Cambridge (CIE) IGCSE Chemistry

Your notes

Experimental Techniques

Contents

- Apparatus for Measurements
- Solutions
- Acid-Base Titrations

Your notes

Time, temperature, mass & volume

Time

- Time can be measured using a **stopwatch** or stopclock which are usually accurate to one or two decimal places
- The units of time normally used are **seconds** or **minutes**
  - Other units may be used for extremely slow reactions (e.g. rusting)
- **Remember:** 1 minute = 60 seconds

Examiner Tips and Tricks

Careful: Units of time often cause issues in results tables.

If the display on a stopwatch showed 1:30.

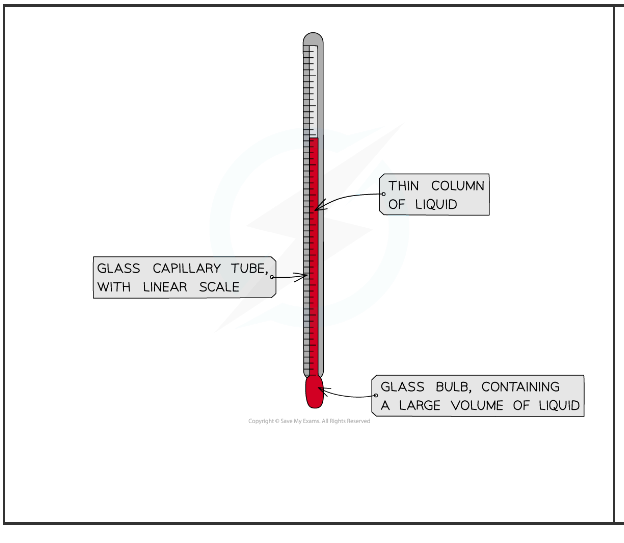
- The incorrect time to record would be 1.30 minutes.
- The correct time would be 1.5 minutes.

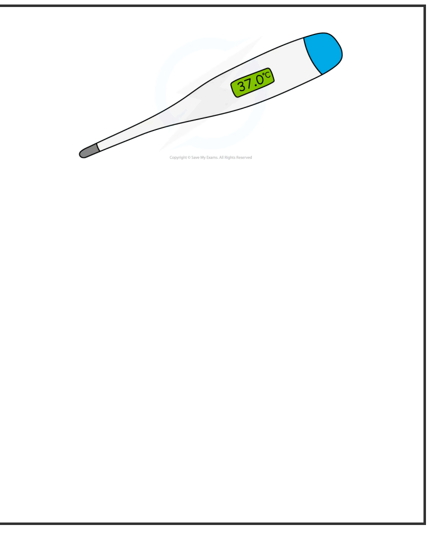
To avoid any confusion, if the time intervals are less than a minute, it is best / easier to change the recorded units to seconds.

- So, the same stopwatch display would be recorded as 90 seconds.

Temperature

- Temperature is measured with a **thermometer** or digital **temperature probe**



