AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.8.3.2

Metal hydroxides

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**15**
Available paper years	**2009–2025**

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.

4.8.3.2 Metal hydroxides

Answer 01 · Mark scheme June 2009 | CHY2H | Original Q2 | Legacy

Question 2

question	answers	extra information	mark
2(a)	hydrogen / H^+ /$2H^+$ / H_3O^+	allow H / 2H do **not** accept H_2 apply list principle	1
2(b)(i)	143	correct answer with or without working = **2** marks ignore units if answer is not correct 40 + (2 × 35.5) + (2 × 16) gains **1** mark	2
2(b)(ii)	49.7% (49.6 to 50)	correct answer with or without working = **2** marks answer 49 gains **1** mark if answer is not correct: (71 ÷ 143) × 100 gains **1** mark allow error carried forward from part (b)(i) ie. (71 or their (2 × 35.5) ÷ answer to (b)(i)) × 100 gains **2** marks if calculated correctly and **1** mark if not calculated correctly. **Special case** 35.5 ÷ 143 × 100 = 24.8 to 25% **or** 35.5 ÷ answer to (b)(i) x 100 correctly calculated for **1** mark	2
2(b)(iii)	9.9 to 10g	allow ecf from (b)(i) or (b)(ii)	1

Question 2 continues on the next page…

4.8.3.2 Metal hydroxides

Answer 01 · Mark scheme

CHY2H

Question 2 Continued

question	answers	extra information	mark
2(c)(i)	an alkali	apply list principle accept named alkali accept hydroxide accept soluble base ignore base	1
2(c)(ii)	a solid / insoluble substance (owtte)		1
2(c)(iii)	filter / filtration	allow decant / centrifuge accept filtration followed by evaporation **or** filtration and evaporation do **not** accept filtration or evaporation do **not** accept evaporation and filtration	1
Total			**9**

4.8.3.2 Metal hydroxides

Answer 01 · Mark scheme

June 2009 | CHY2H | Original Q2 | Legacy

CHY2H

4.8.3.2 Metal hydroxides

Answer 02 · Mark scheme

Question 5

question	answers	extra information	mark
5(a)	limewater / calcium hydroxide (limewater) goes milky / cloudy **or** gives white precipitate / solid	 do **not** allow this mark if lime water added to solution or powder	1 1
5(b)	eg flame colour of (Na) and flame colour of (K) interfere / mask / mix with each other	accept difficult to determine the colour **or** hard to distinguish accept some indication that two distinct colours are not seen	1
5(c)(i)	barium chloride (solution) / $BaCl_2$ white precipitate / white solid	ignore mention of acidification but do **not** allow sulfuric acid. wrong reagent = no mark allow white barium sulfate **or** barium sulfate precipitate	1 1
5(c)(ii)	white precipitate / white solid	ignore goes milky do **not** accept any mention of precipitate dissolving	1
Total			**6**

4.8.3.2 Metal hydroxides

Answer 02 · Mark scheme

January 2011 | CHY3H | Original Q5 | Legacy

CHY3H

4.8.3.2 Metal hydroxides

Answer 03 · Mark scheme

June 2011 | CHY2H | Original Q5 | Legacy

Question 5

question	answers	extra information	mark
5(a)(i)	electron(s)	allow free / delocalised / negative electrons do **not** accept additional particles	1
5(a)(ii)	ion(s)	allow named ions from table ignore positive or negative do **not** accept additional particles	1
5(b)(i)	copper	accept Cu do **not** accept Cu^{2+}	1
5(b)(ii)	it is / they are positive (ions) and it is the least reactive	accept formula of positive ion	1 1
5(c)(i)	loss of electron(s)	ignore numbers	1
5(c)(ii)	$\mathbf{2H^+} + \mathbf{2e^-} \rightarrow H_2$	accept correct multiples / fractions accept e / e^- allow $\mathbf{2H^+} \rightarrow H_2 - \mathbf{2e^-}$	1
Total			**7**

