AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.4.1.3

Extraction of metals and reduction

Mark schemes and examiner comments

Tier	**Foundation**
Question groups	**7**
Available paper years	**2019–2025**

Using this booklet

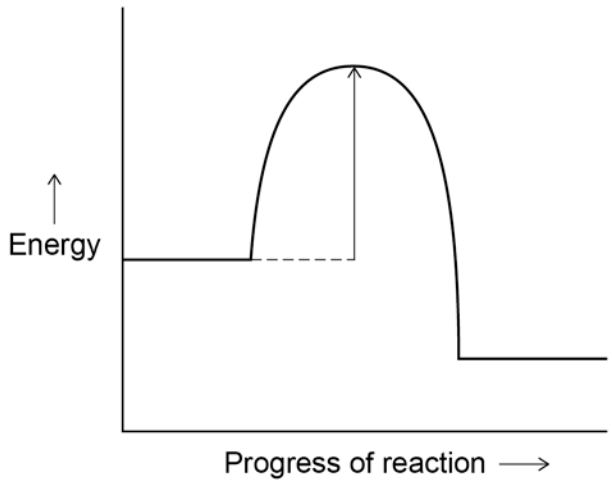
1. Booklet answer numbers match the question booklet.
2. Use the original question number within marking tables.
3. Examiner comments are included where available.

Name: _____ **Date:** _____

Where a precise marking extract is unavailable, the full source document is included in an appendix. Any missing mark scheme is explicitly identified.

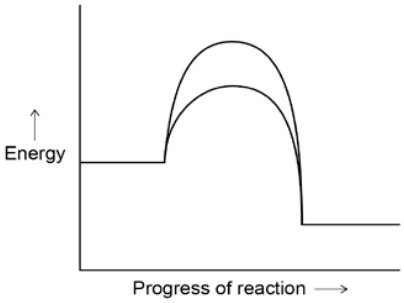
5.4.1.3 Extraction of metals and reduction

Answer 01 · Mark scheme June 2019 | 8464/C/2F | Original Q5

05.1	3.50 %		1	AO2 5.10.1.1
05.2	correct bar to 2.1 (%)	allow a tolerance of ± ½ a small square	1	AO2 5.10.1.1
05.3	(617 + 258) – 648 **or** 875 – 648 = 227 (kg)	an answer of 227 (kg) scores **2** marks	1 1	AO2 5.3.1.1
05.4	 ignore arrow heads		1	AO1 5.6.1.4

5.4.1.3 Extraction of metals and reduction

Answer 01 · Mark scheme

05.5	(curve) starts and ends at same energy levels as existing curve maximum of curve below maximum of existing curve	ignore references to activation energy only award if MP1 correct an answer of  scores **2** marks	1 1	AO1 5.6.1.4

05.6	enzymes		1	AO1 5.6.1.4

Total			**8**

5.4.1.3 Extraction of metals and reduction

Answer 01 · Mark scheme

June 2019 | 8464/C/2F | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.4.1.3 Extraction of metals and reduction

Answer 02 · Mark scheme November 2020 | 8464/C/1F | Original Q6

06.1	13 14	this order only	1 1	AO2 5.1.1.4 5.1.1.5

06.2	loss of oxygen	allow (Al^{3+}) gain of electrons allow aluminium oxide loses oxygen	1	AO1 5.4.1.1 5.4.1.3

06.3	 (at high temperature) oxygen reacts with carbon / electrode (so the positive) electrode burns / wears away to produce carbon dioxide	allow anode for (positive) electrode $C + O_2 \rightarrow CO_2$ scores MP1 and MP3	 1 1 1	 AO1 5.4.3.1 5.4.3.2 5.4.3.3

06.4	(delocalised) electron(s) ion(s) (delocalised) electron(s)		1 1 1	AO1 AO2 AO1 5.2.2.3 5.2.2.8 5.2.3.2

Total			**9**

5.4.1.3 Extraction of metals and reduction

Answer 02 · Mark scheme

November 2020 | 8464/C/1F | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.

