Experiment: Measuring Equipment and Precision

Aims

- To understand how the equipment and the method affect the accuracy of your data.

Activity 1- Measuring the volume of a test tube

Safety

Take care taken when moving around the lab.
Don't fit the pipette filler yourself, ask your teacher.

Apparatus

- 6 small (identical) test tubes
- 3 measuring cylinders of different sizes
- 10 ml graduated pipette & pipette filler
- 5 ml syringe
- 2ml syringe
- 1 small beaker (100ml)

Method

You will measure the volume of a tes tube six times. Record all the measurements in the table below.

1. Fill all six test tubes as full as possible with water
2. Pour the water into a measuring cylinder and measure the volume.
3. Repeat step 2 with a measuring cylinder of a different size.
4. Use a graduated pipette to remove all of the water from the 3rd tube and measure the volume.
5. Use a syringe to remove all the water and measure the volume.
6. pour the water into a small beaker and measure the volume.
7. For each piece of measuring equipment record the smallest unit on its measuring scale and the units.

Results

Record your results in the table.

Measuring Instrument	Volume of water in the test tube	Units	Smallest graduation	Uncertainty of one measurement	Overall uncertainty (if you made multiple measurements)

To do

1. Describe any variation in your results.

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2. Suggest why there are differences in the volumes measured.

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3. What is the measuring error (the uncertainty/degrees of precision) of each piece of equipment? Add this to your results table.
4. If you used the piece of equipment more than once to take one measurement you must multiply the error by the number of times it was used. Add this to your results table.
5. Which piece of equipment gives the most accurate answer?

Degrees of precision and uncertainty in data

For rulers and instruments with digital displays the degree of precision is **plus or minus (±) the smallest division** on the instrument.

The instrument precision is often smaller than this.
For example, a pipette or a measuring cylinder is usually read to **half of the smallest division**.
A reading of 4.1 on a pipette with divisions of 0.1 cm^3 could be anything from 4.05 to 4.15 cm^3

Results in biology experiments must have the same number of decimal places as the instrument's precision. This would mean that a pipette value of 4.1 cm^3 becomes 4.10 cm^3 (± 0.05 cm^3).
Note: the volume is written to **one extra decimal place** so it is consistent with the uncertainty.

The **uncertainty is sometimes bigger** than the precision, for example a measurement of 12s may be recorded using a stopwatch with a precision of 0.01s. The **human error** is greater, +/- 1s is likely.

The International System of Units (SI units).

IB biologists are expected to use the International System of Units (SI Units) agreed in 1960.

Mass: in kilograms (kg) or grams (g) or milligrams (mg)

Length: in metres (m) or millimetres (mm) or micrometres (µm) or nanometres (nm) or centimetres (cm)

Time: is measured in seconds (s)

Volume: the cubic metre (m3) is too large for most biology so the following 'quasi-SI units' are used.

- dm3 equal to 1 (litres)
- cm3 equal to ml (millilitres)

Concentration in solutions is usually given as mass of solute per volume of solution. The units are

- g dm^{-3} or mg dm^{-3} ,

Solution concentrations can also be described as percentages (%) on a weight per volume basis (i.e. % w/v) and refers to g solute dissolved in 100 cm3 water (100cm3 of water has a mass of 100g).