4.8.3.2 Metal hydroxides

Answer 03 · Mark scheme

June 2011 | CHY2H | Original Q5 | Legacy

CHY2H

4.8.3.2 Metal hydroxides

Answer 04 · Mark scheme

January 2012 | CH1HP | Original Q4 | Legacy

Question 4

question	answers	extra information	mark
4(a)(i)	reduction	accept redox / smelting	1
4(a)(ii)	3 4 3		1
4(b)(i)	55	ignore other units	1
4(b)(ii)	water	accept sodium hydroxide accept correct formulae H_2O or NaOH	1
4(b)(iii)	any **one** from: • save energy / fuel for transporting the ore • (old) quarries nearby for waste/red mud	accept less (cost of) transport allow transported quickly	1

Question 4 continues on the next page …….

4.8.3.2 Metal hydroxides

CH1HP

Question 4 cont'd…

question	answers	extra information	mark
4(c)	**Environmental** any **one** from: • less mining / quarrying (of bauxite) • less landfill space needed / used • less use of fossil fuels / energy • less carbon dioxide produced **Ethical or social** any **one** from: • saves resources • creates (local) employment • more people aware of the need for recycling	 allow loss of habitat / less qualified noise pollution allow less red mud / waste allow using resources more than once if answers reversed and both correct award **1** mark allow less qualified noise pollution if not given in environmental	1 1
Total			**7**

4.8.3.2 Metal hydroxides

Answer 04 · Mark scheme

January 2012 | CH1HP | Original Q4 | Legacy

CH1HP

4.8.3.2 Metal hydroxides

Answer 05 · Mark scheme

June 2012 | CH2HP | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)	because calcium is +2 and hydroxide is –1 **or** to make the compound neutral (in terms of charges)	accept to balance the charges allow calcium needs to lose 2 electrons and hydroxide needs to gain one electron	1
6(b)	particles of size 1-100 nm **or** particles with a few hundred atoms / ions **or** particles with a high surface area (to volume ratio) **or** as different properties to 'normal' size particles of the same substance	allow clear comparison to 'normal' size particles	1
6(c)	M_r CaO = 56 **and** M_r $Ca(OH)_2$= 74 2/56 (x74) **or** 0.036 (x74) **or** 74/56 (x2) **or** 1.3(214…) (x2) 2.6(428…) in range 2.6 to 2.96	 allow ecf from step 1 correct answer with or without working gains **3** marks allow ecf carried through from step 1 ignore final rounding to 3	1 1 1
Total			**5**

4.8.3.2 Metal hydroxides

Answer 05 · Mark scheme

June 2012 | CH2HP | Original Q6 | Legacy

CH2HP

4.8.3.2 Metal hydroxides

Answer 06 · Mark scheme

June 2013 | CH3HP | Original Q5 | Legacy

Question 5

question	Answers	extra information	Mark
5(a)(i)	place sample in flame	accept flame test accept any workable method allow burn ignore heat	1
	sodium: yellow (flame)	allow orange	1
	potassium: lilac (flame)	allow purple	1
5(a)(ii)	(lilac) colour (of potassium) obscured by (yellow) colour of sodium	allow difficult to see two colours allow sodium colour is brighter allow colours mix	1
5(b)	acidify (with nitric acid)	do **not** accept if acidified with anything other than nitric acid	1
	add silver nitrate (solution)		1
	white precipitate	depends on second marking point allow white solid ignore silver chloride ignore solution goes cloudy / milky	1
5(c)(i)	add excess (sodium hydroxide)	allow add sodium hydroxide	1
	<u>aluminium</u> (ions / hydroxide) (re)dissolve	depends on first marking point allow if aluminium, (white) precipitate / solid dissolves allow magnesium (ions / hydroxide) do not (re)dissolve	1
5(c)(ii)	place sample in flame	accept flame test accept any workable method allow burn ignore heat	1
	flame does not go red	accept calcium (ions / hydroxide would produce) red flame allow magnesium (ions / hydroxide) (produce) no flame colour	1
Total			**11**

