CIE Chemistry IGCSE

AO3 Practical Skills 3: Make and record observations, measurements and estimates

Notes

Measurements

Introduction

There are two types of data in chemistry: **qualitative** and **quantitative**. Quantitative data is the kind of data that can be **measured**. It is important that these measurements are as **accurate** and **precise** as possible, or the data will be corrupted which may lead to **false conclusions** to an experiment.

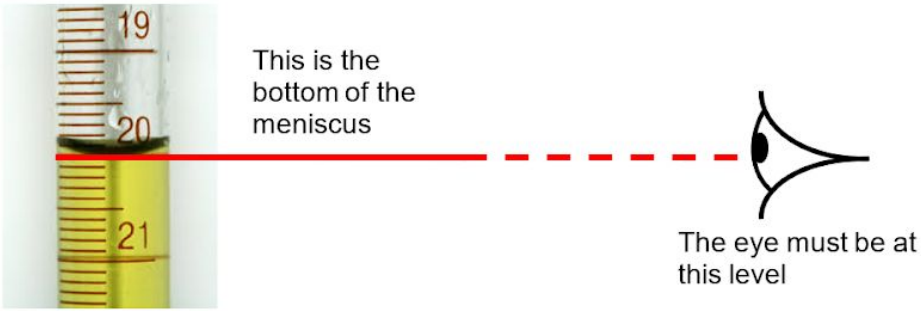
Accuracy and precision

- **Precision** - Precision is **how close a number of measurements are to one another**. Some examples of how to take precise measurements include:
  - Use **appropriate measuring instruments**, for example do not use a meter rule to measure the width of a pencil.
  - Use a pH probe rather than universal indicator to measure pH because it will give the pH to two decimal places.
- **Accuracy** - Accuracy is the **closeness of the recorded data to the true value.** To increase accuracy, measurements should be **repeated**, so it may be necessary to repeat the same experiment several times to get reliable data. Using a **pH probe** to measure pH also increases accuracy as matching the universal indicator colour to a value can be subjective.

Taking and recording readings

There are several key skills required to take readings:

- **Reading a scale with appropriate accuracy and precision:**
  - In order to take an **accurate** reading you should position yourself at **eye level** with the apparatus.
  - When taking readings from apparatus filled with liquid you must take the measurement from **the bottom of the meniscus.** The meniscus is the curve of the liquid.



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- **Interpolating between scale divisions:**
  - It is rare that what you are measuring will fall exactly on a scale division, in this case you can **interpolate** and **estimate** a more precise reading.
  - For instance, if you were measuring a distance with a ruler which had millimetre divisions and the length fell evenly between 77 mm and 78 mm, then it could be recorded as 77.5 mm.

- **Taking repeated measurements, where appropriate:**
    - Taking repeated measurements improves the **accuracy** of the experiment because it allows you to:
        - Spot and discard **anomalous readings.** Anomalous readings are readings which **deviate largely from the trend** of the rest of the data; their occurrence is most likely due to apparatus, method or human **errors**.
        - Calculate a **mean**. This helps to eliminate random errors that occur when taking each of the individual measurements. Anomalous readings must not be included in the mean calculation.

