

How acids, bases and salts behave

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Lesson

Quick answer: Acids are substances that release hydrogen ions, H^+ , in water. Bases neutralise acids, and alkalis are bases that dissolve and form OH^- ions. Neutralisation produces a salt and water, the pH scale measures H^+ concentration, and strong acids ionise completely whereas weak acids ionise only partly.

Level: Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** GCSE C4, IGCSE 7

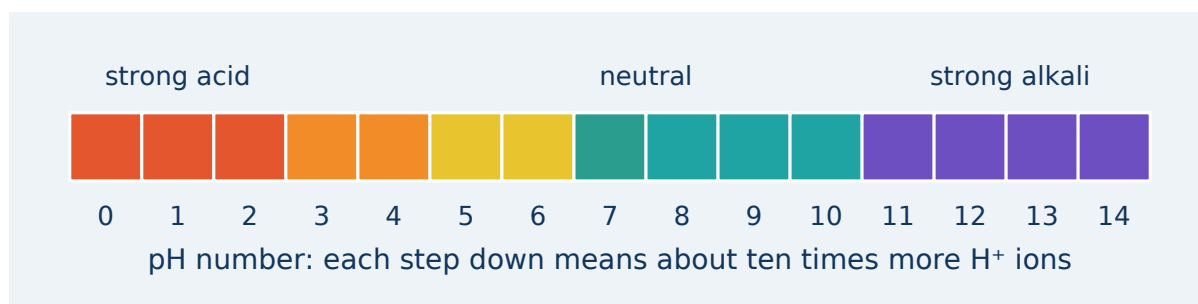
What are acids, bases and alkalis?

Acids taste sour, turn indicators red and react with many metals. Bases are the chemical opposites: they neutralise acids. The word that links them is the **hydrogen ion**, H^+ , which is what every acid releases in water.

Definition

An **acid** is a substance that forms H^+ ions in water. A **base** is a substance that neutralises an acid, for example a metal oxide, hydroxide or carbonate. An **alkali** is a base that dissolves in water and forms OH^- ions.

The **pH scale** measures how acidic or alkaline a solution is. Pure water and neutral solutions are pH 7. Lower numbers mean more H^+ ions, and each step of one pH unit means ten times the amount of H^+ .



The pH scale with the colours of universal indicator.

Indicator	In acid	In neutral	In alkali
Litmus	Red	Purple	Blue
Methyl orange	Red	Orange	Yellow
Phenolphthalein	Colourless	Colourless	Pink
Universal indicator	Red to yellow	Green	Blue to violet

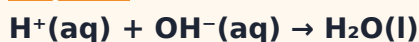
What happens in neutralisation?

In neutralisation an acid reacts with a base to give a **salt** and, if the base is a hydroxide, oxide or carbonate, water. The first part of the salt's name comes from the base or metal. The second part comes from the acid: hydrochloric acid gives chlorides, sulfuric acid gives sulfates and nitric acid gives nitrates.

Reactants	Products	Example
Acid + metal oxide	Salt + water	$\text{CuO} + \text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{H}_2\text{O}$
Acid + alkali	Salt + water	$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$
Acid + carbonate	Salt + water + carbon dioxide	$\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$
Acid + reactive metal	Salt + hydrogen	$\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$

Whatever the acid and the alkali, the essential change is the same: H^+ ions join OH^- ions to form water. The other ions are spectators.

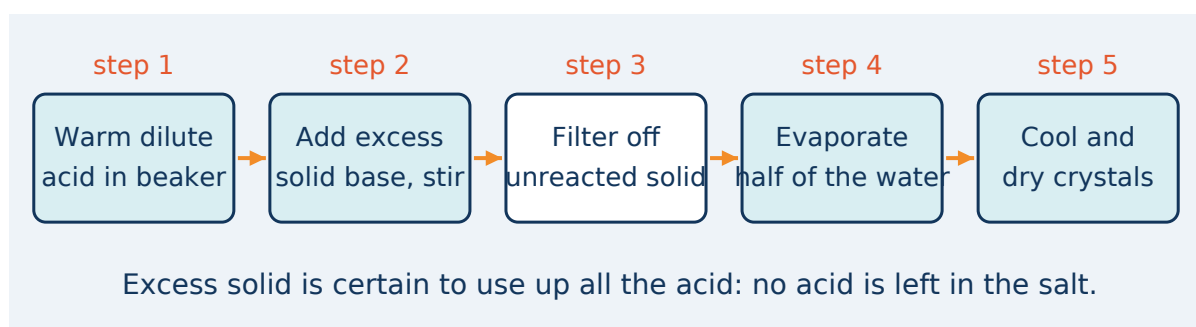
Key law



This ionic equation describes every neutralisation of an acid by an alkali.

How do you make a soluble salt?

Many salts are made by adding an insoluble solid base to a warm acid. The solid is added until it stops dissolving. This excess guarantees that all the acid has reacted. The leftover solid is filtered off, and the clear salt solution is crystallised.



Making a soluble salt from an insoluble base, oxide or carbonate.

Worked example

Esther in Kampala reacts 2.0 g of magnesium oxide with excess dilute sulfuric acid: $\text{MgO} + \text{H}_2\text{SO}_4 \rightarrow \text{MgSO}_4 + \text{H}_2\text{O}$. Calculate the maximum mass of magnesium sulfate (Ar: Mg = 24, O = 16, S = 32).

