Highsted Knowledge Organiser Chemistry: Quantitative Chemistry

What I need to know

Difference between relative atomic mass and relative formula mass
How to calculate concentration of a solution
How to carry out a titration
How to calculate moles
How to use moles to determine limiting reactant
How to calculate percentage yield and atom economy
Why percentage yield isn't 100%
How to calculate gas volumes

Key Vocabulary:

- Mass
- Volume
- Concentration
- Mole
- Balanced symbol equation
- Percentage yield
- Atom economy
- Limiting reactant

Equations

Mass = moles x M_r
Concentration ($moldm^{-3}$) = moles ÷ volume
Concentration (gdm^{-3}) = mass ÷ volume
Volume of gas (dm^3) = amount in mol x 24

Student reference point

The **relative atomic mass (A_r)** of an element is an elements relative mass compared to the mass of an atom of carbon-12. A_r values are given in the periodic table.

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

The **law of conservation of mass** states that during a chemical reaction, no atoms are lost or made.

For example: $2Mg + O_2 \longrightarrow 2MgO$

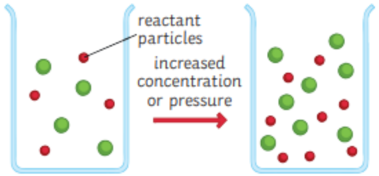
In a chemical reaction, mass is never lost or gained. What **goes in** must **come out**. The **total mass of the reactants** at the beginning of the chemical reaction **equals** the **total mass of the products** made at the end of the reaction.

The volume of one mole of any gas at room temperature and pressure (20°C and 1 atmosphere pressure) is $24dm^3$ (**24 000 cm^3**).

To calculate a known volume of a gas:

volume = amount in mol × molar volume

Concentration is a **measure** of the amount of a **substance** in a **volume** of liquid. The higher the concentration, the more particles of a substance are present in the solution.



In chemistry, there are two ways to measure the concentration of a solution. This can be done by calculating the **mass** of the substance in grams or by calculating the number of **moles**.

In order to calculate concentration, you must be working in dm^3.

If it is not, it may mean that you need to do a conversion.

$cm^3 \longrightarrow dm^3$ = ÷ 1000

$m^3 \longrightarrow dm^3$ = × 1000

A **mole** (mol) is a **measurement** that is used in chemistry.

Example 1

Look at this reaction:

$2Mg + O_2 \longrightarrow 2MgO$

The reaction shows that **two moles** of magnesium react with oxygen to produce **two moles** of magnesium oxide. Using moles in a **balanced symbol equation** shows the **ratio** of **reactants** to **products**.

1 mole = 6.02 × 10^{23}

The number is known as **Avogadro's constant or Avogadro's number**

A chemical reaction ends once one of the **reactants** is used up. The other reactants have nothing to react with and so some are left over.

The **limiting reactant** is the reactant that is **completely used up** in a chemical reaction. This reactant is the one that determines the amount of product that is made.

The reactant in **excess** is the one that is left over and could further react if there was another reactant to react with.

The **amount of product** that is produced during a chemical reaction is **dependent** upon the **amount of the limiting reactant**.

The percentage yield can be calculated from the following equation.

$$\text{percentage yield} = \frac{\text{actual mass of product made}}{\text{maxium theoretical mass of product}} \times 100$$

The **theoretical yield** is **the maximum mass** that can be made during a chemical reaction.

The percentage atom economy can be calculated from the following equation.

$$\text{atom economy} = \frac{\text{relative formula mass of desired product from equation}}{\text{sum of relative formula masses of all reactants from equation}}$$

The **atom economy** is a measure of the amount of starting materials (reactants) that end up as **useful products**. It is important for sustainable development and for economic reasons to use reactions with **high atom economy**. However, not all atoms end up as the desired product and may form other products. We call these **byproducts**.

Titration Method (Chemistry Only)

1. Using the pipette and pipette filler, measure $25cm^3$ sodium hydroxide solution and pour into a conical flask.
2. Add several drops of phenolphthalein to the sodium hydroxide solution.
3. Swirl the flask and the mixture should be pink.
4. Place the conical flask on a white tile.
5. Place the burette into its stand, ensuring the tap is closed. Using the funnel, fill the burette with sulfuric acid to the $0cm^3$ line. Should you go above this line, open the tap and allow the excess to run off into a beaker.
6. Once the burette is correctly filled, place over the conical flask.
7. Carefully open the tap so the acid flows slowly into the conical flask. Swirl the flask and look for the indicator changing from pink to colourless.
8. Continue adding the acid to the flask until the indicator is permanently colourless.
9. Record the total volume of acid added to the sodium hydroxide in the results table.
10. Repeat the experiment twice more.

