Yield and Atom Economy Map

AQA A-level Chemistry · 3.1.2 Amount of substance: yield and atom economy

1 Percentage yield

3.1.2.5 vii

- **Theoretical** yield: from the equation
- Use the **limiting** reactant
- **% yield** = actual ÷ theoretical × 100
- 12.5 g $CuCO_3$ → 8.05 g CuO; 7.20 g: 89.5 %
- Over 100 %? The product is wet or impure



2 Why yields are low

3.1.2.5 vii

- Reversible or incomplete reactions
- **Side reactions** make other products
- Losses in filtering, transfers, purifying
- Industry recycles unreacted gases
- Tonnes work like grams

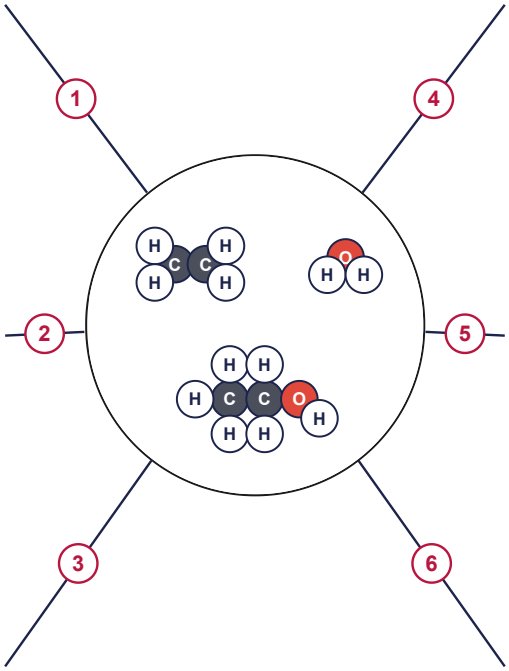


3 Working back and steps

3.1.2.5 vii

- Mass needed **÷ yield** = theoretical
- Then moles, ratio, mass of reactant
- Several steps: **multiply** the yields
- 85 % × 60 % × 90 % = 45.9 %
- Improve the lowest step first





4 Atom economy

3.1.2.5 iii, viii

- M_r(desired) ÷ **Σ M_r(all reactants)** × 100
- Coefficients included
- Addition reactions: **100 %**
- $CaCO_3$ → CaO + CO_2: 56.0 %
- Fixed by the equation, not the lab



5 Comparing routes

3.1.2.5 iii, viii

- Hydration of ethene: 100 %
- From bromoethane: 30.9 %
- Saleable by-products count
- Also yield, rate, energy, cost
- Product = mass × atom economy × yield



6 Why it matters

3.1.2.5 iv

- **Economic**: less raw material per tonne
- Less waste to treat or dispose of
- **Ethical**: finite resources last longer
- **Environmental**: fewer by-products, less pollution
- Sustainable development



Yield and atom economy calculations

yields from the lab; atom economy from the balanced equation (AQA: over the reactants)

Quantity	Equation	Worked example
Percentage yield	actual ÷ theoretical × 100	5.10 g of 17.0 g NH_3: 30.0 %
Mass needed	mass wanted ÷ yield	5.00 g at 85.0 %: 5.88 g theoretical
Overall yield	$yield_1$ × $yield_2$ × …	0.800 × 0.700: 56.0 %
Atom economy	M_r(desired) × 100 ÷ ΣM_r(reactants)	Fe_2O_3 + 3CO → 2Fe: 45.8 %
Atom economy, many products	desired with its coefficient	$2Al_2O_3$ → 4Al + $3O_2$: 52.9 %
Product from a route	reactant mass × atom economy × yield	100 g × 0.60 × 0.90 = 54 g

Worked examples

A yield

- 2.70 g Al → 13.35 g $AlCl_3$
- 11.4 g collected
- **85.4 %**

An atom economy

- $TiCl_4$ + 2Mg → Ti + $2MgCl_2$
- 47.9 ÷ (189.9 + 48.6)
- **20.1 %**

Two routes

- CuO route: 89.9 %
- $CuCO_3$ route: 72.0 %
- **CuO wastes less**

Yield and atom economy return in organic synthesis, where routes are compared step by step.

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