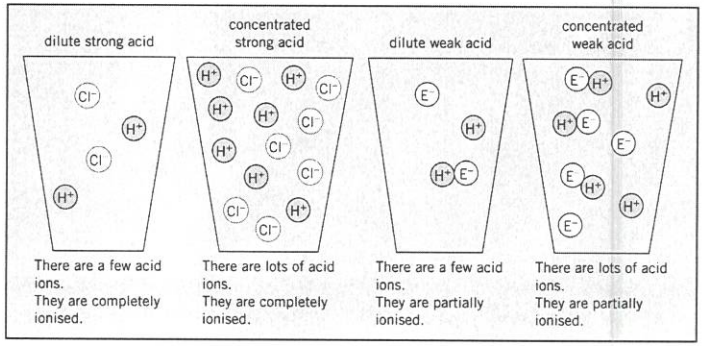
Ethanoic acid, citric acid, and carbonic acid are **weak acids**. This means that only a percentage of their molecules split up into ions when dissolved in water – they are partially ionised.

For a given concentration, the *stronger* the acid, the *lower* the pH.

Concentrated and dilute acids

Concentration tells us how much of a substance there is dissolved in water:

- more concentrated acids have lots of acid in a small volume of water
- less concentrated acids (dilute acids) have little acid in a large volume of water.

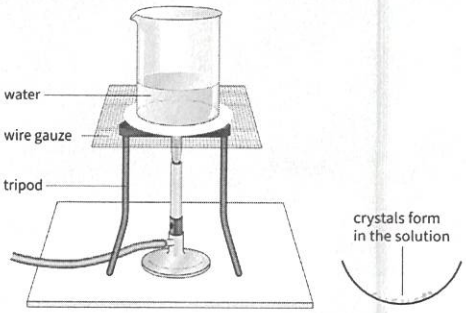


Crystallisation

You can produce a solid salt from an insoluble base by **crystallisation**.

The experimental method is:

1. Choose the correct acid and base to produce the salt.
2. Put some of the dilute acid into a flask. Heat gently with a Bunsen burner.
3. Add a small amount of the base and stir.
4. Keep adding the base until no more reacts – the base is now in excess.
5. Filter to remove the unreacted base.
6. Add the remaining solution to an evaporating dish.
7. Use a water bath or electric heater to evaporate the water. The salt crystals will be left behind.



Key terms

Make sure you can write a definition for these key terms.

displacement, electrolysis, extraction, half equation, ion, ionic equation, metal, ore, oxidation, reactivity, reactivity series, redox, reduction, spectator ion, state symbols

METAL EXTRACTION 1

WHERE DO METALS COME FROM?

Only a few metals are found as elements on Earth – these are the least reactive metals (e.g. gold, platinum)

Most metals are produced by chemical reactions ("extracted") from compounds found in rocks (e.g. aluminium is produced from aluminium oxide found in bauxite).

METAL ORES

if a metal can be extracted for profit from the compounds in a rock, then the rock is called on **ore**.