4.8.3.2 Metal hydroxides

Answer 07 · Mark scheme June 2014 | CH3HP | Original Q7 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
7(a)	lithium yellow	*allow Li^+ / Li* *allow orange*	1 1	2 / 3.4.1a	E
7(b)	silver nitrate (solution) white precipitate	incorrect test = **0** marks ignore (nitric) acid do **not** allow other *named* acids	1 1	1 / 3.4.1e	E
7(c)	blue precipitate (with sodium hydroxide) indicates copper ions and white precipitate (with barium chloride) indicates sulfate ions but iron(II) ions produce a green precipitate (with sodium hydroxide)	*allow Cu^{2+}* *allow SO_4^{2-}* *accept compound X is copper sulfate/$CuSO_4$ for **1** mark*	1 1 1	3 / 3.4.1c/f	E
Total			**7**		

4.8.3.2 Metal hydroxides

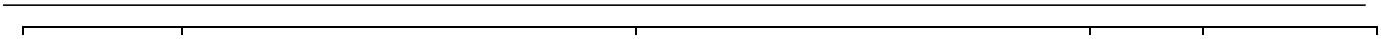
Answer 08 · Mark scheme June 2015 | CH3HP | Original Q7 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
7(a)	**X:** Fe^{2+} / iron(II), SO_4^{2-} / sulfate	allow iron(II) sulfate **or** $FeSO_4$	1	**AO1/ AO2** 3.4.1.a/c/e/f
	Y: Na^+ / sodium, I^- / iodide	allow sodium iodide **or** NaI	1	
	Z: Fe^{3+} **/** iron(III), Br^- / bromide	allow iron(III) bromide **or** $FeBr_3$	1	
		correct identification of any two ions = one mark correct identification of any four ions = two marks		
7(b)	any **five** from: method 1 • weighing is accurate • not all barium sulfate may be precipitated • precipitate may be lost • precipitate may not be dry • takes longer • requires energy method 2 • accurate • works for low concentrations	allow converse arguments allow not all the barium hydroxide has reacted allow reliable / precise	5	**AO3** 3.4.1.a/c/e/f
Total			**8**	

4.8.3.2 Metal hydroxides

Answer 08 · Mark scheme

June 2015 | CH3HP | Original Q7 | Legacy



4.8.3.2 Metal hydroxides

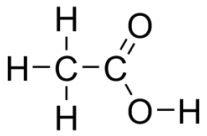
Answer 09 · Mark scheme

June 2017 | CH3HP | Original Q3 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
3(a)(i)	any **one** from: • for undiscovered elements • so elements with similar properties were in same column / group	ignore so they fit the pattern	1	**AO1** 3.1.1b
3(a)(ii)	any **one** from: • they have different properties from elements above them • they are (transition) metals .	ignore electronic configuration ignore they did not fit the pattern allow transition elements	1	**AO1** 3.1.1a,b
3(b)(i)	7 electrons in outer shell / highest energy level	ignore gain of 1 electron	1	**AO2** 3.1.2b
3(b)(ii)	for bromine: outer shell closer to nucleus stronger force of attraction (to nucleus) electron more easily gained to outer shell	'outer' must be mentioned once for 3 marks. comparatives required. ignore references to bromide / iodide allow converse for iodine allow fewer shells allow smaller atom allow less shielding	1 1 1	**AO1** **AO2** 3.1.3g,h

4.8.3.2 Metal hydroxides

Answer 09 · Mark scheme

3(c)(i)	yellow precipitate	allow yellow or dark yellow or light yellow or pale yellow allow dark yellow or light yellow or pale yellow precipitate allow dark yellow or light yellow or pale yellow ppt allow dark yellow or light yellow or pale yellow solid do **not** allow yellow solution	1	**AO1** 3.4.1e
3(c)(ii)	green precipitate	allow green or dark green or light green or pale green or dirty green allow dark green or light green or pale green or dirty green precipitate allow dark green or light green or pale green or dirty green ppt allow dark green or light green or pale green or dirty green solid do **not** allow green solution	1	**AO1** 3.4.1b
3(d)	one colour obscures the other	allow colours mix / blend allow only one colour seen	1	**AO3** 3.4.1a
3(e)(i)		allow -OH in the structure without the -O-H bond shown	1	**AO1** 3.6.2a

