

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		Extraction method			
Some gases of hydrogen gas	vigorous	potassium		Electrolysis			
		calcium					
		aluminium					
Moderately slowly	Some gases of hydrogen gas	aluminium (below)			Reduction with carbon		
		iron					
		tin					
No reaction	No reaction with some acid	tin				Some from the Earth's crust	
		lead					
No reaction	No reaction	lead					
		silver					
		gold					

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 rocks 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:



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:



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 A salt is a compound where the hydrogen from an acid has been replaced by a metal.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 sodium nitrate. The H in nitric acid is replaced with Na.

The table shows how to name salts.

Salt	hydrochloric acid	sulfuric acid	nitric acid
Formula	NaCl	Na_2SO_4	NaNO_3
ions formed in solution	Na^+ and Cl^-	2Na^+ and SO_4^{2-}	Na^+ and NO_3^-
Type of salt formed	metal chloride	metal sulfate	metal nitrate
Reaction with example	metal chloride NaCl	metal sulfate Na_2SO_4	metal 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:



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

Ionic equations (HT only)

When an ionic compound is dissolved in a solution, we can write the compound as its separate ions. For example, $\text{CuSO}_4(\text{aq})$ can be written as $\text{Cu}^{2+}(\text{aq})$ and $\text{SO}_4^{2-}(\text{aq})$.

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



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**.



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

Half equations (HT only)

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



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



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

Reactivity and ions

A metal's reactivity depends on how easily 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.

Steps for writing an ionic equation (HT only)

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

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 acids.
- 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.



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