AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.4.3.1

The process of electrolysis

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**10**
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.

5.4.3.1 The process of electrolysis

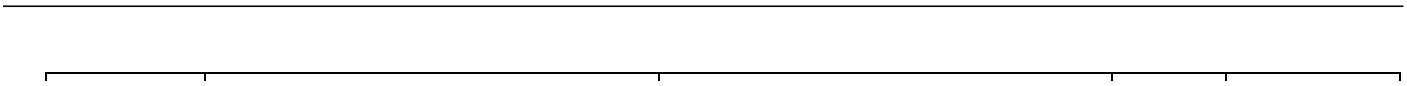
Answer 01 · Mark scheme June 2018 | 8464/C/1H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	chlorine		1	AO2 5.4.3.4
01.2	copper is less reactive than hydrogen		1	AO2 5.4.3.4
01.3	1.8 (mg)	allow an answer in range 1.7–1.9	1	AO3 5.4.3.4
01.4	$\frac{3.02 + 3.01 + x}{3} = 3.06$ 3.15 (mg)	an answer of 3.15 (mg) scores **2** marks allow any other suitable method if no other mark awarded allow 9.18 for **1** mark	1 1	AO2 5.4.3.4
01.5	$\frac{50}{1000}$ **or** $\frac{1}{20}$ **or** 0.05 (0.05) × 300 15 (g) **or** $\frac{300}{1000}$ **or** $\frac{3}{10}$ **or** 0.03 (1) (0.3) × 50 (1) 15 (g) (1)	an answer of 15 (g) scores **3** marks the second mark is dependent on the first mark being scored the second mark is dependent on the first mark being scored if no other mark awarded allow 150 **or** 15 000 for **1** mark	1 1 1	AO2 5.3.2.5
Total			**8**	

5.4.3.1 The process of electrolysis

Answer 01 · Mark scheme

June 2018 | 8464/C/1H | Original Q1



5.4.3.1 The process of electrolysis

Answer 02 · Mark scheme June 2019 | 8464/C/1H | Original Q5

05.1	metal is too reactive to be extracted using carbon **or** metal reacts with carbon	allow metal is more reactive than carbon	1	AO1 5.4.3.3

05.2		either order		AO1 5.4.3.3
	aluminium oxide	ignore bauxite **or** aluminium ore	1	
	cryolite		1	

05.3		allow multiples		AO2 5.4.3.2 5.4.3.5
	negative electrode: $Cu^{2+} + 2e^- \rightarrow Cu$		1	
	positive electrode: $2Cl^- \rightarrow Cl_2 + 2e^-$	allow $2Cl^- - 2e^- \rightarrow Cl_2$	1	

05.4	any **two** from: • concentration / volume of solution was different • impurities in solution • error in timing • copper falls off (electrode) • copper removed when drying electrode • electrode not dry (when weighed) • voltage / current was different	 allow copper at bottom of beaker ignore power supply ignore recorded mass inaccurately	2	AO3 5.4.3.4

5.4.3.1 The process of electrolysis

Answer 02 · Mark scheme

June 2019 | 8464/C/1H | Original Q5

05.5		an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps		AO2 5.4.3.4
	reading of mass at stated time	allow tolerance of ± ½ small square eg at 30 minutes value is 5.4 (mg)	1	
	factor from time to 24 hours	eg 5.4 × 48 $\left(= \frac{24 \text{ hours}}{30 \text{ minutes}}\right)$ allow correct calculation using incorrectly read value for mass at time quoted	1	
	correct evaluation	eg = 259 (mg)	1	
	alternative approach:			
	calculates the gradient (1)	eg (1.8÷10) = 0.18		
	gradient × time in minutes in 24 hours (1)	eg 0.18 × 24 × 60 **or** eg 0.18 × 1440 allow correct use of incorrectly determined gradient		
	correct evaluation (1)	eg = 259 (mg)		

