CIE Chemistry A-Level

4.2.2 Practical Skills for Paper 3 - Manipulation, Measurement and Observation

Notes

Measurement

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 and may lead to false conclusions to an experiment. Being **accurate** *and* **precise** will lead to having a good experiment.

Precision

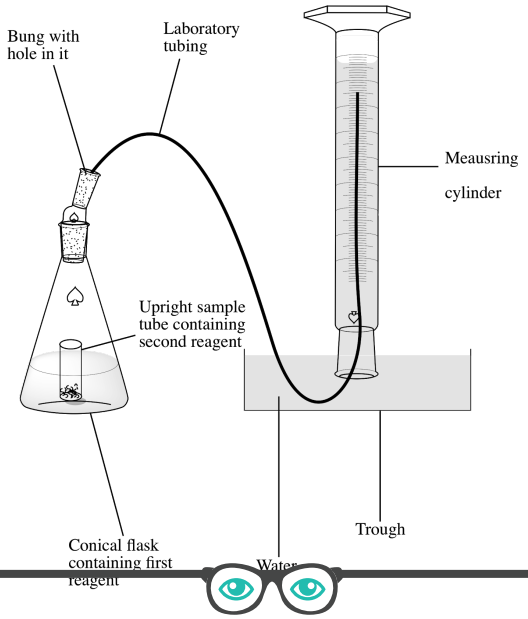
To obtain more precise measurements it is necessary to use equipment that has a high **resolution**, like having a mass balance with more decimal places or a ruler with smaller divisions. However, having more precise instruments does not mean that data obtained will be closer to the true value.

Here are some examples of how to take more precise measurements:

- Always take burette readings to the nearest 0.05 cm^3.
- When using a thermometer of 1ºC resolution, always take measurements to the nearest 0.5ºC.
- Use appropriate measuring instruments, for example do not use a meter rule to measure the width of a pencil.

Accuracy

Accuracy is the **closeness** of the recorded data to the true value. To be more accurate measurements should be **repeated**, so it may be necessary to repeat the same experiment several times to get good data. A student must make a judgement to estimate how long an experiment will take them, so that they can plan how many times they will repeat their experiment in the time they are given. Accuracy of an experiment is affected by different types of **errors**, which all lead to inaccuracy of the data. Being able to identify possible errors in the experiment and knowing methods of correcting them is a key skill as a chemist and will definitely be assessed in the practical part of your course. For example if you have a gas syringe setup in order to collect gas from a conical flask, one possible error could be that some gas escapes the flask before the bung is connected. One way to fix this would be to have one of the reagents inside a sample tube upside down in the conical flask containing the other reagent. The two reagents can then be mixed by shaking the flask so that the sample tube falls over.



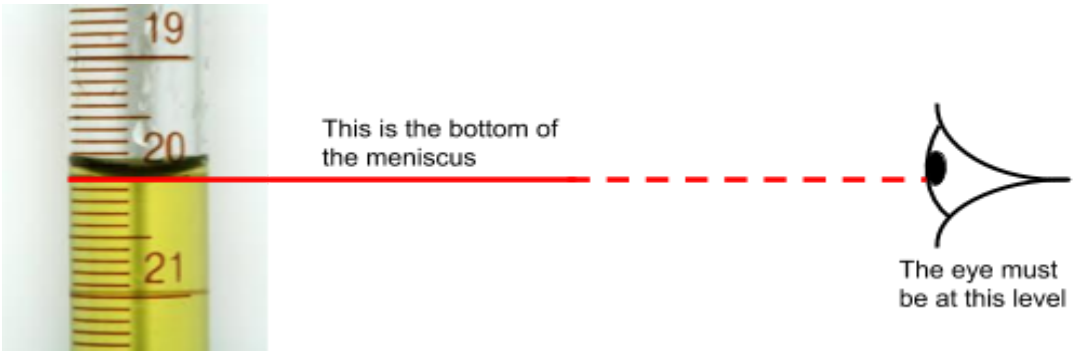
How to measure different quantities

Burette readings

A titre will be measured by recording the starting volume followed by the final volume, then using:

Titre = Start volume - End volume

Always measure the volume from the bottom of the **meniscus**, and measure with the level of the liquid at eye level. This same technique applies to measuring liquids using a graduated cylinder.



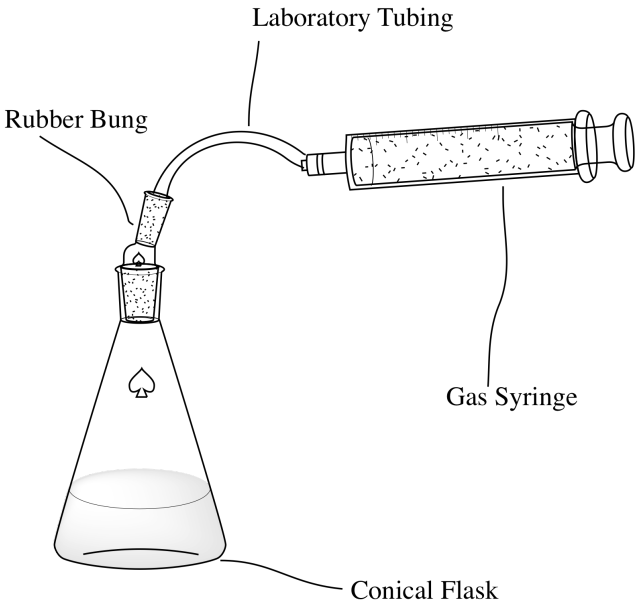
Another thing to note about burette readings is that the reading indicates the volume of liquid 'missing' from the burette, not the volume of liquid in the burette itself.

