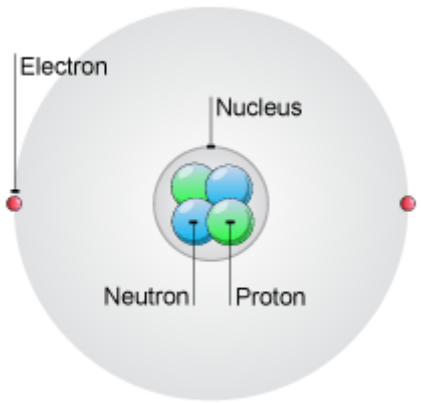
Unit 3: Quantitative Chemistry (Triple Content)



BBC Bitesize—Atomic Structure

Atoms consist of a small, dense nucleus made of protons and neutrons, with electrons arranged in shells around the outside.

The **Atomic Number** is the number of protons an atom of an element has.

The **Relative Atomic Mass** (A_r) is the *average* mass of the atom compared to Carbon-12. The mass of one atom only takes into account protons and neutrons (as the mass of an electron is 2000x smaller—so makes very little difference!)

- When atoms chemically combine (or **bond**) they form **compounds**
- The **Relative Formula Mass** (M_r) of a compound is found by adding together the Relative Atomic Masses of all the atoms in the compound

  E.g. M_r (C_2H_6) = (2 x 12) + (6 x 1) = 30g/mol

Measurement Uncertainty

- Whenever a measurement is made there is always some **uncertainty**.
- This is due to the **resolution** of your equipment e.g. your ruler only allows you to measure to the nearest millimetre!
- Uncertainty can be represented using a ± sign e.g. the temperature is 20 °C ± 2°C
- To calculate **percentage uncertainty** for a set of data:

  Percentage Uncertainty = (Range / Mean) x 100%
- You may be asked to do this from a graph or a table of data.

Conservation of Mass

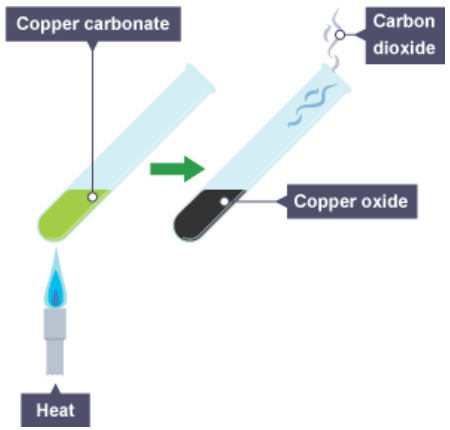
- In a **chemical reaction** no atoms can be **created** (made) or **destroyed** (lost)
- This means the mass of the **reactants** must equal the mass of the **products**
- Chemical reactions can be represented by symbol equations that are balanced in terms of the atoms of each element on both sides of the equation

E.g. $N_2 + 3H_2 \longrightarrow 2NH_3$

2 atoms Nitrogen	2 atoms Nitrogen
6 atoms Hydrogen	6 atoms Hydrogen

The **masses** of both sides of the equation also balance.

E.g. Reactants: (2 x 14) + = 30 Products = (2 x 14) + (6x1) = 30



BBC Bitesize—Thermal decomposition

Reactions involving gases

In a reaction involving gases, the mass may **appear** to change, because not all the atoms are weighed

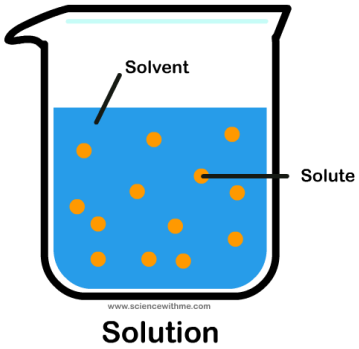
e.g. $CuCO_3$ (s) —> CuO (s) + CO_2 (g)

Although the copper carbonate weighs the same as the copper oxide and carbon dioxide put together, when you weigh your reaction vessel the carbon dioxide has already left—so the mass appears to have decreased.

Likewise, when a metal reacts with oxygen to make a metal oxide, the mass may **appear** to increase.

Look out for state symbols!

Unit 3: Quantitative Chemistry (Triple Content)



Concentration of Solutions

Many reactions take place in a **solution** (i.e. one substance dissolved in another)

Solute - a substance dissolved in another (e.g. salt)

Solvent - a liquid used to dissolve a solute (e.g. water)

Solution - a mixture of solute and solvent

Soluble (adj.) - able to be dissolved

The **ratio** of solute and solvent can be described as the solution's **concentration**.

Concentration = Mass of Solute ÷ Volume of Solvent

(g/dm^3) (g) (dm^3)

E.g. A salt solution containing 100g of salt dissolved in $2dm^3$ has a concentration of $100 \div 2 = 50g/dm^3$

You may also be asked to rearrange this equation, and use it to work out the Mass of Solute in a given volume of solution

Mass of Solute = Concentration x Volume of Solvent

(g) (g/dm^3) (dm^3)

E.g. $5dm^3$ of a $20g/dm^3$ solution contains 20 x 5 = 100g of solute.

Unit Conversion

- A decimetre cubed (dm^3) is the same size as a litre (l)
- There are 1000ml or $1000cm^3$ in 1 litre or 1 dm^3
- E.g. $5dm^3$ = 5l = 5000ml = $5000cm^3$

Balancing Equations

Balancing equations is about making sure there are the same number of atoms of each type on each side. An unbalanced equation like:

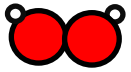
$$H_2 + O_2 \longrightarrow H_2O$$

Suggests that an oxygen atom has been lost: and we know that **never** happens in chemical reactions.

When you balance the equation, you can **only** put numbers **in front** of the chemicals to show that the numbers of them has changed

E.g. $2H_2O$ means there are now two water molecules:

But writing H_2O_2 would mean you had made a completely different chemical!



To Balance Equations

Step 1: Count the atoms you have on both sides of the equation.

$$H_2 + O_2 \longrightarrow H_2O$$

2 hydrogen, 2 oxygen 2 hydrogen, 1 oxygen

Step 2: Pick an element that is unbalanced, and add a number in front of the species containing it to help it balance:

$$H_2 + O_2 \longrightarrow 2H_2O$$

Step 3: Recount the atoms

2 hydrogen, 2 oxygen 4 hydrogen, 2 oxygen

Step 4: Pick a different element that is now unbalanced and add a number in front of the species containing it to help it balance:

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

Continue until all the elements are balanced!