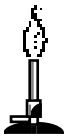
METALS

Some metals, including Gold, Silver and Copper, are found uncombined in the Earth's crust.

Most metals, however, are found combined with other elements, in compounds which we call **ores**. We can get metals from their ores in many ways.

* Heating with Carbon



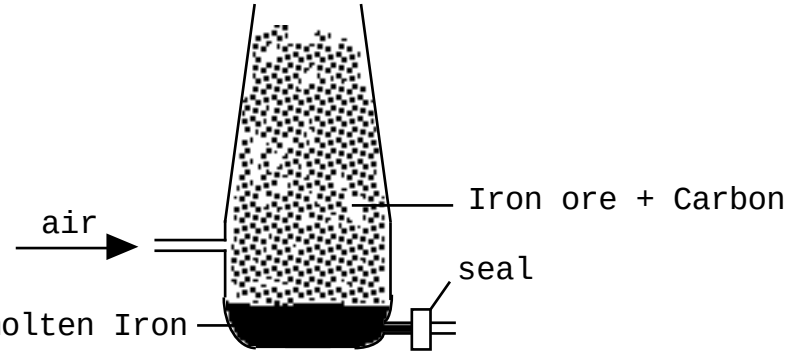
Example 1

Heat a mixture of Lead oxide and Carbon in a test-tube. Blobs of molten Lead are formed.

Lead oxide + Carbon -> Lead + Carbon dioxide

Example 2

Iron is obtained industrially by heating a mixture of Iron oxide and Carbon in a blast furnace.



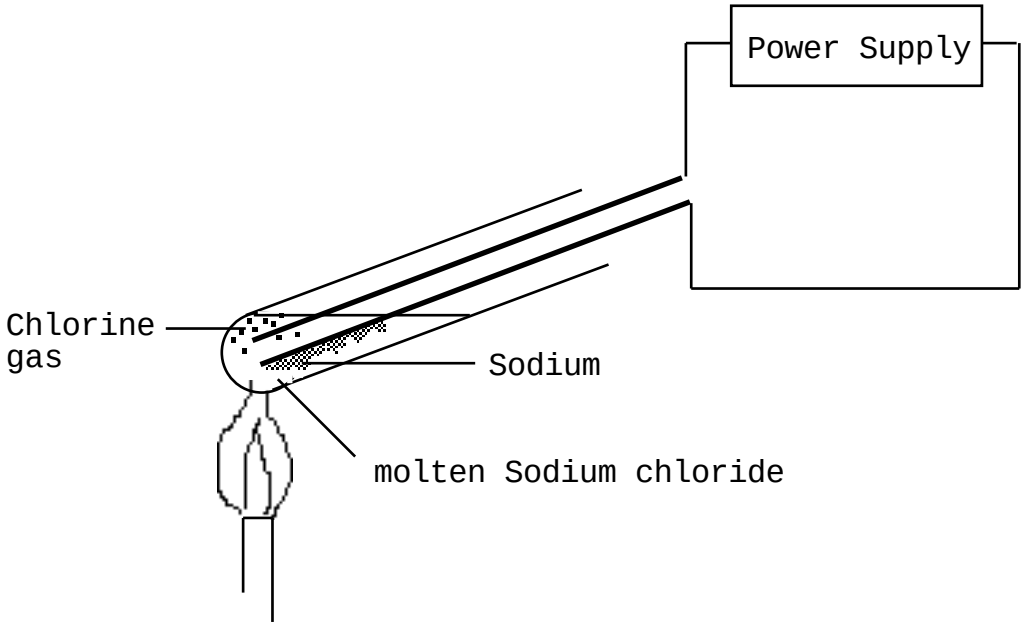
The mixture is heated. Air is forced in at the bottom. The air rushes up through the furnace making a roaring sound. Some of the Carbon burns in the Oxygen. The heat generated raises the temperature of the furnace and the reaction between Iron oxide and Carbon begins:

Iron oxide + Carbon -> Iron + Carbon dioxide

* Using electricity

Example 1

Pass an electric current through molten Sodium chloride.



Sodium is obtained at one of the electrodes.

