The periodic table and formulae

Teacher review edition. Ask your teacher if anything is unclear.

How do we use the periodic table and read chemical formulae?

What you will learn

- Find an element's name, symbol and atomic number.
- Identify groups and periods on the periodic table.
- Count atoms in a chemical formula.
- Use ion charges to work out simple compound formulae.

What is the periodic table?

> **Atomic number**
> The number of protons in an atom's nucleus.

The periodic table is a chart of the chemical elements.

- Each box shows an element's name, symbol and atomic number.
- Atomic number = number of protons.
- Elements are arranged by increasing atomic number: hydrogen has 1 proton; helium has 2.

Groups and periods

> **Group**
> A vertical column in the periodic table.
>
> **Period**
> A horizontal row in the periodic table.

The position of an element helps us predict how it behaves.

- Group: a vertical column. Modern groups are numbered 1–18.
- Period: a horizontal row.
- Elements in the same group often have similar properties.
- Group 1 includes the reactive metals lithium, sodium and potassium.
- Group 18 contains the very unreactive noble gases.

Electrons and patterns

In a simple atom diagram, electrons are arranged in shells around the nucleus.

- For the first 20 elements: put up to 2 electrons in the first shell, 8 in the second and 8 in the third before starting the fourth.
- Sodium: 11 electrons arranged 2, 8, 1. Chlorine: 17 electrons arranged 2, 8, 7.
- Outer electrons help explain reactions. Group 1 has one; group 2 has two; group 17 has seven.
- Occupied shells give the period. Sodium has three occupied shells, so it is in period 3.

Reading a chemical formula

> **Chemical formula**
> Symbols and small numbers that show which elements are present and their amounts.
>
> **Subscript**
> A small number after a symbol or bracket that tells you how many atoms or groups are represented.

- A subscript is the small number after a symbol. It tells you how many atoms of that element are represented.
- No subscript means one.

Formula	How to read it
H_2O	Each water molecule has 2 hydrogen atoms and 1 oxygen atom.
CO_2	Each carbon dioxide molecule has 1 carbon atom and 2 oxygen atoms.
O_2	Each oxygen molecule has 2 oxygen atoms.

A number in front of a formula

A coefficient is the full-sized number written before a formula, such as the 2 in $2H_2O$. It multiplies everything in the formula.

- $3H_2O$ means three water molecules.
- Hydrogen atoms: 3 × 2 = 6.
- Oxygen atoms: 3 × 1 = 3.
- The molecules are still water: the formula H_2O has not changed.

What do brackets mean?

A small number outside brackets applies to everything inside the brackets.

- $Ca(OH)_2$ contains two OH groups: 1 calcium, 2 oxygen and 2 hydrogen atoms per formula unit.

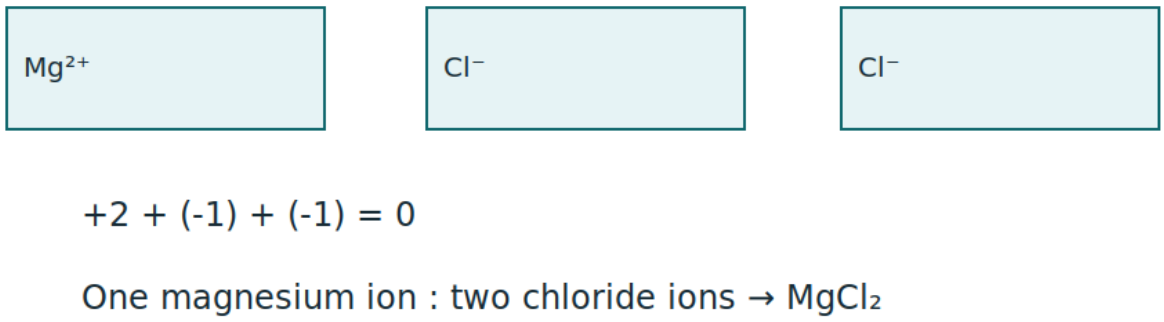
- $3Ca(OH)_2$ multiplies every count by 3: 3 calcium, 6 oxygen and 6 hydrogen.

Ions and simple compound formulae

An ion is an atom or group of atoms with an electrical charge.

- Losing electrons makes an atom positive. Gaining electrons makes it negative.
- In simple ionic compounds: group 1 metals form +1 ions; group 2 metals form +2 ions; group 17 forms −1 ions; group 16 forms −2 ions.
- An ionic compound has no overall charge: positive and negative charges balance.
- Na^+ and Cl^- balance in a 1:1 ratio, giving NaCl.
- One Mg^{2+} needs two Cl^- ions, giving $MgCl_2$. Ionic formulae show the simplest ratio of ions.

Ions	Ratio needed	Formula
Na^+ and Cl^-	1 sodium : 1 chloride	NaCl
Mg^{2+} and Cl^-	1 magnesium : 2 chloride	$MgCl_2$
Na^+ and O^{2-}	2 sodium : 1 oxide	Na_2O
Mg^{2+} and O^{2-}	1 magnesium : 1 oxide	MgO



One magnesium ion with charge +2 balances two chloride ions, each with charge −1. The simplest ratio gives $MgCl_2$.

Atomic number and mass number

> **Mass number**
> The total number of protons and neutrons in one atom.

Atomic number and mass number tell you different things about an atom.

- Atomic number counts protons. Mass number counts protons + neutrons.
- Example: 8 protons and 10 neutrons give atomic number 8 and mass number 18. The atom is oxygen.

- Isotopes are atoms of the same element with different numbers of neutrons.
- Relative atomic mass on a periodic table is an average for the isotopes. It can be a decimal.

Worked examples

How many calcium, oxygen and hydrogen atoms are represented by $3Ca(OH)_2$?

Work through it

1. Start with $Ca(OH)_2$. Ca has no subscript, so it represents 1 calcium atom.
2. The 2 outside the brackets means 2 oxygen atoms and 2 hydrogen atoms.
3. The 3 in front multiplies all three counts: calcium = 3, oxygen = 6, hydrogen = 6.

Another example

1. To find the formula of magnesium chloride, use Mg^{2+} and Cl^{-}.
2. One Mg^{2+} has charge +2. Two Cl^{-} ions have total charge −2.
3. The charges balance in a 1:2 ratio, so write $MgCl_2$.

Common mistakes

Common mistake: A group is a horizontal row.

Remember: A group is a vertical column; a period is a horizontal row.

Common mistake: $3H_2O$ contains only two hydrogen atoms.

Remember: The coefficient multiplies the whole formula: $3H_2O$ contains 6 hydrogen atoms and 3 oxygen atoms.

Answering questions

- When counting atoms, apply bracket subscripts first, then multiply every count by the coefficient.
- For a simple ionic formula, write the ion charges and choose the smallest whole-number ratio that balances them.

Try an investigation

Find sodium, magnesium and chlorine on a periodic table. Record each symbol, atomic number, group and period. Use coloured counters to represent atoms, then build the examples H_2O, CO_2 and $3H_2O$.

Plan, record and review

- Question and prediction: What are you testing, and what do you think will happen? Give a reason.
- Change, measure, keep the same: What will you deliberately change? What will you measure, and in what units? What stays the same to make it a fair test? For an observation, say what you will record consistently instead.
- Record and look for a pattern: Use a table with headings and units. Look for a pattern or a result that does not fit.
- Conclude from evidence: Answer your question using a result or observation. Say if the evidence is unclear.
- Improve the investigation: What would you repeat or change, and how would that make the evidence better?

Do practical work with your teacher and follow the laboratory safety instructions.