AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.4.1.1

Metal oxides

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**12**
Available paper years	**2018–2025**

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.

5.4.1.1 Metal oxides

Answer 01 · Mark scheme June 2018 | 8464/C/1H | Original Q6

<table>
<tr><th>Question</th><th>Answers</th><th>Extra information</th><th>Mark</th><th>AO / Spec. Ref.</th></tr>
<tr><td>06.1</td><td>CaO

CO_2</td><td>either order
ignore names</td><td>1

1</td><td>AO1
5.3.1.3</td></tr>
<tr><td>06.2</td><td>

[12 + (3 × 16)]
or 60

(197 − 60 =) 137

barium or Ba</td><td>an answer of 137 scores the 2 calculation marks

barium or Ba without working scores this mark</td><td>

1

1

1</td><td>AO2
5.3.1.2
5.3.1.3
5.1.1.5</td></tr>
<tr><td>06.3</td><td>

(working) Y increase <u>and</u> X increase measured from graph <u>and</u> substitution into $\frac{\Delta Y}{\Delta X}$

(answer) 167

(units) cm^3/g</td><td>an answer of 160–174 scores the 2 calculation marks

<table><tr><td>y-axis</td><td>80–85</td><td>162–170</td><td>248–252</td><td>330–335</td></tr><tr><td>x-axis</td><td>0.5</td><td>1.0</td><td>1.5</td><td>2.0</td></tr><tr><td>=</td><td>160–170</td><td>162–170</td><td>165–168</td><td>165–168</td></tr></table>
allow answer in range 160–174

allow $cm^3\ g^{-1}$

if no other mark awarded allow 1 mark for the inverse ($\frac{\Delta X}{\Delta Y}$)
or 0.006</td><td>

1

1

1</td><td>AO2
5.3.1.2
5.3.1.3</td></tr>
</table>

5.4.1.1 Metal oxides

Answer 01 · Mark scheme

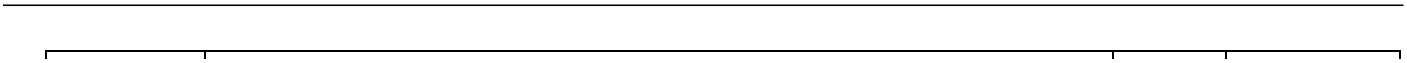
June 2018 | 8464/C/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4		an answer of 140–150 scores **4** marks an answer of 0.14–0.15 scores **3** marks		AO3 5.3.1.2 5.3.1.3
	(from graph) volume to 240 cm^3 mass = 1.45 g	allow answer based on any reading from the graph (eg 250 cm^3 = 1.5 g)	1	
	ratio is $\frac{1}{100}$ (ie $\frac{24\,000}{240}$)	allow ratio from their volume eg $\frac{24\,000}{250}$	1	
	100×1.45	$\left(\frac{24\,000}{250}\right) \times 1.5$	1	
	145	allow range 140–150	1	
	or allow method using answer from question **06.3**			
	$x = \frac{y}{m}$ (1)	(rearrangement of y = mx where m = answer from question **06.3**)		
	24 (dm^3) to 24 000 (cm^3) (1)			
	$\frac{24\,000}{\text{answer from question 06.3}}$ (1)			
	144 (1)	allow range 140–150		
Total			**12**	

5.4.1.1 Metal oxides

Answer 01 · Mark scheme

June 2018 | 8464/C/1H | Original Q6



5.4.1.1 Metal oxides

Answer 02 · Mark scheme

June 2018 | 8464/C/1H | Original Q7

Question	Answers	Mark	AO / Spec. Ref.
07.1	**Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO3
	Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	AO3
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	AO1 AO2
	No relevant content	0	
	Indicative content: A is sodium oxide B is phosphorus oxide C is magnesium oxide D is silicon dioxide **linked statements:** A is sodium oxide because it has highest pH **or** pH = 14 **or** is a strong alkali B is phosphorus oxide because it has lowest pH **or** pH = 3 **or** is an acid C is magnesium oxide because it has 2nd highest pH **or** pH = 9 **or** is a (weak) alkali D is silicon dioxide because it is neutral **or** pH = 7 **or** A and B are sodium oxide **or** phosphorus oxide because both soluble **or** no solid remains C is magnesium oxide because it will be the colourless solution with solid remaining D is silicon dioxide because it will be the colourless liquid with solid remaining for **level 3** the solids must be correctly identified		5.1.2.3 5.4.2.4

5.4.1.1 Metal oxides

Answer 02 · Mark scheme

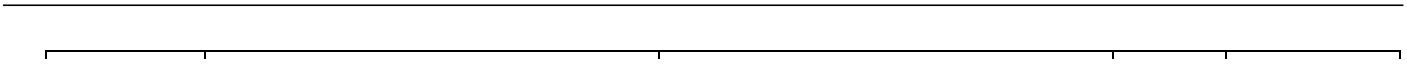
June 2018 | 8464/C/1H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2		an answer of (pH=) 5 gains **2** marks		
	dilution by a factor of 100	allow pH changes by 1 when solution is diluted by factor of 10 **or** allow pH changes by 2	1	AO1 5.4.2.5
	(pH=) 5		1	AO3 5.4.2.5
Total			**8**	