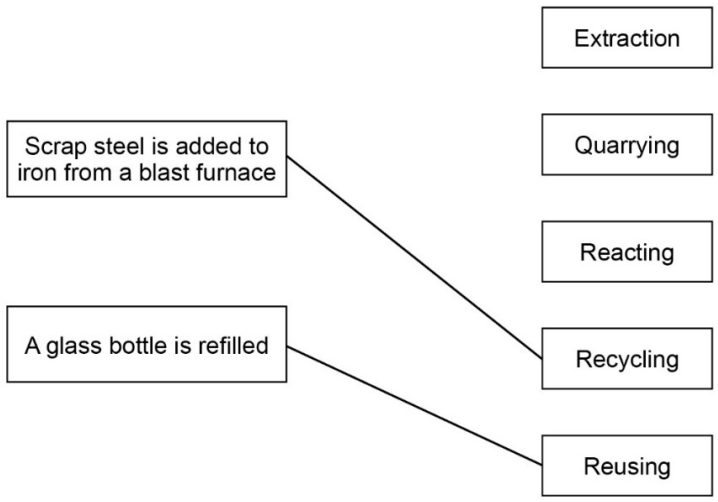
5.4.1.3 Extraction of metals and reduction

Answer 03 · Mark scheme November 2021 | 8464/C/2F | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	as population increased, copper production increased		1	AO3 5.10.1.1
05.2	(copper ore) (70 × 100 =) 7000 (recycled copper) (27×100 =) 2700 (7000 – 2700 =) 4300 (MJ)	 allow correct use of incorrectly determined values for MP1 (copper ore) and/or MP2 (recycled copper)	1 1 1	AO2 5.10.2.2
05.3	any **one** from: • reduces acid rain • reduces respiratory problems (in humans)	 allow sulfur dioxide causes acid rain allow sulfur dioxide causes respiratory problems (in humans)	1	AO1 5.9.3.2
05.4	$\frac{75}{100}$ × 8 = 6 (g)		1 1	AO2 5.10.1.1

5.4.1.3 Extraction of metals and reduction

Answer 03 · Mark scheme

05.5	 do **not** accept more than one line from a box on the left	1 1	AO2 5.10.2.2
05.6	**B**, **C**, **D**, **A**	1	AO1 5.10.2.2
Total		**10**	

5.4.1.3 Extraction of metals and reduction

Answer 03 · Mark scheme

November 2021 | 8464/C/2F | Original Q5

5.4.1.3 Extraction of metals and reduction

Answer 04 · Mark scheme

June 2022 | 8464/C/1F | Original Q4

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	**2** Mg + O_2 → 2 MgO	allow multiples	1	AO2 5.1.2.5 5.4.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	any **one** from: • wear safety glasses / goggles • do not look directly at burning magnesium • wear heat proof glove	allow look through blue glass allow use tongs allow tie hair back	1	AO3 5.4.1.1 5.4.1.2 5.5.1.1

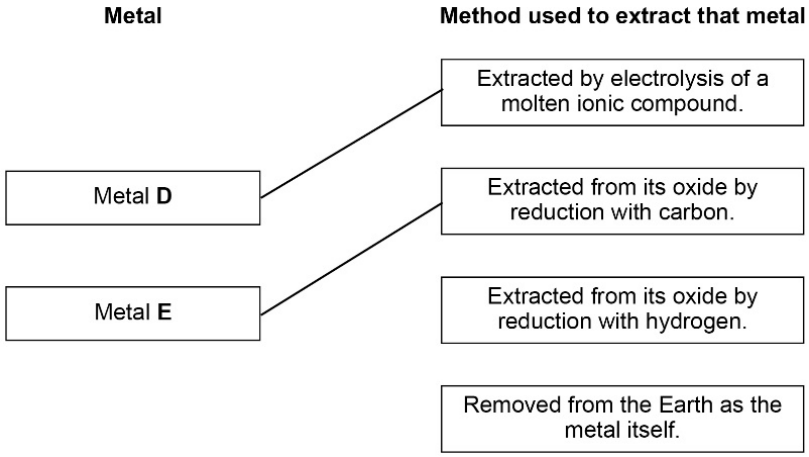
Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	(M_r =) 24 + (2 × 19) = 62		1 1	AO2 5.1.2.5 5.3.1.2

