Percentage yield calculations

Foundation Tier – Worked example

In a reaction, 50 g of product was expected but only 40 g was obtained. Calculate the percentage yield.

$$\text{percentage yield} = \frac{\text{mass of product actually made}}{\text{maximum theoretical mass of product}} \times 100 = \frac{40\text{ g}}{50\text{ g}} \times 100 = 80\%$$

Foundation Tier – Questions

Calculate the percentage yield in each of the following situations.

	Actual yield /g	Theoretical yield /g
1.	60	100
2.	20	80
3.	0.50	1.25
4.	741	780

Higher Tier students must be able to do these calculations too.

Higher Tier – Worked example

Sodium reacts with iodine to form sodium iodide: $2Na + I_2 \longrightarrow 2NaI$

(a) Calculate the maximum theoretical mass of sodium iodide from 2.54 g of iodine.

M_r of $I_2 = (2 \times 127) = 254$ M_r of $NaI = 23 + 127 = 150$

$$\text{amount of } I_2 = \frac{\text{mass of } I_2}{M_r \text{ of } I_2} = \frac{2.54\text{ g}}{254} = 0.01\text{ mol}$$

from 2NaI

$$\text{theoretical mass of NaI} = \frac{\text{amount of } I_2}{1} \times 2 \times M_r \text{ of NaI} = \frac{0.01\text{ mol}}{1} \times 2 \times 150$$

use the chemical equation here

$= 3.00$ g

from I_2

(b) Calculate the percentage yield if only 2.31 g of sodium iodide is obtained.

$$\text{percentage yield} = \frac{\text{mass of product actually made}}{\text{maximum theoretical mass of product}} \times 100 = \frac{2.31\text{ g}}{3.00\text{ g}} \times 100 = 77\%$$

Higher Tier – Questions

In each of the following situations, calculate:

(a) the maximum theoretical mass of product

(b) the percentage yield of product, using your answer to part (a).

5. 3.5 g of calcium oxide was obtained from 25 g of calcium carbonate: $CaCO_3 \longrightarrow CaO + CO_2$
6. 5.5 g of carbon dioxide was obtained from 6.0 g carbon: $C + O_2 \longrightarrow CO_2$
7. 9.0 g of water was obtained from 16 g of oxygen: $2H_2 + O_2 \longrightarrow 2H_2O$
8. 15.3 g of ammonia was obtained from 4.5 g of hydrogen: $N_2 + 3H_2 \rightleftharpoons 2NH_3$

Use these relative atomic masses.

Element	H	C	N	O	Na	Ca	I
A_r	1	12	14	16	23	40	127

Percentage yield calculations – ANSWERS

1. percentage yield = $\frac{60}{100} \times 100 = 60\%$

2. percentage yield = $\frac{20}{80} \times 100 = 25\%$

3. percentage yield = $\frac{0.5}{1.25} \times 100 = 40\%$

4. percentage yield = $\frac{741}{780} \times 100 = 95\%$

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5. (a) M_r of CaO = 40 + 16 = 56 M_r of $CaCO_3$ = 40 + 12 + (3 × 16) = 100

amount of $CaCO_3$ = $\frac{\text{mass of } CaCO_3}{M_r \text{ of } CaCO_3} = \frac{25\text{ g}}{100} = 0.25\text{ mol}$

theoretical mass of CaO = $\frac{\text{amount of } CaCO_3}{1} \times 1 \times M_r \text{ of CaO} = \frac{0.25\text{ mol}}{1} \times 1 \times 56$

= 14 g

(b) percentage yield = $\frac{3.5\text{ g}}{14\text{ g}} \times 100 = 25\%$

6. (a) M_r of CO_2 = 12 + (2 × 16) = 12 + 32 = 44

amount of C = $\frac{\text{mass of C}}{A_r \text{ of C}} = \frac{6.0\text{ g}}{12} = 0.5\text{ mol}$

theoretical mass of CO_2 = $\frac{\text{amount of C}}{1} \times 1 \times M_r \text{ of } CO_2 = \frac{0.5\text{ mol}}{1} \times 1 \times 44$

= 11 g

(b) percentage yield = $\frac{5.5\text{ g}}{11\text{ g}} \times 100 = 50\%$

7. (a) M_r of O_2 = (2 × 16) = 32 M_r of H_2O = (2 × 1) + 16 = 18

amount of O_2 = $\frac{\text{mass of } O_2}{M_r \text{ of } O_2} = \frac{16\text{ g}}{32} = 0.5\text{ mol}$

theoretical mass of H_2O = $\frac{\text{amount of } O_2}{1} \times 1 \times M_r \text{ of } H_2O = \frac{0.5\text{ mol}}{1} \times 2 \times 18$

= 18 g

(b) percentage yield = $\frac{9.0\text{ g}}{18\text{ g}} \times 100 = 50\%$

8. (a) M_r of H_2 = (2 × 1) = 2 M_r of NH_3 = 14 + (3 × 1) = 17

amount of H_2 = $\frac{\text{mass of } H_2}{M_r \text{ of } H_2} = \frac{4.5\text{ g}}{2} = 2.25\text{ mol}$

theoretical mass of NH_3 = $\frac{\text{amount of } H_2}{3} \times 2 \times M_r \text{ of } NH_3 = \frac{2.25\text{ mol}}{3} \times 2 \times 17$

= 25.5 g

(b) percentage yield = $\frac{15.3\text{ g}}{25.5\text{ g}} \times 100 = 60\%$