

Atom economy

4.3.3.2 · Quantitative chemistry · revision notes

Atom economy measures how much of the starting materials ends up in the useful product. You calculate it from the balanced equation. This is in GCSE Chemistry only, not Combined Science.

Key facts

- % atom economy = $\frac{M_r \text{ of desired product}}{M_r \text{ of reactants} \times 100}$
- Total M_r of reactants = total M_r of products
- High atom economy → less waste, more sustainable, cheaper
- Use the balancing numbers: multiply each M_r by them
- Only one product → 100% atom economy

Notes

What atom economy is

- **Atom economy** is a measure of the amount of starting materials that end up as useful products.
- percentage atom economy = $\left(\frac{M_r \text{ of desired product from the reaction}}{\text{sum of } M_r \text{ of all reactants}} \right) \times 100$
- Use the balanced equation, and multiply each M_r by its balancing number.
- Mass is conserved, so the total M_r of all the products equals the total M_r of all the reactants: a useful check.
- A reaction with only one product has an atom economy of 100%.

Worked example

- Hydrogen can be made by reacting methane with steam: $\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3\text{H}_2$.
- Sum of reactants: $16 + 18 = 34$. Desired product: $3\text{H}_2 = 3 \times 2 = 6$.
- Atom economy = $6 \div 34 \times 100 = 17.6\%$ (to 3 significant figures).

reactants (total 34)	
$\text{CH}_4 = 16$	$\text{H}_2\text{O} = 18$
↓	
products (total 34)	
$3\text{H}_2 = 6$	$\text{CO} = 28$ (not wanted)
atom economy = $6 \div 34 \times 100 = 17.6\%$	

Only the blue part (hydrogen, the desired product) counts as useful; the rest of the mass is waste.

Why it matters

- Reactions with a high atom economy are important for **sustainable development** and for **economic reasons**: they use fewer resources and make less waste.
- A low atom economy means a lot of waste product, which must be disposed of unless it can be used or sold.

Don't lose marks

- ✗ Forgetting the balancing numbers, e.g. using 56 for iron instead of $2 \times 56 = 112$.
- ✗ Putting only one reactant on the bottom, or the waste product on top.
- ✗ Confusing atom economy with percentage yield.
- ✗ Saying a high atom economy means a fast reaction or a high yield. It tells you nothing about either.

More tips

Memory tricks

- Wanted over total: the desired product on top, all the reactants on the bottom.
- Check your bottom number by adding up all the products: the total must be the same.
- One product $\rightarrow$ 100%. Two or more products $\rightarrow$ less than 100%.
- Atom economy needs only the equation; percentage yield needs measured masses.

Exam technique

- Write out the sum of the M_r values on the bottom so each part can earn a mark.
- In 'evaluate' questions, compare both routes for each factor, use the data given, and end with a justified conclusion.
- Give the answer to the significant figures asked for, with a % sign.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 4

State what atom economy measures

The amount of the starting materials that ends up as the useful (desired) product.

Grade 5

Calculate atom economy from an equation

Atom economy = M_r of desired product $\div$ sum of M_r of all reactants $\times 100$.

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