5.4.1.1 Metal oxides

Answer 02 · Mark scheme

June 2018 | 8464/C/1H | Original Q7



5.4.1.1 Metal oxides

Answer 03 · Mark scheme November 2020 | 8464/C/1H | Original Q1

01.1	13 14	this order only	1 1	AO2 5.1.1.4 5.1.1.5
01.2	loss of oxygen	allow (Al^{3+}) gain of electrons allow aluminium oxide loses oxygen	1	AO1 5.4.1.1 5.4.1.3
01.3	 (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
01.4	(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**	

5.4.1.1 Metal oxides

Answer 03 · Mark scheme

November 2020 | 8464/C/1H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.4.1.1 Metal oxides

Answer 04 · Mark scheme

03	**Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6	AO3
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	5.3.1.3 5.4.2.2
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content: • weigh test tube • add metal carbonate • weigh test tube and metal carbonate • heat • allow to cool • weigh test tube and metal oxide • repeat (heat, cool and weigh) until no change in mass • determine mass of metal carbonate used • determine mass of carbon dioxide produced • repeat with different metal carbonate(s) an alternative method can be based on any mass of metal carbonates and at end divide by this mass to find mass carbon dioxide per gram metal carbonate level 3 change in mass is determined for at least one other carbonate		

Total			**6**

5.4.1.1 Metal oxides

Answer 04 · Mark scheme

November 2020 | 8464/C/1H | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.4.1.1 Metal oxides

Answer 05 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	green to red		1	AO1 5.4.2.4
02.2	decreases		1	AO1 5.4.2.4
02.3	(aq)	allow aq ignore aqueous ignore HNO_3	1	AO1 5.2.2.2
02.4	any **two** from: • (white) solid disappears • fizzing **/** bubbles / effervescence • (then) stops fizzing • (white) solid left at the end / bottom	allow a gas is produced ignore colourless solution	2	AO3 5.4.2.2 5.4.2.3
02.5	$Zn(NO_3)_2$		1	AO2 5.1.1.1 5.4.2.2

5.4.1.1 Metal oxides

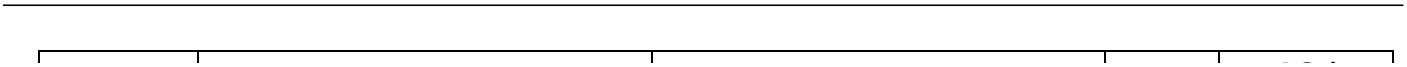
Answer 05 · Mark scheme

Question	Answers	Mark	AO / Spec. Ref.
02.6	**Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6	AO1 5.4.2.2 5.4.2.3 RPA8
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative Content: • react hydrochloric acid • (with) copper oxide • in a suitable container • warm (hydrochloric) acid • add copper oxide • until is in excess **or** until solid remains • stir • filter excess copper oxide • pour solution / filtrate into evaporating basin • use of water bath **or** use of electric heater • to heat gently **or** partially evaporate • leave to cool / crystallise For level 3 the correct chemicals must have been selected.		
Total		**12**	

5.4.1.1 Metal oxides

Answer 05 · Mark scheme

November 2021 | 8464/C/1H | Original Q2



5.4.1.1 Metal oxides

Answer 06 · Mark scheme

November 2021 | 8464/C/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	(mass of oxygen = 0.20 – 0.12) = 0.08 (g)		1	AO2 5.1.1.1 5.3.1.1 5.3.1.3 5.3.2.1 5.4.1.1
	(moles of oxygen) = $\frac{0.08}{32}$	allow **1** mark for 0.005 if derived from $\frac{0.08}{16}$	1	
	= 0.0025		1	
06.2	(without a lid the) mass of magnesium oxide was less		1	AO3 5.4.1.1
	(because) products escaped	allow magnesium oxide escaped	1	
06.3	(mass of copper oxide =) $\frac{79.5}{63.5} \times 0.5$		1	AO2 5.1.1.1 5.3.1.1 5.3.1.3 5.3.2.1 5.3.2.2 5.3.2.3 5.4.1.1
	= 0.62598 (g)		1	
	= 0.626 (g)	allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses all the values in the question	1	

5.4.1.1 Metal oxides

Answer 06 · Mark scheme

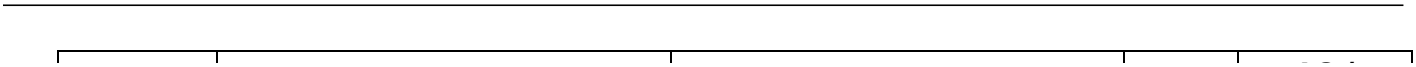
November 2021 | 8464/C/1H | Original Q6

06.4	3:2 ratio Fe : O_2 (molecules) **or** 3:4 ratio Fe : O (atoms)		1	AO2 5.1.1.1 5.3.1.1 5.3.1.3 5.3.2.1 5.3.2.2 5.3.2.3 5.4.1.1
	(formula) Fe_3O_4	allow **1** mark for Fe_3O_2 from 3:2 ratio Fe : O (atoms) (MP2 but not MP1)	1	
	$3\,Fe + 2\,O_2 \rightarrow Fe_3O_4$	allow multiples allow correct use of incorrectly determined formula allow **1** mark for Fe, O_2 and Fe_3O_4 **or** allow **1** mark for Fe, O_2 and incorrectly determined formula	2	
Total			**12**	