Challenge question: Using the equation 2 Mg + O_2 —> 2 MgO. Calculate the mass of magnesium oxide that can be made form 16g of oxygen (3 marks)

Suggested reading: [Quantitative Chemistry - Revise, test yourself and sample exam questions - AQA Separate Chemistry - BBC Bitesize]

Highsted Knowledge Organiser Chemistry: Chemical changes

What I need to know

The reactivity series
How metals react with acids
How to name salts
How acids react with bases
The method to make a soluble salt
How to carry out a titration

Key Vocabulary:

- **Metal**
- **Reaction**
- **pH scale**
- **Strong acid**
- **Weak acid**
- **Alkali**
- **Base**
- **Salt**
- **Dissociate**
- **Reversible**

Equations

Metal + oxygen —> metal oxide
Metal + water —> metal hydroxide + hydrogen
Metal + acid —> salt + hydrogen
Acid + metal oxide —> salt + water
Acid + metal hydroxide —> salt + water
Acid + carbonate —> salt + water + carbon dioxide

Student reference point

The Process of Electrolysis

Electrolysis is the **splitting up** of an ionic substance using **electricity**.

On setting up an electrical circuit for electrolysis, two **electrodes** are required to be placed in the electrolyte. The electrodes are **conducting rods**. One of the rods is connected to the **positive** terminal and the other to the **negative** terminal.

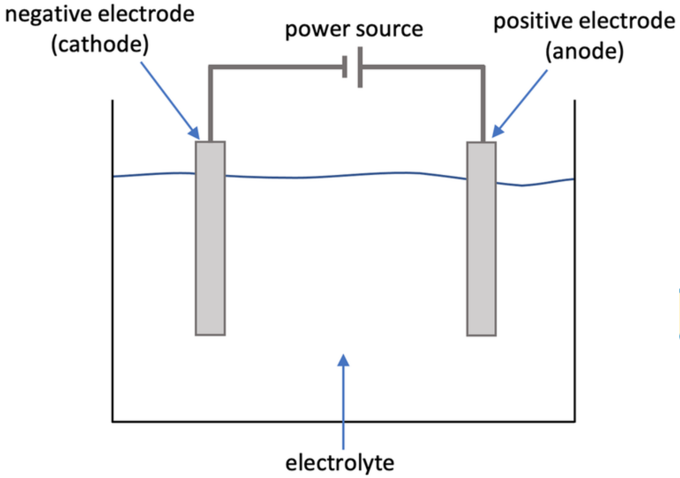
The **electrodes** are **inert** (this means they do not react in the reaction) and are often made from **graphite** or platinum.

During the process of electrolysis, **opposites attract**. The positively-charged ions will be attracted toward the negative electrode. The negatively-charged ions will be attracted towards the positive electrode.

When ions reach the electrodes, the charges are lost and they become elements.

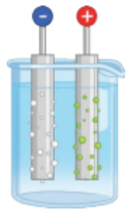
The **positive** electrode is called the **anode**.

The **negative** electrode is called the **cathode**.



Electrolysis of Aqueous Solutions

Gases may be given off or metals deposited at the electrodes. This is dependent on the reactivity of the elements involved.



If the metal is **more reactive** than **hydrogen** in the reactivity series, then **hydrogen** will be **produced** at the **negative cathode**. At the **positive anode**, negatively charged ions **lose** electrons. This is called **oxidation** and you say that the ions have been oxidised.

Using Electrolysis to Extract Metals

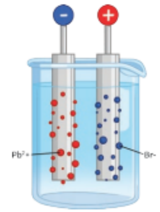
Metals are extracted by electrolysis if the metal in question reacts with carbon or if it is too reactive to be extracted by reduction with carbon. During the extraction process, large quantities of energy are used to melt the compounds.

Aluminium is manufactured by the process of electrolysis. Aluminium oxide has a high melting point and melting it would use large amounts of energy and increase the cost of the process. Therefore, molten **cryolite** is added to aluminium oxide to lower the melting point and thus reduce the cost.

Electrolysis of Molten Ionic Compounds – Lead Bromide

Lead bromide is an **ionic** substance. Ionic substances, when solid, are **not** able to conduct electricity. When molten or in solution, the ions are free to move and are able to carry a charge.

The **positive lead** ions are attracted toward the **negative cathode** at the same time as the **negative bromide** ions are attracted toward the **positive anode**.



Oxidation is the loss of electrons and reduction is the gaining of electrons. **OIL RIG (Higher Tier Only).**

We represent what is happening at the electrodes by using **half equations (Higher Tier Only).**

The lead ions are attracted towards the negative electrode. When the **lead ions** (Pb^{2+}) reach the cathode, each ion **gains two electrons** and becomes a neutral atom. We say that the lead ions have been **reduced**.

$Pb^{2+} + 2e^- \rightarrow Pb$

The bromide ions are attracted towards the positive electrode. When the **bromide ions** (Br-) reach the anode, each ion **loses one electron** to become a neutral atom. Two bromine atoms are then able to bond together to form the **covalent** molecule Br_2.

$2Br^- \rightarrow Br_2 + 2e^-$

Challenge question: For electrolysis of aqueous solutions of copper sulphate and sodium chloride, what would you observe at the negative electrode? (2 marks) Complete the table below (3 marks)

Molten compound electrolysed	Product at the negative electrode	Product at the positive electrode
Zinc chloride		
	Potassium	Iodine

Suggested reading: [Electrolysis - Summary notes, mind maps and exam questions - AQA Separate Chemistry - Physics and maths tutore]