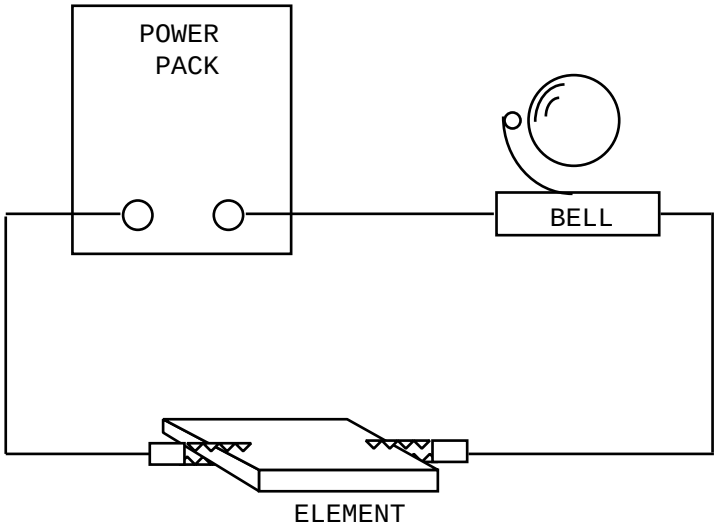
Sodium chloride -> Sodium + Chlorine

Example 2

Aluminium is obtained industrially by passing an electric current through molten Aluminium oxide.

Electrical Conductivity of Metals

We can find out whether an element conducts electricity using the following apparatus:



If the bell rings, the element conducts!

All metals conduct electricity.

Most non-metals (e.g. Sulphur, Helium and Bromine) do not conduct electricity. The exception is Graphite (a form of Carbon) - a non-metal which is a good conductor of electricity!

Uses of Metals

The uses of metals depend on what kind of properties they have. For example, Copper is used to make electrical wires because it is a good conductor of electricity. Here are some other uses of metals related to their properties:

Metal	Use	Related Property
Aluminium	Aircraft	low density (light)
Copper	Copper-based saucepans	good heat conductor
Gold	Jewellery	malleable (soft)
Lead	Ship keels	high density (heavy)

Alloys

Alloys consist of two or more different metals, melted down and mixed together.

e.g. **Brass** contains Zinc and Copper and is used to make the pins for electric plugs etc.

Some alloys contain metals and non-metals

e.g. **Mild steel** contains Iron and Carbon and is used to make girders and beams because it is very strong.

Two other alloys and their uses are listed below:

Alloy	**Elements present**	**Uses**
Solder	Tin Lead	Joining metals
Stainless steel	Iron Carbon Chromium Nickel	Knifes and forks

Three reactions of Metals

1. With Oxygen:

Metals react with Oxygen forming metal oxides.

Burn some Iron wool in air.
The Iron combines **slowly** with the Oxygen in the air forming Iron oxide.

Iron + Oxygen -> Iron oxide

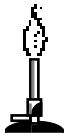
Burn some Magnesium powder in air.
The Magnesium combines **rapidly** with the Oxygen in the air forming Magnesium oxide.

Magnesium + Oxygen -> Magnesium oxide

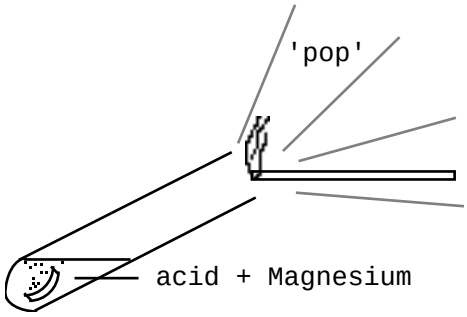
Magnesium reacts faster than Iron because Magnesium is a more reactive metal than Iron.

2. With acid:

Most metals react with acids forming Hydrogen as one of the products.



Add Magnesium ribbon to some dilute Hydrochloric acid in a test tube.
Hydrogen gas is given off.
Hydrogen burns with a 'pop'.



Magnesium + Hydrochloric acid -> Magnesium chloride + Hydrogen

Now add a piece of Calcium to the same acid.