5.4.1.1 Metal oxides

Answer 06 · Mark scheme

November 2021 | 8464/C/1H | Original Q6



5.4.1.1 Metal oxides

Answer 07 · Mark scheme

June 2023 | 8464/C/1H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	$4\,Na + O_2 \rightarrow 2\,Na_2O$	allow multiples	1	AO2 5.1.1.1 5.1.2.5 5.3.1.1 5.4.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	sodium atom loses one electron		1	AO1 5.1.1.7 5.1.2.3
	(and) oxygen atom gains two electrons		1	5.1.2.5 5.2.1.2
	(so) two sodium atoms to one oxygen atom		1	
	any **one** from: • (to form) Na^+ **and** O^{2-} • (to form) sodium ion(s) **and** oxide ion(s) • (to form) ions with full outer shells / levels.		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	yellow flame	allow orange flame	1	AO1 5.1.2.5
	any **one** from: • sodium melts • white smoke / solid / powder		1	

5.4.1.1 Metal oxides

Answer 07 · Mark scheme

June 2023 | 8464/C/1H | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	(potassium) (burns with a) lilac flame	allow (burns with a) different colour flame	1	AO1 5.1.2.5
	burns faster	allow more vigorous reaction	1	

Total Question 3	9

5.4.1.1 Metal oxides

Answer 08 · Mark scheme

June 2023 | 8464/C/1H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	fullerenes and graphene		1	AO1 5.2.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	delocalised electrons (which) move through the structure (and) transfer energy		1 1 1	AO1 5.2.1.5 5.2.2.8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	strong (electrostatic) forces of attraction (between the) oppositely charged ions (so) large amounts of energy needed to break the many / strong bonds / forces	 allow (so) large amounts of energy needed to break the bonds / forces in all directions allow (so) large amounts of energy needed to break the bonds in the lattice	1 1 1	AO1 5.2.1.3 5.2.2.3

5.4.1.1 Metal oxides

Answer 08 · Mark scheme

June 2023 | 8464/C/1H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	small molecules	allow simple molecules	1	AO1 5.2.1.4 5.2.2.4
	(with) weak forces between the molecules **or** (with) weak intermolecular forces	allow (with) weak intermolecular bonds do **not** accept incorrect references to covalent bonds	1	
	(so) little energy required to overcome / break the forces between molecules **or** (so) little energy required to overcome / break the intermolecular forces	allow (so) little energy required to separate the molecules allow (so) little energy required to overcome / break the intermolecular bonds ignore less energy	1	

Total Question 7	10

5.4.1.1 Metal oxides

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	(test) glowing splint	MP2 is dependent upon MP1 being awarded do **not** accept burning / lit splint	1	AO2 AO1
	(result) relights	allow glows more brightly	1	5.8.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	smaller volume of gas produced (per unit time) (so) error in reading is a larger percentage of the total volume		1 1	AO3 5.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	any **one** from: • measuring vessel (for hydrogen peroxide or gas) wrongly calibrated • balance wrongly calibrated • timer slow / fast		1	AO3 5.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	all points plotted correctly line of best fit	allow a tolerance of ± ½ a small square allow at least 4 points plotted correctly for **1** mark	2 1	AO2 AO3 5.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	manganese dioxide (because manganese dioxide) has the steepest gradient	allow ecf from question **06.4** allow (because manganese dioxide) produces the most gas per unit time	1 1	AO3 5.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.6	same number of particles per unit volume (so) same frequency of collisions (with catalyst)	allow same concentration (of hydrogen peroxide solution)	1 1	AO3 5.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.7	tangent drawn at 20 s value for *x* step **and** *y* step from tangent (rate =) $\frac{\text{value for } y \text{ step}}{\text{value for } x \text{ step}}$ correctly calculated to 3 significant figures	 allow evidence of use of two points on tangent either on the graph or in the text allow correct use of incorrectly determined value(s) for *x* step and/or *y* step from a drawn tangent allow a correctly calculated answer to 3 significant figures from an incorrect calculation which uses values determined from the graph	1 1 1 1 1	AO2 5.6.1.1

Total Question 6	17

5.4.1.1 Metal oxides

Answer 10 · Mark scheme

June 2024 | 8464/C/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	gold	allow Au allow silver / Ag allow platinum / Pt allow copper / Cu	1	AO1 5.4.1.2 5.4.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	reduction by carbon	allow heating / reacting with carbon	1	AO3 5.4.1.2 5.4.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	cryolite		1	AO1 5.4.3.1 5.4.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	oxygen is produced (which) reacts with the carbon / electrode / anode to form carbon dioxide (so the electrode) has to be continually replaced	 allow (so) the electrode is used up allow (so) the electrode burns away	1 1 1	AO1 5.4.3.1 5.4.3.2 5.4.3.3

