



The Reactivity Series



Indicates a Flash activity.



Indicates an accompanying worksheet.



Indicates content on a required practical.



Indicates a virtual experiment.



Indicates that there are teacher's notes.



Indicates maths skills practice.



The Reactivity Series



The reactivity series



Building the reactivity series



Metal oxides and oxidation reactions



Displacement reactions



Summary activities



What is the reactivity series

It is possible to arrange a group of elements based on their **reactivity**. This is how reactive each element is.

Different metal elements have different reactivities.

For example, potassium reacts aggressively with water, whereas gold will not react with water.

The metal elements are arranged in the **reactivity series**. The most reactive metal is at the top and the least reactive metal is at the bottom.



The reactivity series

You can remember the order with this silly sentence:

please
send
charlie's
monkeys
and
zebras
in
large
cages
securely
guarded!



| |
|-----------|
| potassium |
| sodium |
| calcium |
| magnesium |
| aluminium |
| zinc |
| iron |
| lead |
| copper |
| silver |
| gold |

Carbon and hydrogen are also in the reactivity series, even though they are non-metals.

← carbon

← hydrogen



Reactivity ordering activity



The Reactivity Series



- The reactivity series
- **Building the reactivity series**
- Metal oxides and oxidation reactions
- Displacement reactions
- Summary activities

Building the reactivity series

During a reaction, metals lose electrons to form **positive ions**.

Therefore, the reactivity of a metal is related to its ability to form positive ions.

Reactions of metals with **water** and **acids** can be used to arrange metal elements in order of reactivity.

We can use the reactivity series to make predictions about the reactions of metals.



Reacting metals with water

When any metal reacts with water, the products are a **metal hydroxide** and hydrogen gas.

The general equation for the reaction of a metal with water is:



Different metals react with water to a different extent.

What test could you do to show hydrogen is produced?



Investigating reactivity with water



Which element is more reactive?

From the experiments with water at room temperature, the order of metals in the reactivity series can be determined.

From their reactions with water, what is the order of reactivity for potassium, lithium and sodium?

| metal | reaction with water |
|-----------|--|
| lithium | bubbles produced |
| sodium | rapid reaction, orange flame occasionally produced |
| potassium | explosive reaction, lilac flame produced immediately |

Why can magnesium only react with water in the form of steam.



Reacting metals with acid

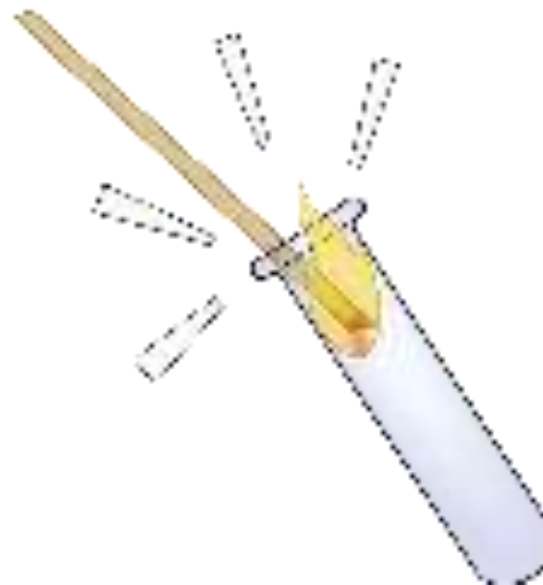


Products of metals reacting with acid

When metals react with acid, a salt and bubbles of gas are produced.

The 'squeaky pop' test shows that this gas is hydrogen.

What is the general equation for the reaction of a metal with acid?