Calcium + Hydrochloric acid -> Calcium chloride + Hydrogen

Calcium reacts much more quickly than Magnesium because Calcium is more reactive than Magnesium.

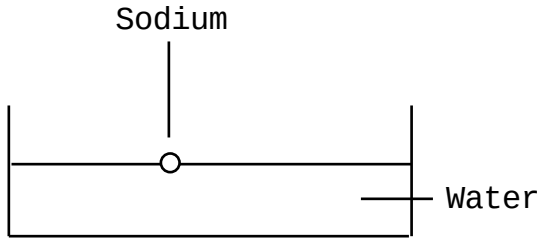
Some of the very unreactive metals do not react with dilute acid e.g. Copper, Silver and Gold

3. With Water:

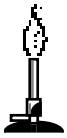
Hydrogen is also produced when metals react with Water.

Add Sodium to Water in a glass trough.

The Sodium shoots across the surface of the water.
The Hydrogen gas given off can be lit with a taper.



Sodium + Water -> Sodium hydroxide + Hydrogen



Now add Potassium to Water.

Potassium + Water -> Potassium hydroxide + Hydrogen

Potassium reacts more quickly than Sodium because Potassium is more reactive than Sodium.

Reactivity Series

Using other metals in the previous experiments we can place the following metals in order of reactivity with the most reactive at the top of the list:

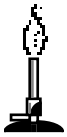
Potassium
Sodium
Lithium
Calcium
Magnesium
Aluminium
Zinc
Iron
Tin
Lead
Hydrogen
Copper
Mercury
Silver
Gold
Platinum

Corrosion of metals

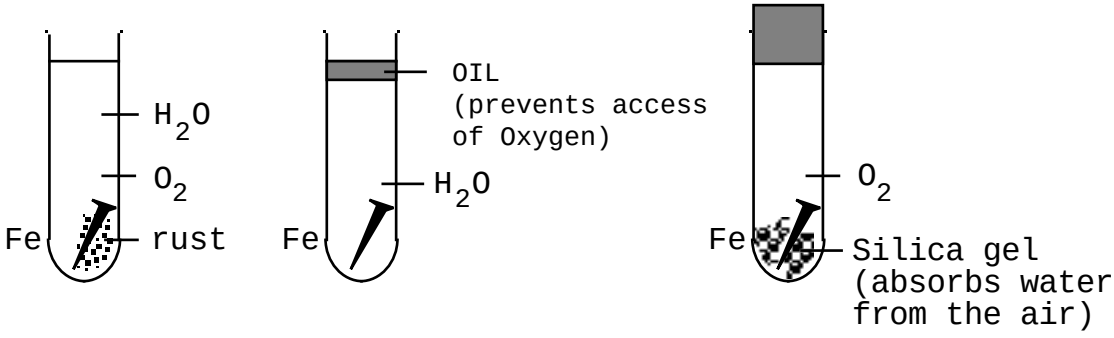
Corrosion is a chemical reaction which involves the surface of a metal changing from an element to a compound.

Iron corrodes slowly in moist air, a reaction we call **rusting**. Rusting weakens Iron structures.

What happens during rusting?

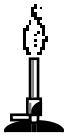


Both **OXYGEN AND WATER** are required as the following experiment shows :

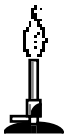


RUSTING **NO RUSTING** **NO RUSTING**

We can use a yellow liquid called 'Rust Indicator' to watch corrosion actually happening. Rusting Iron turns this indicator blue.



Place an Iron nail in a test tube containing Rust Indicator. After a few minutes a blue colour appears around the Iron nail.

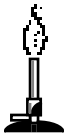


Set up the following two test tubes and compare the rate of corrosion in each:

Iron nail +
Rust indicator

Iron nail +
ACID +
Rust indicator

The blue colour appears faster when ACID is present.
Iron rusts faster when acid is present.
Acid rain increases the rate of corrosion.