5.4.1.1 Metal oxides

Answer 10 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	$Al^{3+} + 3e^- \rightarrow Al$	allow **1** mark for $Al^{3+} + e^- \rightarrow Al$ with no / incorrect balancing numbers	2	AO2 5.4.3.1 5.4.3.2 5.4.3.3 5.4.3.5

Total Question 6	**8**

5.4.1.1 Metal oxides

Answer 11 · Mark scheme

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

Question 4

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	the **mixture** has a lower melting point (than aluminium oxide) (so) less energy is used (to melt the electrolyte)		1 1	AO1 5.4.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	$2\ O^{2-} \rightarrow O_2 + 4\ e^-$	allow multiples allow **1** mark for $O^{2-} \rightarrow O_2 + e^-$ with no / incorrect balancing numbers	2	AO2 5.4.3.3 5.4.3.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	Cr_2O_3 **or** chromium oxide	allow Cr^{3+} ions	1	AO2 5.4.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	extracting aluminium uses more energy (so costs more)		1	AO3 5.4.1.3 5.4.3.3

5.4.1.1 Metal oxides

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	(extracting chromium costs more because) aluminium is used in the extraction of chromium		1	AO3 5.4.1.3 5.4.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.7	alloys contain different sized atoms	allow alloys contain different sized (positive) ions	1	AO1 5.2.2.7
	(so the) layers are distorted		1	
	(so the) layers (of atoms) slide less easily	allow (so the) atoms cannot slide over each other	1	

Total Question 4	11

5.4.1.1 Metal oxides

Answer 12 · Mark scheme

June 2025 | 8464/C/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	a Bunsen burner reaches a higher temperature	allow a water bath will not reach a high enough temperature	1	AO3 5.3.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	(magnesium) (contents of crucible) increase in mass (from 0.24 to 0.38 g)	allow a value in the range 0.38 to 0.39 for 0.38	1	AO2
	(because magnesium) gains oxygen		1	AO3
	(magnesium carbonate) (contents of crucible) decrease in mass (from 0.84 to 0.44 g)	allow a value in the range 0.44 to 0.45 for 0.44	1	AO2
	(because) carbon dioxide is released	allow (because) carbon dioxide gas is produced	1	AO3 5.3.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	both reactions produce 0.01 mol of magnesium oxide		1	AO3 5.3.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	(if solid escaped) the final mass would be lower for the actual results than for the predicted results	allow (solid cannot have escaped because) same mass of solid product formed allow (solid cannot have escaped because) both form 0.4 g of solid allow (solid cannot have escaped because) the final mass of the contents (of the crucible) are the same	1	AO3 5.3.1.3

5.4.1.1 Metal oxides

Answer 12 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	(ratio Fe : H_2O) 3:4		1	AO2 5.1.1.1 5.3.1.1
	(formula) Fe_3O_4	allow formula correctly determined from incorrect ratio	1	5.3.2.1 5.3.2.2 5.3.2.3
	3 Fe + 4 H_2O → Fe_3O_4 + 4 H_2	allow multiples allow correct use of an incorrectly determined formula for iron oxide allow **1** mark for Fe, H_2O, Fe_3O_4 and H_2 **or** allow **1** mark for Fe, H_2O, H_2 and an incorrectly determined formula for iron oxide	2	5.4.1.2

Total Question 6	**11**

5.4.1.1 Metal oxides

Answer 01 · Examiner comments

June 2018 | 8464/C/1H | Original Q6

Question 6 (standard, standard / high & high demand)

06.1 The question was not answered well, with large numbers of students missing the key word 'formula' in the question stem. As a result, lots of responses included the names of a wide range of chemicals. Quite a few knew the formula for carbon dioxide.

06.2 Those students who were aware that carbonate had a formula of CO_3 usually came up with the correct answer. Many opted for more well-known Group 2 carbonates such as calcium and magnesium, usually with little justification.

06.3 A good number of students could successfully calculate the gradient. Most students knew the method but could not get the correct figures from the graph. Students seemed to make their life very difficult when selecting values from the graph to calculate the gradient.

The easiest methods would have been to:

- use the increase in mass from 0 g to 1 g, with the equivalent volume increase of 167 cm^3, to give a simple calculation of 167 ÷ 1
- increase in mass from 0 g to 0.5 g, or 0 g to 2 g would have also given relatively easy calculations.

There were very few inverted equations but very few correct units, these were invariably inverted as g/cm^3

When determining a gradient students should be encouraged to draw the sides of their triangle as large as possible, as this reduces the error in reading the *x* and *y* values from the graph.

06.4 This question was answered well by only the highest-attaining students with 4% achieving full marks. Their working followed those methods in the mark scheme or routes based upon these, which also achieved full credit. These students could either see the link from the graph, where 240 cm^3 had a mass of 1.45 g, and the subsequent conversion from 240 cm^3 to 24 dm^3 or they divided the volume (in cm^3) by their gradient.

Some students used a volume on the *y*-axis of 24 cm^3, which gave a mass of approximately 0.15 g on the *x*-axis, which scaled up to (a correct answer of) 150. However, because their scale was so small, some got the mass as 0.16 g. As this is within half a small square and scaled up to 160, these students were also awarded full credit.

