

GCSE Chemistry

Worksheet: Atom economy

TIME 35 min	TOTAL 32 marks	CALCULATOR Allowed	DIFFICULTY Easy, Medium
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Topics: Atom economy

NAME _____	CLASS _____	DATE _____
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- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Answer all questions in the spaces provided.
- In all calculations, show clearly how you work out your answer.
- The marks for questions are shown in brackets.

0 1

Chemists use percentage atom economy to compare how well different reactions make use of their reactants.

0 1 . 1

State the equation used to calculate percentage atom economy.

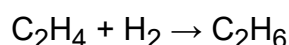
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[1 mark]

0 1 . 2

Ethene reacts with hydrogen to produce ethane (an addition reaction):



Relative formula masses (M_r): $\text{C}_2\text{H}_4 = 28$, $\text{H}_2 = 2$, $\text{C}_2\text{H}_6 = 30$

Calculate the percentage atom economy for this reaction.

.....

.....

.....

.....

Atom economy = %

[2 marks]

0 2

The atom economy of a reaction can be calculated using the equation:

% atom economy = (relative formula mass of desired product ÷ sum of relative formula masses of all reactants) × 100

0 2 . 1

Which type of reaction always has an atom economy of 100%?

Tick (✓) **one** box.

A reaction that has only one product

☐

A reaction that has two products

☐

A reaction that is reversible

☐

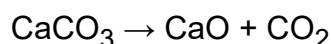
A reaction that uses a catalyst

☐

[1 mark]

0 2 . 2

Calcium oxide is made by heating calcium carbonate:



Relative formula masses (M_r): $\text{CaCO}_3 = 100$, $\text{CaO} = 56$

Calculate the percentage atom economy for making calcium oxide.

.....

.....

.....

.....

Atom economy = %

[2 marks]

0 2 . 3

Give **one** reason why chemical companies use reactions with a high atom economy.

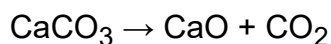
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[1 mark]

0 3

Calcium oxide (quicklime) is made by heating calcium carbonate:



Relative formula masses (M_r): $\text{CaCO}_3 = 100$, $\text{CaO} = 56$, $\text{CO}_2 = 44$

0 3 . 1

Calculate the percentage atom economy for making calcium oxide by this reaction.

.....

.....

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.....

Atom economy = %

[2 marks]

0 3 . 2

Explain why the atom economy of this reaction is less than 100%.

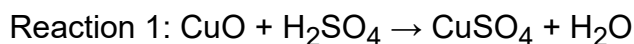
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[1 mark]

0 4

Copper sulfate can be made by two different reactions.



Relative formula masses (M_r): $\text{CuO} = 79.5$, $\text{CuCO}_3 = 123.5$, $\text{H}_2\text{SO}_4 = 98$, $\text{CuSO}_4 = 159.5$

0 4 . 1

Calculate the percentage atom economy for making copper sulfate by reaction 1.

Give your answer to 3 significant figures.

.....

.....

.....

.....

Atom economy = %

[2 marks]

0 4 . 2

The atom economy for reaction 2 is 72.0%.

Explain why the atom economy of reaction 2 is lower than that of reaction 1.

.....

.....

[1 mark]

0 4 . 3

Explain why it is important for sustainable development to use reactions with a high atom economy.

.....

.....

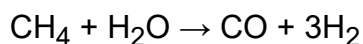
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[2 marks]

0 5

Hydrogen can be made by reacting methane with steam:



Relative formula masses (M_r): $\text{CH}_4 = 16$, $\text{H}_2\text{O} = 18$, $\text{CO} = 28$, $\text{H}_2 = 2$

0 5 . 1

Calculate the percentage atom economy for making hydrogen by this reaction.
Give your answer to 3 significant figures.

.....

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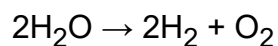
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Atom economy = %

[3 marks]

0 5 . 2

Hydrogen can also be made by the electrolysis of water:



Calculate the percentage atom economy for making hydrogen by this reaction.
Give your answer to 3 significant figures.

.....

.....

.....

.....

Atom economy = %

[2 marks]

0 5 . 3

Suggest how a company using the reaction of methane with steam could make better use of its reactants.

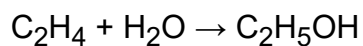
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[1 mark]

0 6

Ethanol can be made by reacting ethene with steam:



Relative atomic masses (A_r): H = 1, C = 12, O = 16

0 6 . 1

Calculate the percentage atom economy for making ethanol by this reaction.

.....

.....

.....

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.....

Atom economy = %

[3 marks]

0 6 . 2

Explain why the atom economy of this reaction is 100%.

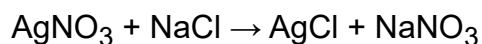
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[1 mark]

0 7

Silver chloride can be made by mixing silver nitrate solution with sodium chloride solution:



Relative formula masses (M_r): $\text{AgNO}_3 = 170$, $\text{NaCl} = 58.5$, $\text{AgCl} = 143.5$

0 7 . 1

Calculate the percentage atom economy for making silver chloride by this reaction.

