AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.4.3.2

Electrolysis of molten ionic compounds

Mark schemes and examiner comments

Tier	**Foundation**
Question groups	**6**
Available paper years	**2019–2024**

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.

5.4.3.2 Electrolysis of molten ionic compounds

Answer 01 · Mark scheme June 2019 | 8464/C/1F | Original Q2

02.1	hydrochloric acid		1	AO1 5.4.2.3
02.2	(black) solid remains (after stirring)	allow copper oxide remains allow no more copper oxide reacts	1	AO1 5.4.2.3
02.3	first stage **B** second stage **A** third stage **C** fourth stage **D**	all 4 correct for **2** marks allow **1** mark if either first stage or fourth stage is correct	2	AO1 5.4.2.3
02.4	(negative electrode) copper (positive electrode) chlorine	allow Cu allow Cl_2 / Cl do **not** accept chloride or Cl^- if no other mark awarded allow **1** mark if elements are reversed	1 1	AO2 5.4.3.2

5.4.3.2 Electrolysis of molten ionic compounds

Answer 01 · Mark scheme

June 2019 | 8464/C/1F | Original Q2

02.5	a reading of an increase in mass correct linked reading of the increase in time correct evaluation of gradient	e.g. 4 (mg) in 10 (mins) scores 2 marks e.g. ($\frac{4}{10}$ =) 0.4 (mg per min) allow correct calculation of gradient from incorrectly determined values for mass and/or time	1 1 1	AO2 5.4.3.4

02.6	cryolite oxide	this order only	1 1	AO1 5.4.3.3

Total			**11**

5.4.3.2 Electrolysis of molten ionic compounds

Answer 01 · Mark scheme

June 2019 | 8464/C/1F | Original Q2

Question	Answers	Extra information	Mark	AO / Spec.

5.4.3.2 Electrolysis of molten ionic compounds

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

06.1	13 14	this order only	1 1	AO2 5.1.1.4 5.1.1.5
06.2	loss of oxygen	allow (Al^{3+}) gain of electrons allow aluminium oxide loses oxygen	1	AO1 5.4.1.1 5.4.1.3
06.3	 (at high temperature) oxygen reacts with carbon / electrode (so the positive) electrode burns / wears away to produce carbon dioxide	allow anode for (positive) electrode $C + O_2 \rightarrow CO_2$ scores MP1 and MP3	 1 1 1	 AO1 5.4.3.1 5.4.3.2 5.4.3.3
06.4	(delocalised) electron(s) ion(s) (delocalised) electron(s)		1 1 1	AO1 AO2 AO1 5.2.2.3 5.2.2.8 5.2.3.2
Total			**9**	

5.4.3.2 Electrolysis of molten ionic compounds

Answer 02 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.4.3.2 Electrolysis of molten ionic compounds

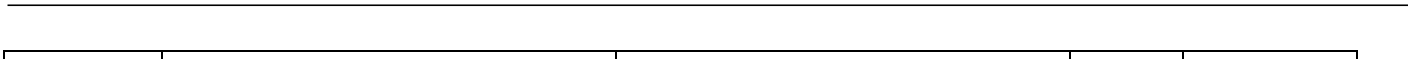
Answer 03 · Mark scheme November 2021 | 8464/C/1F | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	molten		1	AO2 5.2.3.2 5.4.3.1 5.4.3.2
02.2	opposite (charges) attract **or** (the ions) are negative(ly charged)		1	AO1 5.4.3.1 5.4.3.4 RPA9
02.3	water		1	AO1 5.4.3.4
02.4	Cu^{2+}		1	AO2 5.4.3.1 5.4.3.4 RPA9
02.5	(positive electrode) bubbles / effervescence / fizzing (negative electrode) (pink / orange / red / brown) solid	 allow gas (is produced) allow copper (plating) allow metal for solid	 1 1	AO3 5.4.3.1 5.4.3.4 RPA9
02.6	$\frac{40.0}{500} \times 6.50$ = 0.52 (g)		1 1	AO2 5.1.2.6 5.3.2.5
Total			**8**	