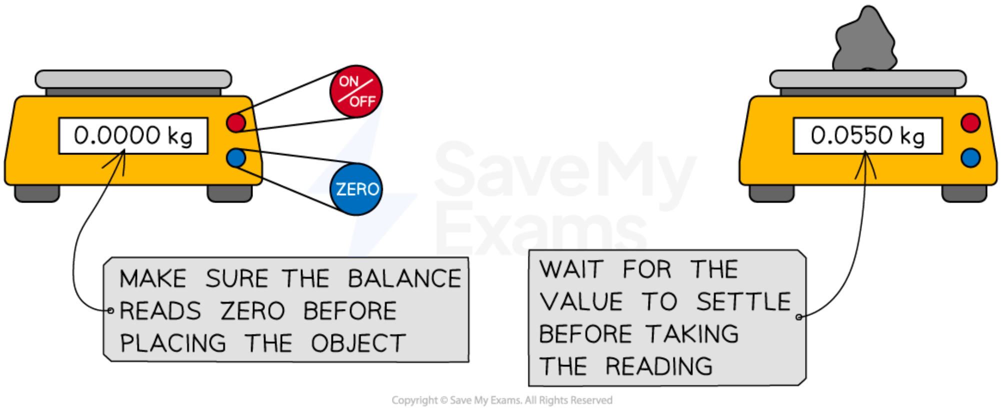


- Laboratory thermometers usually have a precision of a half or one degree

- Digital temperature probes are available which are more **precise** than traditional thermometers and can often read to 0.1 °C
- Traditional thermometers rely upon the uniform expansion and contraction of a liquid substance with temperature
  - Digital temperature probes can be just as, if not, more **accurate** than traditional thermometers
- The units of temperature are **degrees Celsius (°C)**

Mass

- Mass is measured using a **digital balance** which normally gives readings to two decimal places
  - Balances should be tared (set to zero) before use
  - Balances should also be allowed time to settle on a final measurement / reading before it is recorded

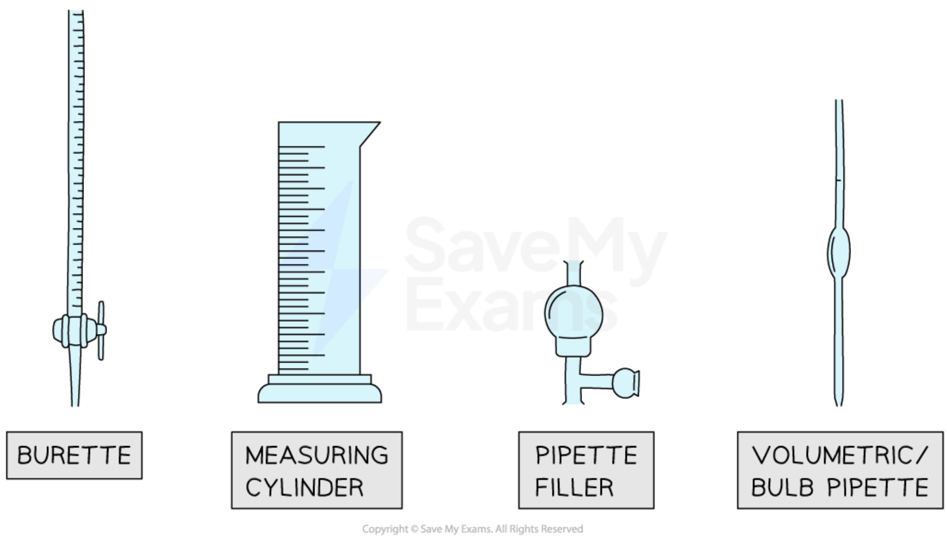


- The standard unit of mass in kilograms (kg)
  - However, in chemistry **grams (g)** are most often used
- **Remember:** 1 kilogram = 1000 grams

Volumes of liquid

- The volume of a liquid can be determined using different pieces of apparatus
  - The choice of apparatus depends on the level of accuracy needed
- Three common pieces of apparatus for measuring the volume of a liquid are:
  - **Burettes**
  - **Volumetric pipettes**
  - **Measuring cylinders**

Your notes



- **Burettes** are the most accurate way of measuring a **variable** volume of liquid between 0 cm^3 and 50 cm^3
  - They are most commonly used in titrations
  - **Careful:** Read the burette scale from top to bottom as 0.00 cm^3 is at the top of the column
- **Volumetric pipettes** are the most accurate way of measuring a **fixed** volume of liquid,
  - They have a scratch mark on the neck which is matched to the bottom of the meniscus to make the measurement
  - A pipette filler is used to draw the liquid into the volumetric pipette
  - The most common volumes for volumetric pipettes are 10 cm^3 and 25 cm^3
- **Measuring cylinders** are used when approximate volumes are required (accuracy is not an important factor)
  - These are graduated (have a scale so can be used to measure)
  - Measuring cylinders typically range from 10 cm^3 to 1 litre (1 dm^3)
- Whichever apparatus you use, you may see markings in millilitres, ml, which are the same as a cm^3

