

Chemical Names and Formulas

How do you name a compound and write its formula?

●○○ Beginner

Foundations

Last reviewed 5 October 2026

Before you start: it helps to understand [Classification of Matter](#).

What is it?

Every compound has a **formula** and a **name**. The formula shows which elements are present and in what ratio; the name says the same thing in words. NaCl is sodium chloride; CO_2 is carbon dioxide. Chemists around the world follow the same naming rules, set by IUPAC (the International Union of Pure and Applied Chemistry), so a name means exactly one substance.

There are two main families, named in different ways:

- **Ionic compounds**, made of a **metal** (or the ammonium ion) combined with a non-metal: name the ions. Example: MgCl_2 , magnesium chloride.
- **Molecular (covalent) compounds**, made of **non-metals only**: use Greek prefixes to count the atoms. Example: N_2O_4 , dinitrogen tetroxide.

KEY IDEA

An ionic compound has **no overall charge**: the positive charges of the cations exactly cancel the negative charges of the anions. That single rule lets you write the formula of any ionic compound from its name.

Why does it matter?

- **It's the language of chemistry.** Equations, labels, recipes and safety data sheets all use formulas and names.
- **Safety.** Sodium chloride is table salt; sodium chlorate is a weedkiller and strong oxidizer. One syllable separates them.
- **Calculations depend on it.** You can't find a molar mass or balance an equation without the correct formula.

How does it work?

1. Common ions

You will meet these ions again and again:

Positive ions (cations)	Negative ions (anions)
H ⁺ hydrogen, Na ⁺ sodium, K ⁺ potassium, Ag ⁺ silver	F ⁻ fluoride, Cl ⁻ chloride, Br ⁻ bromide, I ⁻ iodide
NH ₄ ⁺ ammonium	OH ⁻ hydroxide, NO ₃ ⁻ nitrate, HCO ₃ ⁻ hydrogencarbonate
Mg ²⁺ magnesium, Ca ²⁺ calcium, Ba ²⁺ barium, Zn ²⁺ zinc	O ²⁻ oxide, S ²⁻ sulfide
Al ³⁺ aluminium	SO ₄ ²⁻ sulfate, CO ₃ ²⁻ carbonate
Fe ²⁺ iron(II), Fe ³⁺ iron(III)	PO ₄ ³⁻ phosphate, N ³⁻ nitride
Cu ⁺ copper(I), Cu ²⁺ copper(II)	CH ₃ COO ⁻ ethanoate (acetate)

Groups of atoms that carry a charge together, such as SO₄²⁻, are **polyatomic ions**.

2. Naming ionic compounds

- Name the **cation first**, then the **anion**: KBr is potassium bromide.
- A simple anion from one element ends in **-ide**: chloride, oxide, sulfide.
- Most polyatomic anions containing oxygen end in **-ate**: sulfate, nitrate, carbonate.
- A metal that can form more than one ion (many transition metals) gets a **Roman numeral** for its charge: FeCl₂ is iron(II) chloride; FeCl₃ is iron(III) chloride.
- No prefixes** are used: CaCl₂ is calcium chloride, not calcium dichloride.

3. Writing ionic formulas

- Write the two ions with their charges.
- Choose the **smallest numbers** of each ion that make the total charge zero.
- Write the numbers as subscripts (leave out 1). Put a **polyatomic ion in brackets** if you need more than one of it: Ca(OH)₂, (NH₄)₂SO₄.

4. Naming molecular compounds

Use a Greek prefix for the number of each kind of atom, and end the second element with **-ide**:

Number	Prefix	Number	Prefix
1	mono	6	hexa
2	di	7	hepta
3	tri	8	octa
4	tetra	9	nona
5	penta	10	deca

- “Mono” is **not** used for the first element: CO is carbon monoxide, not monocarbon monoxide.
- The final “a” or “o” of the prefix is dropped before “oxide”: monoxide, tetroxide, pentoxide.

Examples: CO₂ carbon dioxide, SO₃ sulfur trioxide, N₂O₅ dinitrogen pentoxide, SF₆ sulfur hexafluoride. Some molecules keep common names: H₂O is water, NH₃ is ammonia and CH₄ is methane.

5. Common acids

Acids are named by tradition: HCl hydrochloric acid, HNO₃ nitric acid, H₂SO₄ sulfuric acid, H₃PO₄ phosphoric acid, H₂CO₃ carbonic acid and CH₃COOH ethanoic (acetic) acid.

∞ THINK OF IT LIKE THIS

Think of charges as weights on a see-saw that must balance exactly. To balance Al³⁺ (3 units on one side) against O²⁻ (2 units on the other), the smallest balanced load is two aluminium ions (6 units) against three oxide ions (6 units). So aluminium oxide is Al₂O₃.