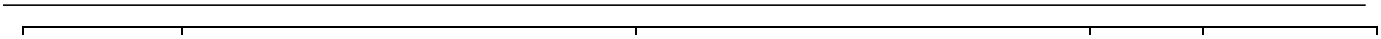
4.8.3.2 Metal hydroxides

3(e)(ii)	weak acid (because) ethanoic acid is not fully ionised / dissociated	allow converse for hydrochloric acid allow (the solution) has a lower concentration of hydrogen ions allow (produces) fewer hydrogen ions. do **not** allow ionising	1 1	**AO3** 3.6.2a,b
Total			**12**	

4.8.3.2 Metal hydroxides

Answer 09 · Mark scheme

June 2017 | CH3HP | Original Q3 | Legacy



4.8.3.2 Metal hydroxides

Answer 10 · Mark scheme June 2017 | CH3HP | Original Q5 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
5(a)(i)	high temp increases rate	allow converse for low temperature	1	**AO1** **AO2** **AO3** 3.5.1d,e,f,h
	but decreases yield	allow shifts equilibrium to the left	1	
	because (forward) reaction is exothermic **or** so this (temperature) is a compromise	this mark dependent on M2 this mark dependent on both M1 and M2	1	
5(a)(ii)	high pressure increases yield	allow converse for low pressure allow shifts equilibrium to the right	1	**AO1** **AO2** 3.5.1d,g,h
	(because) more moles / molecules of gas on LHS	allow (because) greater volume of gas on LHS If no other mark gained, allow 1 mark for high pressure increase rate because molecules closer together **or** increased frequency of collisions.	1	
5(a)(iii)	any **one** from: • less risk of explosion/safer • less energy required • less likely to leak.	allow converse for high pressure ignore cost / strength of plant	1	**AO3** 3.5.1g

4.8.3.2 Metal hydroxides

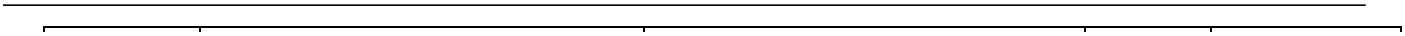
Answer 10 · Mark scheme

5(b)	white precipitate (forms) with aluminium, the ppt dissolves in excess **or** with magnesium, the ppt does not dissolve in excess		1 1	**AO1** 3.4.1b
Total			**8**	

4.8.3.2 Metal hydroxides

Answer 10 · Mark scheme

June 2017 | CH3HP | Original Q5 | Legacy



4.8.3.2 Metal hydroxides

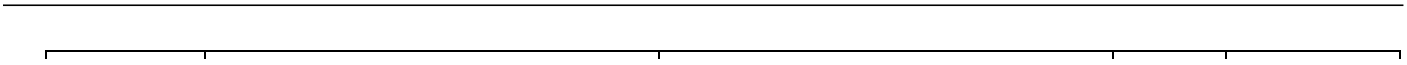
Answer 11 · Mark scheme June 2018 | 8462/2H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	yellow	allow orange allow orange-yellow	1	AO1 4.8.3.1
01.2	copper (ion)	allow Cu^{2+} allow copper (II) allow barium (ion) allow Ba^{2+}	1	AO1 4.8.3.1
01.3	(flame) colours are masked	allow (flame) colours mix / blend allow only see one colour allow cannot see two colours at once ignore hard to distinguish	1	AO1 4.8.3.1
01.4	Li^+ Na^+		1 1	AO2 4.8.3.7
01.5	bromide (ion)	allow Br^- ignore bromine	1	AO1 4.8.3.4
01.6	add barium chloride (solution) add hydrochloric acid white precipitate produced	allow barium nitrate (solution) allow nitric acid allow acidified do **not** accept sulfuric acid dependent on use of a barium compound	1 1 1	AO1 4.8.3.5
Total			**9**	