5.4.3.2 Electrolysis of molten ionic compounds

Answer 03 · Mark scheme

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



5.4.3.2 Electrolysis of molten ionic compounds

Answer 04 · Mark scheme

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

Question 4

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

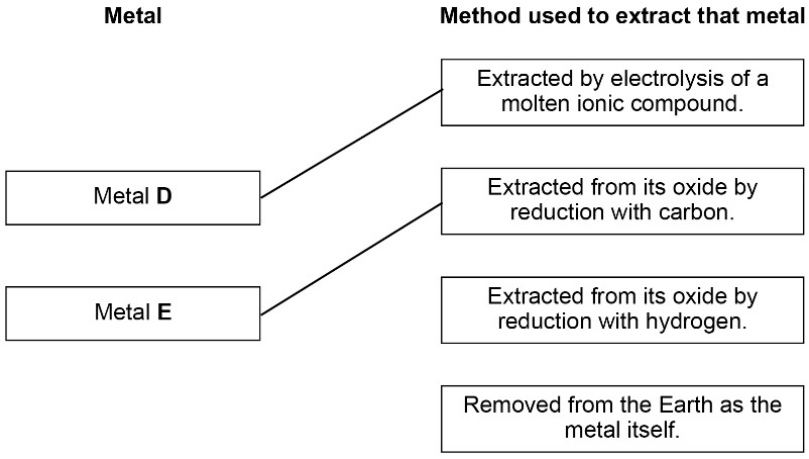
Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	any **one** from: • wear safety glasses / goggles • do not look directly at burning magnesium • wear heat proof glove	allow look through blue glass allow use tongs allow tie hair back	1	AO3 5.4.1.1 5.4.1.2 5.5.1.1

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

5.4.3.2 Electrolysis of molten ionic compounds

Answer 04 · Mark scheme

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

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

5.4.3.2 Electrolysis of molten ionic compounds

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

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

Total Question 4		13

5.4.3.2 Electrolysis of molten ionic compounds

Answer 05 · Mark scheme

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

Question 5

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

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

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

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

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

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

5.4.3.2 Electrolysis of molten ionic compounds

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

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

Total Question 5	**10**

5.4.3.2 Electrolysis of molten ionic compounds

Answer 06 · Mark scheme June 2024 | 8464/C/1F | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	hydrogen		1	AO1 5.4.1.2 5.4.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	$MgCl_2(l)$		1	AO2 5.1.1.1 5.2.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	(negative electrode) magnesium (positive electrode) chlorine	allow Mg allow Cl_2 allow **1** mark if both elements are reversed	1 1	AO2 5.4.3.1 5.4.3.2

5.4.3.2 Electrolysis of molten ionic compounds

Answer 06 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	(most reactive metal) magnesium (iron) copper (least reactive metal) any **two** from: • magnesium reacts with both copper chloride solution and iron chloride solution • iron only reacts with copper chloride solution • copper does not react with either magnesium chloride solution or iron chloride solution	 allow Mg allow Fe allow Cu allow magnesium has two / most reactions allow iron has one reaction allow copper does not react	 1 2	AO3 5.4.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	1.6 (g)		1	AO2 5.4.3.1 5.4.3.2

5.4.3.2 Electrolysis of molten ionic compounds

Answer 06 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.6	(conversion 30.0 cm^3 =) 0.030 dm^3		1	AO2 5.3.2.5
	(mass =) 0.030 × 180	allow correct use of incorrect / no conversion of volume	1	
	= 5.4 (g)		1	
	OR			
	1000 cm^3 contains 180 g $MgCl_2$ (1)			
	30 cm^3 contains $\frac{180}{1000}$ × 30 (g) (1)			
	(30 cm^3 contains) 5.4 (g) (1)			
	OR			
	(ratio of volume $\frac{1000}{30}$ =) 33.3 (1)			
	(so ratio of mass) = $\frac{180}{33.3}$ (1)			
	= 5.4 (g) (1)			

Total Question 5	11

5.4.3.2 Electrolysis of molten ionic compounds

Answer 03 · Examiner comments November 2021 | 8464/C/1F | Original Q2

Question 2 (low demand)

02.1 Just over one third of students correctly chose ‘molten’ to complete the sentence.

02.2 Just over one third of students knew that negative ions are attracted to the positive electrode during electrolysis.

