

# Acids and Bases

Matthew Williams • Chemistry • May 15, 2026

## Acids and Bases

Acid-base chemistry explains digestion, industrial processes, soil management, and dozens of everyday observations. The key is understanding the definitions precisely — particularly the distinction between a base and an alkali — and being able to write balanced equations for every type of acid reaction.

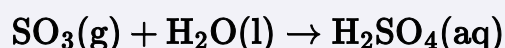
### Definitions

An **acid** is a proton donor — a substance that releases hydrogen ions ( $\text{H}^+$ ) in aqueous solution. Acids have replaceable hydrogen atoms that can be displaced by metals or neutralised by bases.

A **base** is a proton acceptor — a substance that can neutralise an acid. Bases are usually metal oxides or metal hydroxides.

An **alkali** is a soluble base. When dissolved in water, it produces hydroxide ions ( $\text{OH}^-$ ). All alkalis are bases, but not all bases are alkalis — only the soluble ones.

An **acid anhydride** is a non-metal oxide that reacts with water to produce an acid:



#### Exam Tip

A common exam error: saying all bases are alkalis. Only soluble bases dissolve in water to form  $\text{OH}^-$ . Copper(II) oxide is a base but is not an alkali because it does not dissolve in water.

## Types of Oxides

Whether something is acidic or basic is closely linked to the type of oxide it forms. Many common acids and bases are simply non-metal or metal oxides that have reacted with water.

Oxide type	Definition	Examples

Acidic oxide	Non-metal oxide; reacts with water to form an acid, or with a base to form a salt and water	CO, SO, SO <sub>2</sub> , NO <sub>2</sub>
Basic oxide	Metal oxide; reacts with an acid to form a salt and water	CaO, MgO, CuO, FeO
Amphoteric oxide	Reacts with both acids and bases	Al <sub>2</sub> O <sub>3</sub> , ZnO
Neutral oxide	Reacts with neither acid nor base	CO, NO, H <sub>2</sub> O

## The pH Scale

Knowing whether something is an acid or a base is qualitative. The pH scale gives a number.

<PHScale />

The pH scale runs from 0 to 14 and measures how acidic or alkaline a solution is.

pH range	Nature	Examples
0-6	Acidic (lower pH = stronger acid)	Stomach acid ~pH 1, vinegar ~pH 3, rainwater ~pH 5.6
7	Neutral	Pure water
8-14	Alkaline (higher pH = stronger alkali)	Baking soda ~pH 9, bleach ~pH 13

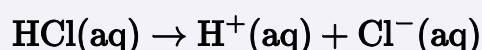
Indicators change colour with pH. **Litmus** turns red in acid and blue in alkali. **Universal indicator** shows a spectrum of colours across the full range. **Phenolphthalein** is colourless in acid and pink in alkali. **Methyl orange** is red in acid and yellow in alkali.

## Strength of Acids and Alkalis

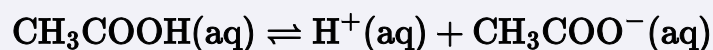
pH tells you how acidic a solution is. Strength explains why: two acids at the same concentration can have quite different pH values depending on how much they ionise.

Strength depends on the **degree of ionisation** — how completely the substance breaks into ions in water.

**Strong acids** ionise completely in water:



**Weak acids** ionise only partially — most molecules remain intact:



	Strong acid	Weak acid
Degree of ionisation	Complete	Partial
pH (same concentration)	Lower	Higher
Examples	HCl, H <sub>2</sub> SO <sub>4</sub> , HNO <sub>3</sub>	Ethanoic acid, carbonic acid (H <sub>2</sub> CO <sub>3</sub> )

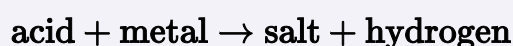
NaOH and KOH are strong alkalis (fully ionise); ammonia solution (NH<sub>3</sub>(aq)) is a weak alkali.

## Reactions of Acids

With the definitions in place, the next question is what acids actually do. There are five reaction types to know.

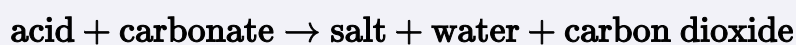
### With Metals

Dilute acids react with metals above hydrogen in the reactivity series, producing a salt and hydrogen:



Test for hydrogen: a burning splint produces a squeaky pop.

### With Carbonates and Hydrogen Carbonates

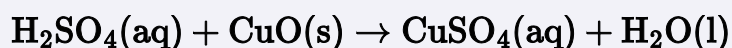
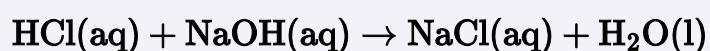




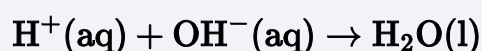
Test for CO<sub>2</sub>: bubble through limewater — turns milky white.

Applications: antacid tablets contain NaHCO<sub>3</sub> for CaCO<sub>3</sub> to neutralise excess stomach acid; baking powder uses this reaction to release CO<sub>2</sub> in baking.

## With Bases (Neutralisation)



The net ionic equation for all strong acid-strong alkali neutralisations is:



## Reaction of Bases with Ammonium Salts

Bases also react with ammonium salts, not just acids. This is important in agriculture: lime and ammonium fertiliser should never be applied to soil together, because the reaction releases ammonia gas and wastes the nitrogen.

When a base is heated with an ammonium salt, ammonia gas is released:



Test for ammonia: turns damp red litmus paper blue.

### Exam Tip

Lime (calcium hydroxide) and ammonium fertiliser must never be applied to soil at the same time — the reaction releases ammonia gas and wastes the nitrogen in the fertiliser.

## Acids in Living Systems

Acids show up well outside the laboratory, in foods, organisms, and animal defence.

Acid	Location/source	Role
Ascorbic acid (vitamin C)	Citrus fruits, green vegetables	Antioxidant; essential vitamin
Methanoic acid (formic acid)	Ants, bee stings, nettles	Defence mechanism
Lactic acid	Muscles during exercise	Produced during anaerobic respiration
Ethanoic acid (acetic acid)	Vinegar	Food preservation (low pH inhibits bacterial growth)
Citric acid	Citrus fruits	Flavouring; removes rust stains

### Applications of neutralisation:

- Toothpaste is mildly alkaline and neutralises acids produced by bacteria in the mouth, protecting tooth enamel.
- Lime (calcium hydroxide) is added to acidic soil to raise the pH and improve conditions for plant growth.
- Antacid tablets neutralise excess hydrochloric acid in the stomach to relieve indigestion.