5.4.1.3 Extraction of metals and reduction

Answer 04 · Mark scheme

June 2022 | 8464/C/1F | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	any **one** from: • argon has a full outer shell • argon has 8 electrons in the outer shell • argon has a stable arrangement of electrons.	allow energy level for shell allow does not need to lose and / or gain electrons	1	AO2
	(so) argon is unreactive	ignore argon is a noble gas	1	AO1 5.1.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	 do **not** accept more than one line from a box on the left		1 1	AO3 5.4.1.2 5.4.1.3 5.4.3.1 5.4.3.2 5.4.3.3

5.4.1.3 Extraction of metals and reduction

Answer 04 · Mark scheme

June 2022 | 8464/C/1F | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	(because) ions (which are) free to move when molten (but are) fixed in solid	 allow reference to charged particles for MP2 and MP3	1 1 1	AO1 5.2.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.7	(sodium contains) delocalised electrons (which) carry (electrical) charge (through the metal / sodium)	allow free electrons ignore throughout for through ignore current / electricity	1 1	AO1 5.2.2.8

Total Question 4		13

5.4.1.3 Extraction of metals and reduction

Answer 05 · Mark scheme

June 2023 | 8464/C/1F | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	energy / electricity		1	AO1 5.4.3.1 5.4.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	carbon dioxide		1	AO1 5.4.3.1 5.4.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	sodium reacts with air / oxygen **or** sodium is highly reactive	allow titanium (chloride) reacts with air / oxygen	1	AO3 5.1.2.5 5.4.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	argon		1	AO3 5.1.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	$TiCl_4 + 4\,Na \longrightarrow Ti + \mathbf{4}\,NaCl$	allow multiples	1	AO2 5.1.1.1 5.4.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.6	4.4 (g)		1	AO2 5.3.1.1 5.3.1.3

5.4.1.3 Extraction of metals and reduction

Answer 05 · Mark scheme

June 2023 | 8464/C/1F | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.7	(the) mass decreased (because) carbon dioxide escapes (into the atmosphere)	 allow (because) carbon dioxide is a gas allow (because) a gas is produced	1 1	AO2 5.3.1.1 5.3.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.8	the copper oxide is reduced (reason) (copper oxide) loses oxygen		1 1	AO2 5.4.1.3