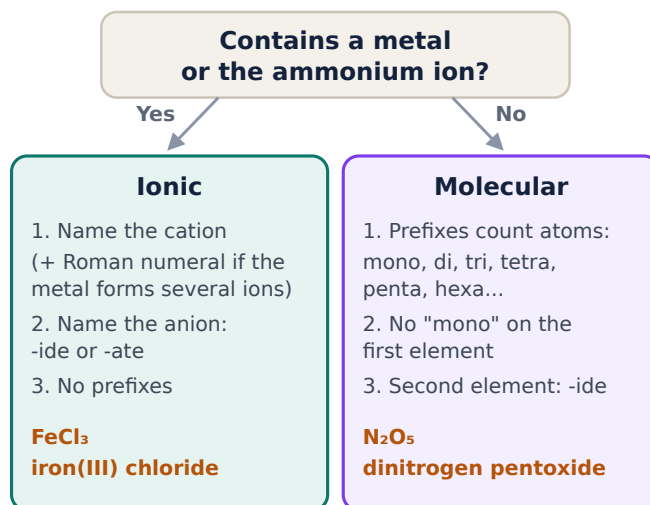
Q MORE PRECISELY

The Roman numeral is the **oxidation state** of the metal (see [Redox Reactions](#)). Older names used endings instead, such as ferrous (Fe²⁺) and ferric (Fe³⁺); you may still see them on old bottles. **Hydrates** include water in the crystal: CuSO₄ · 5 H₂O is copper(II) sulfate pentahydrate. IUPAC prefers “hydrogencarbonate” to the older “bicarbonate”.

Visualise it

Naming a compound

First decide: ionic or molecular?



Ionic or molecular? Decide first; the rules for naming follow.

Worked example

WORKED EXAMPLE: Formula from a name: aluminium oxide

Question: Write the formula of aluminium oxide.

Step 1 Ions: Al^{3+} and O^{2-} .

Step 2 The smallest whole-number total that both 3 and 2 divide into is 6, so use 2 aluminium ions and 3 oxide ions:

$$2 \times (+3) + 3 \times (-2) = 0$$

Step 3 Formula: Al_2O_3 .

WORKED EXAMPLE: A polyatomic ion: calcium nitrate

Question: Write the formula of calcium nitrate.

Step 1 Ions: Ca^{2+} and NO_3^- . Two nitrate ions balance one calcium ion: $(+2) + 2 \times (-1) = 0$.

Step 2 Two nitrate ions need brackets: $\text{Ca}(\text{NO}_3)_2$. The subscript 2 applies to the whole NO_3 group, so the formula contains 1 Ca, 2 N and 6 O.

 WORKED EXAMPLE: Name from a formula: FeCl_3

Question: Name FeCl_3 .

Step 1 Iron forms more than one ion, so find its charge. Three chloride ions give $3 \times (-1) = -3$.

Step 2 The compound is neutral, so iron is $+3$: **iron(III) chloride**.

 WORKED EXAMPLE: Naming a molecular compound

Question: Name P_4O_{10} and write the formula of nitrogen trifluoride.

Step 1 Two non-metals, so use prefixes: 4 = tetra, 10 = deca. P_4O_{10} is **tetraphosphorus decoxide**.

Step 2 Nitrogen trifluoride: no prefix on nitrogen means 1, tri means 3: NF_3 .

Common mistake

 COMMON MISTAKE: Using prefixes for ionic compounds

MgCl_2 is magnesium chloride, **not** magnesium dichloride. The charges already fix the ratio, so ionic names never use prefixes. Prefixes are only for compounds of non-metals.

 COMMON MISTAKE: Mixing up -ide and -ate

Sodium sulfide is Na_2S ; sodium sulfate is Na_2SO_4 . “-ide” usually means a single element; “-ate” means a polyatomic ion with oxygen.

 COMMON MISTAKE: Forgetting brackets, or writing charges in the formula

Calcium hydroxide is $\text{Ca}(\text{OH})_2$, not CaOH_2 , which would mean one O and two H. And the charges are used to work out the formula but are **not written** in it: NaCl , not Na^+Cl^- .

 NOTATION NOTE

- The Roman numeral follows the metal name directly, with no space: iron(III) chloride.
- A charge is written as a superscript with the number first, then the sign: Mg^{2+} and SO_4^{2-} .

Remember this

REMEMBER THIS

- Metal (or NH_4^+) + non-metal: **ionic**. Name the cation, then the anion; no prefixes.
- Roman numerals give the charge of metals that form more than one ion: iron(II), iron(III), copper(II).
- -ide: one element (chloride, oxide). -ate: polyatomic ion with oxygen (sulfate, nitrate).
- Write ionic formulas so the charges add to zero; bracket a polyatomic ion used more than once.
- Non-metals only: **molecular**. Use mono, di, tri, tetra...; no “mono” on the first element.

References

1. Brown, T. L.; LeMay, H. E., Jr.; Bursten, B. E.; Murphy, C. J.; Woodward, P. M.; Stoltzfus, M. W. Chemistry: The Central Science, 15th ed.; Pearson, 2022.

Practise this topic with flashcards and a quiz at chemistryclarity.com/chemistry/chemical-names-and-formulas/