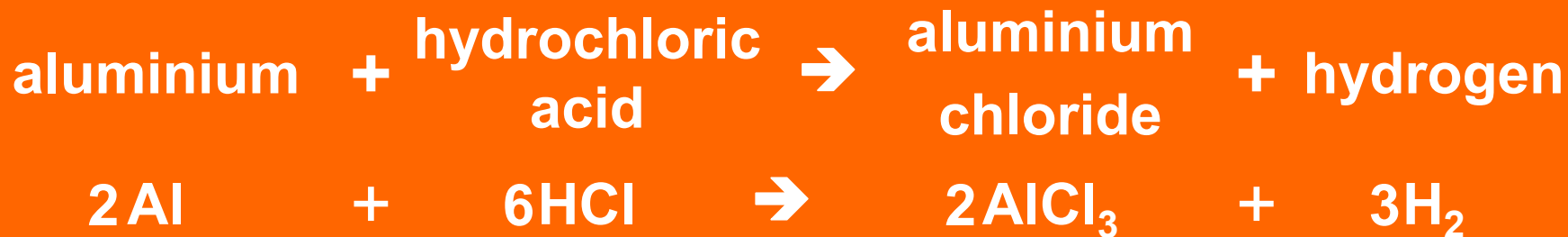
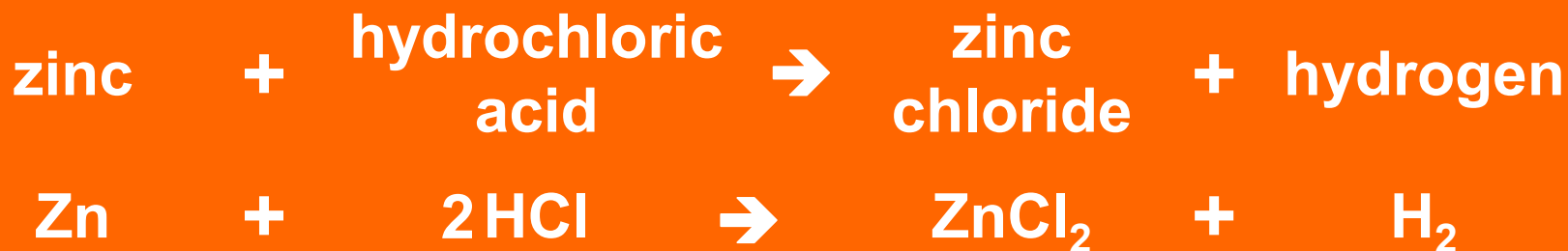
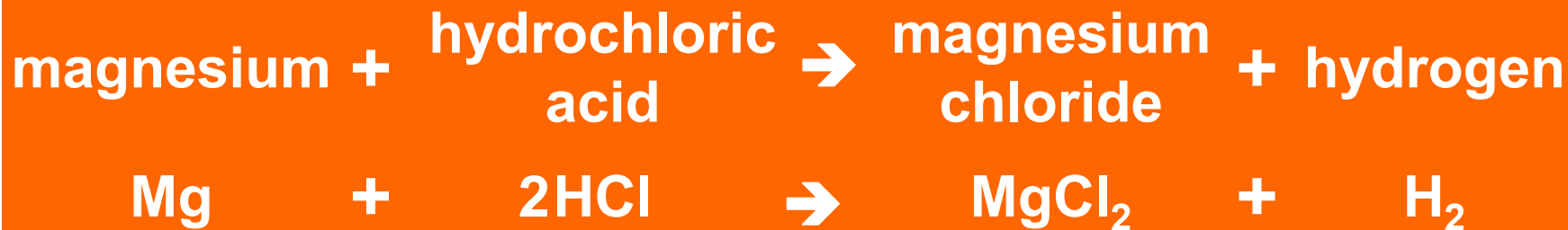


The salt produced depends on the metal and type of acid used in the reaction.



Metals and hydrochloric acid

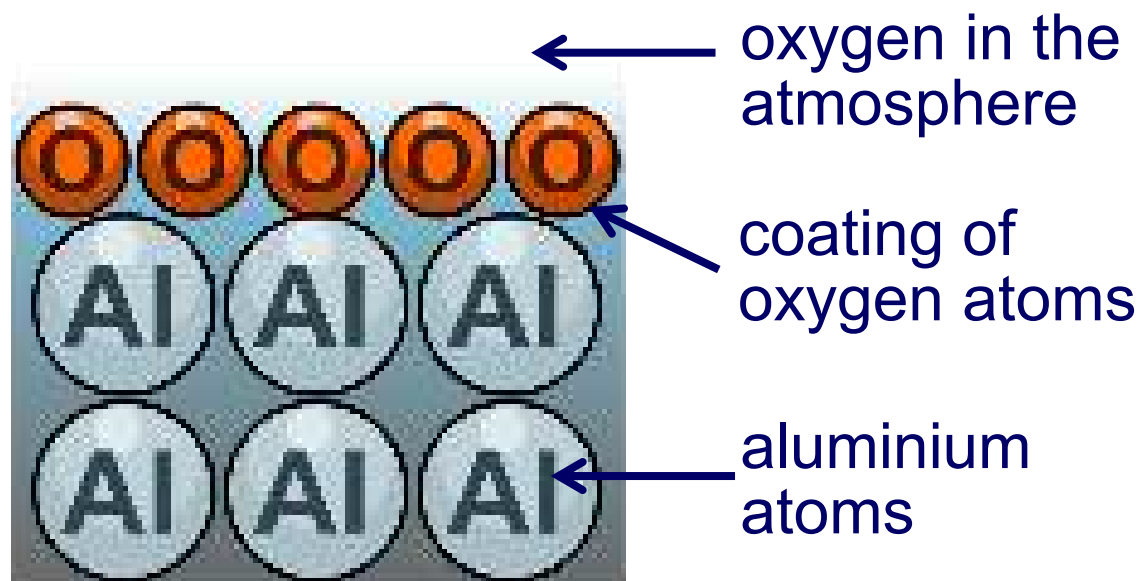
What are the balanced equations for these reactions?



