AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.3.3.2

Atom economy

Past-paper questions

Tier	**Foundation**
Question groups	**9**
Available paper years	**2008–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

4.3.3.2 Atom economy

Question 01

June 2008 | CHY2F | Original Q1 | Legacy

1 This label was taken from a cola drink.



The pH of this drink is 2.5.

1 (a) (i) Which **one** of the ingredients in the cola drink causes the low pH?

.....

(1 mark)

1 (a) (ii) Draw a ring around the name of the ion that gives the cola drink its low pH.

chloride **hydrogen** **hydroxide** **sodium**

(1 mark)

4.3.3.2 Atom economy

Question 01 · continued

for mark

1 (b) The preservative used in the cola drink is sodium benzoate.
Sodium benzoate is made using two chemical reactions.

Reaction 1
Methylbenzene is reacted with oxygen, with the help of a catalyst, to form benzoic acid.

Reaction 2
Benzoic acid is neutralised by sodium hydroxide solution to form sodium benzoate and water.

1 (b) (i) How does the catalyst help **reaction 1**?

.....

.....

(1 mark)

1 (b) (ii) **Reaction 1** has a high atom economy.

The table lists several statements. Put a tick (✓) next to the **one** statement which best describes a high atom economy.

Statement	(✓)
All the atoms used are cheap.	
Most of the starting materials end up as useful products.	
Only a small number of atoms are used in the reaction.	

(1 mark)

1 (b) (iii) **Reaction 2** is a neutralisation reaction.

Complete the equation by writing the formula of the product.

$H^+ + OH^- \rightarrow$ .....

(1 mark)

5

4.3.3.2 Atom economy

Question 02

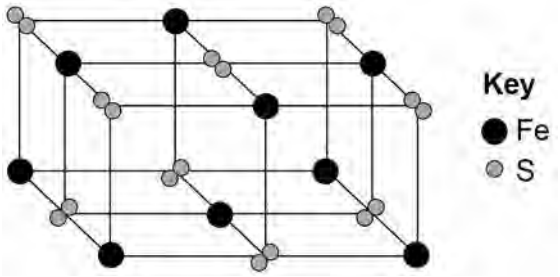
June 2018 | 8462/1F | Original Q9

0 9 This question is about metals and metal compounds.

0 9 . 1 Iron pyrites is an ionic compound.

Figure 12 shows a structure for iron pyrites.

Figure 12



Determine the formula of iron pyrites.

Use **Figure 12**.

[1 mark]

0 9 . 2 An atom of iron is represented as $^{56}_{26}Fe$

Give the number of protons, neutrons and electrons in this atom of iron.

[3 marks]

Number of protons _____

Number of neutrons _____

Number of electrons _____

0 9 . 3 Iron is a transition metal.

Sodium is a Group 1 metal.

Give **two** differences between the properties of iron and sodium.

[2 marks]

1 _____

_____

2 _____

_____

4.3.3.2 Atom economy

Question 02 · continued

Nickel is extracted from nickel oxide by reduction with carbon.

0 9 . 4 Explain why carbon can be used to extract nickel from nickel oxide.

[2 marks]

0 9 . 5 An equation for the reaction is:

$$NiO + C \rightarrow Ni + CO$$

Calculate the percentage atom economy for the reaction to produce nickel.

Relative atomic masses (A_r): C = 12 Ni = 59

Relative formula mass (M_r): NiO = 75

Give your answer to 3 significant figures.

[3 marks]

Percentage atom economy = _____ %

11

4.3.3.2 Atom economy

Question 03

June 2019 | 8462/1F | Original Q6

0 6 This question is about the extraction of metals.

0 6 . 1 Tungsten is a metal.

The symbol of tungsten is W

Tungsten is produced from tungsten oxide by reaction with hydrogen.

The equation for the reaction is:

$$WO_3 + 3H_2 \rightarrow W + 3H_2O$$

Calculate the percentage atom economy when tungsten is produced in this reaction.

Use the equation:

$$\text{percentage atom economy} = \frac{184}{(M_r\ WO_3) + (3 \times M_r\ H_2)} \times 100$$

Relative formula masses (M_r): $WO_3 = 232$ $H_2 = 2$

[2 marks]

Percentage atom economy = _____ %

4.3.3.2 Atom economy

Question 03 · continued

Aluminium is extracted from aluminium oxide.

