Making measurements

Variables

When carrying out investigations in chemistry it is often necessary to pay careful attention to the variables that may affect the results. In a valid experimental design, it is usually the case that one variable (the independent variable) is changed in a systematic way while a second variable (the dependent variable) is measured for each alteration in the independent variable. All other variables (the control variables) are kept constant.

Measuring instruments

A measuring instrument converts the variable being measured into another variable that can easily be read. A laboratory thermometer, for example, converts a temperature into the length of a column of mercury.

Measuring instruments used in practical chemistry include balances, timers, thermometers and graduated glassware to measure the volumes of liquids and gases.

The resolution of a measuring instrument is the smallest change in the quantity being measured that gives a noticeable change in the reading from the instrument. Thus a three-place balance has a higher resolution than a two-place balance.

There are two common standards for glassware: grade A and grade B. The manufacturing tolerances allowed for grade B glassware are larger than for grade A glassware. Grade B glassware is cheaper and commonly used in schools and colleges for advanced chemistry courses.

There are three main sources of uncertainty in the measurements when using volumetric glassware to measure the volumes of liquids:

* manufacturing tolerances mean that the graduation mark may be slightly different from the stated volume
* there are unavoidable variations in the judgement about the position of the meniscus relative to the graduation or scale marks
* glassware is calibrated at 20 °C and the volume will be slightly different is the working temperature if higher or lower than this.

One way of dealing with the uncertainty is to recalibrate the instrument. A suitable procedure for calibrating a pipette, for example, is to use it to measure out a volume of pure water into a weighed beaker and then to weigh it again. The volume of water that has been measured out can then be calculated because the density of water is 1.00 g cm−3.

Measurements

Measurements are evaluated in terms of their accuracy, precision and freedom from bias (see Section 5.9 in Student Book 1).

Two important tests of measurements are whether or not they are repeatable and reproducible. Measurements are repeatable if a set of results is equally accurate and precise when carried out by the same people under the same conditions and with the same equipment.

The test of reproducibility is more severe. Measurements are reproducible if a set of results is equally accurate and precise when carried out by different people using different methods or equipment.