# Indicators

When an **acid** is dissolved in water we get an **acidic** solution. When a **base** dissolves in water it is an **alkali** and makes an **alkaline** solution. If a solution is neither acidic nor alkaline it is **neutral**. Pure water is neutral, and so is **paraffin**.
**Indicators** are substances that change colour when they are added to acidic or alkaline solutions. Litmus, phenolphthalein, and methyl orange are all indicators that are commonly used in the laboratory.

## Litmus

Litmus indicator solution turns red in acidic solutions, blue in alkaline solutions, and purple in neutral solutions.
**Litmus paper** comes as red litmus paper and blue litmus paper. The table shows the colour changes it can make:

| | Red Litmus | Blue Litmus |
|---|---|---|
| **Acidic solution** | Stays red | Turns red |
| **Neutral solution** | Stays red | Stays blue |
| **Alkaline solution** | Turns blue | Stays blue |


Acids turn blue litmus paper red


Alkalis turn red litmus paper blue

## Other indicators

The table shows the colour of methyl orange and phenolphthalein in solutions of different pH:

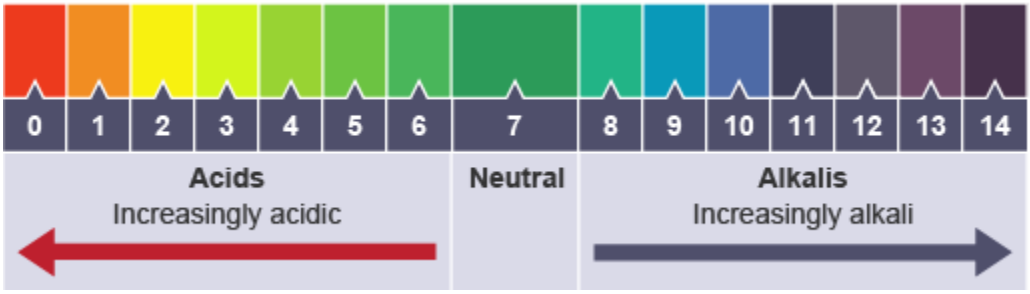
| Indicator | Acidic | Neutral | Alkaline |
|---|---|---|---|
| Methyl orange | Red | Yellow | Yellow |
| Phenolphthalein | Colourless | Colourless | Pink |

## The pH scale

The chemical properties of many solutions enable them to be divided into three categories - **acidic**, **alkaline** and **neutral solutions**.
The pH scale is used to measure acidity and alkalinity:

- solutions with a pH less than 7 are **acidic**
- solutions with a pH of 7 are **neutral**
- solutions with a pH greater than 7 are **alkaline**

If **universal indicator** is added to a solution it changes to a colour that shows the pH of the solution. Universal indicator is a mixture of a variety of other indicators and can be used to measure the approximate pH of a solution. A more accurate value can be obtained using a pH probe.




pH scale and universal indicator colours

## Acids and alkalis

When atoms or groups of atoms lose or gain electrons, charged particles called **ions** are formed. Ions can be either positively or negatively charged.

## Acids

When acids dissolve in water they produce hydrogen ions, $H^+$. These are sometimes called **protons**, because hydrogen ions are the same as a hydrogen **nucleus** (which is a proton).

For example, take a look at the equation for hydrochloric acid:
$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$

Note that (aq) means the substance is in solution.

Acids are often produced from non-metal oxides. For example, sulfur oxides make sulfuric acid.

## Alkalis

When alkalis dissolve in water they produce hydroxide ions, $OH^-$.

For example, take a look at the equation for sodium hydroxide:
$NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$

Ammonia is slightly different. This is the equation for ammonia in solution:
$NH_3(aq) + H_2O(l) \rightarrow NH_4^+(aq) + OH^-(aq)$

## Bases

A base is chemically opposite to an acid. Some bases dissolve in water and are called alkalis. But other bases, including many metal oxides, do not dissolve in water.

## Neutralisation reaction

When the $H^+$ ions from an acid react with the $OH^-$ ions from an alkali, a neutralisation reaction occurs to form water. This is the equation for the reaction: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$
For example, hydrochloric acid and sodium hydroxide solution react together to form water and sodium chloride solution. The acid contains $H^+$ ions and $Cl^-$ ions, and the alkali contains $Na^+$ ions and $OH^-$ ions. The $H^+$ ions and $OH^-$ ions produce the water, and the $Na^+$ ions and $Cl^-$ions produce the sodium chloride, NaCl(aq).

Because neutralisation reactions involve the loss and gain of hydrogen ions, this process is sometimes referred to as ‘proton transfer’.

## Reactions with acids

### Acids and reactive metals

Acids will react with reactive metals, such as magnesium and zinc, to make a salt and hydrogen:

acid + metal → salt + hydrogen

hydrochloric acid + zinc → zinc chloride + hydrogen

The hydrogen causes bubbling during the reaction, and can be detected using a burning splint which produces a squeaky pop sound.

### Acids and metal oxides

When acids react with metal oxides, a salt and water are made:

acid + metal oxide → salt + water

nitric acid + magnesium oxide → magnesium nitrate + water

### Acids and metal carbonates

When acids react with carbonates, such as calcium carbonate (found in chalk, limestone and marble), a salt, water and carbon dioxide are made. In general:

acid + metal carbonate → salt + water + carbon dioxide

sulfuric acid + iron → iron sulfate + water + carbon dioxide

The carbon dioxide causes bubbling during the reaction. It can be detected by passing the gas through limewater, which will go cloudy.