0 6 . 2 38% of a rock sample is aluminium oxide.

Calculate the mass of aluminium oxide in 40 kg of the rock sample.

[2 marks]

Mass of aluminium oxide = _____ kg

0 6 . 3 The formula of aluminium oxide is Al_2O_3

Calculate the relative formula mass (M_r) of aluminium oxide.

Relative atomic masses (A_r): O = 16 Al = 27

[2 marks]

Relative formula mass (M_r) = _____

Question 6 continues on the next page

4.3.3.2 Atom economy

Question 03 · continued

0 6 . 4 60.0 kg of aluminium oxide produces a maximum of 31.8 kg of aluminium.

In an extraction process only 28.4 kg of aluminium is produced from 60.0 kg of aluminium oxide.

Calculate the percentage yield.

Give your answer to 3 significant figures.

Use the equation:

$$\text{percentage yield} = \frac{\text{mass of product actually made}}{\text{maximum theoretical mass of product}} \times 100$$

[3 marks]

Percentage yield = _____ %

0 6 . 5 Extracting metals by electrolysis is a very expensive process.

Explain why aluminium is extracted using electrolysis and not by reduction with carbon.

[2 marks]

11

4.3.3.2 Atom economy

Question 04

November 2020 | 8462/1F | Original Q10

1 0 This question is about silver iodide.

Silver iodide is produced in the reaction between silver nitrate solution and sodium iodide solution.

The equation for the reaction is:

$$AgNO_3(aq) + NaI(aq) \rightarrow AgI(s) + NaNO_3(aq)$$

1 0 . 1 A student investigated the law of conservation of mass.

This is the method used.

1. Pour silver nitrate solution into a beaker labelled **A**.
2. Pour sodium iodide solution into a beaker labelled **B**.
3. Measure the masses of both beakers and their contents.
4. Pour the solution from beaker **B** into beaker **A**.
5. Measure the masses of both beakers and their contents again.

Table 7 shows the student's results.

Table 7

	Mass before mixing in g	**Mass after mixing in g**
Beaker **A** and contents	78.26	108.22
Beaker **B** and contents	78.50	48.54

Explain how the results demonstrate the law of conservation of mass.

You should use data from **Table 7** in your answer.

[2 marks]

4.3.3.2 Atom economy

1 0 . 2 Suggest how the student could separate the insoluble silver iodide from the mixture at the end of the reaction.

[1 mark]

The student purified the separated silver iodide.

This is the method used.

1. Rinse the silver iodide with distilled water.

2. Warm the silver iodide.

1 0 . 3 Suggest **one** impurity that was removed by rinsing with water.

[1 mark]

1 0 . 4 Suggest why the student warmed the silver iodide.

[1 mark]

Question 10 continues on the next page

4.3.3.2 Atom economy

Question 04 · continued

1 0 . 5 Calculate the percentage atom economy for the production of silver iodide in this reaction.

The equation for the reaction is:

$$AgNO_3(aq) + NaI(aq) \rightarrow AgI(s) + NaNO_3(aq)$$

Give your answer to 3 significant figures.

Relative formula masses (M_r): $AgNO_3 = 170$ NaI = 150 AgI = 235 $NaNO_3 = 85$

[4 marks]

Percentage atom economy (3 significant figures) = _____ %

1 0 . 6 Give **one** reason why reactions with a high atom economy are used in industry.

[1 mark]

10

4.3.3.2 Atom economy

Question 05

November 2021 | 8462/1F | Original Q10

1 0 This question is about the extraction of metals.

Element **R** is extracted from its oxide by reduction with hydrogen.

The equation for the reaction is:

$$3\,H_2 + \mathbf{R}O_3 \rightarrow \mathbf{R} + 3\,H_2O$$

1 0 . 1 The sum of the relative formula masses (M_r) of the reactants ($3\,H_2$ + $\mathbf{R}O_3$) is 150

Calculate the relative atomic mass (A_r) of **R**.

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

[2 marks]

Relative atomic mass (A_r) of **R** = _____

1 0 . 2 Identify element **R**.

You should use:

- your answer to **question 10.1**
- the periodic table.