Set up the following two test tubes and compare the rate of corrosion in each:

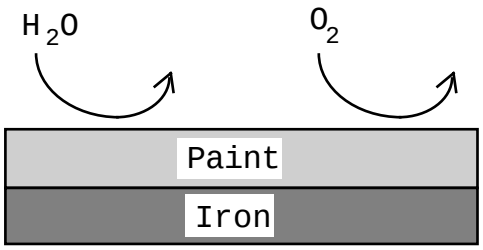
Iron nail +
Rust indicator

Iron nail +
SALT +
Rust indicator

The blue colour appears faster when SALT is present.
Iron rusts faster when SALT is present.
SALT is spread on the roads to stop ice from forming in cold weather. This SALT, unfortunately, increases the rate of corrosion of car bodywork.

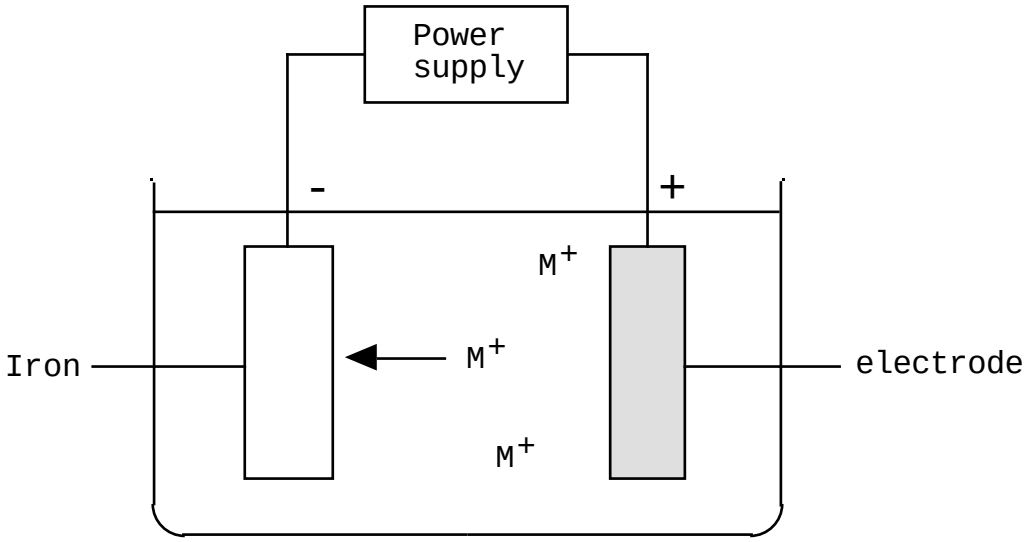
Preventing corrosion

Rusting can be prevented by stopping the Oxygen and Water from getting to the Iron using a barrier e.g. oil, grease, paint, plastic or metal :