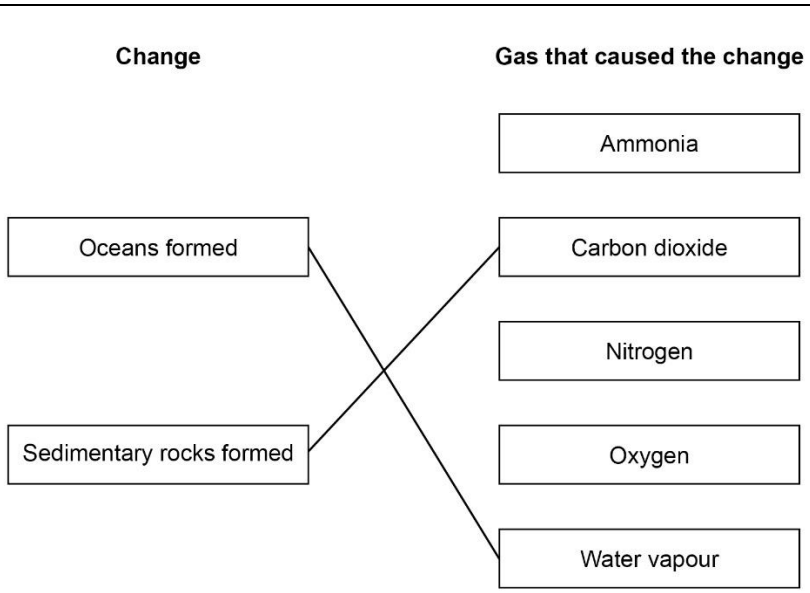
Total Question 5	10

5.4.1.3 Extraction of metals and reduction

Answer 06 · Mark scheme

June 2023 | 8464/C/2F | Original Q2

Question 2

Question	Answers	Mark	AO / Spec. Ref.
02.1	 do **not** accept more than one line from a box on the left	1 1	AO1 5.9.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	nitrogen		1	AO2 5.9.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	(number of times more =) $\frac{95}{0.04}$ = 2375 = 2.375×10^3	 allow a correctly calculated answer in standard form from an incorrect calculation which uses values given in **Table 1**	1 1 1	AO2 5.9.1.1

5.4.1.3 Extraction of metals and reduction

Answer 06 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	increased		1	AO2 5.9.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.5	(mass CO_2 =) $\frac{17.2}{4}$ = 4.3 (kg)		1 1	AO2 5.9.3.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.6	photosynthesis		1	AO1 5.9.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.7	any **two** from: (forest area) • increases in Africa • increases in Europe • decreases in South America • decreases in Asia		2	AO2 5.9.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.8	6 (%)		1	AO2 5.9.2.1 5.9.2.2

5.4.1.3 Extraction of metals and reduction

Answer 06 · Mark scheme

June 2023 | 8464/C/2F | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.9	(**A**) reuse (**B**) recycle		1 1	AO2 5.10.2.2

Total Question 2	**15**

5.4.1.3 Extraction of metals and reduction

Answer 07 · Mark scheme

June 2025 | 8464/C/1F | Original Q4

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	compounds		1	AO1 5.4.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	iron is less reactive than carbon		1	AO1 5.4.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	to reduce the amount of energy used		1	AO1 5.4.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	the electrodes react with oxygen gas		1	AO1 5.4.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	the alloy is harder than the pure metal		1	AO1 5.2.2.7

5.4.1.3 Extraction of metals and reduction

Answer 07 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	(melting point of alloy) decreases		1	AO2 5.2.2.7
	until 70% (silver)	allow a value in the range 69% to 71%	1	
	or			
	until 530 °C	allow a value in the range 520 °C to 540 °C		
	then (melting point) increases		1	
		if no other mark awarded, allow **1** mark for (melting point) increases from 660 °C to 960 °C **or** (melting point) increases by 300 °C		

Total Question 4	**8**

5.4.1.3 Extraction of metals and reduction

Answer 03 · Examiner comments — November 2021 | 8464/C/2F | Original Q5

Question 5 (low and standard demand)

The interpretation of data and the associated calculations were generally well done, and many students scored highly on this question. The exception was question 05.3, where no credit was given for sulfur dioxide being toxic or harmful, as these are not the most significant reasons for reducing the global emissions of the gas.

Answer 04 · Examiner comments — June 2022 | 8464/C/1F | Original Q4

Question 4 (Low and standard demand)

04.1 More than 70% of students correctly balanced the equation. Some students changed the formula, usually from MgO to MgO_2

04.2 Almost three-quarters of students stated a safety precaution that should be taken when heating magnesium and oxygen. The most common correct responses were to wear eye protection and to use tongs.

04.3 Almost one-quarter of students gave the correct answer for the relative formula mass of magnesium fluoride. These students recognised that the subscript 2 means the relative atomic mass of fluorine needed to be doubled before being added to the relative atomic

Answer 04 · Examiner comments — June 2022 | 8464/C/1F | Original Q4

mass of magnesium. Many showed clear steps in their calculation. The most common errors were to either add or multiply 24 and 19.