02.3 Copper chloride proved to be a more commonly seen response than the correct answer, water. This question was only correctly answered by just over one third of the students.

02.4 More than two thirds of students knew that Cu^{2+} ions produce a metal during electrolysis.

02.5 Investigating what happens when aqueous solutions are electrolysed using inert electrodes is one of the required practical activities. When carrying out these investigations students should observe what happens at the electrodes. The figure was provided to help students answer this question. More than three quarters of students gained one mark for stating that fizzing is observed at the positive electrode. Most students were unable to state the correct observation at the negative electrode.

02.6 Just under one third of students were able to determine the correct mass of copper chloride in 40 cm^3 of solution. Students should be encouraged to think about the magnitude of the numbers and whether their answer is reasonable.

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

Question 4 (Low and standard demand)

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

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

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

5.4.3.2 Electrolysis of molten ionic compounds

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

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

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

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

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

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

5.4.3.2 Electrolysis of molten ionic compounds

Answer 05 · Examiner comments

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

Question 5 (low/standard demand)

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

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

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

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

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

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

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

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

Answer 06 · Examiner comments

June 2024 | 8464/C/1F | Original Q5

Question 5 (low demand)

05.1 Just over two thirds of students knew that hydrogen gas is produced when a metal reacts with an acid. A quarter of students selected the distractor nitrogen.

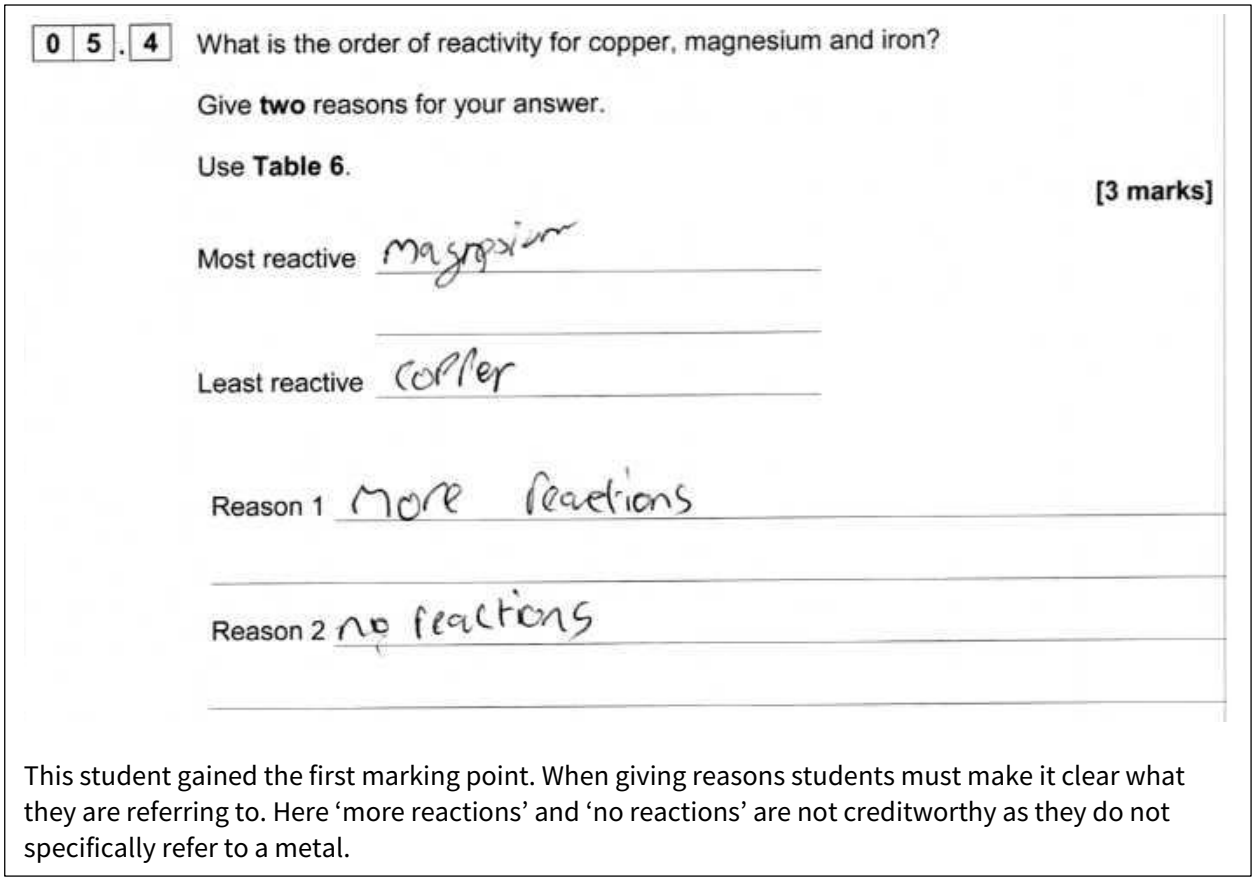
05.2 Nearly two-thirds of students knew molten magnesium chloride is a liquid, which is represented by the state symbol (l). A quarter of students incorrectly selected (g) as the state symbol.