Aluminium – the exception

According to the reactivity series, aluminium should be a fairly reactive metal, but in reality it often appears unreactive. Why?

A protective layer of aluminium oxide quickly forms on its surface. The layer stops aluminium reacting with other substances, such as water in the air. This is why aluminium can be used to build aeroplanes and saucepans.



If the protective layer is removed, the aluminium reacts more quickly.



Predicting simple reactions

Use the reactivity series to predict if a reaction will take place and how intense the reaction will be:

| metal | reacts with | prediction |
|---------|-------------|---------------------------|
| gold | acid | no reaction |
| calcium | water | fizzing |
| sodium | oxygen | burns vigorously |
| silver | oxygen | very slow reaction |
| zinc | oxygen | burns moderately |



increasing reactivity



potassium
sodium
calcium
magnesium
aluminium
zinc
iron
lead
copper
silver
gold



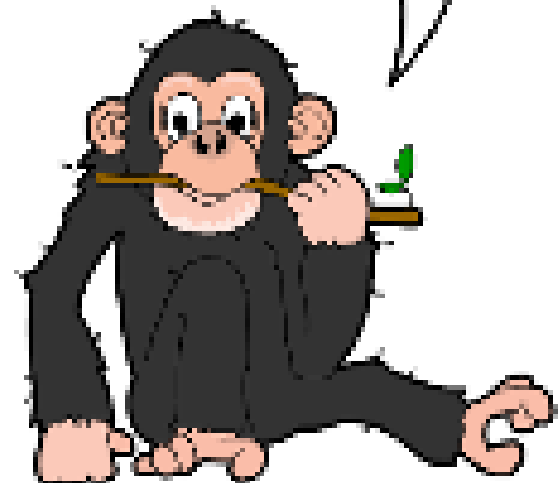
What is the order of reactivity?

What is the order of metals in the reactivity series?

↑
increasing reactivity

- calcium
- aluminium
- gold
- zinc
- sodium
- lead
- potassium
- silver
- magnesium
- copper
- iron

click here
for clue



solve



The Reactivity Series



The reactivity series



Building the reactivity series



Metal oxides and oxidation reactions



Displacement reactions



Summary activities



Reacting metals with oxygen

Most metals react with oxygen.

Some metals react quickly and some only react very slowly. For example, magnesium burns in oxygen with a bright flame.



When a metal reacts with oxygen, the product is a **metal oxide**.



The metal gains oxygen, it is an **oxidation** reaction.



What is oxidation?

Oxidation is the addition of oxygen to a substance, or the loss of electrons from a substance.

When iron or steel rusts, it is actually being oxidised.



The iron atoms gain oxygen in the reaction, and so are oxidised. Oxygen is the **oxidising agent**.

The oxygen is reduced in the reaction, why?



What is reduction?

To obtain a metal from a metal oxide, the oxygen must be removed.

Reduction is the removal of oxygen from a substance, or the addition of electrons to the substance.



Carbon can be used to extract some metals by reduction.



In this reaction, the carbon removes oxygen from lead oxide. The lead loses oxygen, and so is reduced by carbon.



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- The reactivity series
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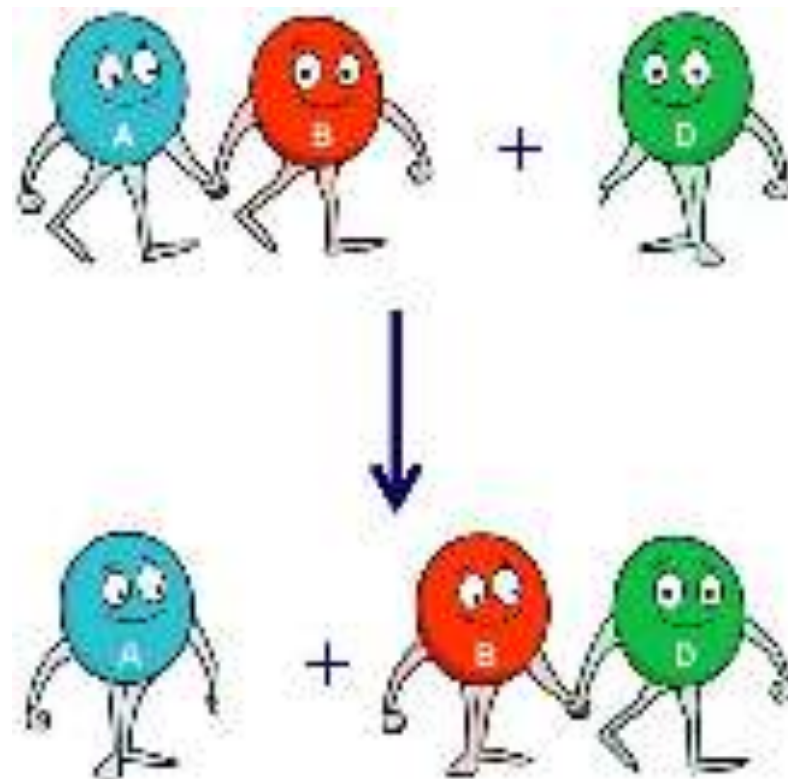
What are displacement reactions