Give your answer to 3 significant figures.

.....

.....

.....

.....

Atom economy = %

[2 marks]

0 7 . 2

Suggest why this reaction has a much lower atom economy than a simple addition reaction.

.....

.....

[1 mark]

0 8

Hydrogen chloride gas can be made by two reactions.

Table 1 gives the relative formula masses needed.

Table 1

Reaction	Equation	M_r of reactants	M_r of HCl
1	$\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$	$\text{H}_2 = 2, \text{Cl}_2 = 71$	36.5
2	$\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{NaHSO}_4 + \text{HCl}$	$\text{NaCl} = 58.5, \text{H}_2\text{SO}_4 = 98$	36.5

0 8 . 1

Calculate the percentage atom economy for making hydrogen chloride by reaction 1.

.....

.....

.....

.....

Atom economy = %

[2 marks]

0 8 . 2

Calculate the percentage atom economy for making hydrogen chloride by reaction 2.

Give your answer to 3 significant figures.

.....

.....

.....

.....

Atom economy = %

[2 marks]

END OF QUESTIONS

Original practice questions written to match the specification. Not produced by, affiliated with or endorsed by AQA.

Mark scheme

GCSE Chemistry · Worksheet: Atom economy · 32 marks

Question 1 (3 marks)

01.1 [1 mark]

- % atom economy = (M_r of desired product $\div$ sum of M_r of all reactants) $\times$ 100 (1)
-

01.2 [2 marks]

Answer: 100%

- $30 \div (28 + 2) \times 100$ (1)
 - 100 (%) (1)
-

Question 2 (4 marks)

02.1 [1 mark]

Correct: A reaction that has only one product

02.2 [2 marks]

Answer: 56%

- $(56 \div 100) \times 100$ (1)
 - 56 (%) (1)
-

02.3 [1 mark]

- less waste is produced / fewer unwanted products (1)
- more sustainable / fewer raw materials used (1)
- more economical / lower cost (1)

Any 1 of the points above.

Question 3 (3 marks)

03.1 [2 marks]

Answer: 56%

- M_r of reactant = 100 (1)
- $56 \div 100 \times 100 = 56$ (%) (1)

03.2 [1 mark]

- another product (carbon dioxide) is also formed, so not all the atoms in the reactants end up in the desired product (1)

Question 4 (5 marks)

04.1 [2 marks]

Answer: 89.9%

- $159.5 \div (79.5 + 98) \times 100$ (1)
- 89.9 (%) (1)

04.2 [1 mark]

- reaction 2 also produces carbon dioxide, so a greater mass of the reactants ends up in unwanted products (1)

04.3 [2 marks]

- a greater proportion of the atoms in the reactants ends up in the useful product (1)
- so fewer raw materials / resources are needed (for the same mass of product) (1)
- less waste is produced that needs to be disposed of (1)

Any 2 of the points above.

Question 5 (6 marks)

05.1 [3 marks]

Answer: 17.6%

- sum of M_r of reactants = $16 + 18 = 34$ (1)
- M_r of desired product = $3 \times 2 = 6$ (1)
- $(6 \div 34) \times 100 = 17.6$ (%) (1)

Notes: An answer of 5.88% (using 2 instead of 6) scores 2 marks.

05.2 [2 marks]

Answer: 11.1%

- $(4 \div 36) \times 100$ (1)
 - 11.1 (%) (1)
-

05.3 [1 mark]

- find a use for / sell the carbon monoxide (e.g. as a fuel) / react the carbon monoxide further to make more hydrogen (1)
-

Question 6 (4 marks)

06.1 [3 marks]

Answer: 100%

- M_r values: $C_2H_4 = 28$, $H_2O = 18$, $C_2H_5OH = 46$ (1)
 - sum of M_r of reactants = $28 + 18 = 46$ (1)
 - $46 \div 46 \times 100 = 100$ (%) (1)
-

06.2 [1 mark]

- there is only one product, so all the atoms in the reactants end up in the desired product (1)
-

Question 7 (3 marks)

07.1 [2 marks]

Answer: 62.8%

- $143.5 \div (170 + 58.5) \times 100$ (1)
- 62.8 (%) (1)

Notes: An answer that is correct but not given to 3 significant figures scores one mark fewer.

07.2 [1 mark]

- this reaction produces a second product (sodium nitrate) as well as the desired product (silver chloride), so some of the reactant mass ends up in a by-product rather than the desired product; an addition reaction has only one product, so all reactant atoms end up in it (1)
-

Question 8 (4 marks)

08.1 [2 marks]

Answer: 100%

- $(2 \times 36.5) \div (2 + 71) \times 100$ (1)
 - 100 (%) (1)
-

08.2 [2 marks]

Answer: 23.3%

- $36.5 \div (58.5 + 98) \times 100$ (1)
- 23.3 (%) (1)

Notes: An answer that is correct but not given to 3 significant figures scores one mark fewer.