Students should be aware that when larger values are taken from the *x* and *y*-axes, errors in subsequent calculations are minimised.

5.4.1.1 Metal oxides

Answer 02 · Examiner comments

June 2018 | 8464/C/1H | Original Q7

Question 7 (standard / high & high demand)

07.1 In this 'extended response' question many students used the information effectively and gave very good explanations. 73% of students were able to achieve at least one mark, while 18% of students gave answers sufficient enough to meet the demands of the level 3 descriptor.

Some misunderstood the solubility data and gave SiO_2 as the most soluble. Many understood how pH related to acid, alkali and neutral. Although a common error was the confusion between whether sodium oxide was alkaline or acidic so many gave C and D correct from the solubility data but A and B incorrect.

In long descriptions, students would often contradict chemical identification or properties due to a lack of organisation within their response. A number gave the identity of the substances as elements instead of oxides. Some did not link the letters with any of the four substances listed in the question, choosing others compounds.

07.2 Students struggled with the concept that is if an acid is diluted by a factor of 10 then the pH increases by 1. Very few showed any attempt at the correct method, with 12% of students achieving one or two marks. Most students simply multiplied the 3 by 100 to give an answer of 300.

5.4.1.1 Metal oxides

Answer 05 · Examiner comments — November 2021 | 8464/C/1H | Original Q2

Question 2 (standard demand)

02.1 Just under half of students correctly choose ‘green to red’ as the colour change observed when nitric acid is added to a mixture of universal indicator and water.

02.2 Just over one half of students knew that the pH of water decreases when nitric acid was added.

Answer 05 · Examiner comments — November 2021 | 8464/C/1H | Original Q2

02.3 Few students were able to give (aq) as the state for a substance dissolved in water.

02.4 The required practical activity of making a soluble salt starts by reacting either an insoluble metal oxide or metal carbonate with an acid. The word equation was provided to help students with this question although many students found difficulty in making links between this and the resulting observations. Since carbon dioxide is produced, initial observations would be fizzing and white solid disappearing. Excess zinc carbonate would result in all the nitric acid reacting; fizzing would stop and excess solid would collect at the bottom. Very few students scored two marks.

02.5 Students found difficulty in determining the formula for zinc nitrate. Just over one third of students gained the mark.

02.6 Students had difficulty in describing the essential steps of the required practical activity of making a soluble salt from an insoluble metal oxide and an acid. Many failed to select the correct chemicals, copper oxide and hydrochloric acid; without these the method would not lead to a valid outcome. Very few students got into level three. Approximately four fifths of students produced a level one answer.

5.4.1.1 Metal oxides

Answer 06 · Examiner comments November 2021 | 8464/C/1H | Original Q6

Question 6 (standard, standard / high and high demand)

06.1 Just over one-tenth of students gained full marks in this calculation. Having correctly calculated the mass of oxygen the most common error was to incorrectly calculate the number of moles by dividing by the relative atomic mass of oxygen (16) rather than the relative formula mass of oxygen molecules (32).

06.2 Few students realised that without a lid the mass of products would decrease as magnesium oxide would escape during the reaction.

06.3 This calculation was answered correctly by approximately one fifth of students. A small number were not able to round their answer correctly to three significant figures.

06.4 Students found this question challenging. Very few students were able to make the link between the moles of reagents that reacted and the formula of the product. Just under one sixth of students were able to correctly write a balanced chemical equation using their iron oxide product from the earlier part of the question.

Answer 07 · Examiner comments June 2023 | 8464/C/1H | Original Q3

Question 3 (standard, standard/high demand and high demand)

03.1 Nearly three-quarters of the students correctly balanced the equation for the reaction of sodium with oxygen to produce sodium oxide.

03.2 This question was a good discriminator. Most students understood the processes involved in this question, but poor use of chemical language meant they often did not achieve the marks. Students often referred to sodium and oxygen, rather than sodium atoms and oxygen atoms and many incorrect terms such as ‘atoms sharing electrons to form ionic bonds’, ‘metal ions losing electrons’ and ‘non-metal ions gaining electrons’ were seen. Formation of O^- was a common misconception, rather than recognising that two sodium atoms each lose one electron, and both electrons are gained by one oxygen atom to form an oxide ion (O^{2-}). A common error was for students to write oxygen ion instead of oxide ion.

5.4.1.1 Metal oxides

Answer 07 · Examiner comments June 2023 | 8464/C/1H | Original Q3

03.3 Students found this question very challenging and instead of giving observations tried to explain what was happening in the reaction. Ver few students gave two observations for burning sodium in oxygen. A yellow flame was a common answer for those who gained one of the marks although ‘flame’ was insufficient. If students wrote ‘smoke’ they often did not state the colour and so did not achieve the mark. Many referred to the reaction of sodium with water so bubbles was a common incorrect response.

03.4 Again very few students gave two differences comparing burning potassium with sodium in oxygen. Most students did not know that potassium burns with a lilac flame. Students did not tend to write ‘burns faster’ for MP2 but they did achieve this mark by making a comparison of the two reactions, for example, by writing the reaction was more vigorous.