Volumes of gas

- For some experiments, the volume of a gas produced needs to be measured
- This is typically done by using one of the following methods:
  - Using a **gas syringe**
  - By **downward displacement of water**
- A **gas syringe** is more precise and accurate than downward displacement of water

Your notes

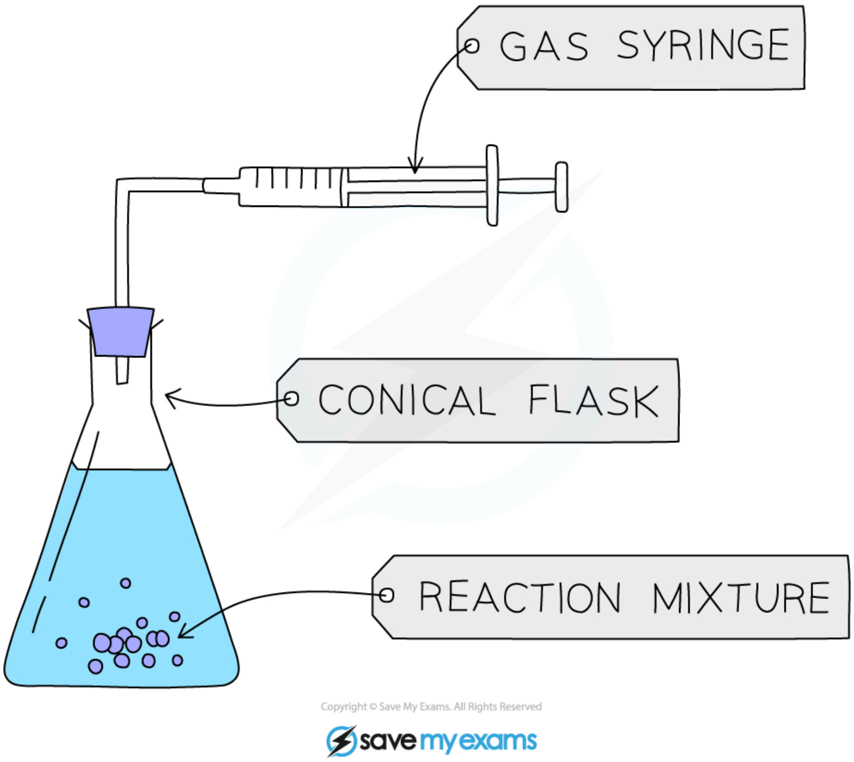


Diagram of the set-up for an experiment involving a gas syringe

- **Downward displacement of water** is where a **measuring cylinder** is inverted in water to collect the gas produced
  - This method does not work if the gas is soluble in water