REDUCTION

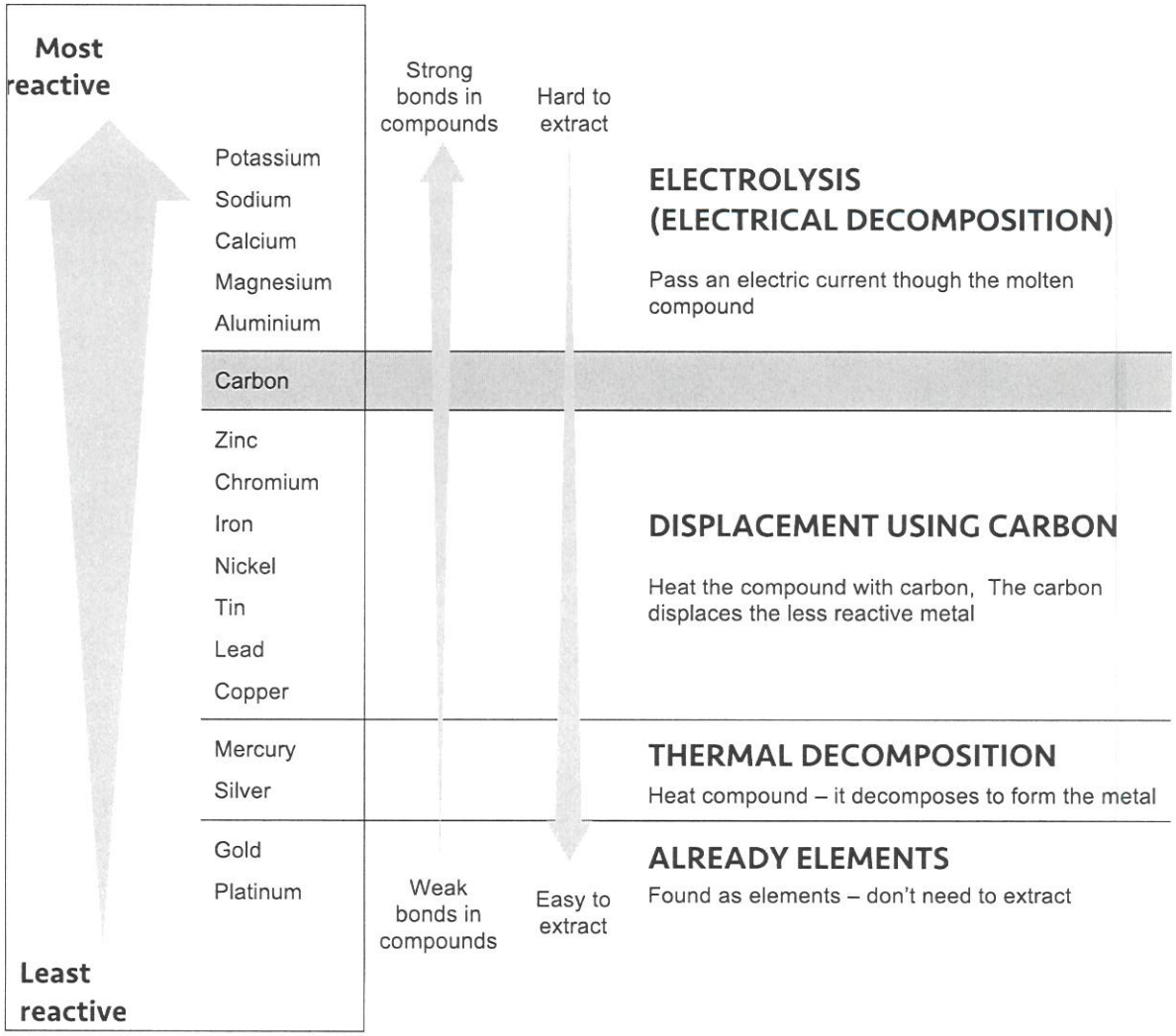
Reduction = loss of oxygen and/or gain of electrons.

Most ores contain **METAL OXIDES**. To extract the metal from the metal oxide, the oxygen is removed. Reactions that remove oxygen are called **reduction reactions**.

e.g. $Al_2O_3 \rightarrow Al$

However, when all metals are extracted, metal ions in the compounds gain electrons to form metal atoms. This means that all extraction reactions involve **reduction**.

e.g. $NaCl \rightarrow Na$ $(Na^+ + e^- \rightarrow Na)$



Questions

1) Most metals are extracted from ores.

   a) Why does gold not need to be extracted from ores?

   .....

   .....

   .....

   .....

   b) Iron is extracted from an ore. What is an ore?

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   .....

   .....

2) Calcium is extracted from calcium chloride by electrolysis.

   a) Explain why calcium cannot be extracted by heating calcium chloride with carbon.

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   b) Explain why this extraction involves a reduction reaction.

   .....

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3) One method of extracting zinc involves the reaction of zinc oxide with carbon. Explain, both in terms of oxygen and electrons, why this extraction is involves reduction.

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4) Lead is extracted by the reduction of lead oxide by heating with carbon:

$$PbO + C \rightarrow Pb + CO$$

   a) Explain why lead can be extracted by heating with carbon.

