

How atoms join to make molecules

Grade 8 science (Year 9 · Class 8) · Lesson

Quick answer: An atom is the smallest particle of an element, and a molecule is two or more atoms bonded together. A chemical formula such as H_2O shows which atoms are in one molecule and how many: two hydrogen atoms and one oxygen atom. A subscript counts atoms; a coefficient in front counts whole molecules.

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What are atoms and molecules?

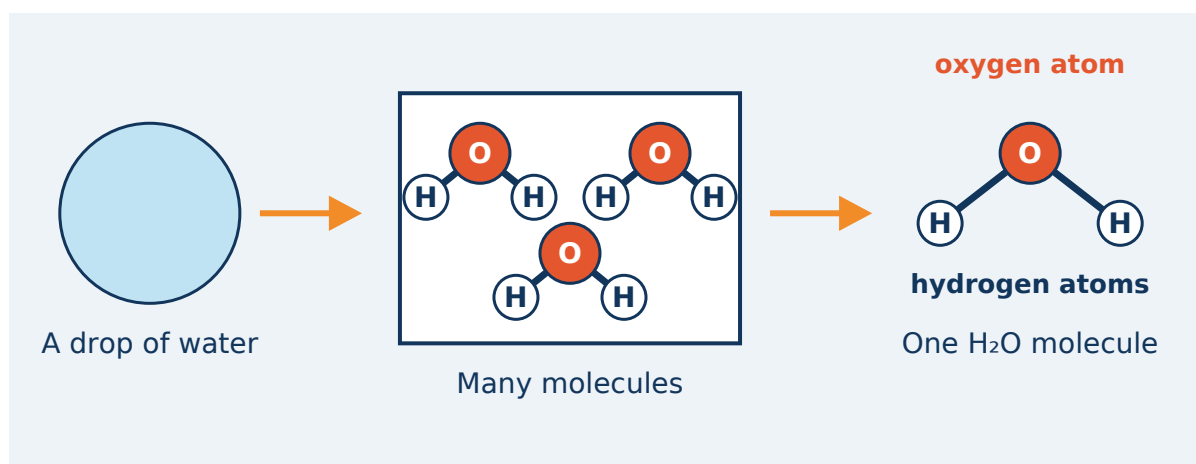
Everything you can touch, from a cricket ball to the air in your lungs, is built from atoms. An atom is far too small to see with a school microscope: about ten million of them side by side would measure only one millimetre. Atoms are the building blocks, and most of the time they do not travel alone.

Definition

An **atom** is the smallest piece of an element that still has the properties of that element. A **molecule** is a group of two or more atoms joined together by chemical bonds and behaving as one particle.

How do atoms join to make molecules?

Atoms link up by **bonds**. When two hydrogen atoms and one oxygen atom bond in a bent shape, they form a water molecule. Change the atoms or the way they connect and you get a completely different substance. Oxygen in the air is made of molecules with two oxygen atoms, yet ozone high in the sky has three, and it behaves very differently.



Zooming in on water: a drop is made of countless molecules, and each molecule is made of three atoms.

Two kinds of molecule exist. An element molecule contains only one kind of atom (such as O_2 or N_2). A compound molecule contains at least two different kinds (such as H_2O or CH_4).

How do you read a chemical formula?

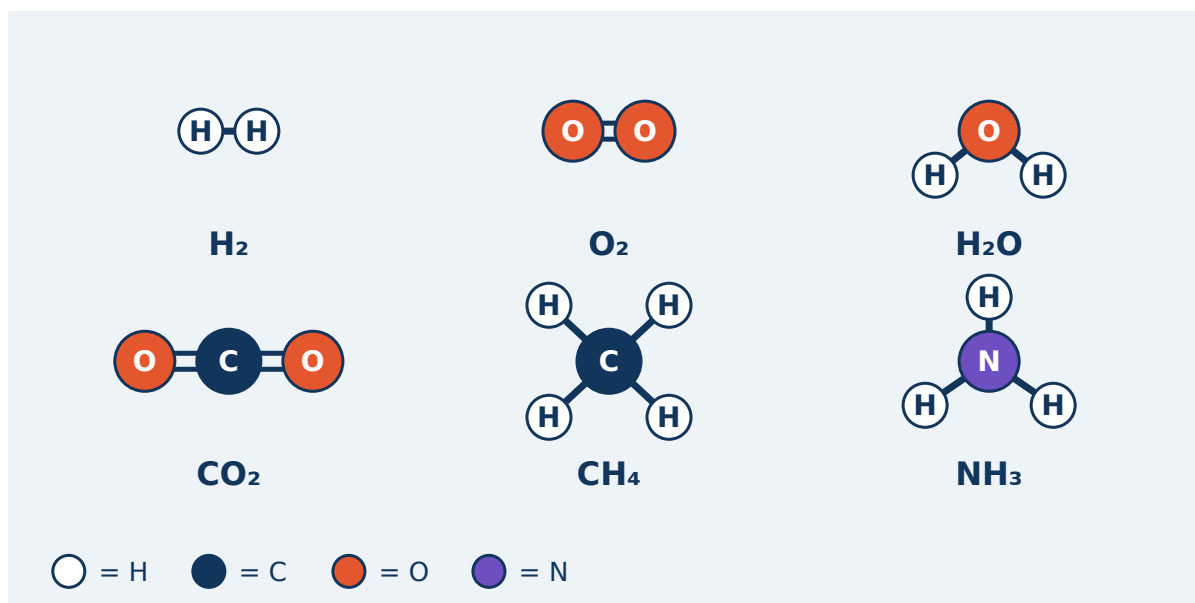
A **chemical formula** is a short code that tells you which atoms are in one molecule and how many. Each atom type is written with a symbol, and a small number written below and to the right, the **subscript**, shows how many atoms of that type there are. No number means one.