5.4.1.1 Metal oxides

Answer 08 · Examiner comments

June 2023 | 8464/C/1H | Original Q7

Question 7 (standard/high and high demand)

07.1 60% of students identified that fullerenes and graphene both contain atoms in hexagonal rings. Diamond / graphite was the most common distractor selected.

07.2 In this question students were asked to explain why the structure of copper allows the conduction of thermal energy. Just under one half of students gained one mark for stating that delocalised electrons were responsible with approximately a quarter of these students then describing that these electrons move through the structure. The idea that these electrons transfer energy through the metal was infrequently recognised for the third marking point. Many answers confused the carrying of movement of electrical charge rather than thermal energy.

07.3 This question proved to be a good discriminator but students found the question difficult. Students were asked to explain why copper oxide has a high melting point. There was a lot of confusion over types of bonding and forces, with students often contradicting themselves during their response. The majority of those who gained 1 mark usually scored MP3 for stating that large amounts of energy is needed to break the strong forces.

07.4 Students had to describe why water has a low melting point. This question also proved to be a good discriminator. If a student refers to breaking the ‘forces’ or ‘bonds’ for then it must be clear they are referring to the intermolecular forces with no possible confusion that it is covalent bonds being broken. Students must explain that little energy is needed to break the bonds, less energy is insufficient. Nearly 40% of students gained at least 1 mark which was usually gained for stating that little energy is required to overcome the intermolecular forces. Few students described water as existing as small molecules which have weak intermolecular forces.

5.4.1.1 Metal oxides

Answer 08 · Examiner comments

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

5.4.1.1 Metal oxides

Answer 09 · Examiner comments

Question 6

06.1 Fewer than half of the students were able to identify oxygen from the equation then recall the test for oxygen gas and its result. Frequently, a description of a glowing splint was inadequate, such as a blown out splint or just a splint.

06.2 Practical errors are not well known by students and fewer than one in ten gained any marks on this question, usually for the idea that a smaller volume of hydrogen peroxide would lead to a smaller volume of gas. Students did not then make the link to a greater percentage reading error.

06.3 Understanding what a systematic error is was not well known by students with fewer than one in twenty five gaining this mark. There is significant confusion with a zero error, which could be systematic, but there was little realisation that the error has to be the same for every reading taken.

06.4 Three quarters of students were able to correctly plot the points on the graph. However, with the anomaly (which was not flagged in the question) and the curve, only about a quarter actually scored all three marks. It did appear that many thought the line had to be straight because the two already on the graph were. However, there was no realisation that these would also slow as the maximum volume of oxygen had been produced.

06.5 Nearly half of students correctly identified manganese oxide (not magnesium oxide) as the catalyst that gave the fastest rate of reaction with the reason. Since the question asked for the fastest rate, the superlative was required in the answer, which many students missed, so a quarter gained one mark, most frequently for this.

5.4.1.1 Metal oxides

Answer 09 · Examiner comments June 2023 | 8464/C/2H | Original Q6

06.6 Most students did not answer the question, preferring to talk about what the reaction was dependent on. Some talked about concentration, temperature, or surface area affecting rate without linking it to this specific question so failed to gain any credit.

06.7 Nearly a quarter of students gained full marks on this question. It appeared that if a student knew to draw a tangent, they could often work it through to an answer. The most common way of not gaining marks when a tangent was drawn was for misreading the scales, or not giving an answer to three significant figures. If a tangent was not drawn, then the mark was limited to a maximum of one for a correct calculation of an expression given to three significant figures.

5.4.1.1 Metal oxides

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

Answer 10 · Examiner comments

June 2024 | 8464/C/1H | Original Q6

Question 6 (standard, standard/high & high demand)

06.1 Many students correctly named a metal that is found in the Earth as the metal itself. The most common answer was gold.

06.2 Students were given a reactivity series and asked to suggest the most economical method for extracting a metal from its metal oxide. 18% of students answered this correctly. Electrolysis was a common incorrect response as this would not be the most economical method.

Many students used 'it' in their response but 'it' refers to the metal so heating 'it' with carbon was not creditworthy but displacing 'it' with carbon was.

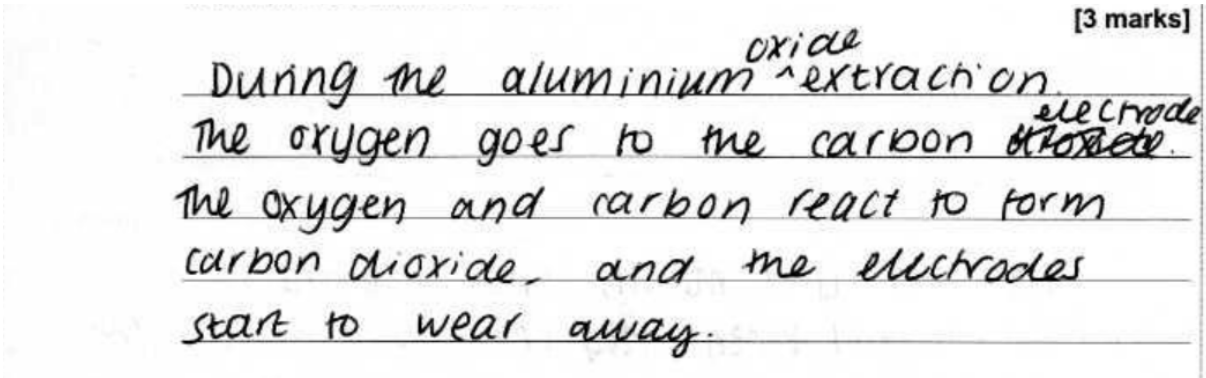
06.3 Few students were able to identify that cryolite was the unknown substance in the molten mixture used in electrolysis to extract aluminium from aluminium oxide.

