

Molarity and Solution Stoichiometry

How do you calculate molarity?

●●○ Intermediate

Solutions

Last reviewed 3 October 2026

Before you start: it helps to understand [The Mole Concept](#) and [Stoichiometry](#).

What is it?

A **solution** is a mixture in which one substance, the **solute**, is dissolved in another, the **solvent** (often water).

Molarity tells you how concentrated a solution is: the number of **moles of solute per litre of solution**.

$$\text{molarity} = \frac{\text{moles of solute}}{\text{litres of solution}}$$

Its unit is mol/L, written **M** (read “molar”). A 0.500 M solution contains 0.500 mol of solute in every litre.

KEY IDEA

Molarity turns a **volume** of solution into **moles**: $\text{moles} = \text{molarity} \times \text{volume (in litres)}$. That makes reactions in solution work just like the stoichiometry you already know.

Why does it matter?

Most chemistry in the lab, in medicine and in living things happens in solution. Chemists can't weigh a substance once it's dissolved, but they can measure volumes very accurately. Molarity connects the volume measured with a pipette or burette to the number of moles that react, for example in a **titration**, where an acid is measured against a base to find an unknown concentration.

How does it work?

1. Calculating molarity

Find the moles of solute, convert the volume of **solution** to litres ($\text{mL} \div 1000$), then divide.

2. Making a solution

Rearranging gives $\text{moles} = \text{molarity} \times \text{volume}$. Convert those moles into a mass with the molar mass, weigh it out, dissolve it in some water, then add water **up to** the final volume (usually in a volumetric flask).

3. Diluting a solution

Adding water spreads the same number of moles through a bigger volume. The moles of solute don't change, so:

$$M_1 V_1 = M_2 V_2$$

where M_1 , V_1 are the concentration and volume before dilution and M_2 , V_2 after. The volumes can be in any unit, as long as both use the same one.

4. Solution stoichiometry

Use the same road map as before, with volumes in place of masses: **volume** → **moles** → **(mole ratio)** → **moles** → **volume**.

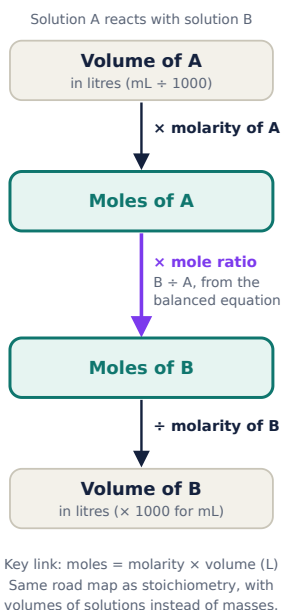
∞ THINK OF IT LIKE THIS

Think of fruit squash. Adding more water doesn't change the amount of sugar in the jug; it only spreads it out, so each glass tastes weaker. That's dilution: same moles of solute, bigger volume, lower molarity.

🔍 MORE PRECISELY

Molarity depends slightly on temperature, because the volume of a solution expands or contracts as it warms or cools. For work where that matters, chemists sometimes use **molality** (moles of solute per kilogram of solvent), which doesn't change with temperature.

Visualise it



Solution stoichiometry: volume → moles → moles → volume.

Worked example

WORKED EXAMPLE: Calculating molarity

Question: 5.85 g of sodium chloride is dissolved in water to make 250.0 mL of solution. What is the molarity? (Na = 22.99, Cl = 35.45)

Step 1 Moles: $M(\text{NaCl}) = 58.44 \text{ g/mol}$, so $n = \frac{5.85}{58.44} = 0.1001 \text{ mol}$

Step 2 Volume in litres: $250.0 \text{ mL} \div 1000 = 0.2500 \text{ L}$

Step 3 Molarity = $\frac{0.1001 \text{ mol}}{0.2500 \text{ L}} = 0.400 \text{ M}$

WORKED EXAMPLE: Making a solution

Question: What mass of sodium hydroxide is needed to make 500.0 mL of 0.200 M NaOH solution? (Na = 22.99, O = 16.00, H = 1.008)

Step 1 Moles needed: $0.200 \text{ mol/L} \times 0.5000 \text{ L} = 0.1000 \text{ mol}$

Step 2 Molar mass of NaOH: $22.99 + 16.00 + 1.008 = 40.00 \text{ g/mol}$

Step 3 Mass: $0.1000 \times 40.00 = 4.00 \text{ g}$

Answer: dissolve **4.00 g** of NaOH and make the solution up to 500.0 mL.

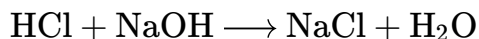
 WORKED EXAMPLE: Dilution

Question: 25.0 mL of 6.00 M HCl is diluted with water to 150.0 mL. What is the new concentration?

$$M_2 = \frac{M_1 V_1}{V_2} = \frac{6.00 \times 25.0}{150.0} = 1.00 \text{ M}$$

 WORKED EXAMPLE: Titration

Question: What volume of 0.100 M NaOH exactly neutralizes 25.00 mL of 0.150 M HCl?



Step 1 Moles of HCl: $0.150 \times 0.02500 = 0.003750 \text{ mol}$

Step 2 Mole ratio 1 : 1, so moles of NaOH = 0.003750 mol

Step 3 Volume of NaOH: $\frac{0.003750}{0.100} = 0.0375 \text{ L} = 37.5 \text{ mL}$

Common mistake

 COMMON MISTAKE: Forgetting to convert mL to litres

Molarity uses **litres**. Using 250.0 instead of 0.2500 in the first example gives 0.000400 M, a thousand times too small.

 COMMON MISTAKE: Volume of solvent instead of volume of solution

“Make 250.0 mL of solution” means the **final** volume is 250.0 mL. Dissolving the solid in 250.0 mL of water gives a slightly different volume, and therefore a slightly different molarity.

 COMMON MISTAKE: Ignoring the mole ratio in titrations

Sulfuric acid, H_2SO_4 , has two protons: $\text{H}_2\text{SO}_4 + 2 \text{NaOH} \longrightarrow \text{Na}_2\text{SO}_4 + 2 \text{H}_2\text{O}$. It needs **twice** as many moles of NaOH as HCl does. Always use the balanced equation.

NOTATION NOTE

- The letter **M** is used for two different things: **molar mass** (g/mol, often italic *M*) and the unit **molar** (mol/L). Read the context and the units carefully.
- IUPAC calls molarity the **amount concentration**, with symbol *c* and unit mol/L, also written mol dm⁻³ (1 dm³ = 1 L), especially in UK courses.
- Square brackets show a concentration: [NaCl] = 0.400 M.

Remember this

REMEMBER THIS

- Molarity (M) = moles of solute ÷ litres of solution.
- moles = molarity × volume (L).
- Dilution: $M_1 V_1 = M_2 V_2$ (moles stay the same).
- Solutions in reactions: volume → moles → mole ratio → moles → volume.

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.

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