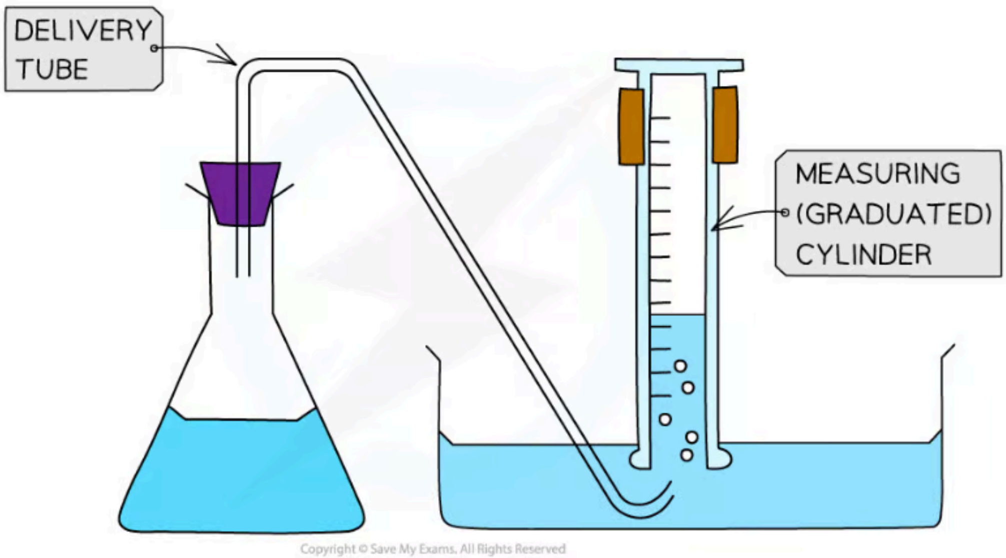


Diagram of the set-up for an experiment collecting gas by downward displacement of water

Your notes

- If the gas happens to be heavier than air and is coloured, the cylinder does not need to be inverted

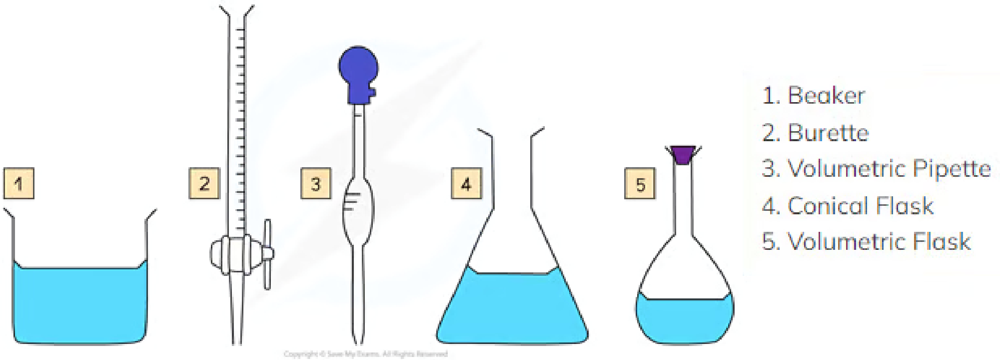
Your notes

Advantages & disadvantages of methods & apparatus

- In the lab, we often have choices of different apparatus to do the same job
- Evaluating which piece of apparatus is the best one to use is part of good experimental planning and design
- This means appreciating some of the advantages and disadvantages of laboratory apparatus

Advantages and disadvantages of lab apparatus

Apparatus	Advantage	Disadvantage
Temperature probe	▪ More precise readings ▪ Easy to make multiple repeat readings ▪ Can be automated to run over long periods of time	▪ Can be corroded by some reagents ▪ More expensive (to replace)
Volumetric pipette	▪ Accurate measurement of a fixed volume	▪ Harder to use than a normal pipette ▪ Only measures one fixed volume
Gas syringe	▪ Easy to set up ▪ Keeps the gas dry	▪ The syringe can stick ▪ Collects limited volumes ▪ Expensive and delicate / fragile
Microscale experiments	▪ Less wasteful ▪ Saves energy ▪ Safer	▪ Hard to see what's happening ▪ Lose a lot of material separating / purifying the products



Five pieces of apparatus that can be used to measure the volume of a liquid. They all have their pros and cons

Your notes

Planning your method

- Good experimental design includes the answers to questions like
  - Have I chosen a suitable apparatus for what I need to measure?
  - Is it going to give me results in an appropriate time frame?
  - Is it going to give me enough results to process, analyse and make conclusions?
  - Does it allow for repetitions to check how **reliable** my results are?
  - Does my plan give a suitable **range** of results?
  - How can I be sure my results are **accurate**?
  - Have I chosen an appropriate scale of quantities without being wasteful or unsafe?
- You may be asked about experimental methods in exam questions and your experience and knowledge of practical techniques in chemistry should help you to spot mistakes and suggest improvements

Examiner Tips and Tricks

Make sure you know the names of common laboratory apparatus.