Formula

Total atoms in a molecule = sum of all the subscripts (a missing subscript counts as 1).

Example: in H_2SO_4 the symbol H has subscript 2, S has 1 and O has 4.

Substance	Formula	Atoms in one molecule	Elements
Oxygen gas	O_2	2	1 (oxygen)
Water	H_2O	3	2 (hydrogen, oxygen)
Carbon dioxide	CO_2	3	2 (carbon, oxygen)
Methane	CH_4	5	2 (carbon, hydrogen)
Ammonia	NH_3	4	2 (nitrogen, hydrogen)



Ball-and-stick models: balls are atoms, sticks are bonds. Colours: white H, navy C, red O, violet N.

Worked example 1

Aarav in Pune reads the formula of glucose on a sports-drink label: $\text{C}_6\text{H}_{12}\text{O}_6$. How many atoms are in one molecule?

Subscripts: C is 6, H is 12, O is 6.

Total = $6 + 12 + 6 = \mathbf{24 \text{ atoms}}$.

What is the difference between a subscript and a coefficient?

A subscript sits inside a formula and cannot be changed without changing the substance. A

coefficient is a large number written in front of the whole formula and counts how many molecules there are. It multiplies every subscript after it.



coefficient = 3

subscript = 2



3 oxygen atoms + 6 hydrogen atoms
= 9 atoms in total

The coefficient 3 counts molecules; the subscript 2 counts hydrogen atoms inside each molecule.

Worked example 2

Chiamaka in Lagos writes 4 NH_3 . How many atoms of each element, and how many in total?

Coefficient 4 means 4 molecules. Nitrogen: $4 \times 1 = 4$. Hydrogen: $4 \times 3 = 12$.

Total = $4 + 12 = \mathbf{16 \text{ atoms}}$ (4 N and 12 H).

Common mistake

Many students read $2 \text{ H}_2\text{O}$ as "two hydrogens and one oxygen". In fact $2 \text{ H}_2\text{O}$ is two whole molecules: 4 hydrogen atoms and 2 oxygen atoms. Multiply the coefficient by every subscript.

Why do scientists use molecular models?

Atoms are so small that nobody can look at a single molecule with the naked eye, so chemists build models. In a ball-and-stick model each ball is an atom and each stick is a bond. Models show how many atoms there are and how they are connected, but not their true size, colour or the empty space inside. Real atoms have no colours; the colours are just a code.

Lina's tip

Always count atoms in two steps: first read the subscripts for one molecule, then multiply by the coefficient. Underline each symbol as you go so none is missed.

Key points to remember

- An atom is the smallest particle of an element; a molecule is two or more atoms bonded together.
- A subscript in a formula counts atoms of that type inside one molecule (H_2O has 3 atoms).
- A coefficient in front of a formula counts molecules and multiplies every subscript ($3 \text{ H}_2\text{O}$ has 9 atoms).

- Atoms are about 1×10^{-10} m across, too small to see.
- Ball-and-stick models show connections, not true size or colour.

How atoms join to make molecules: frequently asked questions

What is the difference between an atom and a molecule?

An atom is a single particle of an element, while a molecule contains two or more atoms joined by bonds. For example, one oxygen atom is O, but the oxygen we breathe is made of O₂ molecules.

How do you count atoms in a formula?

Add the subscripts of all the symbols, counting a missing subscript as 1. For CH₄ that gives 1 + 4 = 5 atoms. If there is a coefficient in front, multiply the total by it.

What does the number in front of a formula mean?

It is a coefficient and shows how many molecules there are. So 2 CO₂ means two molecules of carbon dioxide, which contain 2 carbon atoms and 4 oxygen atoms.

How big is an atom?

A typical atom is about 0.1 nm, or 1×10^{-10} m, across. About ten million atoms in a row would fit across 1 mm.

Why are molecular models coloured?

The colours are a code that makes it easy to tell the atoms apart, such as red for oxygen and white for hydrogen. Real atoms are not coloured like this, and models do not show true sizes.