Guidance for Practical 4 – Chapter 1

Determination of the A_r of lithium

If this practical is to be used for assessment, the minimum amount of information must be given to students. They must not be told how to present the data or how to carry out the calculation.

Safety

- Lithium is corrosive.
- The gas produced in the reaction is highly flammable.
- The solution produced is an irritant to the eyes and the skin.
- Wear eye protection.

Data collection and processing

It would be expected that students will present the data in a table such as the one below.

Volume of water / cm^3	100 ± 1
Mass of lithium / g	0.10 ± 0.01
Volume of gas / cm^3	165 ± 1
Temperature / °C	23 ± 1
Pressure / mmHg	756 ± 1

The students should also record qualitative data.

They should carry out the calculation as follows, and will be expected to propagate errors to arrive at a suitable number of significant figures for the final answer.

The number of moles of gas produced can be calculated using $PV = nRT$.

Convert to an appropriate set of units:

- pressure = 756 × 133.4 = 100 850 Pa
- temperature = 23.0 + 273 = 296 K
- volume = 165×10^{-6} m^3

$$n = \frac{PV}{RT}$$

$$n = \frac{100850 \times 165 \times 10^{-6}}{8.31 \times 296}$$

$$n = 6.765 \times 10^{-3} \text{ mol}$$

The equation for the reaction is: $2Li + 2H_2O \rightarrow 2LiOH + H_2$

The number of moles of Li is thus twice the number of moles of H_2: 0.01353 mol

$$\text{relative atomic mass} = \frac{\text{mass}}{\text{number of moles}}$$

$$A_r = \frac{0.10}{0.01353}$$

$$A_r = 7.391$$

Error analysis

Error analysis must now be carried out to determine the number of significant figures that can be quoted.

Since the calculation involves multiplying and dividing quantities, percentage errors must be calculated.

		Unit conversion	Percentage uncertainty
Mass of lithium	0.10 ± 0.01 g		10%
Volume of gas	165 ± 1 cm^3	$165 \times 10^{-6} \pm 1 \times 10^{-6}$ m^3	0.61%
Temperature	23 ± 1 °C	296 ± 1 K	0.34%
Pressure	756 ± 1 mmHg	100 850 ± 130 Pa	0.13%

The conversion of °C to K involves adding what is considered to be a pure number and so the absolute uncertainty stays the same.

When the units are converted for pressure the percentage uncertainty remains the same, thus the percentage uncertainty of the pressure in mmHg is $\frac{1}{756} \times 100 = 0.13\%$

The percentage uncertainty on the number of moles of hydrogen is calculated by adding the percentage uncertainties for volume, temperature and pressure:

the percentage uncertainty for *n* is 0.61 + 0.34 + 0.13 = 1.1%

This percentage uncertainty stays the same when *n* is multiplied by 2 (as 2 is a pure number it does not have an uncertainty).

the percentage uncertainty on the number of moles of Li is thus 1.1%

The percentage uncertainty on the relative atomic mass of Li is the sum of the percentage uncertainty on the number of moles and the percentage uncertainty on the mass, i.e. 11.1%.

This is then converted to an absolute uncertainty by multiplying by the value of A_r,

so absolute uncertainty = $\frac{11.1 \times 7.391}{100} = 0.8$, to one significant figure

The uncertainty is in the first decimal place and therefore the final value can be quoted as 7.4 ± 0.8.

Further ideas

The practical can be extended by measuring the volume of water in the conical flask more precisely, withdrawing 10.0 cm^3 samples using a pipette and then titrating these against 0.10 mol dm^{-3} hydrochloric acid.

The practical procedure can also be adapted to determine the relative atomic mass of magnesium by using 0.20 g magnesium instead of lithium and 100 cm^3 of 0.50 mol dm^{-3} hydrochloric acid in the conical flask.