Your notes

Solutions

- You need to know all the following terms used when describing solutions:

Terminology about solutions table

Term	Meaning	Example
Solvent	The liquid in which a solute dissolves	The water in seawater
Solute	The substance which dissolves in a liquid to form a solution	The salt in seawater
Solution	The mixture formed when a solute is dissolved in a solvent	Seawater
Saturated solution	A solution with the maximum concentration of solute dissolved in the solvent, at agiven temperature	Seawater in the Dead Sea
Soluble	A substance that will dissolve	Salt is soluble in water
Insoluble	A substance that will not dissolve	Sand is insoluble in water
Filtrate	The liquid or solution that has passed through a filter	Fresh coffee in a cup
Residue	The substance that remains after evaporation, distillation, filtration or any other similar process	Coffee grounds in filter paper

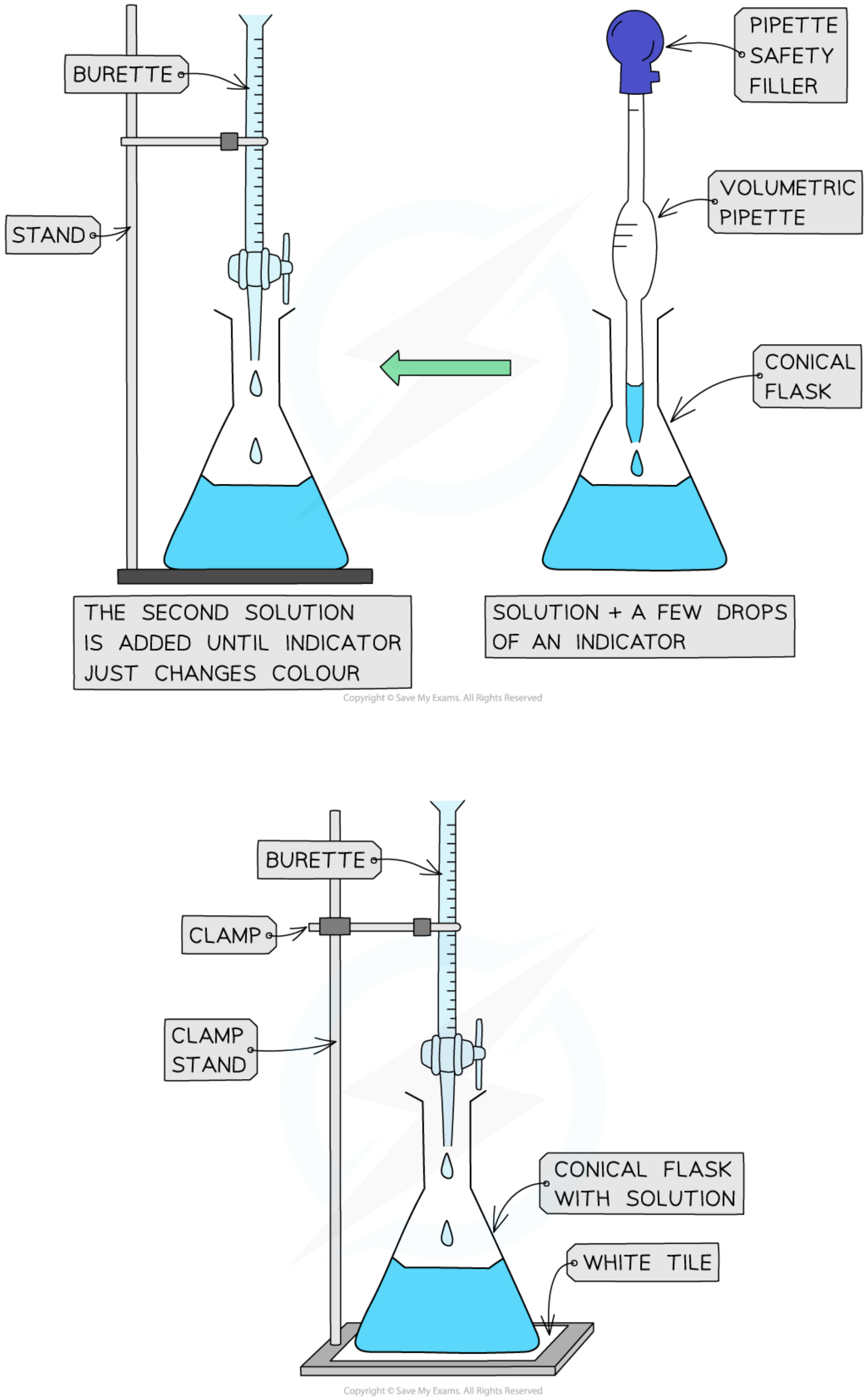
Your notes

Acid-base titrations

- Titrations are a method of analysing the **concentration** of solutions
- They can determine exactly how much alkali is needed to neutralise a quantity of acid – and vice versa
- You may be asked to perform titration calculations to determine the **moles** present in a given amount or the **concentration / volume** required to **neutralise** an acid or a base
- Titrations can also be used to prepare salts

Apparatus

- 25 cm^3 volumetric pipette
- Pipette filler
- 50 cm^3 burette
- 250 cm^3 conical flask
- Small funnel
- 0.1 mol / dm^3 sodium hydroxide solution
- Sulfuric acid of unknown concentration
- A suitable indicator
- Clamp stand, clamp & white tile



The steps in performing a titration

Your notes

Method

1. Use the pipette and pipette filler and place exactly 25 cm^3 sodium hydroxide solution into the conical flask

Your notes

2. Using the funnel, fill the burette with hydrochloric acid placing an empty beaker underneath the tap. Run a small portion of acid through the burette to remove any air bubbles
3. Record the starting point on the burette to the nearest 0.05 cm^3
4. Place the conical flask on a white tile so the tip of the burette is inside the flask
5. Add a few drops of a suitable indicator to the solution in the conical flask
