

**Box 1: Keywords**

Atom economy	Is a measure of the amount of starting materials that end up as useful products.
Burette	A piece of apparatus used to add varying but measured volumes of solution during a titration.
Yield	The amount of a product obtained in a reaction is known as the yield.
Percentage yield	A measure of how much product is actually made, calculated from: $100 \times (\text{actual yield}) \div (\text{theoretical yield})$.
Pipette	A piece of apparatus used to measure accurate and repeatable volumes of liquid.
Concordant	Titres within 0.10 cm^3 of each other
Titration	A quantitative procedure in which two solutions react in a known ratio, so if the concentration of one solution is known and the volumes of both are measured, the concentration of the other solution can be determined.
Titre	Volume of one reactant needed to react completely with the other reactant in a titration.
Theoretical yield	The maximum possible mass of a product that can be made in a chemical reaction.

Box 2: Key skills

- Calculate the volume of a gas at room temperature and pressure from its mass and relative formula mass
- Perform a titration and calculate the concentration of an unknown solution

Box 3: Cross curricular links

Maths – multi-step calculations

- converting units
- changing the subject of equations

Box 4: Theoretical yield

The theoretical yield is the maximum possible mass of a product that can be made in a chemical reaction.

It is not possible to obtain the theoretical yield because:

- Some of the product can be lost during separation
- Unexpected side reactions can take place
- The reaction could be reversible.

The theoretical yield is calculated based on reacting masses and the balanced symbol equation

Box 5: Percentage yield and atom economy

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

The atom economy measures the amount of starting materials that end up as useful products.

High atom economies are more sustainable as they fewer atoms are being wasted in products that are not useful

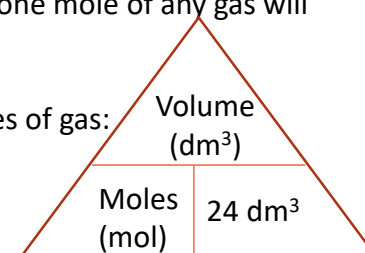
$$\text{atom economy} = \frac{M_r \text{ of useful product}}{M_r \text{ of all products}} \times 100$$

Box 6: Moles and gas calculations

At any given temperature and pressure, the same number of moles of a gas will occupy the same volume. At 25°C and 1 atm pressure, one mole of any gas will occupy 24 dm^3 .

To calculi the number of moles of gas:

$$\text{Moles of gas} = \frac{\text{volume (dm}^3\text{)}}{24 \text{ dm}^3}$$

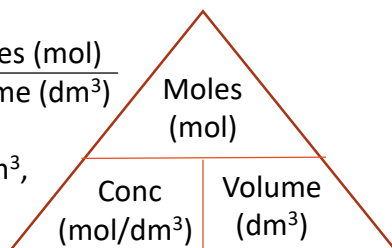


Box 7: Concentration in mol/dm³

Concentration can also be measured in mol/dm³

$$\text{Concentration (mol/dm}^3\text{)} = \frac{\text{moles (mol)}}{\text{volume (dm}^3\text{)}}$$

Volume must be converted to dm³, not cm³



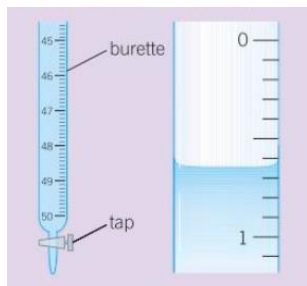
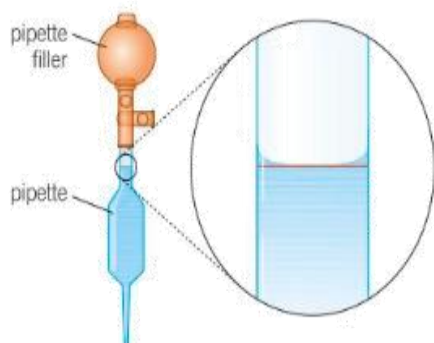
Box 8: Titration

Titrations are a very accurate experiments that are used to find the concentration of a solution by reacting it with a solution of known concentration. We can use a titration to calculate the concentration of an unknown acid or alkali

Titrations use apparatus including a pipette, conical flask and burette.

A pipette is a glass tube designed to measure a specific volume of a solution very accurately.

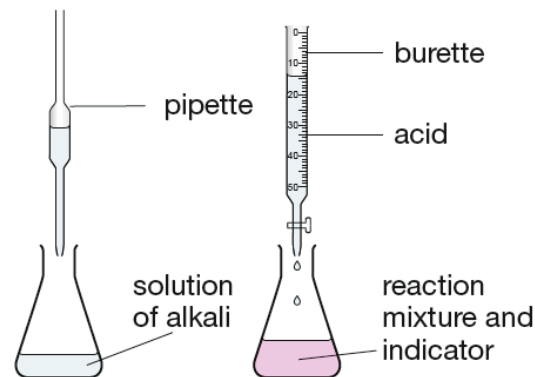
A typical pipette measures out 25 cm³ ± 0.05 cm³



A burette is a glass tube with a tap with marking on to show the volume to the nearest 0.1 cm³

Box 9: Titration required practical

1. A known volume of a solution of an acid or alkali is measured out using a pipette and placed into a conical flask
2. A few drops of a suitable **indicator** are added. For most acid-alkali titrations, methyl orange or phenolphthalein is suitable
3. The other solution, the acid or alkali, is added to the conical flask from a burette
4. The solution is added from the burette until the indicator changes colour (the **end point**). The solution is added dropwise around the point where the indicator changes colour to ensure the exact volume required is used.
5. The volume added from the burette is recorded
6. The experiment is repeated until concordant results are achieved (results that are very close to each other). The mean volume is found using the **concordant** results.



Calculating concentration from a titration

The concentration of a solution can be found using the results of a titration.

1. Work out the moles of the solution whose concentration is known
2. Use molar ratios from the balanced equation to work out the moles of the unknown solution
3. Calculate the concentration of the unknown solution

Box 10: Pathway

Previous knowledge: KS3 chemical reactions, KS4 quantitative chemistry

Future links: KS4 chemical changes, KS5 quantitative chemistry

Careers: pollutant controllers, forensic scientists, organic chemists, art pharmacists