5.4.3.1 The process of electrolysis

05.6	4.75 (g)	allow values in range 4.7–4.8 (g)	1	AO2 5.4.3.4

05.7		an answer in the range 0.18–0.25 scores **2** marks (**3** marks with correct unit)		AO2 5.4.3.4
	(working) Y increase **and** X increase measured from graph	allow ecf from question **05.6**		
	and substitution into $\frac{\text{Y increase}}{\text{X increase}}$	eg = $\frac{2.0}{10}$	1	
	correct evaluation	eg = 0.2	1	
	(units) g/hour	allow g/h **or** g/hr **or** g per hour	1	

Total			**14**

5.4.3.1 The process of electrolysis

Answer 02 · Mark scheme

June 2019 | 8464/C/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.4.3.1 The process of electrolysis

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**

5.4.3.1 The process of electrolysis

Answer 03 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.4.3.1 The process of electrolysis

Answer 04 · Mark scheme

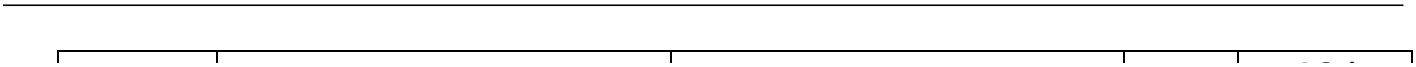
November 2021 | 8464/C/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	reduction (as H^+ ions) gain electrons	ignore electrolysis	1 1	AO2 AO1 5.4.1.4 5.4.3.1 5.4.3.4 RPA 9
05.2	$2\,Cl^- \rightarrow Cl_2 + 2\,e^-$	allow $2\,Cl^- - 2\,e^- \rightarrow Cl_2$ ignore state symbols allow **1** mark for $Cl_2 + e^-$ allow **1** mark for $-\ e^-$ (on lhs) **and** Cl_2 (on rhs)	2	AO2 5.4.1.4 5.4.3.1 5.4.3.4 RPA9
05.3	water molecules break down to produce OH^- ions (which are) attracted to the positive electrode (where OH^- ions are) oxidised **or** (where OH^- ions) lose electrons	 allow dissociate to produce OH^- ions ignore discharged ignore oxygen is produced as no halide is present	1 1 1 1	AO1 5.4.1.4 5.4.3.1 5.4.3.4 5.4.3.5 RPA9
Total			**8**	

5.4.3.1 The process of electrolysis

Answer 04 · Mark scheme

November 2021 | 8464/C/1H | Original Q5



5.4.3.1 The process of electrolysis

Answer 05 · Mark scheme

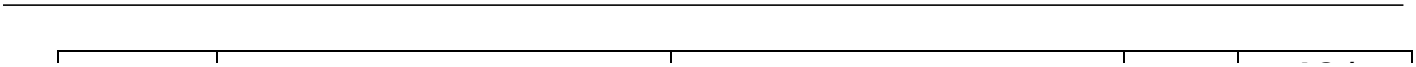
Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	production of copper is increasing at an increasing rate		1 1	AO2 5.10.1.1
04.2	increase in population / demand	allow more uses for copper	1	AO3 5.10.1.1
04.3	any **one** from: • more use of recycling • copper is a finite resource and may run out • alternative metals may be used in future	ignore only an estimate	1	AO3 5.10.1.1
04.4	**B**, **D**, **C**, **A**, **E**		1	AO1 5.10.1.4
04.5	any **two** from: • (phytomining is) slower to produce copper • large area of land required • insufficient yield to meet demand	ignore reference to cost ignore references to carbon dioxide ignore references to global warming allow plants grow slowly	2	AO3 5.10.1.4

04.6	(energy use through recycling = $27.2 \times 8.89 \times 10^9 \times \frac{41}{100}$) $= 9.914 \times 10^{10}$ (energy use through extraction = $70.4 \times 8.89 \times 10^9 \times \frac{59}{100}$) $= 3.693 \times 10^{11}$ (total consumption today = $9.914 \times 10^{10} + 3.693 \times 10^{11}$) $= 4.6844 \times 10^{11}$ (energy use if only recycling used = $27.2 \times 8.89 \times 10^9$) $= 2.418 \times 10^{11}$ (energy saving = $4.6844 \times 10^{11} - 2.418 \times 10^{11}$) $= 2.27 \times 10^{11}$ (MJ)	allow correct use of an incorrect energy use determined in MP1 and/or MP2 allow an answer correctly calculated to 3 significant figures which uses the values in the question	1 1 1 1 1 1	AO2 5.10.2.2
Total			**12**	

