

GCSE Chemistry (9 – 1)

Atom Economy

Name:

Group:

Instructions

- Read each question carefully before you begin to answer it.
- Use black ink or black ball-point pen for your answers.
- Fill in the boxes at the top of this page with your name and group.
- Attempt to answer every question in the booklet.
- Answer the questions in the spaces provided – there may be more space than you need in some answer spaces.
- Calculators may be used for this booklet.
- For any calculations, you **must** show all your working.
- Any and all drawings or graphs should be completed in pencil.



For markers use	
Question	Mark
1	/4
2	/6
3	/9
4	/7
5	/7
6	/6
Total	/39
%	
Grade	

Information

- The maximum mark for this paper is 39 marks.
- The marks for each question are shown in brackets.
- Please be aware that good English and clear presentation are required in your answers.



1. In the drive for a “greener chemical industry”, atom economy is a vital calculation that tells us how sustainable a reaction is by measuring how much of the starting material ends up as waste.

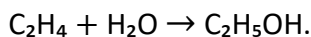
Circle the letter of the correct answer for each.

- a) Which statement best defines atom economy?

- A** The amount of product made in a reaction.
- B** The speed at which reactants are turned into products.
- C** A measure of the reactant atoms that become part of the desired product.
- D** The amount of energy needed to start the reaction.

(1 mark)

- b) The reaction for the hydration of ethene is:



What is the atom economy of this reaction?

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|----------|----------|----------|----------|
| A | B | C | D |
| 50% | 75% | 80% | 100% |

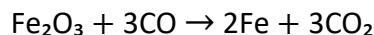
(1 mark)

- c) A chemical company wants to choose a reaction pathway that is the most sustainable and profitable. Which of the following would be the most important factor to consider?

- A** A reaction with a low percentage yield but a high atom economy.
- B** A reaction that uses the cheapest possible reactants, regardless of waste.
- C** A reaction with a high atom economy.
- D** A reaction that is very fast, even if it produces a lot of waste.

(1 mark)

- d) Iron is extracted from iron oxide using this reaction:



Why is the atom economy for this reaction less than 100%?

- A** Because carbon monoxide is a toxic gas.
- B** Because the reaction is not reversible.
- C** Because a waste product, carbon dioxide, is also formed.
- D** Because a high temperature is needed, which uses a lot of energy.

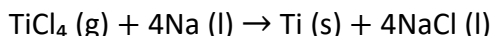
(1 mark)

(Total for Question 1 is 4 marks)

2. Determine the atom economies for the following reactions.

- a) Titanium is a strong, low-density metal used in high-performance aircraft. It is extracted from titanium(IV) chloride by reacting it with sodium.

The balanced equation for the reaction is:



Calculate the atom economy for this reaction.

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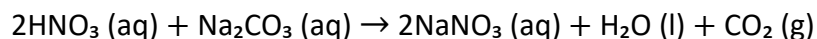
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(3 marks)

- b) Sodium nitrate, a compound used in fertilisers, can be made by reacting nitric acid with sodium carbonate. The balanced equation for the reaction is:



The desired product is sodium nitrate (NaNO_3).

Calculate the atom economy for this reaction.

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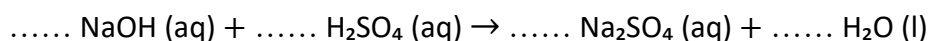
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(3 marks)

(Total for Question 2 is 6 marks)

3. Sodium sulfate is an important industrial chemical used in the manufacture of detergents and soaps. It can be made by reacting sodium hydroxide with sulfuric acid.

The unbalanced chemical equation for the reaction is:



- a) Balance the equation for the reaction using the spaces provided. **(2 marks)**

- b) Calculate the atom economy for this reaction.

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(3 marks)

- c) It is important for industrial processes to use reactions with a high atom economy. Describe **two** reasons why reactions with a high atom economy are important in industry.

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(2 marks)

This reaction has an atom economy below 100%.

- d) Explain why this is not an environmental concern for this reaction.

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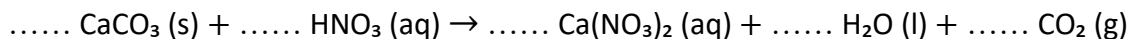
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(2 marks)

(Total for Question 3 is 9 marks)

4. Calcium nitrate is a compound used in fertilisers. It can be made by reacting calcium carbonate (limestone) with nitric acid.

The unbalanced chemical equation for the reaction is:



- a) Balance the equation for the reaction using the spaces provided. **(2 marks)**

- b) Calculate the atom economy for this reaction.

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(3 marks)

- c) It is important for industrial processes to use reactions with a high atom economy.
Describe **two** reasons why reactions with a high atom economy are important in industry.

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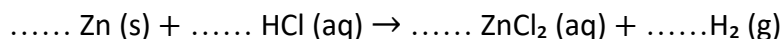
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(2 marks)

(Total for Question 4 is 7 marks)

5. Zinc chloride (ZnCl_2), a salt used in soldering fluxes, can be prepared by reacting zinc metal (Zn) with hydrochloric acid (HCl).

The unbalanced chemical equation for the reaction is:



- a) Balance the equation for the reaction using the spaces provided. **(2 marks)**

- b) Calculate the atom economy for this reaction.

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(3 marks)

- c) Explain the difference between atom economy and percentage yield.

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(2 marks)

(Total for Question 5 is 7 marks)

6. A chemist investigates the reaction of an unknown Group 2 metal carbonate with hydrochloric acid. The formula of the metal carbonate is MCO_3 , where M is an unknown metal.

The balanced equation for the reaction is:



The chemist wants to produce the aqueous salt, MCl_2 . Once the reaction was complete the chemist calculated the atom economy. It was found to be 60.5%.

Use this information to determine the identity of the metal **M**.

Show all working.

The identity of metal M is

(6 marks)

(Total for Question 6 is 6 marks)