



**1) Conservation of mass** – No atoms are lost or made during a chemical reaction so the mass of the products equals the mass of the reactants.

If an element is heated in the air, the mass appears to increase due to it reacting with oxygen.

In thermal decomposition reactions of metal carbonates the mass appears to decrease as one of the products is a gas and escapes.

e.g.

calcium carbonate → calcium oxide + carbon dioxide

### 2) Relative Atomic Mass (Ar)

The relative atomic mass of an element (Ar) is the average mass of the isotopes of that element.

### 3) Relative Formula Mass (Mr)

The relative formula mass (Mr) of a compound is the sum of the relative atomic masses of the atoms in the chemical formula.

(e.g. Mr of NaOH = 23 + 16 + 1 = 40)

**4) Isotopes** – Elements with the same number of protons but different number of neutrons (so they will have different relative masses).

### 5) Percentage by mass of an element

$$\% \text{ Mass} = \frac{\text{Total relative mass of the element}}{\text{Relative mass of whole compound}} \times 100$$

### 6) The mole (HT only)

A mole is an amount of substance. 1mol of any substance will contain the same number of particles ( $6.02 \times 10^{23}$ ).

This is known as the Avogadro constant.

e.g. 1 mol of H<sub>2</sub>O will contain  $6.02 \times 10^{23}$  molecules.

The relative mass of any substance, in grams, is equivalent to 1mol of that substance.

### 7) Calculating moles (HT only)

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

n = no. of moles (mols)

m = mass (grams)

M<sub>r</sub> = Relative atomic mass

### 8) Reacting Masses



If you have a 60g of Mg, what mass of HCl do you need to convert it to MgCl<sub>2</sub>?

A<sub>r</sub> : Mg = 24 so mass of 1 mole of Mg = 24g

M<sub>r</sub> : HCl (1 + 35.5) so mass of 1 mole of HCl = 36.5g

So 60g of Mg is  $60/24 = 2.5$  moles

Balanced symbol equation tells us that for every one mole of Mg, you need two moles of HCl to react with it.

So you need  $2.5 \times 2 = 5$  moles of HCl

You will need  $5 \times 36.5\text{g}$  of HCl = 182.5g

### 9) Limiting reactants

The reactant that is used up first is called the limiting reactant.

The other reactant is in excess.

This limits the amount of product that is made and ensures that one of the reactants is completely used up.

### 10) Concentration of solutions

Worked out by knowing the mass of solid dissolved and the volume of liquid it's dissolved in

$$\text{conc} = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}} \times 1000 \quad \text{or} \quad \text{conc} = \frac{\text{mass (g)}}{\text{volume (dm}^3\text{)}}$$

$$1\text{dm}^3 = 1000\text{cm}^3$$

### 11) Using moles to balance equations (HT only)

Convert the masses in grams to amounts in moles and convert the number of moles to simple whole number ratios.

e.g. 8.5g of sodium nitrate is heated in a test tube, it forms 6.9g of sodium nitrite and the remainder is oxygen. Balance the equation

$$\begin{array}{r} \text{NaNO}_3 \rightarrow \text{NaNO}_2 + \text{O}_2 \\ \text{Work out mols} \quad 8.5/85 \quad 6.9/69 \quad 1.6/32 \\ \quad \quad \quad = 0.1 \quad \quad = 0.1 \quad \quad = 0.05 \end{array}$$

then divide each number by smallest

$$\text{Equation is} \quad 2\text{NaNO}_3 \rightarrow 2\text{NaNO}_2 + \text{O}_2$$

**12) Yield**

The amount of a product obtained in a reaction

**13) Percentage yield**

$$\% \text{ Yield} = \frac{\text{actual mass of product}}{\text{maximum theoretical mass}} \times 100$$

**14) Factors affecting percentage yield**

- Reaction may be reversible
- Unwanted / competing reactions
- Loss of product in handling / separation
- Reactants may not be pure.

**15) Atom economy**

A measure of the amount of starting materials that end up as useful products:

$$\% \text{ atom economy} = \frac{\text{Mr of useful products}}{\text{Mr of all the reactants}} \times 100$$

**16) Calculating moles for solutions (HT only)**

$$n = \frac{CV}{1000}$$

n = no. of moles (mols)

C = concentration (mol/dm<sup>3</sup>)

V = Volume (cm<sup>3</sup>)

**17) Volumes of gases (HT only)**

- 1mol of any gas at room temperature & pressure has a volume of 24dm<sup>3</sup> (24000cm<sup>3</sup>)

So if you have 0.5mol of O<sub>2</sub> gas then it would have a volume of 12dm<sup>3</sup>

**18) Titrations**

- The volumes of acid and alkali solutions that react with each other can be measured by titration using a suitable indicator.
- If the concentration of one of the reactants is known, the results of a titration can be used to find the concentration of the other reactant.

- Fill the burette with acid (bottom of meniscus level with mark).
- Measure out known volume of alkali using a pipette.
- The pipette is filled with a pipette filler and then emptied under gravity into a conical flask.
- 2-3 drops of a suitable indicator (e.g. phenolphthalein) is added which will go pink in alkali and then colourless in acid.
- Place conical flask on a white tile so the colour change is clearer to see.
- Add acid slowly from the burette to the alkali until the last drop of pink disappears. This is called the end-point.
- The reading on the burette is taken at eye level (to reduce any errors).
- Repeat the experiment until you obtain **concordant** results (within ± 0.1cm<sup>3</sup> of each other)

- Looking at the results in the table below, you would use your two concordant results which would be from experiments 2 & 3. The average would be 21.33cm<sup>3</sup>.

Titration	1	2	3
Initial burette reading (cm <sup>3</sup> )	0.00	0.00	0.30
Final burette reading (cm <sup>3</sup> )	22.50	21.30	21.65
Vol of acid added (cm <sup>3</sup> )	22.50	21.30	21.35

**19) Titration calculations (HT only)**

What is the concentration of hydrochloric acid if 21.33cm<sup>3</sup> of acid were needed to neutralise 25cm<sup>3</sup> of 0.5mol/dm<sup>3</sup> solution of sodium hydroxide?  
e.g.



From the equation 1mol HCl needs 1mol of HCl

Using  $n = \frac{CV}{1000}$  work out moles of NaOH

$$\text{Moles NaOH} = \frac{0.5 \times 25}{1000} = 0.0125$$

So from the equation the same amount of HCl would be needed so we have 0.0125mols of HCl.

Rearrange the equation to get the concentration:

$$\text{Conc} = \frac{1000 \times n}{V(\text{acid})} = \frac{1000 \times 0.0125}{21.33} = 0.59 \text{ mol/dm}^3$$