4.8.3.2 Metal hydroxides

Answer 11 · Mark scheme

June 2018 | 8462/2H | Original Q1



4.8.3.2 Metal hydroxides

Answer 12 · Mark scheme

November 2020 | 8462/1H | Original Q4

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	CrO_4^{2-} / chromate ions moved to the positive electrode	allow anode for positive electrode allow yellow (coloured) ions moved to the positive electrode	1	AO2
	(because) opposite charges attract	allow (because) negative ions are attracted to the positive electrode	1	AO1 4.4.3.1 RPA 3
04.2	water	ignore copper chromate solution	1	AO1 4.4.3.4 RPA 3
04.3	copper ions gain two electrons	allow Cu^{2+} for copper ions allow **1** mark for copper ions gain electrons **or** allow **1** mark for copper ions are reduced do **not** accept copper ions are oxidised	2	AO2
	(to) form copper (atoms)	allow Cu for copper (atoms) the equation: $Cu^{2+} + 2e^- \rightarrow Cu$ scores **3** marks	1	AO3 4.4.3.1 4.4.3.4 RPA 3
04.4	(negative electrode) hydrogen (positive electrode) iodine	allow H_2 allow I_2	1 1	AO2 4.4.3.4 RPA 3
Total			**8**	

4.8.3.2 Metal hydroxides

Answer 13 · Mark scheme

November 2020 | 8462/2H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	green	allow blue-green	1	AO1 4.8.3.1 RPA 7
01.2	did not clean the metal wire (between tests) **or** copper sulfate (solution) is still present (so) colours are mixed / blended / masked		1 1	AO3 4.8.3.1 RPA 7
01.3	(copper sulfate solution) blue precipitate (calcium iodide solution) white precipitate	allow blue solid allow white solid	1 1	AO1 4.8.3.2 RPA 7
01.4	barium chloride (solution)	allow barium nitrate (solution)	1	AO1 4.8.3.5 RPA 7
01.5	silver nitrate (solution) yellow precipitate	 allow yellow solid allow pale yellow precipitate / solid	1 1	AO1 4.8.3.4 RPA 7
Total			**8**	

4.8.3.2 Metal hydroxides

Answer 14 · Mark scheme

November 2021 | 8462/2H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	flame test lilac (flame)	allow description of flame test	1 1	AO1 4.8.3.1 RPA7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	flame emission spectroscopy		1	AO1 4.8.3.6 4.8.3.7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	white precipitate	ignore precipitate dissolves	1	AO1 4.8.3.2 RPA7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	(add) excess sodium hydroxide (solution) precipitate dissolves	allow (add) more sodium hydroxide (solution)	1 1	AO3 AO1 4.8.3.2 RPA7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5	add barium chloride (solution) add (dilute) hydrochloric acid white precipitate	allow add barium nitrate (solution) allow add (dilute) nitric acid dependent on MP1 being awarded	1 1 1	AO1 4.8.3.5 RPA7

Total			9

4.8.3.2 Metal hydroxides

Answer 15 · Mark scheme

June 2025 | 8462/2H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	calcium (ions) **or** magnesium (ions)	allow Ca^{2+} (ion) allow Mg^{2+} (ion) allow zinc / Zn^{2+} (ion)	1	AO1 4.8.3.2 RPA7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	(test) add excess sodium hydroxide (solution) (result) with sodium hydroxide the (white) precipitate dissolves	 allow with sodium hydroxide a colourless solution is produced	1 1	AO1 4.8.3.2 RPA7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	Ca^{2+}	ignore calcium	1	AO1 4.2.1.2 4.8.3.1 RPA7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	Cl^-	ignore chloride	1	AO1 4.2.1.2 4.8.3.4 RPA7

