Chapter 4: Calculations

Knowledge organiser

Formula mass

Every substance has a **formula mass**, M_r.

formula mass M_r = sum (relative atomic mass of all the atoms in the formula)

Avogadro's constant (HT only)

One mole of a substance contains 6.02×10^{23} atoms, ions, or molecules. This is **Avogadro's constant**.

One mole of a substance has the same mass as the M_r of the substance. For example, the M_r (H_2O) = 18, so 18 g of water molecules contains 6.02×10^{23} molecules, and is called one mole of water.

You can write this as: moles = $\frac{\text{mass}}{M_r}$

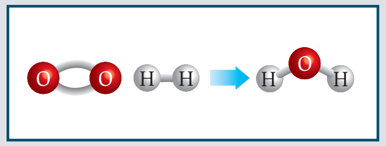
Balancing symbol equations

When writing symbol equations you need to ensure that the number of each atom on each side is equal.

$H_2 + O_2 \rightarrow H_2O$

unbalanced

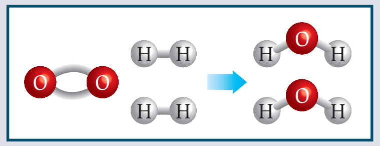
there are 2 hydrogen atoms on each side, but 2 oxygen atoms in the reactants and 1 in the product



$2H_2 + O_2 \rightarrow 2H_2O$

balanced

there are 4 hydrogen atoms on each side, and 2 oxygen atoms on each side



State symbols

A balanced symbol equation should also include state symbols.

State	Symbol
solid	(s)
liquid	(l)
gas	(g)
aqueous or dissolved in water	(aq)

Ratios

Look back at the reaction. In the reaction between hydrogen and oxygen, the ratio of hydrogen to oxygen molecules is 2:1. This means that for every *one* molecule of oxygen, you would need *two* molecules of hydrogen, for example:

- if you had 10 molecules of oxygen you would need 20 molecules of hydrogen
- if you had 1 mole of oxygen you would need 2 moles of hydrogen
- if you had 1.75 moles of oxygen you would need 3.5 moles of hydrogen.

A balanced symbol equation shows the ratios of the reactants and products in a chemical reaction.

mol is a the unit of moles

Concentration

Concentration is the amount of solute in a volume of solvent.

The unit of concentration is g/dm³.
Concentration can be calculated using:

$$\textit{concentration } (g/dm^3) = \frac{\textit{mass } (g)}{\textit{volume } (dm^3)}$$

Sometimes volume is measured in cm³:

$$\textit{volume } (dm^3) = \frac{\textit{volume } (cm^3)}{1000}$$

- lots of solute in little solution = high concentration
- little solute in lots of solution = low concentration

Concentration in mol/dm³

Concentration can also be measured in mol/dm³.

$$\textit{concentration of solution } (mol/dm^3) = \frac{\textit{number of moles of solute}}{\textit{volume of solution } (dm^3)}$$

You can use this formula and mass = moles × M_r to calculate the mass of solute dissolved in a solution.

- The greater the mass of solute in solution, the greater the number of moles of solute, and therefore the greater the concentration.
- If the same number moles of solute is dissolved in a smaller volume of solution, the concentration will be greater.

Using balanced equations (HT only)

In a balanced symbol equation the sum of the M_r of the reactants equals the sum of the M_r of the products.

If you are asked what mass of a product will be formed from a given mass of a specific reactant, you can use the steps below to calculate the result.

1. balance the symbol equation
2. calculate moles of the substance with a known mass using moles = $\frac{\text{mass}}{M_r}$
3. using the balanced symbol equation, work out the number of moles of the unknown substance
4. calculate the mass of the unknown substance using mass = moles × M_r

If you are asked to balance an equation, you can use the steps below to work out the answer.

1. work out M_r of all the substances
2. calculate the number of moles of each substance in the reaction using moles = $\frac{\text{mass}}{M_r}$
3. convert to a whole number ratio
4. balance the symbol equation

Excess and limiting reactants (HT only)

reactants, often one of the reactants will run out before the others. You then have some of the other reactants left over. The reactant that is left over is in **excess**. The reactant that runs out is the **limiting reactant**.

To work out which reactants are in excess and which is the limiting reactant, you need to:

1. write the balanced symbol equation for the reaction
2. pick one of the reactants and its quantity as given in the question
3. use the ratio of the reactants in the balanced equation to see how much of the other reactant you need
4. compare this value to the quantity given in the question
5. determine which reactant is in excess and which is limiting.

Key terms

Make sure you can write a definition for these key terms.

Avogadro's constant · concentration · excess · formula · mass · limiting reactant · mole

Chapter 4: Calculations

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	C4 questions	Answers
1	What is a mole?	mass of a substance that contains 6.02×10^{23} particles
2	Give the value for Avogadro's constant.	6.02×10^{23}
3	Which formula is used to calculate the number of moles from mass and M_r?	moles = $\frac{\text{mass}}{M_r}$
4	Which formula is used to calculate the mass of a substance from number of moles and M_r?	mass = moles × M_r
5	What is a limiting reactant?	the reactant that is completely used up in a chemical reaction
6	What is a unit for concentration?	g/dm^3 or mol/dm^3
7	Which formula is used to calculate concentration from mass and volume?	concentration (g/dm^3) = $\frac{\text{mass (g)}}{\text{volume (dm}^3\text{)}}$
8	Which formula is used to calculate volume from concentration and mass?	volume (dm^3) = $\frac{\text{mass (g)}}{\text{concentration (g/dm}^3\text{)}}$
9	Which formula is used to calculate mass from concentration in g/dm^3 and volume?	mass (g) = concentration (g/dm^3) × volume (dm^3)
10	How can you convert a volume reading in cm^3 to dm^3?	divide by 1000
11	If the amount of solute in a solution is increased, what happens to its concentration?	increases
12	If the volume of water in a solution is increased, what happens to its concentration?	decreases
13	How can concentration in mol/dm^3 be calculated?	$\frac{\text{moles of solute}}{\text{volume (dm}^3\text{)}}$

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