The reactivity series can be used to predict the products of reactions involving metals.

If two metal compounds react, the more reactive metal pushes out, or **displaces**, the less reactive metal from its compound.

These are called **displacement reactions**.

The two metals are competing with each other, and the more reactive metal wins!



Displacement reactions



Displacement of copper by magnesium



During the reaction of solid magnesium and aqueous copper sulfate, the copper is displaced by magnesium.



What is the ionic equation for this reaction?



The sulfate ions (SO_4^{2-}) are unchanged in the reaction, they are therefore not included in the final ionic equation:

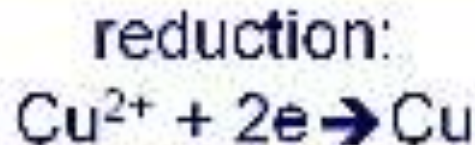
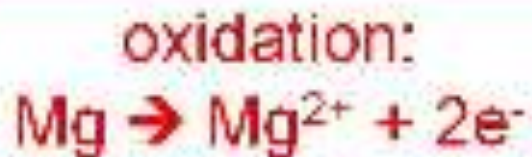


What happens to the electrons?

What happens to the electrons when magnesium reacts with copper sulfate?



Half equations show what happens to the electrons during oxidation and reduction:



The magnesium atom loses electrons. It is **oxidised**.

The copper ion gains electrons. It is **reduced**.

Predicting the order of reactivity

Displacement reactions can be used to predict the order of reactivity.

Look at the reactions of iron (Fe), copper (Cu) and silver (Ag) below.

| reactants | products |
|--|--|
| $\text{Fe(s)} + \text{CuSO}_4\text{(aq)}$ | $\text{Cu(s)} + \text{FeSO}_4\text{(aq)}$ |
| $\text{Cu(s)} + 2\text{AgNO}_3\text{(aq)}$ | $2\text{Ag(s)} + \text{Cu(NO}_3)_2\text{(aq)}$ |

What is the order of reactivity?

Fe

most reactive

Cu

Ag

least reactive

Will displacement take place?

Will displacement take place?

| Reactants | | Reaction? |
|----------------|-----------------|-----------|
| iron oxide | magnesium | |
| copper sulfate | zinc | |
| potassium | copper sulfate | |
| gold | iron chloride | |
| calcium | sodium chloride | |
| calcium | silver nitrate | |



↑
potassium
sodium
calcium
magnesium
aluminium
zinc
iron
lead
copper
silver
gold

yes

no

solve

Displacement reactions – metal oxides

Metal oxides are involved in displacement reactions.

When a metal is added to a metal oxide, competition occurs for the oxygen atom.

The more reactive metal will displace the less reactive metal, to form a new metal oxide.

Look at the displacement reaction between magnesium (Mg) and zinc oxide (ZnO):



As magnesium is more reactive, it displaces zinc. This results in the formation of magnesium oxide (MgO) and zinc (Zn).

Predicting displacement reactions

What happens if silver (Ag) reacts with zinc oxide (ZnO)?



Silver cannot be oxidised as it is below zinc in the reactivity series.

This means it is less reactive than zinc, and no reaction will occur.



potassium
sodium
calcium
magnesium
aluminium
carbon
zinc
iron
lead
hydrogen
copper
→ **silver**
gold
platinum

Working out reactivity using metal oxides

Look at the table below. Based on the reactions given, what is the order of reactivity of the metals?

| reactants | products |
|--------------------------|-----------------------------------|
| $\text{Mg} + \text{ZnO}$ | $\text{MgO} + \text{Zn}$ |
| $\text{Na} + \text{MgO}$ | $\text{Na}_2\text{O} + \text{Mg}$ |
| $\text{Zn} + \text{CuO}$ | $\text{ZnO} + \text{Cu}$ |

increasing
reactivity



Na
Mg
Zn
Cu

What is oxidised and what is reduced in each of these reactions?

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Building the reactivity series



Metal oxides and oxidation reactions



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Multiple-choice quiz