5.4.3.1 The process of electrolysis

Answer 05 · Mark scheme

November 2021 | 8464/C/2H | Original Q4



5.4.3.1 The process of electrolysis

Answer 06 · Mark scheme

June 2022 | 8464/C/1H | Original Q2

Question 2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	K_2SO_4		1	AO2 5.1.1.1 5.4.3.4 RPA9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	(volume of hydrogen) 30 (cm^3) **and** (volume of oxygen) 15 (cm^3)		1	AO2 5.4.3.4 RPA9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	(because) the ratio of volume of hydrogen : oxygen is 2 : 1 (and this is the) **same** as the ratio of hydrogen (atoms) : oxygen (atoms) in (formula of) H_2O **OR** (because) the ratio of volume of hydrogen : oxygen is **not** 2 : 1 (1) (and this is) **different** to the ratio of hydrogen (atoms) : oxygen (atoms) in (formula of) H_2O (1)	**must** relate to the volumes given in question **02.2**	1 1	AO3 5.4.3.4 RPA9

Answer 06 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	9 ± 3 cm^3		1	AO2 5.3.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.5	(conversion) ($\frac{25}{1000}$ =) 0.025 (dm^3)		1	AO2 5.3.2.5 5.4.3.4
	(concentration =) $\frac{0.86}{0.025}$	allow correct use of incorrect / no conversion	1	
	= 34.4 (g per dm^3)	allow 34 (g per dm^3)	1	
	OR			
	(conversion) $\frac{1000}{25}$ (1)			
	= 40 (1)			
	(40 × 0.86) = 34.4 (g per dm^3) (1)	allow correct use of incorrect / no conversion allow 34 (g per dm^3)		
	OR			
	(concentration =) $\frac{0.86}{25}$ (1)			
	= 0.0344 (1)			
	(conversion) (0.0344 × 1000) = 34.4 (g per dm^3) (1)	allow 34 (g per dm^3)		

Total Question 2		8

5.4.3.1 The process of electrolysis

Answer 07 · Mark scheme

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

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	ions are not free to move		1	AO1 5.2.2.3 5.4.3.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	liquid **or** molten	allow (when) the solid is melted ignore references to aqueous solutions ignore references to dissolving	1	AO1 5.4.3.1 5.4.3.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	carbon / graphite	allow platinum / gold / silver	1	AO3 5.4.3.1 5.4.3.4 RPA9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	$2\ Cl^- \rightarrow Cl_2 + 2\ e^-$	ignore state symbols allow **1** mark for $Cl_2 + e^-$	2	AO2 5.4.1.4 5.4.3.1 5.4.3.4 5.4.3.5 RPA9

5.4.3.1 The process of electrolysis

Answer 07 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	water (molecules) break down to produce (equal numbers of) H^+ and OH^- (ions) (so) the hydrogen / H^+ ions are attracted to the negative electrode (where) hydrogen ions are discharged / reduced (because) hydrogen is less reactive than sodium (so there is) a decrease in (the relative number of) hydrogen / H^+ ions **or** (so there is) an increase in the relative number of hydroxide / OH^- ions		1 1 1 1	AO3 AO1 AO3 AO3 5.4.2.4 5.4.3.1 5.4.3.4 5.4.3.5 RPA9

Total Question 5	9

5.4.3.1 The process of electrolysis

Answer 08 · 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		1	AO1 5.4.3.1
	(which) reacts with the carbon / electrode / anode to form carbon dioxide		1	5.4.3.2 5.4.3.3
	(so the electrode) has to be continually replaced	allow (so) the electrode is used up allow (so) the electrode burns away	1	

