Science 10

## Unit A: Energy and matter in chemical change

# The mole and conservation of mass

# The mole

- A dozen always means 12 objects; one mole always means $6.022 \times 10^{23}$ representative particles.
- Individual atoms and molecules are too small to count directly, so chemists count moles by measuring a sample's mass.
- About 18.02 g of water is one mole of water molecules because water's molar mass is about 18.02 g/mol.

# Amount and number of particles

- A 0.50 mol water sample contains about $3.011 \times 10^{23}$ water molecules because amount is multiplied by Avogadro's number.
- Each water molecule contains three atoms, so 0.50 mol of water molecules contains about $9.033 \times 10^{23}$ atoms in total.
- In a balanced reaction, coefficients compare amounts in moles, for example, 2 mol hydrogen reacts with 1 mol oxygen.

# Key terms

### mole

The International System of Units (SI) amount unit: $6.022 \times 10^{23}$ representative particles. (mol)

### Avogadro's number

The number of representative particles in one mole: $6.022 \times 10^{23}$ per mole. ($N_a$)

### molar mass

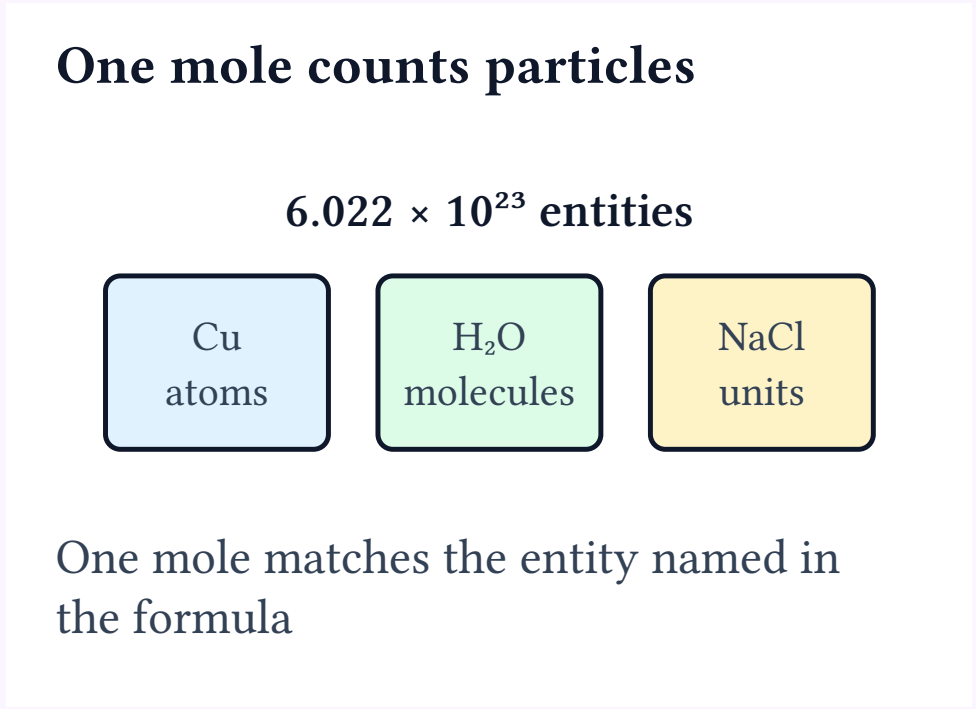
The mass of one mole of a substance, usually measured in grams per mole.

### coefficient

A whole number placed before a chemical formula that multiplies every atom in that formula.

# What one mole counts

- One mole contains $6.022 \times 10^{23}$ specified representative entities.
- Use atoms for elements such as copper, molecules for substances such as water, and formula units for ionic compounds such as sodium chloride.
- A numerical particle answer is incomplete unless the entity and unit are named.



# Molar mass

- For $CO_2$, add one carbon atomic mass and two oxygen atomic masses.
- Calculation: 12.01 g/mol + 2(16.00 g/mol) = 44.01 g/mol.
- A coefficient changes the amount of $CO_2$ present; the molar mass of $CO_2$ stays the same.