[1 mark]

Identity of **R** = _____

4.3.3.2 Atom economy

Question 05 · continued

1 0 . 3 Carbon is used to extract tin (Sn) from tin oxide (SnO_2).

The equation for the reaction is:

$$SnO_2 + C \rightarrow Sn + CO_2$$

Calculate the percentage atom economy for extracting tin in this reaction.

Relative atomic masses (A_r): C = 12 O = 16 Sn = 119

[3 marks]

Percentage atom economy = _____ %

Question 10 continues on the next page

4.3.3.2 Atom economy

Question 05 · continued

1 0 . 4 Tungsten (W) is a metal.

Tungsten is extracted from tungsten oxide (WO_3).

All other solid products from the extraction method must be separated from the tungsten.

Table 9 shows information about three possible methods to extract tungsten from tungsten oxide.

Table 9

Method	Reactant	Relative cost of reactant	Products
1	Carbon	Low	Tungsten solid Carbon dioxide gas Tungsten carbide solid
2	Hydrogen	High	Tungsten solid Water vapour
3	Iron	Low	Tungsten solid Iron oxide solid

Evaluate the three possible methods for extracting tungsten from tungsten oxide.

[4 marks]

10

4.3.3.2 Atom economy

Question 06

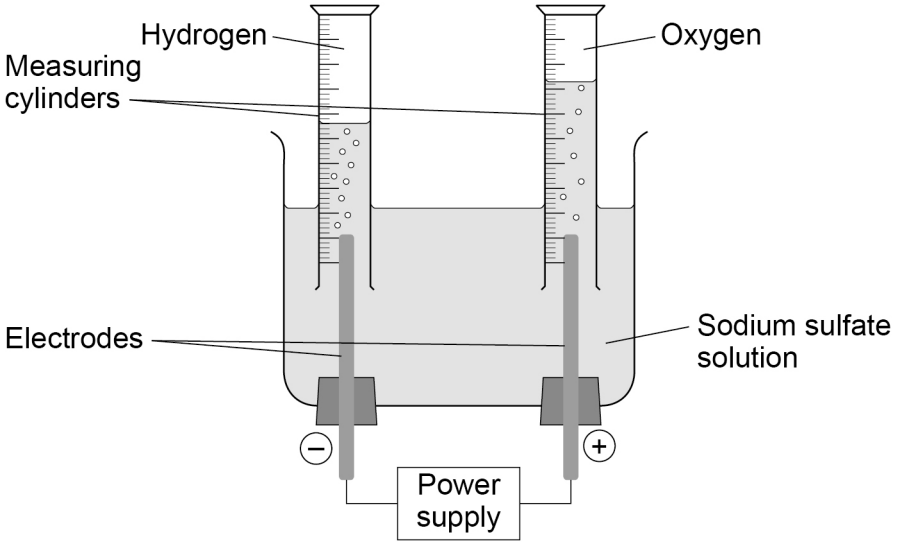
0 8 This question is about electrolysis.

Ionic compounds decompose when they are electrolysed.

A student electrolyses sodium sulfate solution.

Figure 13 shows the apparatus used.

Figure 13



0 8 . 1 Sodium sulfate solution contains:

- hydrogen ions
- hydroxide ions
- sodium ions
- sulfate ions.

Oxygen is produced at the positive electrode.

Which ions are discharged at the positive electrode to produce oxygen?

[1 mark]

Tick (✓) **one** box.

Hydrogen ions ☐

Hydroxide ions ☐

Sodium ions ☐

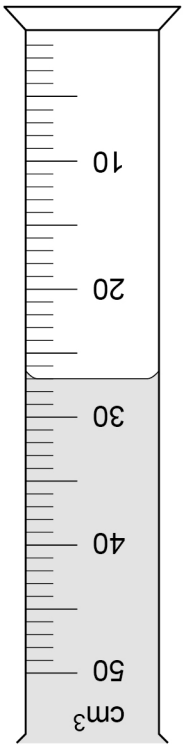
Sulfate ions ☐

4.3.3.2 Atom economy

Question 06 · continued

0 8 . 2 **Figure 14** shows one of the measuring cylinders during the electrolysis.

Figure 14



What is the volume of gas in the measuring cylinder?

[1 mark]

Volume of gas = _____ cm^3

0 8 . 3 Ionic compounds can be electrolysed when molten or dissolved in water.