5.4.3.1 The process of electrolysis

Answer 08 · Mark scheme

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

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**

5.4.3.1 The process of electrolysis

Answer 09 · Mark scheme

June 2025 | 8464/C/1H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	any **one** from: • do experiment in a fume cupboard • do experiment in a well-ventilated laboratory / room	ignore references to safety glasses or gloves allow use an extractor fan allow descriptions of well-ventilated such as open windows allow use a gas mask	1	AO3 5.4.3.4 RPA9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	all 6 points plotted correctly line of best fit	allow a tolerance of ± ½ a small square allow **1** mark for 4 or 5 points plotted correctly	2 1	AO2 5.4.3.4 RPA9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	any **one** from: • the increase in mass (for successive 60 second intervals) decreases • after 300 seconds the mass remains constant	allow evidence of two correctly determined changes in mass (for 60 second intervals) from **Table 1** allow the difference in mass (every 60 seconds) is not the same	1	AO3 5.4.3.1 5.4.3.4 RPA9

5.4.3.1 The process of electrolysis

Answer 09 · Mark scheme

June 2025 | 8464/C/1H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	(volume conversion 25 cm^3 =) 0.025 (dm^3)		1	AO2 5.3.2.5
	(concentration =) $\frac{5.5}{0.025}$	allow correct use of an incorrect / no conversion of volume	1	
	= 220 (g/dm^3)		1	
	OR			
	(concentration =) $\frac{5.5}{25}$ (1)			
	= 0.22 (g/cm^3) (1)			
	(conversion = 0.22 × 1000) = 220 (g/dm^3) (1)	allow correct use of an incorrectly determined concentration in g/cm^3 using the values in the question		
	OR			
	(ratio of volume $\frac{1000}{25}$ =) 40 (1)			
	(so ratio of mass =) 40 × 5.5 (1)			
	= 220 (g/dm^3) (1)			

5.4.3.1 The process of electrolysis

Answer 09 · Mark scheme

June 2025 | 8464/C/1H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	hydrogen is less reactive than potassium		1	AO2 5.4.3.4 RPA9

Total Question 1	9

5.4.3.1 The process of electrolysis

Answer 10 · 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

5.4.3.1 The process of electrolysis

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

5.4.3.1 The process of electrolysis

Answer 01 · Examiner comments

June 2018 | 8464/C/1H | Original Q1

Question 1 (standard demand)

01.1 Halogens are produced at the positive electrode if the solution contains a halide ion. 51% of students correctly selected chlorine as the gas produced.

01.2 Students could have linked their knowledge of the reactivity series, with which ion is discharged when an aqueous solution is electrolysed. In this case, the production of copper at the negative electrode informs students that copper is less reactive than hydrogen. 46% of students were able to correctly deduce this.

01.3 Students needed to look at the data and see that the mass produced at three minutes was missing from the table. Experimental errors account for the trend not being exactly directly proportional. In this instance 63% of students noticed the relationship and correctly deduced the mass. The mark scheme did allow a small range around the expected answer.

01.4 68% of students achieved full marks for this question giving an answer of 3.15 (mg), however, a significant number did so without showing their working. This was not an issue where they obtained the correct answer, but some didn't and therefore gained no credit as it was not possible to see how they had obtained their answer.

A working mark was available and showing 9.18 (mg) was the most likely way that this was gained by students.

5.4.3.1 The process of electrolysis

Answer 01 · Examiner comments

June 2018 | 8464/C/1H | Original Q1

01.5 A unit conversion between cm^3 and dm^3 in this question requires a division of either:

- 50 by 1000 to convert cm^3 to dm^3 or
- 300 by 1000 to convert mass per dm^3 to mass per cm^3

This conversion is essential to make progress in this calculation. 14% of students understood this concept and achieved the maximum three marks for this question.

A significant number either divided 300 by 50 with an answer of 6 or multiplied 300 by 50. The latter led to a compensatory mark for 15 000.

5.4.3.1 The process of electrolysis

Answer 02 · Examiner comments

June 2019 | 8464/C/1H | Original Q5

Question 5

As well as an increase in demand through each question in the paper, there was a ramping of demand in this question from standard/high demand to high demand.

05.1 A fifth of students were able to give the reason that electrolysis was used when a metal was more reactive than carbon. Many answers were too vague in terms of metals being reactive, rather than including the comparison with carbon. It was very rare to see a response showing that a student knew that some metals might react with carbon.

05.2 Students found this question challenging. Cryolite was usually the answer that gained one mark. Very few students gave two-mark answers. The most common incorrect responses mentioned a wide variety of elements including the products of electrolysis ‘aluminium’ and ‘oxygen’.

