

count in particles, weigh in grams: the mole is the bridge between them

Particles

N

the actual count of atoms, molecules, ions, whatever you're counting

→ converts to

Moles

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

divide the count by Avogadro's number, 6.022×10^{23} per mole

→ converts to

Mass

$$m = nM$$

multiply moles by M , the molar mass: the mass of one mole, in grams

mass divides by M to give moles back, and moles multiply by N_A to give the particle count back

Laws of chemical combination

- conservation of mass: total mass of reactants equals total mass of products, nothing created or destroyed
- definite proportions: a given compound always has its elements in the same mass ratio, however it's made
- multiple proportions: if two elements form more than one compound, the masses of one that combine with a fixed mass of the other are in a small whole-number ratio
- Gay Lussac's law of gaseous volumes: gases react, and their gaseous products form, in volumes that are simple whole-number ratios, at the same T and P
- Avogadro's law: equal volumes of any gas, at the same T and P, hold equal numbers of molecules

Atomic, molecular, formula mass

1 amu, one-twelfth the mass of a ^{12}C atom $1 \text{ amu} \approx 1.66 \times 10^{-24} \text{ g}$

molecular mass = sum of atomic masses of every atom in the molecule

$$M(\text{H}_2\text{O}) = 2(1) + 16 = 18 \text{ amu}$$

formula mass, used for ionic solids, which have no single discrete molecule

$$M(\text{NaCl}) = 23 + 35.5 = 58.5 \text{ amu}$$

gram atomic/molecular mass is the same number, just measured in grams instead of amu, and that's the step that turns a mass into a mole count

a mole is just a counting unit, the same job "dozen" does for eggs, and the number is 6.022×10^{23}

Dalton's atomic theory, briefly *

- matter is made of tiny indivisible atoms; atoms of one element are all identical, atoms of different elements differ in mass and properties
- compounds form when atoms of different elements combine in small whole-number ratios
- a chemical reaction just rearranges atoms: none are created, destroyed, or split, which is why mass is conserved
- it explains definite and multiple proportions neatly, but not isotopes, since atoms of one element turned out not to be quite identical after all

The mole, three ways to count

from a particle count

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

from a mass

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

from a gas volume, at STP only

$$n = \frac{V}{22.4 \text{ L}}$$

$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$, Avogadro's number, the same constant whether you're counting atoms, molecules, or ions