Why can ionic compounds **not** be electrolysed when solid?

You should answer in terms of ions.

[1 mark]

_____

_____

Question 06 · continued

0 8 . 4 **Table 7** shows the products of electrolysis of two molten compounds.

Table 7

Molten compound	Product at negative electrode	Product at positive electrode
Potassium iodide	Potassium	_____
Zinc bromide	_____	Bromine

Complete **Table 7**.

[2 marks]

0 8 . 5 The electrolysis of molten sodium chloride is used to extract sodium metal.

Why is sodium metal extracted by electrolysis instead of by reduction with carbon?

[1 mark]

Tick (✓) **one** box.

Carbon conducts electricity. ☐

Carbon is less reactive than sodium. ☐

Carbon reduction uses more energy. ☐

0 8 . 6 What is the state symbol for molten sodium chloride?

[1 mark]

Tick (✓) **one** box.

(aq) ☐ (g) ☐ (l) ☐ (s) ☐

4.3.3.2 Atom economy

Question 06 · continued

0 8 . 7 Titanium can be produced from titanium oxide by electrolysis.

The equation for the reaction is:

$$TiO_2 \rightarrow Ti + O_2$$

Calculate the percentage atom economy for the production of titanium from titanium oxide by electrolysis.

Use the equation:

$$\text{Percentage atom economy} = \frac{\text{Relative atomic mass of desired product}}{\text{Relative formula mass of reactant}} \times 100$$

Relative atomic mass (A_r): Ti = 48

Relative formula mass (M_r): TiO_2 = 80

[2 marks]

Percentage atom economy = _____ %

9

4.3.3.2 Atom economy

Question 07

June 2022 | 8462/2F | Original Q5

0 5 Ammonia is produced in the Haber process.

The raw materials for the Haber process are nitrogen and hydrogen.

0 5 . 1 Draw **one** line from each raw material to the source of that raw material.

[2 marks]

Raw material	Source of raw material
	Air
	Clay
Nitrogen	
	Limestone
Hydrogen	
	Natural gas
	Sand

0 5 . 2 What are the states of nitrogen and of hydrogen when used in the Haber process?

[1 mark]

Tick (✓) **one** box.

State of nitrogen	State of hydrogen	
Gas	Gas	☐
Gas	Liquid	☐
Liquid	Gas	☐
Liquid	Liquid	☐

4.3.3.2 Atom economy

Question 07 · continued

0 5 . 3 The word equation for the production of ammonia is:

nitrogen + hydrogen ⇌ ammonia

The atom economy of the reaction is 100%.

How does the word equation show that the atom economy is 100%?

[1 mark]

Tick (✓) **one** box.

The reaction is reversible. ☐

There are two reactants. ☐

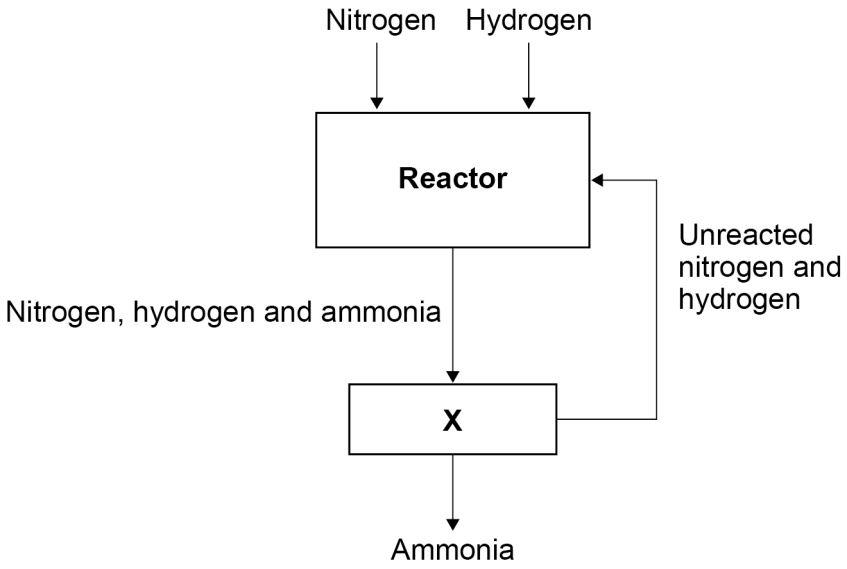
There is one product. ☐

4.3.3.2 Atom economy

Question 07 · continued

0 5 . 4 **Figure 5** represents the Haber process.