05.3 10% of students gained both marks and students were awarded 1 mark if both elements were correct but reversed. Chlor*ide* is not creditworthy although was a common response.

Many students wrote the formula of the ions that were attracted to the electrodes rather than the element that is discharged. Nearly 20% of students did not attempt this question.

05.4 More than half of students gained 2 or 3 marks for correctly deducing the order of reactivity, with magnesium being the most reactive and copper the least reactive and giving one or two reasons. Students were able to give a reason associated with each metal eg iron only reacts with copper chloride solution or copper does not react.

Common incorrect responses included magnesium reacts with both metals (rather than both metal chloride solutions) or reasons which were not clearly linked to a metal (see example below).



This student gained the first marking point. When giving reasons students must make it clear what they are referring to. Here 'more reactions' and 'no reactions' are not creditworthy as they do not specifically refer to a metal.

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5.4.3.2 Electrolysis of molten ionic compounds

Answer 06 · Examiner comments June 2024 | 8464/C/1F | Original Q5

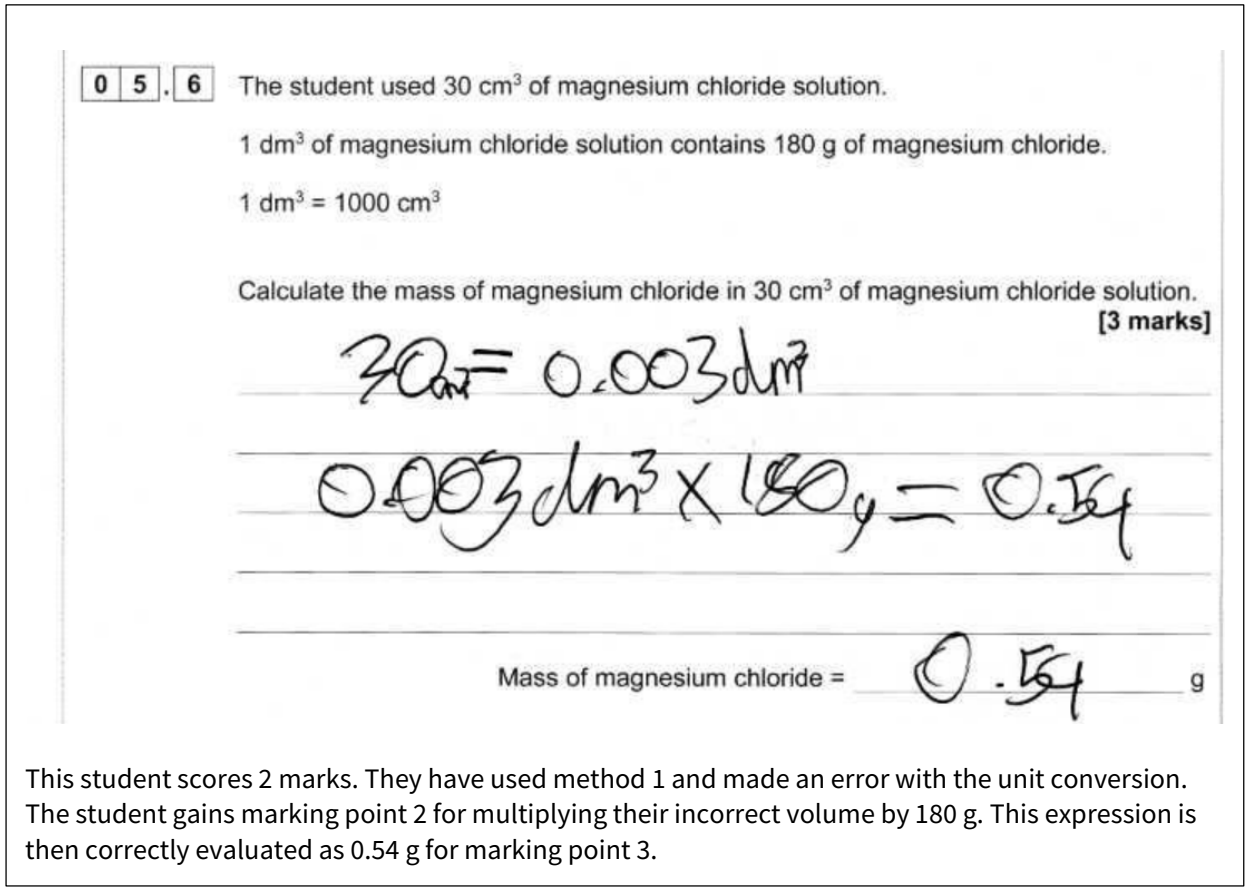
05.5 The law of conservation of mass states that the mass of reactants equals the mass of products. In this question a third of students correctly evaluated that the mass of iron oxide that reacts with 0.72 g of magnesium.