04.4 Magnesium does not react when heated with argon - argon is unreactive because argon atoms have eight electrons in the outer shell. Common responses referred to magnesium (and argon) both being unreactive, that metals (or solids) do not react with gases or that both elements had full outer shells. This question discriminated well.

04.5 Almost 60% of students gained at least one of the two marks for correctly deducing the method used to extract a metal. The students were given a reactivity series showing the position of these two metals compared to other known metals, carbon and hydrogen.

04.6 Students found difficulty in explaning why sodium chloride conducts electricity when molten but not when a solid. Many indicated that this was due to something being able to move but failed to link this to ions or charged particles. Most referred to moving particles, atoms or electrons.

04.7 Students also found difficulty in explaning why sodium conducts electricity when solid. Delocalised electrons were rarely seen as was the concept of these delocalised electrons carrying charge through the sodium.

5.4.1.3 Extraction of metals and reduction

Answer 05 · Examiner comments

June 2023 | 8464/C/1F | Original Q5

Question 5 (low/standard demand)

05.1 More than a third of students knew that the extraction of aluminium is expensive because the process uses large amounts of energy. Heat was a very common response that was insufficient to gain credit.

05.2 More than 50% of students knew that carbon dioxide is produced when oxygen reacts with the positive carbon electrodes when aluminium is extracted by electrolysis from a molten mixture of aluminium oxide and cryolite.

05.3 Only a very small number of students were able to suggest that when titanium was extracted from a mixture of titanium chloride and sodium an inert atmosphere was essential to prevent the sodium reacting with air.

05.4 A third of students knew that argon is used for the inert atmosphere when titanium is extracted from a mixture of titanium chloride and sodium.

05.5 Just over half of the students correctly balanced the equation for the reaction of sodium with titanium chloride. Students should be aware that they should not change the formula of the compounds in the equation.

05.6 Students should know that the law of conservation of mass states that the mass of reactants equals to the mass of products. In this experiment the mass of carbon dioxide produced equals the difference between the sum of the mass of copper oxide and carbon (reactants) minus the mass of copper produced (other product). Only 20% of students calculated this correctly.

05.7 Students were asked to explain why the mass of a mixture of copper oxide and carbon in a crucible changed when the mixture was heated. Few students recognised that the mass would decrease because the carbon dioxide produced is a gas that escapes into the atmosphere. The term evaporation was incorrectly used by a large number of students. Only a small number of students gained two marks.

05.8 This question asked what happens to copper oxide in the reaction between copper oxide and carbon. Students should be careful with their use of technical terms as many incorrectly stated that ‘copper’ loses oxygen. Approximately 30% of students knew that copper oxide was reduced but very few students were then able to give a reason why.

5.4.1.3 Extraction of metals and reduction

Answer 06 · Examiner comments

June 2023 | 8464/C/2F | Original Q2

Question 2

02.1 Around a quarter of students gained both marks on this question. Half of all students gained one mark, most frequently for the idea that the oceans were formed from water. Far fewer were able to make the link between rock formation and carbon dioxide.

02.2 Nine in ten students were able to identify nitrogen as having the highest percentage.

02.3 One in five students gained all three marks here. A quarter completed the calculation correctly without then expressing it in standard form. Of the remaining students, very few were able to make progress, with one in twenty achieving one mark, usually for expressing an incorrect calculation in standard form. There were all combinations of calculations seen by examiners using the numbers 95 and 0.04.

02.4 This question proved to be the easiest on this year's examination, with over 97% achieving the correct answer.

02.5 Three quarters of students correctly calculated the mass of carbon dioxide. The most common incorrect response saw students multiply rather than divide the two numbers.

02.6 Around half of students correctly identified photosynthesis as the correct answer. The most common incorrect responses were respiration, distillation and deforestation.

02.7 Approximately one third of students gained two marks for this question, with one in ten gaining one mark. Many students did not identify the direction of change, suggesting Africa or South America changed the most, which was not creditworthy. Also, students often responded with ideas about developing areas and industrialised areas, without talking about the continents on the bar chart.