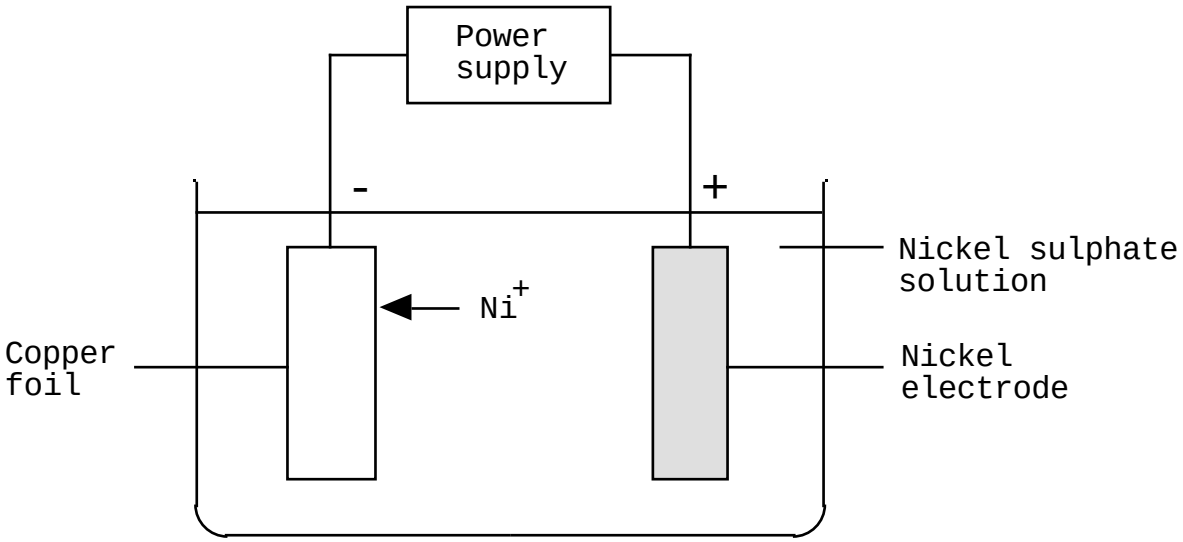
Electroplating

A layer of metal can be deposited on to Iron by electroplating. An electric current is passed through a solution containing positive ions of the metal M^+ :



The piece of Iron forms the negative electrode. The positive ions are therefore attracted to the negatively charged Iron, stick to it and form a layer of metal. Tin plating is carried out in this way.

A layer of Nickel is deposited on to a piece of Copper foil by passing an electric current through a solution of Nickel sulphate (this contains the positive Nickel ions).



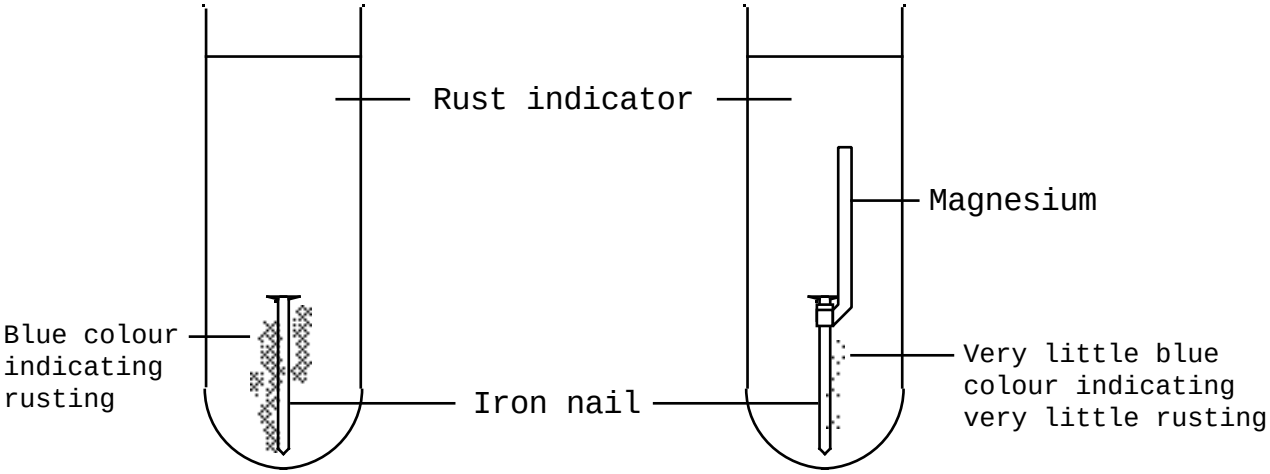
Galvanising

A layer of Zinc can be deposited on Iron by dipping the Iron into molten Zinc. The Zinc forms a barrier and prevents rusting. Protecting Iron with Zinc is known as **galvanising**.

Galvanising has the added advantage that Zinc is more reactive than Iron - the Zinc corrodes before the Iron! Iron rusts more slowly when connected to more reactive metals.

Magnesium scrap is often used to protect Iron pipelines.