Figure 5



A mixture of nitrogen, hydrogen and ammonia enters **X**.

Complete the sentences.

Choose answers from the box.

[2 marks]

evaporated	**filtered**	**liquefied**	**recycled**

In **X**, the mixture is cooled.

The ammonia can be removed from **X** because the ammonia is

_____.

The unreacted nitrogen and hydrogen are

_____.

4.3.3.2 Atom economy

Question 07 · continued

Table 8 shows the percentage yield of ammonia at different pressures.

Table 8

Pressure in atmospheres	Percentage (%) yield of ammonia
50	20
100	33
150	44
200	52
250	59
300	64

4.3.3.2 Atom economy

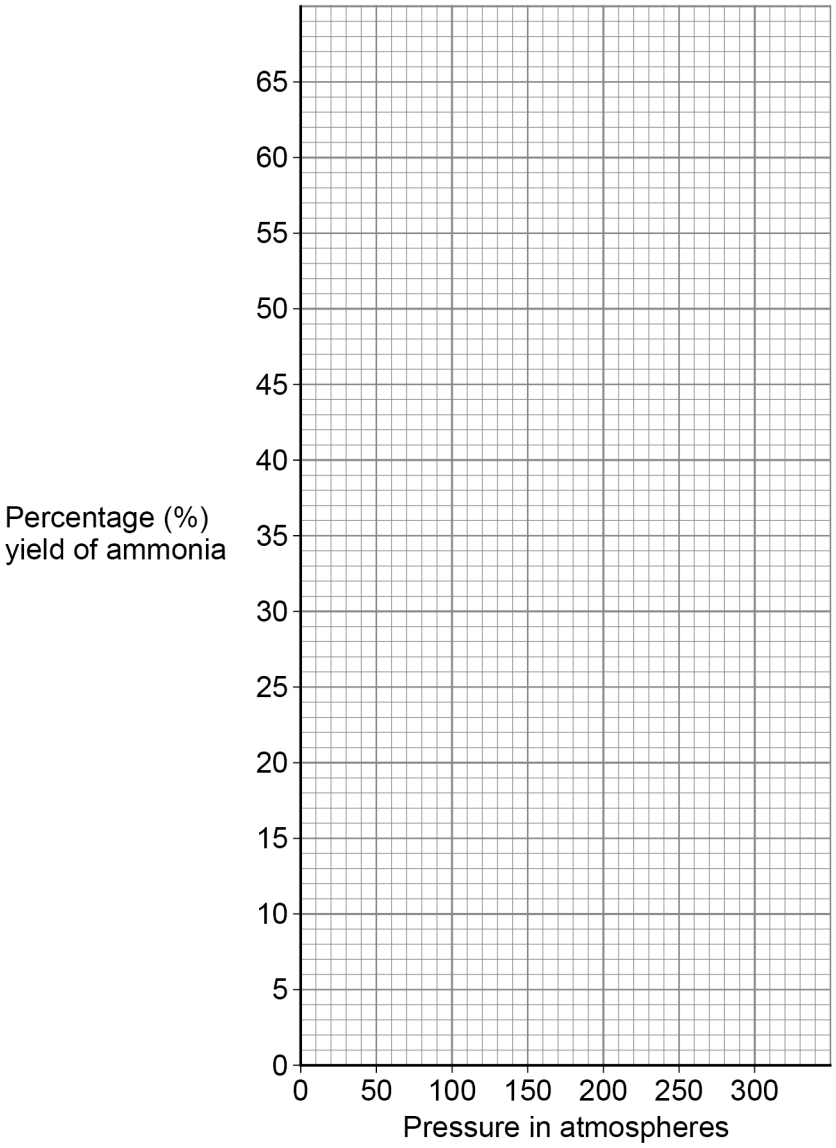
Question 07 · continued

0 5 . 5 Plot the data from **Table 8** on **Figure 6**.

Draw a line of best fit.

[3 marks]

Figure 6



0 5 . 6 What is the effect of increasing the pressure on the percentage yield of ammonia?

Use **Table 8**.