05.3 This high demand question discriminated very well. Students should recognise that electrons are negatively charged. To balance ‘charges’, electrons need to be added as a reactant in the first equation and are produced as a product in the second; the negative charge on the electron must be shown. The first equation was more successfully attempted than the second. Symbols should always have the second letter as lower case.

05.4 Many students answered for a standard yield type question without considering the circumstances of the experiment. Common non-creditworthy responses included:

- not all reacted
- some lost as a gas
- unexpected products formed.

Many thought the electrode being made from copper would affect the mass measured. A number questioned the power supply without specifying voltage or current.

05.5 This question was very well answered with more than two-thirds of students scoring all 3 marks. There were 2 common approaches to this question. Many students read the mass and scaled up. A mass of 5.4g at 30 minutes was a common starting point, which resulted in an answer of 259 mg. A tolerance was allowed reading the graph which led to a range of

5.4.3.1 The process of electrolysis

Answer 02 · Examiner comments June 2019 | 8464/C/1H | Original Q5

results, which was narrower at longer initial times. Others calculated the gradient (0.18) and then used this value to determine the mass after 24 hours. Students used many variations of both methods to obtain a valid and correct answer. A common error was to misread the graph (e.g. mass of 5.2 g at 30 minutes); 2 of the remaining 3 marks were awarded for a subsequent correct evaluation.

05.6 Over three-quarters of students were able to determine the mass of the electrode from the graph.

05.7 This question was well answered and discriminated well. The increases in Y and X were usually calculated correctly. However, a small number of students then inverted the values when calculating the gradient. Some did not evaluate the calculation giving an answer for the gradient as 1/5 for example. The unit mark was generally correct.

Answer 04 · Examiner comments November 2021 | 8464/C/1H | Original Q5

Question 5 (standard / high and high demand)

05.1 A small number of students gained both marks for recognising that when hydrogen ions gain electrons a reduction reaction occurs.

05.2 Few students were able to correctly complete the half equation for the formation of chlorine from chloride ions. Many failed to correctly write chlorine as a diatomic molecule.

05.3 Students found this question challenging. The idea that water molecules break down to produce hydroxide ions was very rarely seen. Many students stated that oxygen gas was produced because there were no halide ions present; this was ignored.

Answer 05 · Examiner comments November 2021 | 8464/C/2H | Original Q4

Question 4 (standard, standard / high and high demand)

Most students were successfully able to describe the general trend in the graph and account for the changes. In question 04.1, however, many failed to gain the second mark point as they did not recognise that the increase was not the same throughout the graph.

The disadvantages of phytomining compared to traditional mining tended to focus on pollution, carbon dioxide emissions and global warming as a result of the combustion of the plants. This did not gain credit as traditional mining methods also lead to a similar increase in the gas.

Students approached the calculation in question 04.6 using a variety of methods, which is to be encouraged. A significant number merely calculated the difference in mass rather than energy. Marking point 5 was awarded for an answer to a calculation using the data provided, given to 3 significant figures.

5.4.3.1 The process of electrolysis

Answer 06 · Examiner comments June 2022 | 8464/C/1H | Original Q2

Question 2 (Standard demand)

02.1 Students were given the formula of the potassium and sulfate ions and asked to deduce the formula of potassium sulfate. Just over 50% of students correctly determined the formula as K_2SO_4. The formulae KSO_4 and $K(SO_4)_2$ proved to be good distractors.

02.2 Just over 45% of students were able to correctly read the volumes of hydrogen and oxygen in the measuring cylinders. Many wrote the volumes of solution left in the measuring cylinder rather than the gas, stating 20 cm^3 for hydrogen and 35 cm^3 for oxygen.

02.3 This question was a good discriminator. A third of students answered this correctly. Students were given a hypothesis linking the ratio of the volumes of gases collected in an electrolysis experiment with the ratio of hydrogen to oxygen atoms in a water molecule. When students deduced that the volumes of hydrogen gas and oxygen gas collected were 30 cm^3 and 15 cm^3, they were able to simplify this ratio to 2:1 which they recognised as the ratio of hydrogen atoms to oxygen atoms in a water molecule and were thus able to confirm the hypothesis. When the ratio of their volumes was not 2:1 many lacked the confidence to state that the hypothesis was incorrect.