06.4 This question proved challenging with just under 10% gaining 2 or 3 marks. It was common for students to refer to oxygen being attracted to the electrode or oxide ions reacting with carbon. Some answers focused on explaining why oxygen gas was produced, suggesting that oxide ions were discharged because of the absence of halide ions but not then describing what further happens to the oxygen and the electrode whilst others described the production of aluminium by the reduction of aluminium ions. Thus, oxygen being produced at the positive electrode was frequently omitted.

When students gained 1 mark it was either for saying that carbon dioxide is produced or that the electrode has to be continually replaced.

0 6 . 4 Explain what happens to the **positive** carbon electrodes during the extraction of aluminium from aluminium oxide.

[3 marks]



This response does not state that oxygen is produced at the positive electrode but 2 marks are awarded for oxygen reacting with the carbon electrode to form carbon dioxide (so the electrode) has to be continually replaced.

06.5 Students found writing the half equation at the negative electrode to show the reduction of aluminium ions very challenging. A number did not attempt the question and few gained 2 marks. One mark was infrequently scored, since identifying the correct reactants and not the balancing appeared to be the problem.

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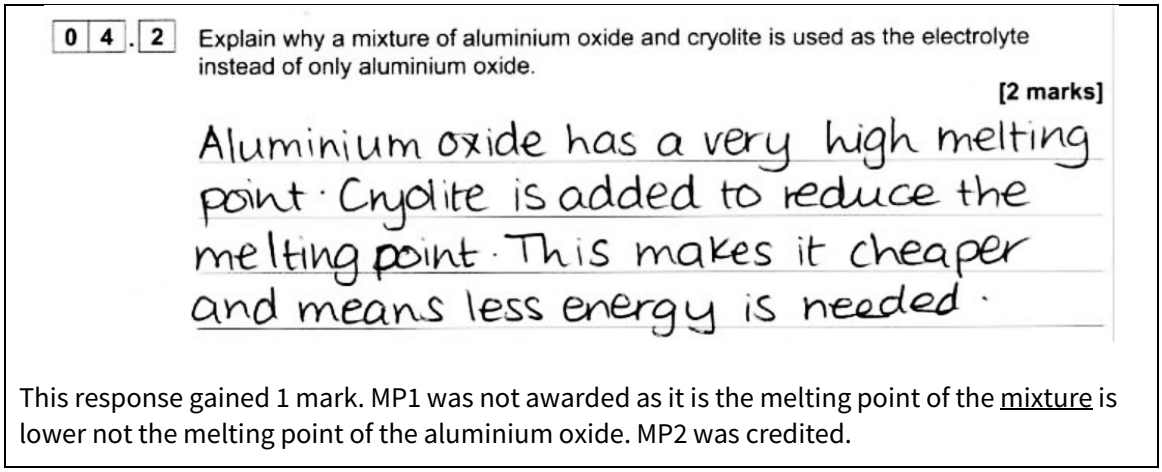
Answer 11 · Examiner comments

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

Question 4 (Standard, Standard/High and High demand)

04.1 Many correctly stated iron can be extracted by reduction with carbon because iron is less reactive than carbon. The converse statement was the most common incorrect response.

04.2 Very few students were able to achieve both marks on this question as the idea that the melting point of the mixture is lower, was rarely seen. Many responses incorrectly stated that it is the melting point of the aluminium oxide or aluminium that is lowered. A large majority of students gained marking point 2 by stating that less energy is used. However, those who qualified this by saying that less energy is needed for the 'reaction' were not awarded the mark. Many students thought that cryolite was a catalyst.


0 4 . 2 Explain why a mixture of aluminium oxide and cryolite is used as the electrolyte instead of only aluminium oxide.

[2 marks]

Aluminium oxide has a very high melting point. Cryolite is added to reduce the melting point. This makes it cheaper and means less energy is needed.

This response gained 1 mark. MP1 was not awarded as it is the melting point of the mixture is lower not the melting point of the aluminium oxide. MP2 was credited.

04.3 Students found writing the half equation at the positive electrode to show the oxidation of oxide ions very challenging. Many students could not give the formula for the oxide ion (O_2^- was common), oxygen or electron (e either with a + charge or no charge was common). One mark was infrequently scored, since identifying the correct reactants and not the balancing appeared to be the problem.

04.4 Few students identified the species being reduced. Chromium, a product of the reaction, was a common incorrect answer.

04.5 This AO3 question required students to use data to give a reason for the difference in the cost of extracting aluminium and iron. Most provided a comparative, which was good, but many chose to compare reactivity or to state what the extraction methods of the metals were rather than comment on the energy implication.

