

Chapter 5: Chemical changes 1

Knowledge organiser

Reactions of metals

The reactivity of a metal is how chemically reactive it is. It is often related to water, some metals react with oxygen - these metals have high reactivity. Other metals will barely react with water or not, so aren't as reactive at all - these metals have low reactivity.

Reaction with water	Reaction with acid	Reactivity series	Displacement reactions
Reacts, gives off hydrogen gas	Reacts	most potassium sodium calcium magnesium aluminium zinc iron lead copper silver gold	more reactive
Reacts, gives off hydrogen gas	Reacts, gives off hydrogen gas		
Reacts, only slowly	Reacts, only slowly		
Reacts, slowly with water only	Reacts, slowly with water only		
Does not react	Does not react		more reactive than the substance it reacts with

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 will be compounds in metal ores and have to be extracted from the rock. This is a process called metal extraction or the metal being extracted is a metal 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.

Salts

When acids react with metals or metal compounds, they form salts. It can be a compound where the hydrogen from an acid has been replaced by a metal. For example, when acid, HNO_3 , reacts with sodium hydroxide, NaOH , they will combine and be replaced with Na.

This table shows how to name salts.

Base	Acids (name acid)	Salts (name salt)	Other (name)
Hydroxide	HCl	NaCl	HNO_3
Sulfate (sulfuric acid)	H_2SO_4	Na_2SO_4	H_2SO_4
Nitrate (nitric acid)	HNO_3	NaNO_3	HNO_3
Carbonate (carbonic acid)	H_2CO_3	Na_2CO_3	H_2CO_3

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.

Neutralisation reactions

Reactions of acids with metal hydroxides

Acids react with metal hydroxides to form salts and water.

$\text{hydrochloric acid} + \text{sodium hydroxide} \rightarrow \text{sodium chloride} + \text{water}$

The ionic equation for this reaction is always:



Reactions of acids with metal oxides

Acids react with metal oxides to form salts and water.

$\text{hydrochloric acid} + \text{sodium oxide} \rightarrow \text{sodium chloride} + \text{water}$

Reactions of acids with metal carbonates

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

$\text{hydrochloric acid} + \text{sodium carbonate} \rightarrow \text{sodium chloride} + \text{water} + \text{carbon dioxide}$

Balancing symbol equations

When writing symbol equations you need to ensure that the number of each atom is the same on both sides.

$\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$

unbalanced

There are 2 hydrogen atoms on each side, but 1 oxygen atom on the left and 2 on the right.

$\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

balanced

There are 2 hydrogen atoms on each side, and 2 oxygen atoms on each side.

$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

balanced

There are 4 hydrogen atoms on each side, and 2 oxygen atoms on each side.

$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

balanced

$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

balanced

Alkalis and bases

Some reactions with acids to form water in neutralisation reactions.

Some metal hydroxides dissolve in water to form alkalis.

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

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Displacement reactions

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

For example:



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

Ionic equations (HIT 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, metal compounds, and solid ionic substances do not split into ions in the ionic equation.

Half equations (HIT only)

In the displacement reaction, iron atom loses two electrons to form a Fe^{2+} ion.



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



These two equations are called half equations - they each show half of the reaction.

Reactivity and ions

A metal's reactivity depends on how easily it loses an ion by losing electrons.

In the displacement reaction of copper sulfate and iron, iron atoms can lose their outer electrons.

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

Steps for writing an ionic equation (HIT only)

1. Write the full ionic equation.
2. Identify the spectator ions.
3. Cancel the spectator ions on both sides.
4. Remove the spectator ions.

Reduction and oxidation: electrons (HIT only)

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

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

In the example displacement reaction:

- Iron atom loses two electrons to form a Fe^{2+} ion.
- Copper ion gains two electrons to form a copper atom.

Iron is oxidised, and copper is 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 ranges from 0 to 14.

- Acidic solutions with pH < 7 are acids.
- Neutral solutions with pH = 7 are neutral.
- Alkaline solutions with pH > 7 are alkalis.

The pH scale

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

acidic neutral alkaline

Indicators

Indicators are substances that change colour when they are in an acid or an alkali.

Universal indicator can also tell us the approximate pH of a solution.

Electron's pH scale can give us the exact pH of a solution.

The pH scale

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

acidic neutral alkaline

Strong and weak acids

Sulfuric acid, nitric acid, and hydrochloric acid are all strong acids. This means that, when dissolved in water, every molecule of the acid splits into ions.

Weak acids, like ethanoic acid, are only partially ionised.

$\text{HCl(aq)} \rightarrow \text{H}^+(\text{aq}) + \text{Cl}^-(\text{aq})$

$\text{H}_2\text{SO}_4(\text{aq}) \rightarrow 2\text{H}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$

$\text{CH}_3\text{COOH(aq)} \rightleftharpoons \text{CH}_3\text{COO}^-(\text{aq}) + \text{H}^+(\text{aq})$

$\text{HCOOH(aq)} \rightleftharpoons \text{HCOO}^-(\text{aq}) + \text{H}^+(\text{aq})$

Ethanoic acid, nitric acid, and carbonic acid are weak acids.

This means that only a percentage of their molecules split 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 more of the acid in a given volume of water.

Less concentrated acids have less of the acid in a given volume of water.



Crystallisation

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

The steps for crystallisation are:

1. Choose the correct acid and base to produce the salt.
2. Put some of the acid and base 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 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.



Section Chemical Changes Answers

LAKHMIR SINGH



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