02.8 Students were able to calculate the percentage of landfill methane emissions from the pie chart with over 85% of students completing the question correctly.

02.9 Around half of students achieved both marks for interpreting the graphic. Only one in ten gained one mark. The most common response that gained no credit was for reuse and recycle the wrong way round. However, all of the other responses were commonly seen.

Answer 07 · Examiner comments

Question 4 (Low demand)

04.1 Half the students were able to select the word from the box to complete the sentence that most metals are found in the Earth as compounds. Elements was the common incorrect distractor. Credit was awarded if the student identified the correct answer in the box.

04.2 Half the students knew that iron is extracted from iron oxide by reduction with carbon because iron is less reactive than carbon. A third of students selected the incorrect converse response that iron is more reactive than carbon.

04.3 Less than half of students knew that cryolite is added to aluminium oxide to reduce the amount of energy used in the extraction of aluminium from aluminium oxide by electrolysis. The most popular incorrect distractor was to reduce the rate of reaction.

04.4 In the extraction of aluminium from aluminium oxide by electrolysis the positive electrodes need to be replaced. Fewer than 20% of students knew that this is because the electrodes react with oxygen gas. The other three options were all more popular. The electrodes react with aluminium was the most common incorrect response.

04.5 Just under half of students recalled that an alloy is harder than a pure metal. The converse statement an alloy is less hard than a pure metal was the most popular incorrect distractor.

04.6 When describing trends in graphs examiners are looking for students to state how the change in the *x*-axis (an increase in the independent variable) affects the value plotted on the *y*-axis (the dependent variable). In figure 9 as the percentage of silver in the mixture (*x*-axis) increased the melting point (*y*-axis) decreased. However, there was a marked change in the trend at 70% silver (where the curve was a minimum) after which the melting point increased. Students may have realised how the 3 marks were allocated. Examiners were not looking for a description of the rate of changes e.g. a sharp increase after 70% silver. Some students were careless with their terminology referring to the percentage of aluminium not silver and the boiling point of the alloy. A third of students gained all 3 marks. Many were awarded 1 mark usually for the initial decrease in melting point.

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5.4.1.3 Extraction of metals and reduction

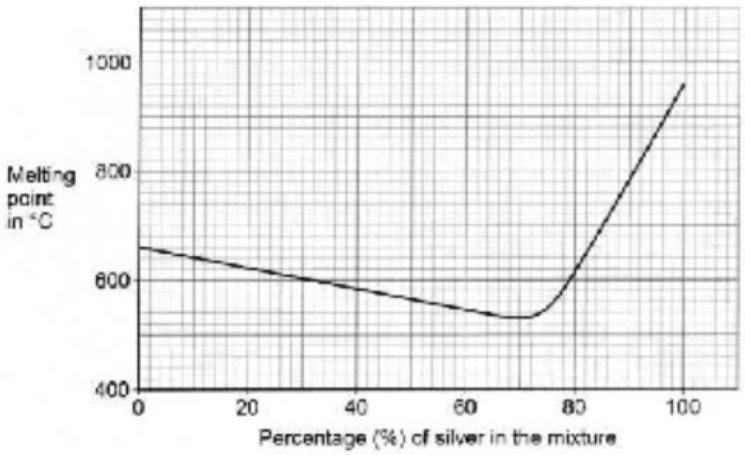
Answer 07 · Examiner comments

June 2025 | 8464/C/1F | Original Q4

0 4 . 6 Aluminium can form an alloy with silver.

Figure 9 shows how the melting point of the alloy changes with the percentage (%) of silver in the mixture.

Figure 9



Describe how the melting point of the alloy changes as the percentage of silver in the mixture increases.

Use data from **Figure 9**.

[3 marks]

the melting point decreases as the percentage of silver increases, however once the mixture is over 70% the melting point significantly increases.

All 3 marking points were awarded. The student has described an initial decrease (in melting point), followed by an increase and has also indicated the point at which the change occurs.

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