



Atom Economy and Percentage Yield

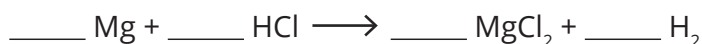
Percentage Yield

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

1. In a reaction between magnesium and hydrochloric acid, it was calculated that 2.5g of magnesium chloride could be produced. The actual yield of magnesium chloride produced was 1.5g. Calculate the percentage yield of the reaction.

Percentage yield = _____ %

2. Balance the symbol equation for the reaction between magnesium and hydrochloric acid.



3. In a reaction between calcium oxide and water, it is calculated that 27g of calcium hydroxide will be produced. The actual yield of calcium hydroxide produced is 13g. Calculate the percentage yield of the reaction.

Percentage yield = _____ %

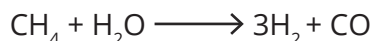
4. Write the balanced symbol equation for the reaction between calcium oxide (CaO) and water (H₂O) to produce calcium hydroxide (Ca(OH)₂).

Atom Economy

$$\text{Atom economy} = \frac{\text{total } M_r \text{ of the desired product}}{\text{total } M_r \text{ of all reactants}} \times 100$$

Worked example

Hydrogen is produced when methane and water react together.



Calculate the atom economy of the reaction.

Step 1 – Calculate the M_r of the desired product. In this case the desired product is hydrogen. From the balanced symbol equation, we know that 3 moles of hydrogen are produced.

$$M_r \text{ of hydrogen (H}_2\text{)} = 1 \times 2 = 2$$

$$M_r \text{ of 3 moles of hydrogen} = 3 \times 2 = 6$$

Step 2 – Calculate the M_r of all the reactants.

Reactants	CH ₄	H ₂ O
M_r	$12 + (1 \times 4) + 16$	$(1 \times 2) + 16 = 18$

$$\text{Total } M_r \text{ of all reactants} = 16 + 18 = 34$$

Step 3 – Using the equation, calculate the percentage atom economy for the reaction.

$$\text{Atom economy} = \frac{6}{34} = 0.176$$

$$0.176 \times 100 = 17.6 \%$$

Use the worked example to help you answer the questions below.

5. Ammonia can be made in two different ways. Ammonia can be made by reacting calcium oxide and ammonium chloride or by reacting hydrogen and nitrogen.
 - a. Write the balanced symbol equation for the reaction between calcium oxide (CaO) and ammonium chloride (NH₄Cl) to produce calcium chloride (CaCl₂), water (H₂O) and ammonia (NH₃).

- b. Calculate the atom economy for the reaction.

$$\text{Atom economy} = \underline{\hspace{2cm}} \%$$



- c. Write the balanced symbol equation for the reaction between hydrogen and nitrogen to produce ammonia.

- d. Calculate the atom economy for the reaction.

Atom economy = _____ %

6. The fermentation of glucose produces ethanol and carbon dioxide. Carbon dioxide is a waste product.

- a. Balance the symbol equation for the reaction.



- b. Calculate the atom economy for the reaction.

Atom economy = _____ %

Atom Economy and Percentage Yield Answers

Percentage Yield

1. In a reaction between magnesium and hydrochloric acid, it was calculated that 2.5g of magnesium chloride could be produced. The actual yield of magnesium chloride produced was 1.5g. Calculate the percentage yield of the reaction.

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

$$\text{percentage yield} = \frac{1.5}{2.5} = 0.6$$

$$\text{percentage yield} = 0.6 \times 100 = 60\%$$

2. Balance the symbol equation for the reaction between magnesium and hydrochloric acid.



3. In a reaction between calcium oxide and water, it is calculated that 27g of calcium hydroxide will be produced. The actual yield of calcium hydroxide produced is 13g. Calculate the percentage yield of the reaction.

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

$$\text{percentage yield} = \frac{13}{27} = 0.48$$

$$\text{percentage yield} = 0.48 \times 100 = 48\%$$

4. Write the balanced symbol equation for the reaction between calcium oxide (CaO) and water (H₂O) to produce calcium hydroxide (Ca(OH)₂).



Atom Economy

5. Ammonia can be made in two different ways. Ammonia can be made by reacting calcium oxide and ammonium chloride or by reacting hydrogen and nitrogen.

- a. Write the balanced symbol equation for the reaction between calcium oxide and ammonium chloride to produce calcium chloride, water and ammonia.



- b. Calculate the atom economy for the reaction.

The desired product in this reaction is ammonia.

$$M_r \text{ of ammonia (NH}_3\text{)} = 14 + (1 \times 3) = 17$$

$$M_r \text{ of 2 moles of ammonia} = 2 \times 17 = 34$$

Reactants	CaO	2NH ₄ Cl
M _r	40 + 16 = 56	2 × (14 + (1 × 4) + 35.5) = 107

$$\text{Total } M_r \text{ of all reactants} = 56 + 107 = 163$$

$$\text{percentage yield} = \frac{\text{total } M_r \text{ of the desired product}}{\text{total } M_r \text{ of all reactants}} \times 100$$

$$\text{percentage yield} = \frac{34}{163} \times 100 = 20.86\%$$

- c. Write the balanced symbol equation for the reaction between hydrogen and nitrogen to produce ammonia.



- d. Calculate the atom economy for the reaction.

$$M_r \text{ of ammonia (NH}_3\text{)} = 14 + (1 \times 3) = 17$$

$$M_r \text{ of 2 moles of ammonia} = 2 \times 17 = 34$$

Reactants	3H_2	N_2
M_r	$3 \times 2 = 6$	$14 \times 2 = 28$

$$\text{Total } M_r \text{ of all reactants} = 6 + 28 = 34$$

$$\text{atom economy} = \frac{\text{total } M_r \text{ of the desired product}}{\text{total } M_r \text{ of all reactants}} \times 100$$

$$\text{atom economy} = \frac{34}{34} \times 100 = 100\%$$

6. The fermentation of glucose produces ethanol and carbon dioxide. Carbon dioxide is a waste product.

- a. Balance the symbol equation for the reaction.



- b. Calculate the atom economy for the reaction.

$$M_r \text{ of ethanol (C}_2\text{H}_5\text{OH)} = (12 \times 2) + (1 \times 5) + 16 + 1 = 46$$

$$M_r \text{ of 2 moles of ethanol} = 2 \times 46 = 92$$

$$M_r \text{ of glucose (C}_6\text{H}_{12}\text{O}_6\text{)} = (12 \times 6) + (1 \times 12) + (16 \times 6) = 180$$

$$\text{atom economy} = \frac{\text{total } M_r \text{ of the desired product}}{\text{total } M_r \text{ of all reactants}} \times 100$$

$$\text{atom economy} = \frac{92}{180} \times 100 = 51.1\%$$