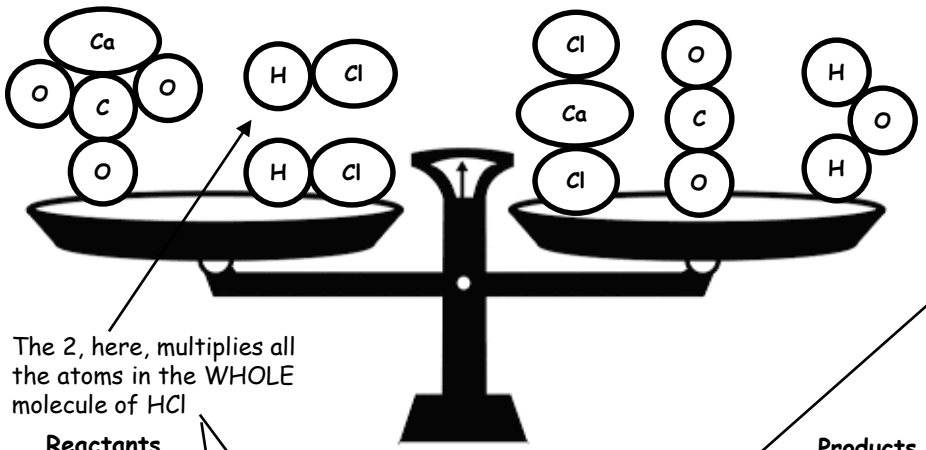
CONSERVATION of MASS (from C1)
The law of conservation of mass states that the total amount of substance in a chemical reaction does not change during the reaction. Another way of saying this is the total mass of **reactants** is the same as the total mass of the **products**

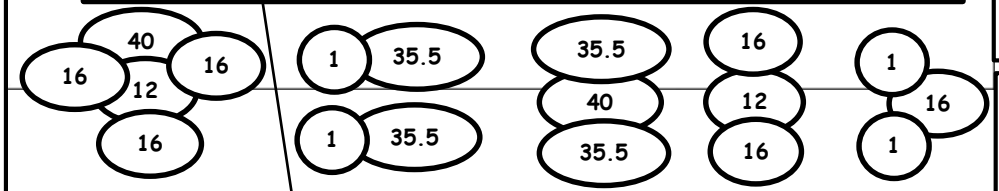
A balanced chemical equation represents this in a different way: it uses symbols and molecular formulae to show the same balance. The numbers of each type of atom at the start and the finish are the same.



The 2, here, multiplies all the atoms in the WHOLE molecule of HCl

Reactants **Products**

$$CaCO_{3(aq)} + 2\,HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2\,(g)} + H_2O_{(l)}$$



M_r = 40+12+16+16+16 = **100**

M_r = 1 + 35.5 = **36.5**

But there are 2 of them!

M_r = 40+35.5+35.5 = **111**

M_r = 12+16+16 = **44**

M_r = 16+1+1 = **18**

OH NO! THE LAW IS WRONG!
Sometimes it can appear that the law of conservation of mass is wrong! It can appear that the mass of substance has either increased or decreased.
This occurs in OPEN-SYSTEMS where (usually) a gas is allowed to escape or is used in the reaction.

In this reaction one of the products, CO_2, is a gas and can escape the reaction.

If I weigh the products it will appear that the mass has decreased.

BUT if I could catch and weigh the CO_2 and add it on, I would find the mass does balance! Phew!

RELATIVE masses, A_r and M_r
We cannot actually weigh atoms and molecules because they are TOO SMALL. However we can use RELATIVE masses to help us.

Each atom of an element has a RELATIVE ATOMIC MASS, A_r
This is how heavy the atom is compared to a single carbon atom. We assume a carbon atom has a relative mass of exactly 12.
Everything else is compared to this.

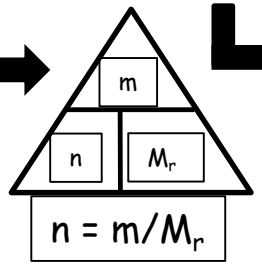
Symbols on the periodic table tell us how heavy each element is:

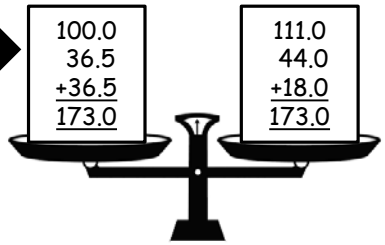
12	40	11
C	Ca	B
carbon	calcium	boron
6	20	5

← Atomic Mass A_r

In molecules we can add up the relative masses of EVERY ATOM to give the FORMULA MASS, M_r

MOLES 1 **(Higher)**
A MOLE is a numerical term, much like the words PAIR or DOZEN. It relates to a fixed number of something.
This fixed number is called the AVOGADRO NUMBER, 6.02×10^{23}
A MOLE of a substance will have a mass equal to its formula mass: e.g. if I have 6.02×10^{23} molecules of calcium carbonate, $CaCO_3$, it will have a mass of 100.0 g. There is a direct relationship between the number of **moles, n,** the **mass of substance, m** and the **formula mass of the same substance, M_r**

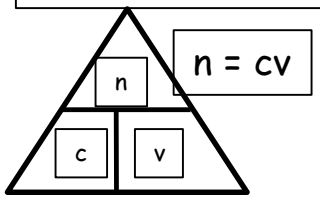




A useful check of your maths is to add up the formula masses for ALL reactants and compare to the total formula masses for ALL products. They MUST be the SAME!

MOLES 2 (Higher)
The equation shows **RATIOS of moles** of substance. I can read this as 1 mole of $CaCO_3$ reacts with 2 moles of HCl. If I start with 2 moles of $CaCO_3$, I will use 4 moles of HCl….and if I start with a $\frac{1}{4}$ mole of $CaCO_3$, I will need $\frac{1}{2}$ mole of HCl.

MOLES 3 (higher)
There are other tricks I can do knowing about moles.
1) LIMITING reagents
If I have LESS of one substance than expected for an equation it will stop the reaction once it has run out. It will **LIMIT** the reaction.
e.g. If I start with only 50 g of $CaCO_3$ in this reaction, instead of 100 g, it will only use up half the amount of HCl, even if I have more HCl present.
2) Working out MOLE ratios for equations
I can work backwards from masses to give the RATIOS by turning masses into moles, using $n = m/M_r$ then simplifying the ratio of moles.



Reactants → Products

$$CaCO_{3(aq)} + 2\,HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2\,(g)} + H_2O_{(l)}$$

M_r = **100** M_r = **36.5** M_r = **111** M_r = **44** M_r = **18**

CONCENTRATIONS of solutions

When a substance is dissolved in a solvent to produce a solution we can calculate the strength of the solution. The substance dissolved is called the solute and the amount of the solute per volume is called the CONCENTRATION.

Concentration, c (g/dm^3)= mass(g)/volume (dm^3)

If I dissolve 11.1 g of $CaCl_2$ in 1 dm^3 of water, the concentration c = 11.1/1 = 11.1 g/dm^3.
However if I dissolve 11.1 g of $CaCl_2$ in 0.25 dm^3, the concentration c = 11.1/0.25 = 44.4 g/dm^3
If the volume is given in different units make sure to convert it into dm^3 first:
11.1 g $CaCl_2$ dissolved in 200 cm^3 becomes (convert it into dm^3) 200/1000 dm^3 = 0.20 dm^3
And concentration c = 11.1/0.20 = 55.5 g/dm^3