6. Perform a rough titration by taking the burette reading and running in the solution in 1 – 3 cm^3 portions, while swirling the flask vigorously
7. Quickly close the tap when the end-point is reached
   - The endpoint is when one drop causes a sharp colour change
8. Record the volume of hydrochloric acid added, in a suitable results table as shown below
   - Make sure your eye is level with the meniscus
9. Repeat the titration with a fresh batch of sodium hydroxide
10. As the rough end-point volume is approached, add the solution from the burette one drop at a time until the indicator just changes colour
11. Record the volume to the nearest 0.05 cm^3
12. Repeat until you achieve two concordant results (two results that are within 0.1 cm^3 of each other) to increase accuracy

	Rough titre	Titre 1	Titre 2	Titre 3
Final reading (cm^3)				
First reading (cm^3)				
Titre (cm^3)				

Examiner Tips and Tricks

Common errors during a titration include:

- Not removing the funnel from the burette
  - This can lead to some liquid dripping into the burette and cause false / high readings
- Not filling the jet space of the burette
  - The jet space is the part of the burette after the tap
  - Not filling this space can lead to false readings

- Reading the volume from the burette incorrectly
  - Readings should be taken from the bottom of the meniscus
  - **Careful:** The scale on the burette has 0.0 cm^3 at the top and 50 cm^3 (typically) at the bottom

Your notes

Indicators

- **Indicators** are used to show the endpoint in a titration
- Wide range indicators such as litmus are not suitable for titration as they do not give a sharp colour change at the endpoint
  - However, methyl orange and phenolphthalein are very suitable
- Some of the most common indicators with their corresponding colours are shown below:

Common acid-base indicators

Indicator	Colour in acid	Colour in alkali	Colour in neutral
Litmus solution	Red	Blue	Purple
Red litmus paper	Stays red	Turns blue	No change
Blue litmus paper	Turns red	Stays blue	No change
Methyl orange	Red	Yellow	Orange
Phenolphthalein	Colourless	Pink	Colourless
Thymolphthalein	Colourless	Blue	Colourless