Common incorrect responses were 1.67 (multiplying 0.72 by 2.32) together with 3.2 and 0.31 (evaluated by dividing 2.32 by 0.72 or 0.72 by 2.32 respectively).

05.6 This question required a unit conversion as data is given in dm^3 and needed to be converted to cm^3. This conversion factor was given to lower the demand of the question.

Nearly 30% of students gained all 3 marks. Approximately 10% of students gained 2 marks usually for either not using the conversion factor, for multiplying rather than dividing by 1000 or for using an incorrect factor (eg dividing by 100 rather than 1000). A further 10% of students who gained 1 mark usually calculated the volume correctly in dm^3 but then did not multiply their answer by 180 g or used method 3 in the mark scheme and calculated the ratio of volume as 33.3 but then incorrectly multiplied this by 180 g.

17% of students did not attempt this question.



0 5 . 6 The student used 30 cm^3 of magnesium chloride solution.

1 dm^3 of magnesium chloride solution contains 180 g of magnesium chloride.

1 dm^3 = 1000 cm^3

Calculate the mass of magnesium chloride in 30 cm^3 of magnesium chloride solution.

[3 marks]

30cm³ = 0.003dm³

0.003dm³ x 180g = 0.54

Mass of magnesium chloride = 0.54 g

This student scores 2 marks. They have used method 1 and made an error with the unit conversion. The student gains marking point 2 for multiplying their incorrect volume by 180 g. This expression is then correctly evaluated as 0.54 g for marking point 3.

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