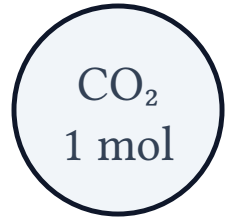
**Molar mass of $CO_2$**

**C 12.01 g/mol**

**O 16.00 g/mol × 2**

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**12.01 + 2(16.00) = 44.01 g/mol**



# From equation to mole ratios

- In $2H_2 + O_2 \longrightarrow 2H_2O$, the coefficient ratio $H_2$:$O_2$:$H_2O$ is 2:1:2.
- For 4.50 mol $H_2$, multiply by 1 mol $O_2$ / 2 mol $H_2$ to obtain 2.25 mol $O_2$.
- The $H_2$ unit cancels; the remaining mol $O_2$ unit identifies the requested substance and amount.

$$2\ H_2 + O_2 \longrightarrow 2\ H_2O$$

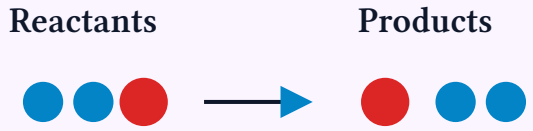
| 2 mol $H_2$ | 1 mol $O_2$ | 2 mol $H_2O$ |
|---|---|---|
| given | requested | product |

$$4.50\ \text{mol}\ H_2 \times (1\ \text{mol}\ O_2 / 2\ \text{mol}\ H_2) = 2.25\ \text{mol}\ O_2$$

The $H_2$ unit cancels; mol $O_2$ remains

# Conservation revisited

- For $2H_2 + O_2 \longrightarrow 2H_2O$, both sides contain 4 mol of H atoms and 2 mol of O atoms.
- The total amount of chemical substances changes from 3 mol of reactants to 2 mol of product; conservation applies to atoms and mass, so substance moles can change.
- Using molar masses gives 4.032 g $H_2$ + 32.00 g $O_2$ = 36.032 g $H_2O$, so total mass is conserved.




Same atoms: rearranged, not created or destroyed

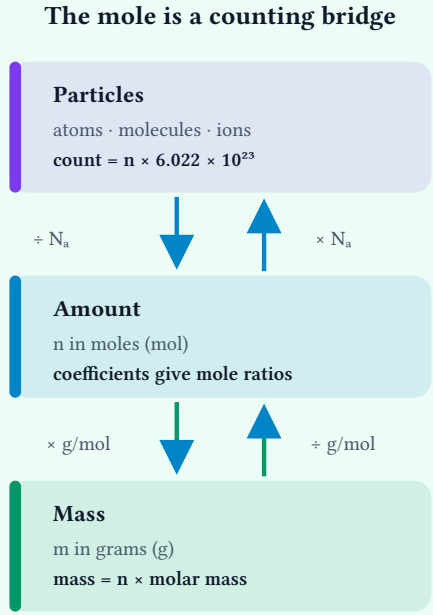
aw of conservation of mass ↔ balanced equations ↔ mole ratio

## Calculations

- Mole ratio: 4.0 mol $H_2$ × (1 mol $O_2$ / 2 mol $H_2$) = 2.0 mol $O_2$.
- Particle count: 0.500 mol NaCl × 6.022 × $10^{23}$ formula units/mol = 3.011 × $10^{23}$ formula units.
- In each calculation, choose the relationship, show unit cancellation, and name the representative entity.

# Directions on the mole map

- Convert $1.2044 \times 10^{24}$ water molecules to moles of water.
- Convert 0.125 mol water to number of water molecules.
- Before calculating, state whether the map calls for division or multiplication and identify the final unit.




Start from the known quantity; keep units beside every value.

# Mole and conservation retrieval check

- Convert 0.25 mol of water molecules to number of molecules.
- Find the molar mass of carbon dioxide from its formula.
- Use $2H_2 + O_2 \longrightarrow 2H_2O$ to find oxygen required for 6.0 mol hydrogen.