02.4 Just over 40% of students identified that the measure of uncertainty in the 4 experiments was 9 ± 3 cm^3. The mean volume was 9 cm^3 and the range of reading was from 6 to 11 cm^3. The option of 9 ± 2 cm^3 proved to be a good distractor.

02.5 A quarter of students gained all 3 marks with a similar number gaining 2 of the 3 marks available. The most common method was to divide the mass of 0.86 g by the volume of 25 cm^3. Some students then went onto carry out the unit conversion of cm^3 into dm^3 which required multiplying their answer (in g/cm^3) by 1000.There was still a small minority of students who showed no working at all.

Answer 07 · Examiner comments June 2023 | 8464/C/1H | Original Q5

Question 5 (standard and high demand)

05.1 Just over 10% of students stated that solid sodium chloride does not conduct electricity because ions are not free to move. The majority of students answered by linking the conducting of electricity in the solid with no free delocalised electrons.

05.2 Just over half of students stated that sodium chloride solution also conducts electricity where liquid or molten. Many students did not read the question carefully enough or failed to understand that in solution was equivalent to dissolved and responded with either aqueous or in solution.

5.4.3.1 The process of electrolysis

Answer 07 · Examiner comments June 2023 | 8464/C/1H | Original Q5

05.3 More than 40% of students named a correct element that could be used as the inert electrode with carbon or graphite being the most common response. Gold, silver and platinum were also creditworthy and were occasionally given by students.

05.4 Students found this question difficult. Students should be aware that halogens all exist as diatomic molecules and that a negative sign on an electron is necessary to balance the charges in the equation.

05.5 This question was very challenging but proved to be a good discriminator. The idea that water molecules break down to produce hydrogen and hydroxide ions was very rarely seen. MP2 was rarely awarded as students failed to provide all the necessary detail which included making reference to three terms: (hydrogen) ions, attracted and discharged/reduced. When one mark was gained it usually was for a reference to hydrogen being less reactive than sodium. MP4 was for explaining why the pH increased and when gained it was usually for stating that there was a decrease in number of the hydrogen ions; an increase in the relative number of hydroxide ions was a comparable answer for MP4 but was rarely seen.

Answer 08 · 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.

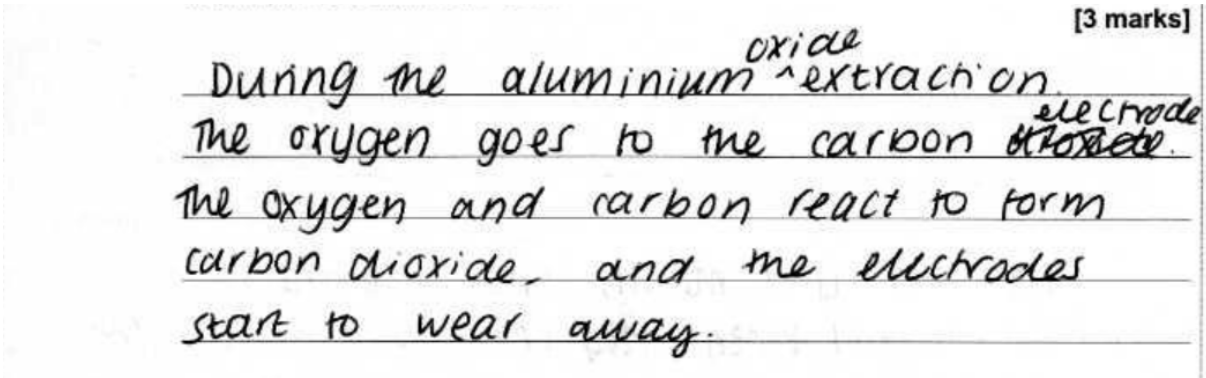
06.3 Few students were able to identify that cryolite was the unknown substance in the molten mixture used in electrolysis to extract aluminium from aluminium oxide.