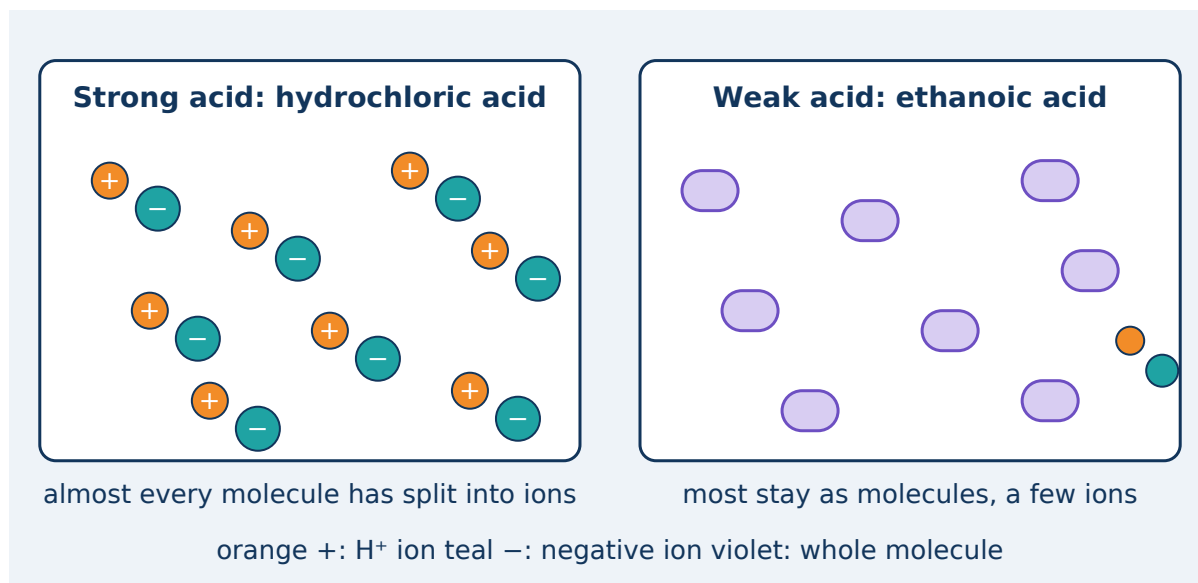
$n(\text{MgO}) = 2.0 \div 40 = 0.050$ mol. The ratio $\text{MgO} : \text{MgSO}_4$ is 1 : 1, so $n(\text{MgSO}_4) = 0.050$ mol.
 $M(\text{MgSO}_4) = 24 + 32 + 64 = 120$ g/mol, so $m = 0.050 \times 120 = \mathbf{6.0\text{ g}}$.

Common mistake

You cannot use excess solid to make a salt from a soluble base such as sodium hydroxide, because the excess would dissolve. Use exact volumes found by titration instead.

What is the difference between strong and weak acids?

A **strong acid**, such as hydrochloric, sulfuric or nitric acid, ionises completely in water. A **weak acid**, such as ethanoic or citric acid, ionises only a little, and the reaction is reversible, shown with $\rightleftharpoons$: $\text{CH}_3\text{COOH} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}^+$.



Strength depends on how many molecules ionise, not on how much acid is dissolved.

Strength and concentration are different ideas. Concentration says how much acid is dissolved. Strength says what fraction of the molecules ionise. A concentrated solution of a weak acid can have a lower pH than a very dilute solution of a strong acid.

Worked example

Solution A has pH 2 and solution B has pH 5. Compare their H⁺ concentrations.

The difference is $5 - 2 = 3$ pH units, and each unit is a factor of 10. So A has $10 \times 10 \times 10 =$ **1000 times** more H⁺ ions than B.

Lina's tip

Think of pH as a staircase going down into acid: every step down is ten times more H⁺. Count the steps and multiply by ten each time.

Key points to remember

- Acid: forms H⁺ in water; alkali: forms OH⁻ in water
- Neutralisation: $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$; acid + base $\rightarrow$ salt + water
- Salt names: chlorides, sulfates, nitrates from HCl, H₂SO₄, HNO₃
- pH 7 is neutral; each pH unit is a factor of ten in H⁺

- Strong acids ionise completely; weak acids only partly ($\rightleftharpoons$)

How acids, bases and salts behave: frequently asked questions

What is the difference between a base and an alkali?

A base is any substance that neutralises an acid. An alkali is a base that dissolves in water. Copper oxide is a base but not an alkali; sodium hydroxide is both.

What ion makes a solution acidic?

The hydrogen ion, H^+ , makes a solution acidic. In water it is more correctly written H_3O^+ , but GCSE and IGCSE courses use H^+ . Alkaline solutions contain OH^- ions.

Why does the pH change by one when the H^+ concentration changes tenfold?

The pH scale is logarithmic. A solution at pH 3 has ten times more H^+ ions than a solution at pH 4 and a hundred times more than one at pH 5.

Is a weak acid the same as a dilute acid?

No. Weak describes the acid itself, which ionises only partly. Dilute describes the amount dissolved in the solution. You can have a concentrated weak acid or a dilute strong acid.

How can I tell which salt an acid will make?

Use the metal or ammonium ion from the base and the negative ion from the acid. Sulfuric acid makes sulfates, hydrochloric acid makes chlorides and nitric acid makes nitrates.