04.6 Another AO3 question looking for a difference in the cost of extracting aluminium and chromium. Few students answered this correctly. Common answers referred to the rarity or difficulty of extracting chromium ores from Earth.

04.7 Just under half of students gained 1 or more marks. Students should know that pure metals are soft so are mixed with other metals to make alloys, which are harder. Those who gained one mark usually referred to the difference in the sizes of the atoms and the second most common mark was for layers not being able to slide. Layers are distorted was less frequently given. Many students gave good descriptions why metals are soft but their answers for alloys were less accurate. Many referred incorrectly to intermolecular forces.

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Answer 12 · Examiner comments

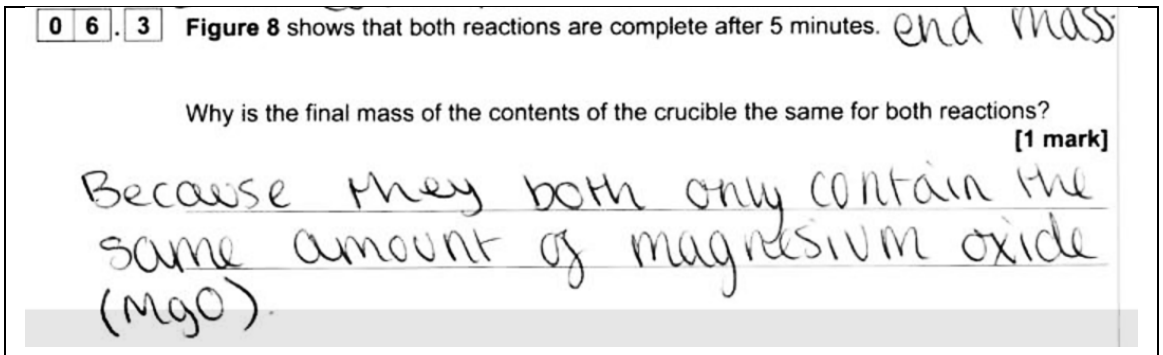
June 2025 | 8464/C/1H | Original Q6

Question 6 (Standard, Standard/High and High demand)

06.1 The reason why the student used a Bunsen burner instead of a water bath is that the Bunsen burner reaches a higher temperature. Common responses which were not creditworthy made no reference to a temperature comparison or stated that a Bunsen burner gives more heat.

06.2 The question asked students to explain the trends in the graph for the first 3 minutes. The trends of magnesium increasing in mass or magnesium carbonate decreasing in mass were described well. Many students who attempted to support their trends with data misread the graph scale so did not gain MP1 and/or MP2; 0.82 g and 0.22 g were common incorrect starting masses, similar errors were made at 3 minutes and others referred to the common mass of 0.4 g at 4 minutes. Reasons for these changes namely magnesium gaining oxygen and carbon dioxide being released from magnesium carbonate were frequently omitted.

06.3 Making the link with the equations and graphs made this a demanding question. When students wrote about moles they usually referred to the moles of the reactants being the same rather than the moles of the product.



0 6 . 3 **Figure 8** shows that both reactions are complete after 5 minutes. end mass

Why is the final mass of the contents of the crucible the same for both reactions?

[1 mark]

Because they both only contain the same amount of magnesium oxide (MgO).

This response did not score but was a near miss. The student is referring to the product from both reactions but the same amount (of MgO) is not equivalent to the same moles.

06.4 This high-demand AO3 question proved challenging. Students could have either described what happened if the conclusion was correct which would result in a final mass lower than predicted or use the graph to conclude that both lines have the same final mass (0.4 g) so solid cannot have escaped. Responses often failed to include mass.

06.5 Many students were able to calculate the ratio of iron to water but only those who gave the simplest ratio were credited with MP1. Most were unable to make the link between the moles of reagents that reacted and the formula of the product so MP2 was rarely awarded. When writing symbols lowercase letters must be discernibly smaller than upper case letters. Many students gave a balanced equation using their formula for iron oxide; FeO and FeO_2 were common incorrect responses which were then used correctly to access MP3 and MP4. Those students who gave the formula of hydrogen as H were unable to access the final 2 marks.

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5.4.1.1 Metal oxides

Answer 12 · Examiner comments June 2025 | 8464/C/1H | Original Q6

0 6 . 5 Iron reacts with steam (H_2O) to produce an oxide of iron and hydrogen gas.

0.120 moles of iron reacts with 0.160 moles of steam.

Determine the balanced equation for the reaction.

You should determine:

- the simplest whole number mole ratio of Fe : H_2O
- the formula of the iron oxide produced.

[4 marks]

0.12 mol : 0.16 mol

12 : 16 mol

Simplest mole ratio of Fe : H_2O = 12 : 16

Formula of the iron oxide = FeO_2

Balanced equation for the reaction:

$Fe + 2H_2O \rightarrow FeO_2 + 2H_2$

This response was awarded 2 marks. The student has not evaluated the simplest ratio and the formula is incorrect. However, they gave a balanced equation using their formula for iron oxide (FeO_2) so gain MP3 and MP4.

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