

Estimating Errors in Chemistry

Introduction

You must be able to estimate the size and importance of errors in practical work to gain full marks in your practical assessments. The table summarises what you need to do about errors in each Skill:

Skill	You must be able to:
Skill P Planning	Organise the procedure to be followed, selecting appropriate techniques, reagents and apparatus, with due regard to precision of measurement and scale of working.
Skill I Implementing	Make and record measurements to a degree of precision allowed by the apparatus used.
Skill A Analysing	Identify sources of error, and recognise the limitations of experimental measurements.
Skill E Evaluating	Assess the reliability of your data and the conclusions drawn from them, taking into account the errors in the data obtained.

The detail required is much less than that required for Physics A Level, but you must say more than “I might have forgotten to wash out my beaker” – this is *operator incompetence* rather than an *error* in the sense required by the examination board. This guide is intended to show you how you can estimate the size and importance of errors in Chemistry to help you to gain full marks in assessments.

Mass

1. Consider weighing 1g of solid. If you use a two decimal place balance, the mass recorded will be to the nearest 0.01g. In this example, the % error will be:

$$\frac{0.01}{1} \times 100 = \mathbf{1\%}$$

2. Consider weighing the same 1g of solid on a three decimal place balance. The mass recorded will be to the nearest 0.001g, and so the % error will be:

$$\frac{0.001}{1} \times 100 = \mathbf{0.1\%}$$
 There is much less error involved in this procedure, but other procedures like volume measurements might swamp this improvement.

3. Consider weighing 10g of solid on the two decimal place balance. In this case the % error will be:

$$\frac{0.01}{10} \times 100 = \mathbf{0.1\%}$$
 This is less than weighing 1g on this balance, so choose the right balance for the amount of material to be weighed.

Volume

4. Consider measuring 25cm³ in a 25cm³ measuring cylinder. The measurement will normally be to the nearest 0.5cm³, so the % error will be:

$$\frac{0.5}{25} \times 100 = \mathbf{2.0\%}$$
 Rather upsetting if you have just weighed to $\pm 0.1\%$, so what can you do? Turn over to find out ...

5. If you use a transfer pipette, the accuracy is quoted on the apparatus itself, but is normally **0.25%**, so using this is usually more appropriate than a measuring cylinder. It is important to remember when designing your own experiments that pipettes come in a limited range of volumes with 25cm³ being most commonly used, so try to avoid peculiar volumes which would need measuring cylinders. You could, however, consider graduated pipettes.

6. If you use a graduated pipette, as with all measuring equipment, specify a capacity closest to the target volume. For example, if you want 25cm³ of liquid using a 25cm³ graduated pipette, the reading will usually be to the nearest 0.2cm³, so the % error will be:

$$\frac{0.2}{25} \times 100 = \mathbf{0.8\%}$$

Much better than using the measuring cylinder, but still worse than choosing to measure the same volume with a transfer pipette.

7. If you use a burette, you can obtain readings to the nearest 0.05cm³. If you aim for a titre of 25cm³, the % error would be:

$$\frac{0.05}{25} \times 100 = \mathbf{0.2\%}$$

Used well, the burette is very accurate (note that many Skill 2 assessments – Implementing – concentrate on burette skills).

Why aim for a titre of 25cm³? If you obtain a titre of 5cm³, the error involved is 1% (very much more than 0.2%); if you obtain a titre of 50cm³, the error is 0.1% (not much of an improvement for using twice as much titrant).

8. Finally, consider the standard flask. Like the transfer pipette, the accuracy is quoted on the apparatus itself, but is normally **0.125%**. For large volumes it is likely to be the most accurate piece of apparatus, but again remember to avoid peculiar volumes in your experimental designs.

Time

9. Consider a reaction time of 100s. Measured on a common laboratory stopclock, the % error is:

$$\frac{1}{100} \times 100 = \mathbf{1.0\%}$$

This is quite large, and gets worse if reaction rates are faster. For example, the error involved in a 10s reaction is $\pm 10\%$. Doing a preliminary experiment may help avoid this when designing.

10. Finally, consider a reaction time of 100s measured on a digital stopwatch. These often show times to the nearest 0.01s. The % error would be:

$$\frac{0.01}{100} \times 100 = \mathbf{0.01\%}$$

This is wonderful, but how quickly can you stop and start it? Lots of people practice this when they should be doing something else – my best times are around 0.10s. In this case, the error is really more like 0.1%, and operator incompetence becomes important.

Skill area	You should:
Skill P Planning	Do some preliminary calculations to establish the likely quantities. Alter these, if appropriate, to avoid non-standard volumes. Specify the most suitable apparatus.
Skill I Implementing	Record your results to the precision allowed by the apparatus. For example, if the balance reads to 0.01g, make sure you don't round up 6.78g to 6.8g or 7g.
Skill A Analysing	Estimate the % error involved in each measurement. Work out the total apparatus error. Identify the apparatus or step that produces the biggest error.
Skill E Evaluating	Work out whether the apparatus error is enough to account for any difference between your result and your teacher's result. Suggest more precise apparatus.