

counting atoms by weighing them, and the mole that makes the counting possible

The laws of chemical combination

- law of conservation of mass : in a chemical reaction, matter is neither created nor destroyed, so the total mass before equals the total mass after
- this is why a chemical equation must be balanced, and it is the reason a coefficient may be changed but never a subscript
- law of constant proportions : a pure compound always contains the same elements in the same proportion by mass, however it was made
- so water from any source is always 1 part hydrogen to 8 parts oxygen by mass
- Dalton's atomic theory explained both: matter is made of indivisible atoms, atoms of one element are identical, and they combine in simple whole number ratios
- two of Dalton's claims are now known to be wrong, since atoms are divisible and isotopes mean atoms of one element are not all identical



mass conserved

the two sides of a reaction weighed against each other: the atoms are rearranged into new combinations but none is created or lost, so the total mass on the right matches the total on the left exactly

Atomic and molecular mass

- masses of atoms are compared against a standard, one twelfth of a carbon-12 atom, called one atomic mass unit
- atomic mass is how many times heavier one atom is than that unit, so it is a ratio and has no unit of its own
- molecular mass is the sum of the atomic masses of every atom in the molecule
- for water, 2 hydrogens at 1 plus one oxygen at 16 gives 18
- formula unit mass is the same sum for an ionic compound, which has no true molecules: NaCl is 23 + 35.5 = 58.5
- count every atom, including those inside brackets: Ca(OH)₂ has two oxygens and two hydrogens

The mole relations *

Avogadro's number, particles in a mole

$$N_A = 6.022 \times 10^{23}$$

moles from mass

$$n = \frac{m}{M}$$

moles from number of particles

$$n = \frac{N}{N_A}$$

so number of particles from mass

$$N = \frac{m}{M} \times N_A$$

volume of a gas at standard conditions

$$V = n \times 22.4 \text{ litres}$$

the mole is the bridge in every calculation here: mass goes to moles, moles go to particles or volume, and there is no direct route from grams to atoms that does not pass through it