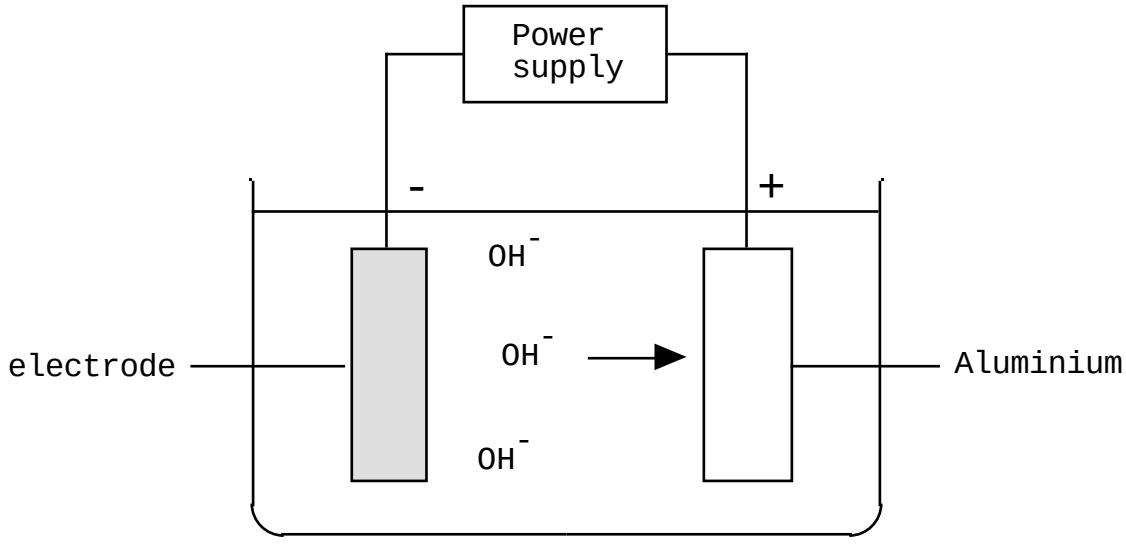
Set up the following two test tubes and compare the rate of corrosion of Iron in each:



Anodising

The thin layer of Aluminium oxide which covers Aluminium gives Aluminium some protection against corrosion. The thickness of the oxide layer can be increased by anodising.

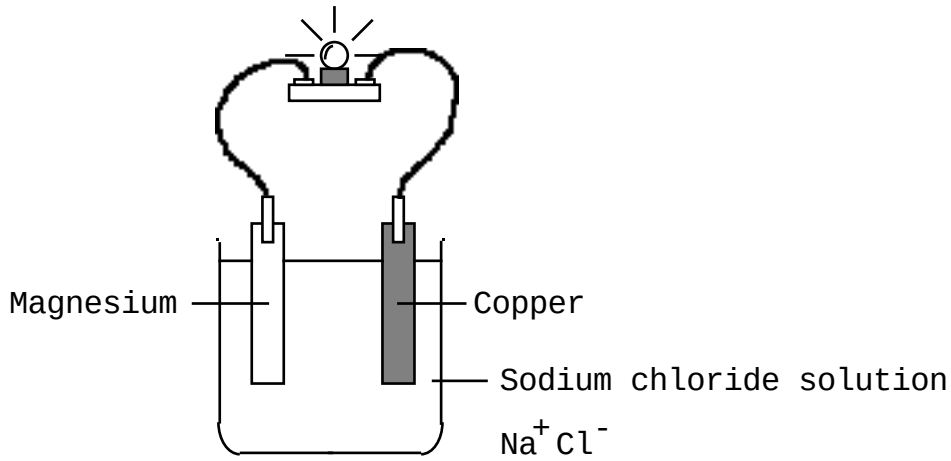
An electric current is passed through a solution containing negative hydroxide ions OH- :



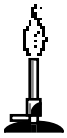
The piece of Aluminium forms the positive electrode. The negative ions are therefore attracted to the positively charged Aluminium and react with it forming Aluminium oxide.

Batteries

Electricity can be produced by connecting different metals together in a solution containing ions.



We call this device a **cell** or **battery**.



Make the cell shown above.

Electricity flows from the Magnesium, through the bulb, through the Copper and through the solution back to the Magnesium again. The solution must therefore contain ions to enable it to conduct electricity.

The further apart the two metals are in reactivity, the higher the voltage.

The Magnesium/Copper cell above has a voltage of about 2.7 volts.

A Magnesium/Zinc cell has a voltage of only about 1.6 volts.

A battery makes electricity from a chemical reaction taking place inside it. When the chemicals run out, the battery goes 'flat' and needs to be replaced.

Some batteries can be recharged e.g. the Lead-Acid battery used in a car and the Lithium ion battery used in camcorders, laptops etc.