[1 mark]

10

4.3.3.2 Atom economy

Question 08

June 2023 | 8462/1F | Original Q8

0 8 This question is about displacement reactions.

Iron is extracted from iron oxide by a displacement reaction with carbon.

0 8 . 1 Balance the equation for the reaction.

[2 marks]

$$Fe_2O_3 + 3\,C \rightarrow ____Fe + ____CO$$

0 8 . 2 Iron oxide is reduced in this reaction.

How does the equation show that iron oxide is reduced?

[1 mark]

0 8 . 3 Calculate the relative formula mass (M_r) of Fe_2O_3

Relative atomic masses (A_r): O = 16 Fe = 56

[2 marks]

M_r = _____

Question 8 continues on the next page

Question 08 · continued

0 8 . 4 Copper oxide reacts with hydrogen to produce copper.

The equation for the reaction is:

$$CuO + H_2 \rightarrow Cu + H_2O$$

Calculate the percentage atom economy for obtaining copper from this reaction.

Use the equation:

$$\text{Percentage atom economy} = \frac{A_r \text{ of Cu}}{M_r \text{ of } H_2 + M_r \text{ of CuO}} \times 100$$

Relative atomic mass (A_r): Cu = 63.5
Relative formula masses (M_r): H_2 = 2 CuO = 79.5

[2 marks]

Percentage atom economy = _____ %

A student investigated the reactivity of four different metals, **A**, **B**, **C** and **D**.

The student:

- added each metal to aqueous solutions of each of the metal sulfates
- observed whether a reaction took place.

0 8 . 5 Give **one** observation that would show a reaction took place.

[1 mark]

4.3.3.2 Atom economy

Question 08 · continued

0 8 . 6 **Table 4** shows the results.

Table 4

	Metal sulfate solution			
Metal	**A sulfate**	**B sulfate**	**C sulfate**	**D sulfate**
A	×	×	✓	×
B	✓	×	✓	×
C	×	×	×	×
D	✓	✓	✓	×

✓ shows that a displacement reaction took place.
× shows that a displacement reaction did not take place.

Write metals **A**, **B**, **C** and **D** in order of reactivity.

Give a reason for your order of reactivity.

[2 marks]

Most reactive _____

_____

_____

Least reactive _____

Reason _____

_____

10

4.3.3.2 Atom economy

Question 09

June 2025 | 8462/1F | Original Q10

1 0 This question is about metals and metal oxides.

Tin (Sn) is extracted from tin oxide using carbon.

The equation for the reaction is:

$$SnO_2 + C \longrightarrow Sn + CO_2$$

1 0 . 1 Which substance is reduced in this reaction?

Give **one** reason for your answer.

Answer in terms of oxygen.

[2 marks]

Substance reduced _____

Reason _____

_____

1 0 . 2 Why can carbon be used to extract tin from tin oxide?

[1 mark]

_____

_____

Question 10 continues on the next page

Question 09 · continued

1 0 . 3 Cadmium (Cd) can be extracted by the reaction of cadmium oxide with carbon.

The equation for the reaction is:

$$CdO + C \longrightarrow Cd + CO$$

Calculate the percentage atom economy for the production of cadmium in this reaction.

Relative atomic masses (A_r): C = 12 Cd = 112

Relative formula mass (M_r): CdO = 128

[3 marks]

Percentage atom economy = _____ %

1 0 . 4 Tungsten is a transition metal.

Potassium is a Group 1 metal.

Give **two** differences between the properties of tungsten and the properties of potassium.

[2 marks]

1 _____

2 _____

4.3.3.2 Atom economy

Question 09 · continued June 2025 | 8462/1F | Original Q10

Tungsten oxide reacts with hydrogen to give tungsten (W) and water.

1 0 . 5 The equation for the reaction is:

$$WO_3 + 3\,H_2 \longrightarrow W + 3\,H_2O$$

The law of conservation of mass states:

'The mass of the products equals the mass of the reactants during a chemical reaction.'

Show that the equation obeys the law of conservation of mass.

Relative atomic mass (A_r): W = 184

Relative formula masses (M_r): H_2 = 2 WO_3 = 232 H_2O = 18

[2 marks]

1 0 . 6 The reaction producing tungsten has a high atom economy.

Why is it important to use reactions with a high atom economy in industry?

[1 mark]

11