

## 5 Percentage yields and percentage errors

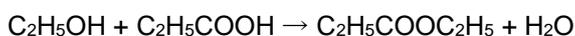
### 5.1 Calculating percentage yield

Chemists often find that an experiment makes a smaller amount of product than expected. They can predict the amount of product made in a reaction by calculating the percentage yield.

The percentage yield links the actual amount of product made, in moles, and the theoretical yield, in moles:

$$\text{percentage yield} = \frac{\text{actual amount (in moles) of product}}{\text{theoretical amount (in moles) of product}} \times 100$$

Look at this worked example. A student added ethanol to propanoic acid to make the ester, ethyl propanoate, and water.



The experiment has a theoretical yield of 5.00 g.

The actual yield is 4.50 g.

The molar mass of  $\text{C}_2\text{H}_5\text{COOC}_2\text{H}_5 = 102.0 \text{ g mol}^{-1}$

Calculate the percentage yield of the reaction.

$$\text{Actual amount of ethyl propanoate: } n = \frac{m}{M} = 4.5/102 = 0.0441 \text{ mol}$$

$$\text{Theoretical amount of ethyl propanoate: } n = \frac{m}{M} = 5.0/102 = 0.0490 \text{ mol}$$

$$\text{percentage yield} = (0.0441/0.0490) \times 100\% = 90\%$$

### Practice questions

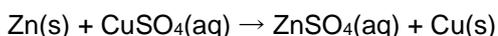
- 1 Calculate the percentage yield of a reaction with a theoretical yield of 4.75 moles of product and an actual yield of 3.19 moles of product. Give your answer to 3 significant figures.
- 2 Calculate the percentage yield of a reaction with a theoretical yield of 12.00 moles of product and an actual yield of 6.25 moles of product. Give your answer to 3 significant figures.

### 5.3 Calculating percentage error in apparatus

The percentage error of a measurement is calculated from the maximum error for the piece of apparatus being used and the value measured:

$$\text{percentage error} = \frac{\text{maximum error}}{\text{measured value}} \times 100\%$$

Look at this worked example. In an experiment to measure temperature changes, an excess of zinc powder was added to 50 cm<sup>3</sup> of copper(II) sulfate solution to produce zinc sulfate and copper.



The measuring cylinder used to measure the copper(II) sulfate solution has a maximum error of  $\pm 2 \text{ cm}^3$ .

- a Calculate the percentage error.

$$\text{percentage error} = (2/50) \times 100\% = 4\%$$

- b** A thermometer has a maximum error of  $\pm 0.05$  °C.

Calculate the percentage error when the thermometer is used to record a temperature rise of 3.9 °C. Give your answer to 3 significant figures.

$$\text{percentage error} = (2 \times 0.05) / 3.9 \times 100\% = 2.56\%$$

(Notice that two measurements of temperature are required to calculate the temperature change so the maximum error is doubled.)

### Practice questions

- 3** A gas syringe has a maximum error of  $\pm 0.5$  cm<sup>3</sup>. Calculate the maximum percentage error when recording these values. Give your answers to 3 significant figures.
- a** 21.0 cm<sup>3</sup>                      **b** 43.0 cm<sup>3</sup>
- 4** A thermometer has a maximum error of  $\pm 0.5$  °C. Calculate the maximum percentage error when recording these temperature rises. Give your answers to 3 significant figures.
- a** 12.0 °C                      **b** 37.6 °C