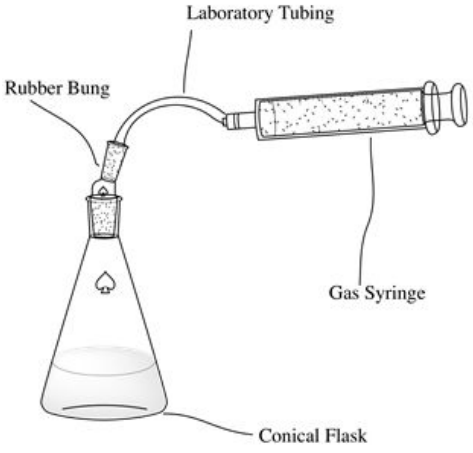
Types of measurements

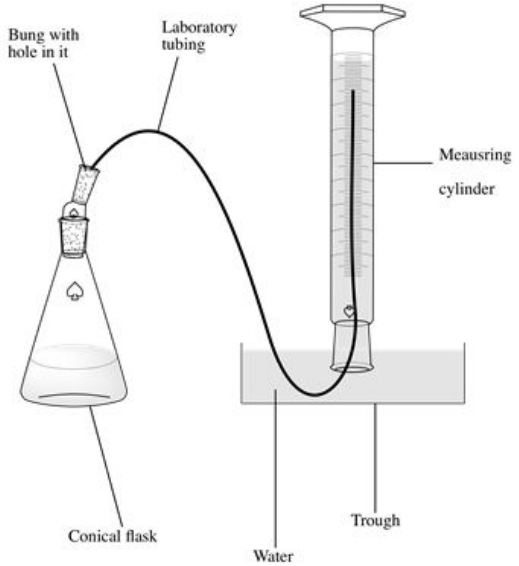
Measuring mass

- **Solids** are usually weighed on a **weighing boat** using a mass balance, this is to prevent contamination of the pan on the mass balance and contamination of the solid used. Solids can be **measured by difference** to get a more accurate value. This means the weighing boat is weighed with the solid and then again after the solid is added to the mixture. This calculates exactly how much solid is added to the mixture, taking into account any grains left in the weighing boat.

Measuring volume of gas

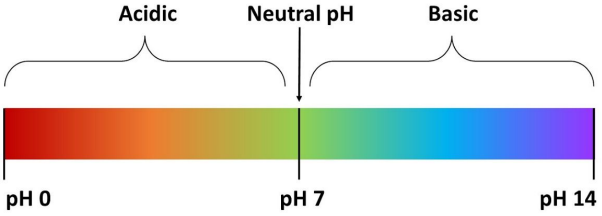
- In some experiments it may be necessary to collect a **volume of gas**, this may seem difficult but with the right setup it is easily achieved using either of the two setups below. For the setup with the measuring cylinder, note that the measuring cylinder must be full of water before the experiment starts.
- Once you have set up the apparatus as shown, you may mix the reagents in the conical flask and quickly close the conical flask using the bung. The gas produced in the reaction will then collect in the **gas syringe** or **measuring cylinder.**





Measuring pH

- pH is measured in two different ways. It can be measured with a **pH probe** or using **pH scales** with a suitable **indicator**.
- Using a pH probe is quite simple. The probe is placed in the solution you are testing. You wait until the reading is **steady** and record the pH shown on the digital display. To get consistent results with a pH probe, the electrode must be **washed**, then **calibrated** using **buffer solutions** of known pH.
- Using pH scales to find pH typically has a **greater uncertainty** and is **less precise**, but works when a pH meter is not available or cannot be used. To find pH using a scale add an **indicator** to the solution (or add solution to paper containing the indicator), then compare the **colour** that is produced to a suitable scale, like the one shown below:



Observation

Qualitative data is the type that is **observed**. Things like colour changes or the type of chemical present **cannot be described with a number**. In an experiment it is important to write down every change seen, even if it seems insignificant, it may come into play when you make your **conclusions** and **analysis**. It is also important that everything you do is written down: the changes made to the experiment should be recorded exactly so that observations and measurements can be repeated. If an experiment cannot be repeated all conclusions drawn from that experiment could be completely wrong.

Estimates

Estimates, or **approximations**, are useful measurements which **quickly** can show a **rough relationship** between variables. It can be used at the beginning of an experiment to show the region in which an exact value will lie.

Examples of the use of estimates can be seen in titrations:

In an **acid-alkali titration** an estimate is used to get the rough point at which **neutralisation** occurs. The estimate is often referred to as a **'rough titration'**. It distinguishes the approximate volume of solution that needs to be added from the burette which means, on future titrations, care can be taken around this region by adding the solution **dropwise** to get a value which is as accurate as possible. This use of an estimate speeds up the process and means accurate results are collected early on in the experiment since the region of neutralisation is established straight away.