Quantitative Chemistry

Conservation of Mass

The law of conservation of mass states that **no atoms are lost or made** during a chemical reaction so the mass of the products equals the mass of the reactants.

The sum of reactants
=
The sum of products

Balancing Equations: same number of atoms on both sides

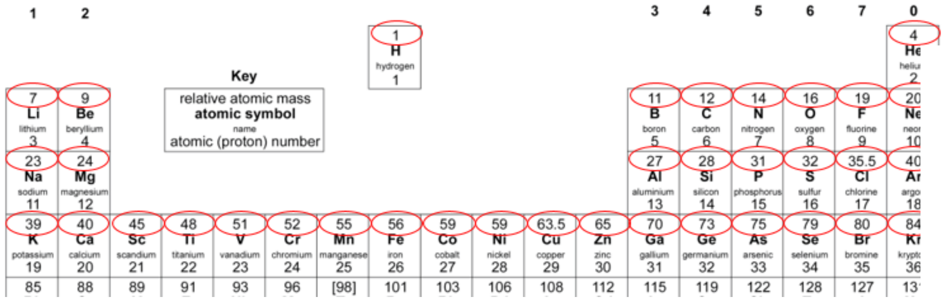
Reactants | Products

$2\,H_2 + O_2 \rightarrow 2\,H_2O$

Reactants	Products
H = 4	H = 4
O = 2	O = 2

Relative Formula Mass

The relative formula mass (M_r) of a compound is the sum of **the relative atomic masses** of the atoms in the numbers shown in the formula.



Use the relative atomic mass (**top number**)

CO_2

C atomic mass = 12

O atomic mass = 16

We have TWO oxygen

So 12 + (16 x 2) = **44**

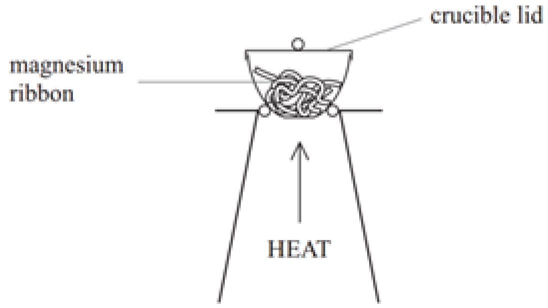
Increase in mass

Some reactions may appear to involve a change in mass but this can usually be explained because **a reactant or product is a gas** and its mass has not been taken into account.

magnesium + *oxygen* → *magnesium oxide*

$2\,Mg_{(s)} + O_{2\,(g)} \rightarrow 2\,MgO_{(s)}$

48 g/mol | 32 g/mol | 80 g/mol



Moles

Chemical amounts are measured in **moles** *(mol)*.

One mole of a substance contains the **same number** of the stated *particles, atoms, molecules or ions* as **one mole** of any other substance.

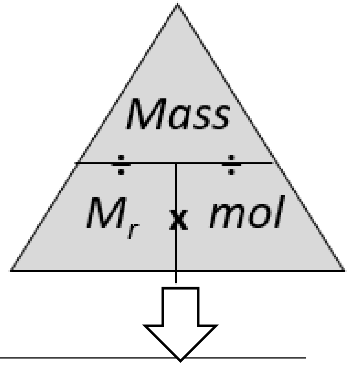
The number of atoms, molecules or ions in a mole of a given substance is the **Avogadro constant**. The value of the Avogadro constant is **6.02×10^{23} per mole**.

Important Equation

1 mol = 6.02×10^{23} atoms, molecules or ions (Avogrado's number)

$$Mass = M_r \times mol$$

Real world mass (g) — Relative formula mass (g/mol) — Number of moles (mol)



Amounts of substances

The masses of reactants and products can be calculated from **balanced symbol equations.**

Chemical equations can be interpreted in terms of moles. For example:

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

shows that one mole of magnesium reacts with two moles of hydrochloric acid to produce one mole of magnesium chloride and one mole of hydrogen gas

The coefficient is the number in front of a formula.
If there is no number in front, it is a 1.

Example Question

$1\ Mg_{(s)} + 2\ HCl_{(aq)} \rightarrow 1\ MgCl_{2\ (s)} + 1\ H_{2\ (g)}$

1) How many moles of hydrochloric acid would you need if you started with 3 moles of Mg?

6 moles of HCl, as for every 1 mole of Mg, you need 2 moles of HCl

2) How many moles of $MgCl_2$ would be produced if you had 10 moles of HCl?

5 moles of $MgCl_2$ are produced, as for every 1 mole of HCl, you produce 0.5 moles of $MgCl_2$

3) How many moles of Mg are required to fully react with 8 moles of HCl?

4 moles of Mg are required, because for every 1 mole of HCl, you need 0.5 moles of Mg.

Limiting Reactants

In a chemical reaction involving two **reactants**, it is common to use an excess of one of the reactants to ensure that all of the other **reactant** is used. The reactant that is completely used up is called **the limiting reactant** because it limits the amount of products.

Example Question

$CH_{4\ (g)} + 2\ O_{2\ (g)} \rightarrow CO_{2\ (g)} + 2\ H_2O_{\ (l)}$

	CH_4		O_2
Mass =	16 g	Mass =	50 g
M_r =	16 g/mol	M_r =	32 g/mol
Mol =	~~1.0 mol~~ 0.78 mol	Mol =	2.0 mol 1.56 mol

- We needed 2 moles but we actually only have 1.56 mol!
- 1.56 mol ÷ 2 = 0.78 mol.
- This means only 0.78 moles of methane can react, based on the 1:2 ratio.
- Oxygen is a limiting reagent and methane is in excess.

Concentrations

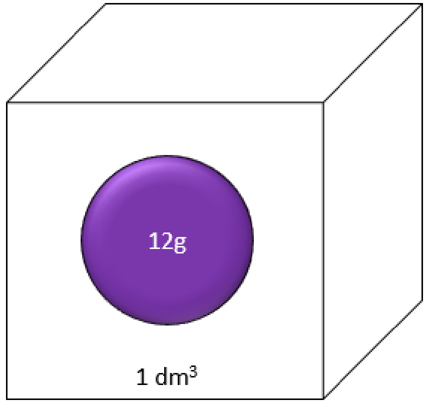
Chemists use a special unit called **decimetres**

$1\ dm^3 = 1000\ cm^3$

So to convert cm^3 into dm^3 you just have to divide by 1000

Example:
A solution has a volume of $500cm^3$, what is its volume in dm^3?

$$\frac{500\ cm^3}{1000} = 0.5\ dm^3$$



12 grams per dm^3 = 12 g/dm^3

Concentration = Quantity of solute ÷ volume