AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.4.1.4

Oxidation and reduction in terms of electrons (HT only)

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**4**
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.

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 01 · Mark scheme June 2018 | 8464/C/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	hydrogen **or** H_2	allow hydrogen gas ignore H without the 2 subscript	1	AO1 5.4.2.1
08.2	filtration / filter	allow magnet **or** decant ignore heating	1	AO1 5.1.1.2
08.3		an answer of 185–190 (mg) scores **5** marks an answer of 0.185–0.19 scores **4** marks		AO2 5.3.2.2
	(Mg) $\frac{0.12}{24}$ or 0.005 (moles)	mark is for ÷ by 24	1	
	(Fe) $\frac{2}{3} \times 0.005 = 0.00333$(moles)	mark is for $\times \frac{2}{3}$	1	
	(mass Fe) = 0.00333 × 56	mark is for × 56	1	
	= 0.1866 (g)		1	
	= 187 (mg)		1	
		an answer of 280 (mg) scores **4** marks an answer of 0.280 scores **3** marks (no ratio from equation) 184 scores **0** [=(3×24) + (2×56)]		
	OR			
	(Mg) = $\frac{0.12}{(3 \times 24 =)\ 72}$ (1)			
	= 0.00166 **or** $\frac{1}{600}$ (moles) (1)			
	(mass of Fe) = 0.00166			
	or $\frac{1}{600} \times 112\ (2 \times 56)$ (1)			
	= 0.1866 (g) (1) 187 (mg) (1)			

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 01 · Mark scheme

June 2018 | 8464/C/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.3 cont.	**OR** 72 g Mg → 112g Fe (1) 1 g Mg → $\frac{112}{72}$ **or** 1.56 g Fe (1) 0.12 g Mg → $\frac{112}{72}$ × 0.12 (1) = 0.1866 (g) (1) = 187 (mg) (1)			
08.4	Fe^{3+} (because) reduction is gain <u>of electrons</u> $Fe^{3+} + 3e^{(-)}$ ➔ Fe	allow change in oxidation state / (+)3 to 0	1 1 1	AO2 AO1 AO2 5.4.1.2 5.4.1.4
Total			**10**	

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 02 · 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**	

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 02 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 03 · Mark scheme

June 2022 | 8464/C/1H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	electrolysis of molten compound (of metal **Y**) **OR** displacement (1) by heating with a more reactive metal **or** by heating with potassium / magnesium (1)	 allow liquid for molten	1 1	AO3 5.4.1.3 5.4.3.2 5.4.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	$4\ Na + TiCl_4 \rightarrow 4\ NaCl + Ti$	allow multiples allow **1** mark for NaCl **and** Ti with incorrect / no balancing	2	AO2 5.1.1.1 5.3.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	$Na \rightarrow Na^+ + e^-$	ignore state symbols allow multiples allow **1** mark for $Na \rightarrow Na^+ + e^-$ with incorrect balancing	2	AO2 5.4.1.2 5.4.1.4

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 03 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	**method 1:** (moles of Al = $\frac{108}{27}$ =) 4		1	AO2 5.3.2.2 5.3.2.4
	(moles $CuCl_2$ = $\frac{1210}{134.5}$ =) 8.996	allow 9	1	
	(identifying limiting reactant) 4 moles Al gives 6 moles Cu 8.996 moles $CuCl_2$ gives 8.996 moles Cu	allow correct use of an incorrectly calculated value(s) for moles of Al and / or $CuCl_2$	1	
	therefore aluminium is the limiting reactant	must follow on from MP3	1	
	(mass of Cu = 2 × 3 × 63.5) = 6 × 63.5		1	
	= 381 (g)		1	

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 03 · Mark scheme

June 2022 | 8464/C/1H | Original Q7

07.4 cont.	**method 2:** $2\,Al + 3\,CuCl_2 \rightarrow 3\,Cu + 2\,AlCl_3$ (2×27) (3×134.5) (3×63.5) 54 (g) 403.5 (g) 190.5 (g) (1) (1) (1) (so) 108 g Al (reacts with 807 g $CuCl_2$) to produce 381 g Cu (1) (so) there is excess $CuCl_2$ **or** 807 g $CuCl_2$ is less than 1210 g $CuCl_2$ (1) therefore aluminium is limiting reactant (1) **method 3:** 134.5 g $CuCl_2$ produces 63.5 g Cu (1) (mass conversion 1.21 kg $CuCl_2$ =) 1210 (g) (1) 1210 g $CuCl_2$ produces ($\frac{63.5}{134.5}$ × 1210 =) 571 g Cu (1) 54 g Al produces 190.5 g Cu (1) 108 g Al produces ($\frac{190.5}{54}$ × 108 =) 381 (g) (1) (therefore) aluminium is the limiting reactant (1)	 allow correct use of an incorrect calculation of mass for Al / $CuCl_2$ / Cu must follow on from MP4 / MP5 allow correct use of an incorrect / no conversion of mass of $CuCl_2$ must follow on from MP3 and MP5		

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 03 · Mark scheme

June 2022 | 8464/C/1H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5	delocalised electrons carry (electrical) charge through the metal / sodium	allow free electrons ignore throughout for through ignore current / electricity MP2 is dependent upon MP1	1 1	AO1 5.2.2.8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.6	(conducts electricity) when liquid / molten **or** (conducts electricity) in (aqueous) solution (because) ions (ions) are free to move **or** (ions) allow charge to flow	allow (conducts electricity) when dissolved in water	1 1 1	AO1 5.2.2.3

Total Question 7		17

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 04 · 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

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 04 · Mark scheme

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

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 01 · Examiner comments

June 2018 | 8464/C/1H | Original Q8

Question 8 (standard, standard / high & high demand)

08.1 66% of students answered this question correctly. The most common incorrect answer was water.