   .....

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   b) Explain why this is a redox reaction.

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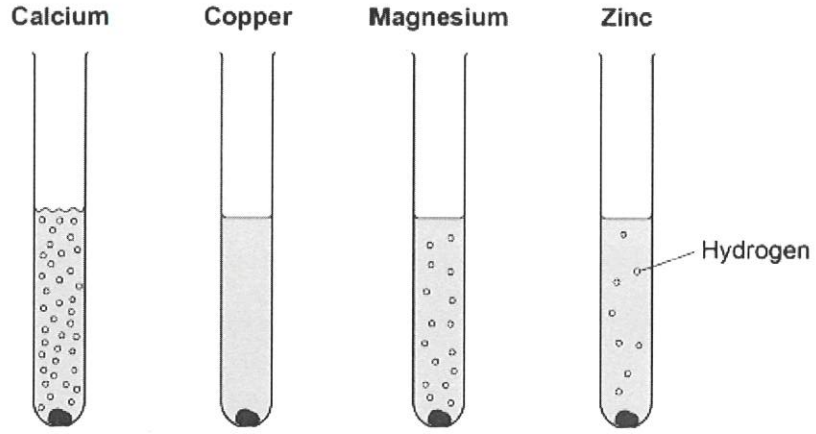
Q1.

This question is about reactions of metals.

The diagram shows what happens when calcium, copper, magnesium and zinc are added to hydrochloric acid.



(a) What is the order of decreasing reactivity of these four metals?

Tick (✓) **one** box.

Zn Ca Cu Mg ☐

Ca Cu Mg Zn ☐

Ca Zn Ca Mg ☐

Ca Mg Zn Cu ☐

(1)

A student wants to make a fair comparison of the reactivity of the metals with hydrochloric acid.

(b) Name **two** variables that must be kept constant.

1 _____

_____

2 _____

_____

(2)

(c) What is the independent variable in this reaction?

_____

_____

(1)

(d) Predict the reactivity of beryllium compared with magnesium.

Give a reason for your answer.

Use the periodic table.

_____

Reason _____

_____

_____

(2)

(e) A solution of hydrochloric acid contains 3.2 g of hydrogen chloride in 50 cm^3

Calculate the concentration of hydrogen chloride in g per dm^3

_____

_____

_____

_____

Concentration = _____ g per dm^3

(3)

(Total 9 marks)

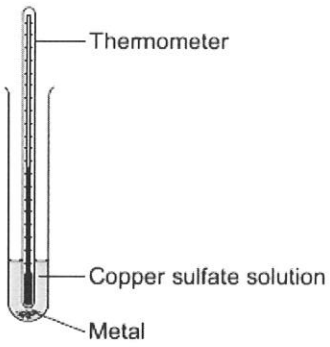
Q2. A student investigated displacement reactions of metals.

The student added different metals to copper sulfate solution and measured the temperature change.

The more reactive the metal is compared with copper, the bigger the temperature change.

The apparatus the student used is shown in **Figure 1**.

Figure 1



(a) State **three** variables that the student must control to make his investigation a fair test.

1. _____

2. _____

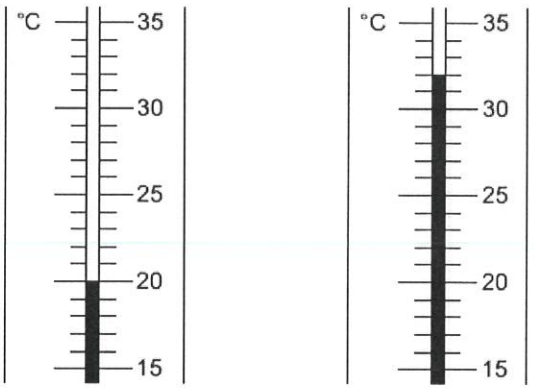
3. _____

(3)

(b) **Figure 2** shows the thermometer in one experiment before and after the student added a metal to the copper sulfate solution.

Figure 2

Before adding metal **After adding metal**



Use **Figure 2** to complete **Table 1**.