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 09 · Examiner comments

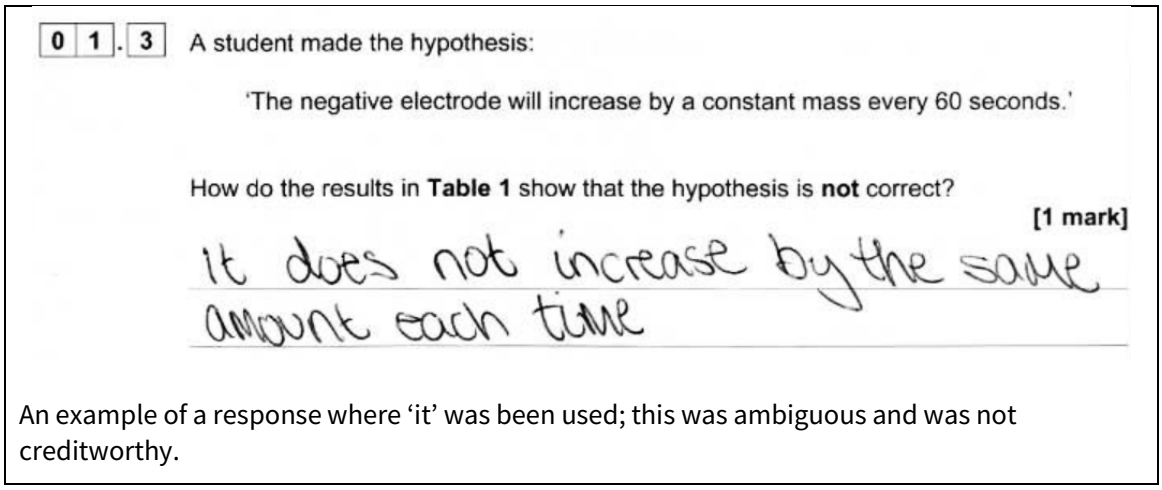
June 2025 | 8464/C/1H | Original Q1

Question 1 (Standard demand)

01.1 The most common response of reducing the risk of harm from chlorine gas was 'wear a mask' which was insufficient to gain credit, as was 'face mask', when what was required was the use of 'a gas mask'. Conducting the experiment 'in a fume cupboard' was a less commonly seen correct response as was ventilation which was well-remembered from the required practical.

01.2 The majority of students were able to plot the six points. Drawing a line of best fit remains slightly more problematic: lines failed to go through the points, lines between the points were drawn with a ruler or double lines are drawn, lines were stopped and restarted and many were drawn with a thick pen or blunt pencil that was more than half a small square thick. Numerous students drew a straight line, despite the points clearly indicating a curve and some drew both a straight line and a curve.

01.3 This question was well answered. Some students referred to the graph for their answer, when the question demanded that they use the results from Table 1. The results show that as time increased in 60 second intervals the mass of the negative electrode increased but at a decreasing rate until 300 seconds when the mass remained constant. Rather than stating 'increase/changes in mass' in their responses, some students referred to 'it'; this was ambiguous and did not gain credit. The most common correct answer was that the mass was constant after 300 sec. Using two correctly determined changes in mass was creditworthy, but simply quoting numbers from the table was insufficient.


0 1 . 3 A student made the hypothesis:

'The negative electrode will increase by a constant mass every 60 seconds.'

How do the results in **Table 1** show that the hypothesis is **not** correct?

[1 mark]

it does not increase by the same amount each time

An example of a response where 'it' was been used; this was ambiguous and was not creditworthy.

01.4 This calculation was well done. Many students were able to convert 25 cm^3 to 0.025 dm^3 for 1 mark. Some attempted the unit conversion but either divided by 100 or multiplied by 100 or 1000. Numerous students laid out their working clearly, giving units throughout, although few used words e.g. 'concentration ='. Those who didn't quote an equation for concentration occasionally went on to get mass and volume the wrong way up or multiplied them.

01.5 More than three quarters of students knew that when potassium chloride solution is electrolysed hydrogen gas was given off at the negative electrode because hydrogen is less reactive than potassium. The reverse statement hydrogen is more reactive than potassium was the most popular incorrect distractor.

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Answer 10 · 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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