

AM-03.02 — Molecule and chemical formula: why H₂O means exactly two H for one O

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Course compass

Guiding question: What does a chemical formula tell you, and what does it still leave out?

Markers: MEASURED · CONVENTION · CALCULATED · TEACHING ASSUMPTION · APPROXIMATION

- read H₂O
- distinguish subscript and coefficient
- count atoms
- prepare for chemical reactions

Essential answer

Molecule and chemical formula: why H₂O means exactly two H for one O. The question to solve is: What does a chemical formula tell you, and what does it still leave out? Markers: MEASURED · CONVENTION · CALCULATED · TEACHING ASSUMPTION · APPROXIMATION read H₂O distinguish subscript and coefficient count atoms prepare for chemical reactions? A molecule is a bonded set of atoms. A formula states which elements are present and, in a simple molecular formula, how many atoms of each kind. The rest of the course turns that idea into an auditable line of reasoning: explicit units, stated assumptions, reproducible calculations, order-of-magnitude checks and interpretation limits. A result is useful only when the reader can explain what it measures, where every input came from and which engineering decision it can support.

Starting synthesis: derivations, examples, limitations and sources are developed in the course body.

Key terms before you start

mole · unit · order of magnitude · assumption · approximation

1 — A molecule combines atoms

A molecule is a bonded set of atoms. A formula states which elements are present and, in a simple molecular formula, how many atoms of each kind.

The small lower number is a subscript.

2 — Read H₂O step by step

H = hydrogen; subscript 2 = two H atoms; O = oxygen; no subscript after O = one O atom.

The formula does not mean “two hydrogen molecules plus oxygen”.

3 — Coefficient and subscript do different jobs

2 H₂O means two water molecules. Coefficient 2 multiplies the entire formula; subscript 2 belongs only to H inside each molecule.

This becomes essential when balancing reactions.

4 — Formula complete structural drawing

A molecular formula does not always show geometry, bond energy, or physical state.

It is compact notation, not a photograph.

Three complete examples: change one assumption to understand

Before each calculation, identify where every number comes from and whether it is measured, conventional, assumed, or calculated.

Example A — H_2O

One molecule: $2 \text{ H} + 1 \text{ O} = 3$ atoms total.

Count from subscripts.

Example B — $3 \text{ H}_2\text{O}$

Three molecules: $3 \times 2 = 6$ H and $3 \times 1 = 3$ O.

The coefficient multiplies every atom in the formula.

Example C — CO_2

$1 \text{ C} + 2 \text{ O} = 3$ atoms per molecule. Two CO_2 molecules contain 2 C and 4 O.

Same reading logic.

Inverse calculation

If a collection contains 8 H atoms as H_2O molecules, the corresponding molecule count is $8/2=4$, so it also contains 4 O atoms.

Common trap and result check

Trap: changing a subscript to balance a reaction. Changing a subscript changes the substance; coefficients are adjusted instead.

Check units, sign, order of magnitude, and consistency with a limiting case.

Exercises and answers

Restate

Explain in your own words what the equation connects.

Vary

Halve one input and predict the result before calculating.

Check

What independent check can you perform?

Primary and educational sources

- NASA Science - Basics of Space Flight Glossary
- NIST - International System of Units (SI)