AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.4.3.3

Using electrolysis to extract metals

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**7**
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.

5.4.3.3 Using electrolysis to extract metals

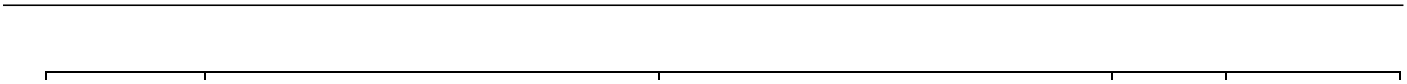
Answer 01 · Mark scheme June 2018 | 8464/C/1H | Original Q1

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**	

5.4.3.3 Using electrolysis to extract metals

Answer 01 · Mark scheme

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



5.4.3.3 Using electrolysis to extract metals

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

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

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

5.4.3.3 Using electrolysis to extract metals

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)		

5.4.3.3 Using electrolysis to extract metals

Answer 02 · Mark scheme

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

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**

5.4.3.3 Using electrolysis to extract metals

Answer 02 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.4.3.3 Using electrolysis to extract metals

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**

5.4.3.3 Using electrolysis to extract metals

Answer 03 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.4.3.3 Using electrolysis to extract metals

Answer 04 · Mark scheme

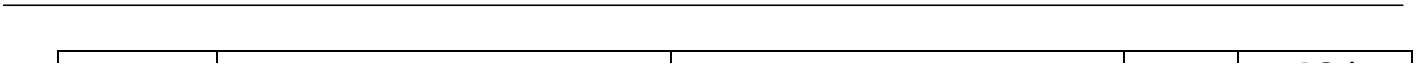
November 2021 | 8464/C/1H | Original Q5

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**	

5.4.3.3 Using electrolysis to extract metals

Answer 04 · Mark scheme

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



5.4.3.3 Using electrolysis to extract metals

Answer 05 · 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

5.4.3.3 Using electrolysis to extract metals

Answer 05 · 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

5.4.3.3 Using electrolysis to extract metals

Answer 06 · 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	

5.4.3.3 Using electrolysis to extract metals

Answer 06 · 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**

5.4.3.3 Using electrolysis to extract metals

Answer 07 · 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

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**

5.4.3.3 Using electrolysis to extract metals

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.

5.4.3.3 Using electrolysis to extract metals

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.

5.4.3.3 Using electrolysis to extract metals

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

5.4.3.3 Using electrolysis to extract metals

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 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.

5.4.3.3 Using electrolysis to extract metals

Answer 05 · 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 06 · 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.

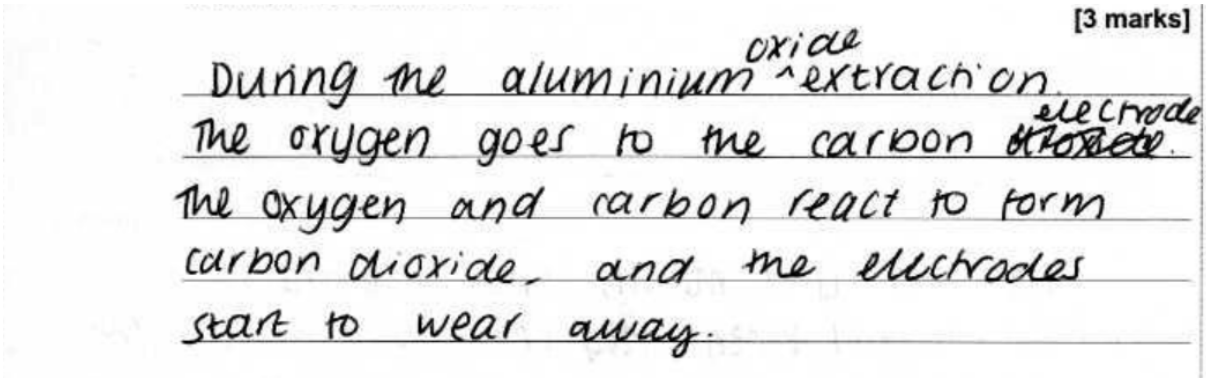
06.3 Few students were able to identify that cryolite was the unknown substance in the molten mixture used in electrolysis to extract aluminium from aluminium oxide.

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 07 · 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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