08.2 47% of students appreciated the need for filtration or the use of a magnet. The most common incorrect responses were electrolysis, distillation, heating / evaporation or displacement using carbon.

Students need to understand the list principle. If they give two answers (one correct and one incorrect) when only one is required, no mark can be awarded. This was the case with those students who gave filter and another method that was incorrect eg simple distillation.

08.3 Students found this question tough, but it discriminated well with higher-attaining students being able to achieve four or five marks (10%). 74% of students scored zero marks.

The most common mistake found in correct calculation methods was the absence of a conversion from g to mg. Some got to 0.185 g and then stopped or converted g to mg incorrectly. Common errors were dividing by 1000 rather than multiplying by 1000 or using a factor of 10 or 100 to convert g to mg.

Stoichiometry was not well understood which resulted in students obtaining an answers of:

- 280 mg or 0.280 g due to the omission of the stoichiometric ratio (× 2/3) or
- 124 mg or 0.124 g where they had divided by 72 and multiplied by 112, and had multiplied by 2/3 as well, so they had taken the ratio into account twice.

Some students got as far as 0.12/24 or 0.12/72 and then no further. Others tried to calculate RFMs for the compounds involved and got no further and gained no marks.

08.4 The most common mark achieved was for stating that reduction was the gaining of electrons. Many students quoted OILRIG but gave an incomplete answer of ‘reduction was gain’, without stating what it was that was being gained.

Few students specifically identified the ‘reduced species’ being reduced. Some did identify iron was reduced but didn’t say which ion of iron, others gave magnesium or iron chloride.

Only a small number of students correctly wrote the half equation. 1% of students achieved two or three marks.

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 01 · Examiner comments

June 2018 | 8464/C/1H | Original Q8

Use of statistics

Statistics used in this report may be taken from incomplete processing data. However, this data still gives a true account on how students have performed for each question.

Mark Ranges and Award of Grades

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

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 03 · Examiner comments

June 2022 | 8464/C/1H | Original Q7

Question 7 (Standard/high and high demand)

07.1 Students had to recognise the relative position of a metal in a reactivity series and to deduce the method and conditions used to extract the metal from a compound of the metal. Over 50% of students gained 1 mark. Electrolysis was the most common answer. However, many students then went on to talk about electrolysis of a solution rather than the molten compound. The displacement route was less common and those who chose this method often only scored 1 mark as they failed to mention 'heating' when talking about potassium or magnesium.

07.2 Students had to complete an equation for the displacement reaction between sodium and titanium chloride. Some students were not able to identify the products. Titanium was usually identified, but sodium chloride was often written as $NaCl_4$. Without the correct formulae balancing was not possible. Generally, element symbols were written well with upper and lower case letters in the appropriate place. Nearly 20% of students gained both marks.

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 03 · Examiner comments

June 2022 | 8464/C/1H | Original Q7

07.3 Students were asked to write the half equation to show the oxidation of sodium. This proved very challenging. Approximately 5% gained two marks with about a fifth of students not attempting the question. One mark was infrequently scored, since identifying the equation and not the balancing proved to be the problem.

07.4 This reacting mass calculation where students had to identify the limiting reagent proved very challenging. Only a small percentage of students were able to show that aluminium was the limiting factor. Although there were several methods available to students, many attempted to use more than one method to get to the answer. Many students could work out the number of moles of aluminium and copper chloride or the ratio of masses that reacted together, but then were unable to use these numbers further. 30% of students scored 3 marks in this calculation but few scored any further marks..

07.5 Students had to describe how sodium metal conducts electricity. More than 50% of students gained 1 mark for stating that delocalised electrons or free electrons were responsible for electrical conduction in metals. The idea that these delocalised electrons carry the charge through the metal was infrequently given (the second marking point). Many students suggested throughout or around, which did not give direction to their answer.

07.6 Students had to explain how sodium chloride conducts electricity. Many students gave the impression that sodium chloride is a liquid or (to a lesser extent) aqueous solution, rather than conveying that conductivity is restricted to when sodium choride is in these states. Many incorrectly described the electrons as the particles that were able to move. 10% of students gained all 3 marks for stating that sodium chloride needed to be either molten or in aqueous solution in order to conduct electricity and went on to mention ions that are free to move.

5.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 03 · Examiner comments

June 2022 | 8464/C/1H | Original Q7

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Answer 04 · 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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