Table 1

Temperature before adding metal in °C	_____
Temperature after adding metal in °C	_____
Change in temperature in °C	_____

(3)

(c) The student repeated the experiment three times with each metal.

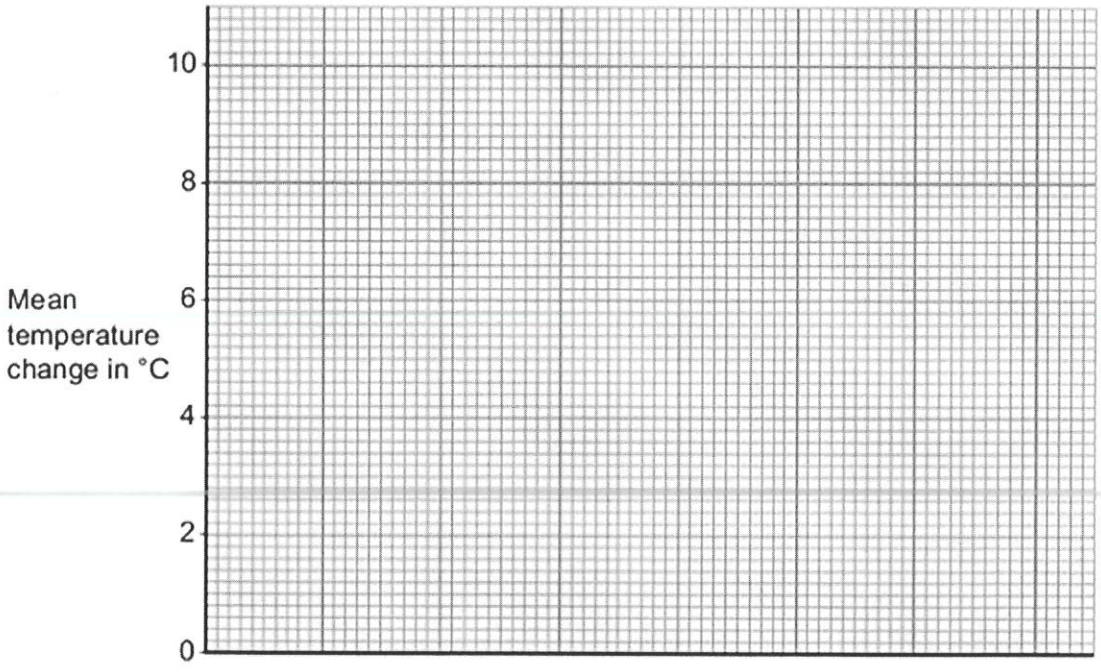
Table 2 shows the mean temperature change for each metal.

Table 2

Metal	**Mean temperature change in °C**
Cobalt	4.5
Gold	0.0
Magnesium	10.0
Nickel	3.0
Silver	0.0
Tin	1.5

(i) On **Figure 3**, draw a bar chart to show the results.

Figure 3



(3)

(ii) Why is a line graph **not** a suitable way of showing the results?

_____

_____

(1)

(iii) Use the results to work out which metal is the most reactive.

Give a reason for your answer.

Most reactive metal _____

Reason

_____

_____

(2)

(iv) Explain why there was no temperature change when silver metal was added to the copper sulfate solution.

_____

_____

_____

_____

(2)

(v) It is **not** possible to put all six metals in order of reactivity using these results.

Suggest how you could change the experiment to be able to put all six metals into order of reactivity.

_____

_____

_____

_____

_____

(2)

(Total 16 marks)

Q3. Magnesium is added to dilute hydrochloric acid.

An exothermic reaction takes place.

Magnesium chloride solution and hydrogen gas are produced.

The equation for the reaction is:

$$Mg\ (s) + 2HCl\ (aq) \longrightarrow MgCl_2\ (aq) + H_2\ (g)$$

(a) Describe the test for hydrogen gas.

Give the result of the test if hydrogen gas is present.

Test

Result

(2)

(b) A student investigates how the mass of magnesium used affects the temperature change during the reaction.

Plan a method the student could use.

You should include:

- the apparatus needed
- the measurements to be taken.

(6)

(Total 8 marks)