

Core Concept: Atom Economy is a measure of the amount of starting materials that end up as useful products. A higher atom economy means less waste.

Formula: $\text{Atom Economy} = \frac{M_r \text{ of desired product}}{\sum M_r \text{ of all reactants}} \times 100$

Rearranged Forms:

$$\sum M_r \text{ of all reactants} = \frac{M_r \text{ of desired product}}{\text{Atom Economy}} \times 100$$

$$M_r \text{ of desired product} = \frac{\text{Atom Economy} \times \sum M_r \text{ of all reactants}}{100}$$

Units: M_r (Relative Formula Mass) has no units. Atom Economy is expressed as a percentage (%).

Section A: Understanding the Formula & M_r

1. State the unit for each of the following terms in the atom economy formula:

- a) Atom Economy: _____
- b) M_r of desired product: _____
- c) Sum of M_r of all reactants: _____

2. Write down the rearranged forms of the atom economy formula:

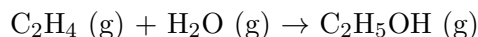
- a) To find the sum of M_r of all reactants: _____
- b) To find the M_r of the desired product: _____

3. Calculate the relative formula mass (M_r) for the following compounds. Use the atomic masses: H=1, C=12, O=16, Na=23, Cl=35.5.

- a) H_2O : _____
- b) CO_2 : _____
- c) C_2H_4 : _____
- d) $\text{C}_2\text{H}_5\text{OH}$: _____
- e) NaCl : _____

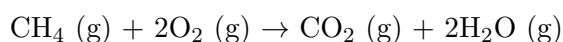
Section B: Practice Calculations

1. Ethene reacts with steam to produce ethanol. Ethanol is the desired product.



Calculate the atom economy for this reaction.

2. Methane can be combusted to produce carbon dioxide and water. If carbon dioxide is the desired product:



Calculate the atom economy for this reaction. (Atomic masses: C=12, H=1, O=16)

3. A chemical process has an atom economy of 75%. If the relative formula mass (M_r) of the desired product is 60, calculate the total relative formula mass of all reactants.

4. A reaction has an atom economy of 90%. The total relative formula mass (M_r) of all reactants is 120. Calculate the relative formula mass of the desired product.

Section C: Challenge Context

1. Hydrogen gas (H_2) is an important fuel. One industrial method for its production is the steam reforming of methane, as shown in the reaction scheme below.

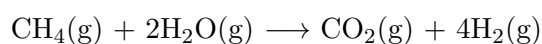


Figure 1: Steam reforming of methane

If hydrogen (H_2) is the desired product, calculate the atom economy for this reaction. (Atomic masses: C=12, H=1, O=16)

2. Magnesium oxide (MgO) is used in refractory linings. Consider two different routes for its production:

Route 1: $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

Route 2: $MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$

For both routes, magnesium oxide (MgO) is the desired product. (Atomic masses: Mg=24, O=16, C=12) Calculate the atom economy for each route and state which route is more atom economical.