Measuring mass

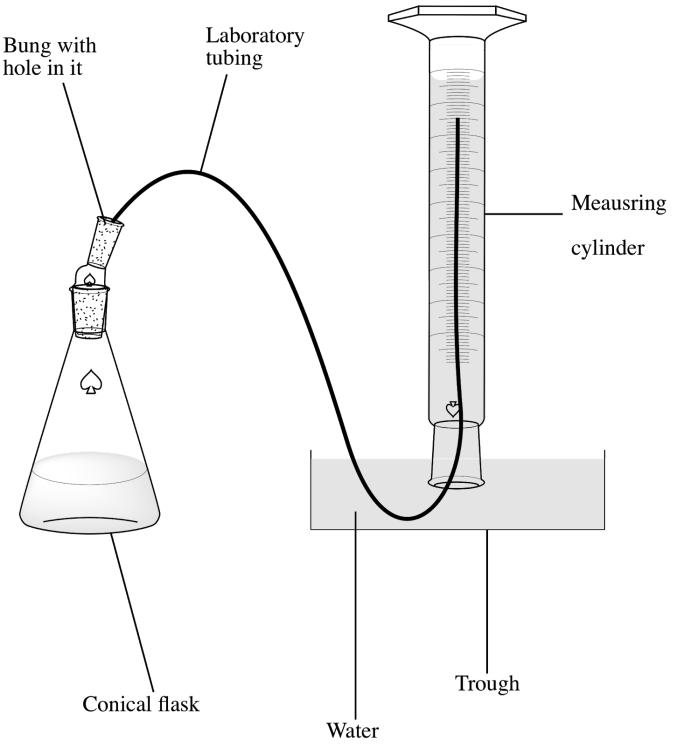
Solids are usually weighed on a weighing boat using a mass balance, this is to prevent contamination of the pan on the mass balance and contamination of the solid used. Using this method, however, consistently does not give an accurate value of the mass of solid you are using in the experiment. This latter reason is why the '**weighing-by-difference**' method is used: first weigh the container with the solid in it, then add the solid to the reaction and reweigh the container, the difference between these two values would be the mass of solid added.

Measuring volume of gas

In some paper 3 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 completely full of water before the experiment starts. The first diagram shows the setup using a **gas syringe** and the second diagram shows the setup using an upside down **measuring cylinder in a water trough.**



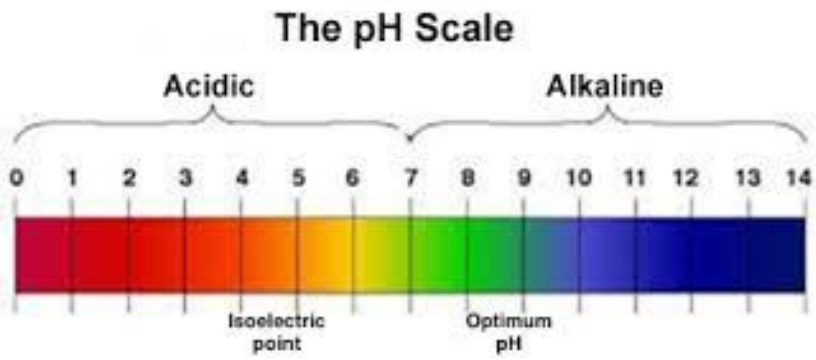
Once you have set up the apparatus as shown, you may **mix the reagents in the conical flask** and quickly close the conical flask using the bung. The gas produced in the reaction will then collect in the gas syringe or measuring cylinder.



Measuring pH

A solution's pH can be measured in two different ways: with a **pH probe** or using an **indicator** with a pH scale. Using a pH probe is quite simple, you simply put the probe in the solution you are testing, wait for a while until the reading is steady and record the pH shown on the digital display. To get consistent results with a pH probe, the probe 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. It is suitable for producing **quick qualitative results**. 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. The scale for universal indicator is shown below. This method is not very accurate as the colour is **subjective** and people often disagree about which value it matches on the scale.



Measuring colour

Although colour is typically thought of as **qualitative** data, colour is a phenomenon that arises due to the **absorption of light**, so it can be measured. The colour of a solution of a transition metal ion typically gives us a good idea of its concentration. First, create a series of solutions of known concentration with the transition metal ion. Then measure their absorptions using a suitable setup. Create a '**calibration curve**' which is a graph of the change in absorption with the concentration. This curve can then be used to identify concentrations of transition metal solutions by their absorptions.

A way to qualitatively measure colour more effectively is to put a **white tile** under the container you are measuring the colour in, this technique can be used in titrations to better see the endpoint of a reaction.

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.

Anomalous data

A chemistry student should be able to recognise **anomalous** data, any data that does not fit the current **trend** is anomalous. If a student is performing a rates of reaction experiment and they decrease the concentration of a first order reactant by a small amount, we would expect the rate of reaction to slightly decrease, if instead the rate of reaction recorded shows a large increase the student should suspect that an error has been made. This data point should be marked as anomalous.