Chem Factsheet

September 2002 Number 42

Critical Analysis of Experimental Procedures and Levels of Accuracy

To succeed in this topic you need to:
- be familiar with the concepts raised in Factsheet 36 (Laboratory Chemistry – Continuous Practical Assessment) and the other Factsheets mentioned in this topic;
- have a copy of your AS/A2 specification so that you can refer to the specifics on 'evaluation and interpretation of practical results'.

After working through this Factsheet you will:
- have met a range of issues about 'accuracy' relating to practical work;
- know the appropriate level of accuracy for practical results;
- be able to calculate 'percentage errors'.

AS/A2 specification requirements

The specifications list the following under 'Interpretation and evaluation of experimental results':

The ability to:

(1) evaluate critically experimental work i.e. experimental error, anomalous results, suggest improvements.

(2) assess how reliable data is and the conclusions drawn from it

(3) recognise the limitations of various techniques

(4) calculate experimental error

Laboratory practical work

Although it is not possible to cover all the specific practical situations that you may be presented with in an examination question, we can, however, put experimental work into broad categories:

(1) Test on compounds – if you do this test and the substance reacts like this what can you tell about the substance?

To answer questions on this type of situation you need to learn the specific tests and reactions of compounds as given in your specification. Factsheet 24 gives the commonly asked tests.

(2) Titrations – acid/base, redox and 'one off' analysis examples e.g EDTA.

All titrations involve the generation of data by the use of very accurate glassware and balances. Questions on titrations are the most common in the area of evaluation and interpretation. This Factsheet has examples on titration work; see also Factsheet 23.

(3) Preparation and purification of compounds – these are usually organic compounds but occasionally inorganic compounds as well.

The methods are different for **solids** and **liquids** - see Factsheet 30.

Examination questions usually involve describing a method for a preparation and purification of a compound then asking you what happens at specific stages. Sometimes an error will be put into the procedure and often a percentage yield calculation included. This involves, as for tests/inferences, a thorough learning of the procedures from your specification and your own practical work.

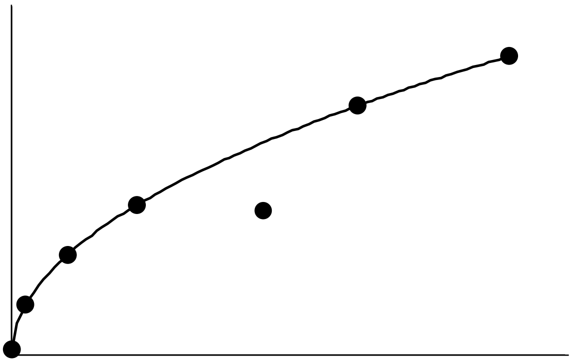
(4) Reaction kinetics – following a rate of reaction and changing variables to see the effect on the rate.

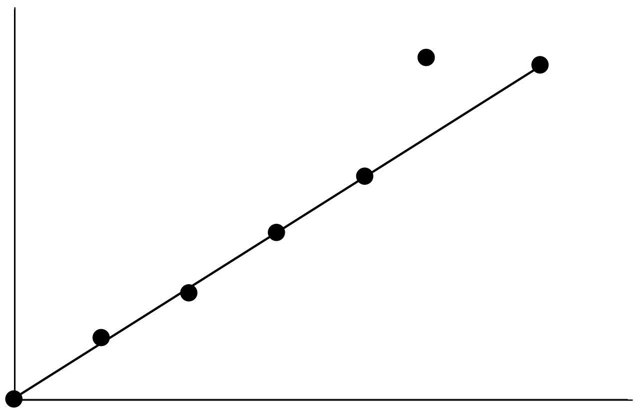
These experiments generate data which usually then need plotting as graphs. You are likely to be asked to:
- comment on the procedure
- spot anomalous results.

Categories of questions

(1) Anomalous results

These are results that do not fit a pattern or trend. They are hard to see just from the raw figures but once plotted as a graph they stand out – as you can see in the two examples below.





(2) Percentage yield

The equation is

$$\textit{Percentage yield} = \frac{\textit{mass obtained} \times 100}{\textit{mass expected from calculation}}$$

Worked example
0.25 mol ethanol is converted into bromoethane as in the equation.

$C_2H_5OH + HBr \rightarrow C_2H_5Br + H_2O$

If 18.30g of bromoethane is produced, what is the percentage yield?

Answer	Explanation
(a) 0.25 mol bromoethane should be produced	From equation 1 mol ethanol produces 1 mol bromoethene
(b) $M_r (C_2H_5Br) = 109$	C = 12, H = 1, Br = 80
(c) Mass $C_2H_5Br = 109 \times 0.25 = 27.25g$	0.25 mol expected if 100% conversion
(d) Percentage purity = $\frac{18.30 \times 100}{27.25}$ = 67.16%	Use equation

(3) Level of accuracy

(a) The rule is clear for all calculated answers – only 2 or 3 figures after the decimal point.

If we go back to the percentage yield calculation:

$$\text{percentage yield} = \frac{18.30 \times 100}{27.25}$$

the calculator answer was 67.15596g

Only 67.16g **or** 67.156g are acceptable.

***Exam Hint: -** Even strong candidates can be prone to lose marks through giving the answer to an otherwise correct calculation to an inappropriate numbers of decimal places. Always look back at your answer!*

(b) Titration work throws up many examples of levels of accuracy because:

electronic balances	-	3 figures after the decimal point
burette readings	-	___.___5 or ___.___0 is the level of accuracy
pipettes	-	$25.00cm^3/50.00cm^3$ i.e. 2 decimal places

Worked example
A student produced the following results from a titration:

burette reading	**1**	**2**	**3**
final cm^3	23.40	23.67	23.40
start cm^3	0.00	0.05	0.05
volume used cm^3	23.40	23.62	23.35

Mean titre = 23.40 + 23.62 + 23.35 = 23.4566 cm^3

What are the three errors in the student's work?

Answers

(a) $23.67cm^3$ is incorrect because the burette cannot be read to that level of accuracy.

(b) $23.62cm^3$ should not have been used to calculate the mean titre because it is not in the range of accuracy of the other two values. You need two titres that are the same or $\pm$ $0.10cm^3$ of each other.

(c) Too many significant figures in the mean titre answer.

(4) Percentage Errors
The equation is

$$\textit{Percentage error} = \frac{\textit{error amount} \times 100}{\textit{actual amount}}$$

Worked examples
What is the percentage error in each of the following situations?

(a) A student weighs out 0.80g instead of 0.70g

$$\text{Percentage error} = \frac{(0.80 - 0.70) \times 100}{0.70} = 14.29\%$$

(b) The M_r of a compound is calculated to be 125 from experimental data. The actual M_r is 127.

$$\text{Percentage error} = \frac{(127 - 125) \times 100}{127} = 1.57\%$$

(c) A student leaves $0.30cm^3$ in a beaker after pouring out the $25.00cm^3$ he originally put in it.

$$\text{Percentage error} = \frac{0.30 \times 100}{25.00} = 1.20\%$$

Acknowledgements:
This Factsheet was researched and written by Sam Goodman
Curriculum Press, Unit 305B, The Big Peg, 120 Vyse Street, Birmingham, B18 6NF
***ChemistryFactsheets** may be copied free of charge by teaching staff or students, provided that their school is a registered subscriber.*
No part of these Factsheets may be reproduced, stored in a retrieval system, or transmitted, in any other form or by any other means, without the prior permission of the publisher. ***ISSN 1351-5136***