Guidance on uncertainties in analytical glassware

Analytical glassware is produced to within a certain tolerance, or degree of error. Glassware may be either Class A or Class B. The Class A glassware has roughly half the tolerances of Class B, but can be three or four times more expensive. It is also important to remember that temperature will affect both the capacity of a glass vessel, and the volume of the measured liquid. In the UK, volumetric glassware is calibrated at 20°C.

The tolerances of Class A and Class B glassware are given below:

Volumetric flasks

Flask size (cm^3)	5	10	25	50	100	250	500	1000
Class A tolerance (cm^3)	0.025	0.025	0.04	0.06	0.10	0.15	0.25	0.40
Class B tolerance (cm^3)	0.04	0.04	0.06	0.12	0.20	0.30	0.50	0.80

Graduated pipettes

Flask size (cm^3)	1	2	5	10
Reading[1] uncertainty (cm^3)	0.005	0.01	0.025	0.05
Volume[2] uncertainty (cm^3)	0.01	0.02	0.05	0.10

Example

For example, if you used a 5cm^3 graduated pipette to measure 3.5cm^3, then the percentage error in volume readings would be:

Reading uncertainty:	((0.025 x 2)/3.5) x 100	=	1.4%
Pipette tolerance:	(0.05/5)	=	1.0%
Total uncertainty:		=	2.4%

Bulb pipettes

Pipette capacity (cm^3)	1	2	5	10	20	25	50	100
Class A tolerance (cm^3)	0.006	0.006	0.015	0.020	0.030	0.030	0.050	0.080
Class B tolerance (cm^3)	0.012	0.012	0.030	0.040	0.060	0.060	0.100	0.150

[1] The percentage uncertainty is doubled since two readings are taken.
[2] This is the uncertainty due to the pipette itself.

Bulb pipettes are more accurate than graduated pipettes, and should always be used where there is a choice.

The percentage uncertainty in a measurement is defined as:

$$\text{Percentage uncertainty} = \frac{\text{absolute uncertainty}}{\text{measurement}} \times 100$$

The percentage uncertainty in a 10cm^3 volumetric pipette is:

% uncertainty = (0.04/10) x 100 = 0.40%

When given the percentage uncertainty in a measurement, the absolute uncertainty can be calculated by rearranging the above expression to:

Burettes

Burette capacity (cm^3)	5	10	25	50	100
Class A tolerance (cm^3)	0.02	0.01	0.03	0.05	0.10
Class B tolerance (cm^3)	0.04	0.02	0.05	0.10	0.20

There will be an additional uncertainty due to the titre, which is a result of the two readings (initial and final). This is half of the smallest division of the scale. So, the percentage uncertainty should be doubled.

Analytical balances

A four figure digital analytical balance will be accurate to ± 0.0001g. The percentage uncertainty would not be meaningful for most masses measured (<0.01%).
It is more likely however that balances will be out of calibration due to drift.

Leaners should always use the same balance for all their mass measurements during a given practical.

Thermometers

An analogue thermometer with a scale will have an absolute uncertainty which is half of the smallest division of the scale. For example, if the thermometer has 1 degree intervals then the absolute uncertainty will be ± 0.5oC.

Remember that temperature will affect both the capacity of a glass vessel, and the volume of the measured liquid. In the UK, volumetric glassware is calibrated at 20^{o}C.

Example

Chemical A (0.2135g) was dissolved in deionised water, making up to 50cm3 in a volumetric flask (Class B). A bulb pipette (10cm3, Class B) was used to withdraw portions for titration. Using a standard 50cm3 burette, an average titre value of 9.85cm3 was obtained.

The uncertainties are as follows:

	Uncertainty	**Percentage uncertainty**	
Mass balance	0.0001 g	(0.0001/0.2135) x 100	0.05%
Volumetric flask	0.12 cm^3	(0.12/50) x 100	0.24 %
Pipette	0.04 cm^3	(0.04/10) x 100	0.40 %
Burette reading	0.10 cm^3	(0.10/9.85) x 100	1.02 %
Burette tolerance	0.10 cm^3	(0.10/50) x 100	0.20%
Total			**1.91%**