Percentage Yield **Answers**

Use a calculator and a periodic table to answer the following questions.

1. 19.62 g of zinc reacted with an excess of hydrochloric acid to produce a solution of zinc chloride.

$$Zn(s) + 2HCl(aq) \longrightarrow ZnCl_2(aq) + H_2(g)$$

Crystallisation of the solution yielded 35.46 g of zinc chloride.

Calculate the percentage yield.

Give your answer to an appropriate number of significant figures.

moles of Zn = $\frac{\text{mass of substance (g)}}{A_r \text{ or } M_r \text{ of substance } (\text{g mol}^{-1})}$

A_r of Zn = 65.4

$\frac{19.62}{65.5}$ = 0.3000 moles

stoichiometric ratio of Zn : $ZnCl_2$ = 1 : 1

maximum possible moles of $ZnCl_2$ = 0.3000 moles

theoretical yield of $ZnCl_2$ = number of moles × A_r

M_r of $ZnCl_2$ = (65.4 × 1) + (35.5 × 2) = 136.4

0.3000 × 136.4 = 40.92 g

percentage yield = $\frac{\text{actual yield}}{\text{theoretical yield}}$ × 100

$\frac{35.46}{40.92}$ × 100 = 86.6568915

percentage yield = **86.66% (4 s.f.)**

2. At room temperature and pressure, 120 cm^3 of sulfur dioxide reacts with 100 cm^3 of oxygen to produce 109 cm^3 of sulfur trioxide.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

a. Calculate the percentage yield of this reaction.

Give your answer to an appropriate number of significant figures.

at room temperature and pressure the volume of one mole of gas = 24.0 dm^3

stoichiometric ratio of SO_2 : O_2 = 2 : 1

O_2 is in excess (only 60 cm^3 of O_2 needed to react completely with 120 cm^3 of SO_2)

stoichiometric ratio of SO_2 : SO_3 = 2 : 2 = 1 : 1

theoretical yield of SO_3 = 120 cm^3

percentage yield = $\frac{\text{actual yield}}{\text{theoretical yield}} \times 100$

$\frac{109}{120} \times 100 = 90.83333333$

percentage yield = **90.8% (3 s.f.)**

b. Explain why the percentage yield of this reaction is not 100%.

The reaction is reversible. Therefore, some of the sulfur trioxide will always decompose to form sulfur dioxide and oxygen.

c. The above reaction occurs during one of the steps in the Contact process. In the next step of the Contact process, sulfur trioxide reacts with water to make sulfuric acid.

$$SO_3(g) + H_2O(l) \longrightarrow H_2SO_4(aq)$$

The percentage yield of this step is 93.3%.

Calculate the overall percentage yield of the steps shown above.

$\frac{90.8}{100} \times \frac{93.3}{100} \times 100 = 84.7164$

overall percentage yield = **84.7% (3 s.f.)**.

3. On heating, 62.1 g of calcium carbonate produced 16.5 g of carbon dioxide.

$$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$$

Calculate the percentage of the calcium carbonate that decomposed.

Give your answer to an appropriate number of significant figures.

initial moles of $CaCO_3$ = $\frac{\text{mass of substance (g)}}{A_r \text{ or } M_r \text{ of substance } (\text{g mol}^{-1})}$

M_r of $CaCO_3$ = (40.1 × 1) + (12.0 × 1) + (16.0 × 3) = 100.1

$\frac{62.1}{100.1}$ = 0.6203796204 moles

stoichiometric ratio of $CaCO_3$: CO_2 = 1 : 1

number of moles of $CaCO_3$ decomposed = number of moles of CO_2 produced

moles of CO_2 = $\frac{\text{mass of substance (g)}}{A_r \text{ or } M_r \text{ of substance } (\text{g mol}^{-1})}$

M_r of CO_2 = (12.0 × 1) + (16.0 × 2) = 44.0

$\frac{16.5}{44.0}$ = 0.375 moles

percentage decomposition = $\frac{\text{actual number of moles decomposed}}{\text{theoretical number of moles decomposed}}$ × 100

$\frac{0.375}{0.6203796204}$ × 100 = 60.4468599

percentage decomposition = **60.4% (3 s.f.)**

4. 4.745 g of bromomethane (CH_3Br) reacted with an excess of sodium hydroxide. The percentage yield of the reaction is 93.1%.

$$CH_3Br + NaOH \longrightarrow CH_3OH + NaBr$$

What is the mass of methanol (CH_3OH) produced?

A. 1.09 g ☐

B. 1.49 g ☑

C. 1.93 g ☐

D. 2.04 g ☐

Working:

moles of CH_3Br = $\frac{4.745}{94.9}$ = 0.05

theoretical yield of CH_3OH = 0.05 × 32.0 = 1.60 g

actual yield = $\frac{93.1}{100}$ × 1.60 = 1.4896 g = 1.49 g (3 s.f.)