4.8.3.2 Metal hydroxides

Answer 15 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	(test) (bubble the gas through) limewater	allow (bubble the gas through) calcium hydroxide solution	1	AO1 4.8.2.3 4.8.3.3 RPA7
	(result) (which) turns milky / cloudy	MP2 is dependent upon MP1 being awarded	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.6		allow converse argument		
	(using ethanoic acid) the rate of reaction is lower		1	
	(because) ethanoic acid is a weak(er) acid		1	
	(so) the concentration of hydrogen ions is lower	allow (so) ethanoic acid is (only) partially ionised	1	
	(and) the frequency of collisions is lower		1	

Total Question 6	11

4.8.3.2 Metal hydroxides

Answer 11 · Examiner comments

June 2018 | 8462/2H | Original Q1

Question 1 (standard demand)

01.1 80% of students gave yellow or orange. There was a lot of variety in the wrong answers with all the colours of the spectrum represented.

01.2 This was well answered. Copper was the most common answer given although a few gave barium and gained credit.

01.3 60% of students achieved this mark. Popular incorrect responses implied that the flame colours were similar or the same.

01.4 87% of students could correctly identify both of the ions in the flame emission spectrum.

01.5 33% of students identified the correct answer as bromide. A few put bromine but many seemed to guess.

01.6 The test for sulfate ions was not well known with many students gaining only the acidification mark. 27% of students achieved full marks.

4.8.3.2 Metal hydroxides

Answer 12 · Examiner comments November 2020 | 8462/1H | Original Q4

Question 4 (standard and standard / high demand)

04.1 Students needed to give the idea of movement of the relevant ions to the positive electrode and to give a reason for that movement in terms of the attraction of opposite charges. Students often managed to convey one, but not both, of those ideas.

04.2 Only a third of students recognised that water provided the hydroxide ions. Vague references to the electrolyte were not sufficient.

04.3 Whilst many students realised that the solid was copper, some expressed this poorly, saying that copper ions were deposited on the electrode. Some students were able to explain the process in terms of the copper ions being reduced, or gaining electrons, but few scored all three marks by saying that the ions gained two electrons to form atoms.

04.4 Many students deduced that iodine would be the product at the positive electrode. Potassium was seen as the response to the product at the negative electrode far more often than hydrogen.

Answer 13 · Examiner comments November 2020 | 8462/2H | Original Q1

Question 1 (standard demand)

01.1 The majority of students were able to answer this item.

01.2 Most students were aware that the wire should be cleaned, though many suggested the wire (loop) should be sterilised. Far fewer were able to describe the effect on the results with many just repeating the third line of the question stem.

01.3 Few of the students were able to give correct precipitate colours for both copper and calcium ions. There was no real pattern in the incorrect responses, but green or brown were often seen.

01.4 Few students were able to name barium chloride (solution). Many unsuitable reagents were named, including silver nitrate

01.5 Some students were able to name the solution. Those who gave the correct solution sometimes gave the result for a different halide ion.

4.8.3.2 Metal hydroxides

Answer 14 · Examiner comments

November 2021 | 8462/2H | Original Q7

Question 7 (standard, standard / high and high demand)

07.1 Over half of the students knew that a flame test should be used but fewer knew the correct result for potassium.

07.2 Only a few students mentioned flame emission spectroscopy as an instrumental alternative to a flame test.

07.3 Just over a third of students gave white precipitate.

07.4 Very few students were able to complete the steps needed to differentiate between metal ions producing a white metal hydroxide precipitate.

07.5 Students found this difficult with many students unable to go beyond the need to acidify the solution being tested.

4.8.3.2 Metal hydroxides

Answer 15 · Examiner comments

June 2025 | 8462/2H | Original Q6

Question 6

06.1 Three quarters of students correctly identified either calcium or magnesium. A few students gained credit for zinc.

06.2 Just over a quarter of students scored both marks on this item. Many students repeated the information given to them in the stem of the question, stating that they would add sodium hydroxide and observe a white precipitate, which did not gain marks. Some described adding more sodium hydroxide, without specifying that this should be until excess and whilst these students were not awarded the first marking point, they still had access to the second marking point.
Descriptions of the result were often vague. Some responses stated that 'the precipitate would dissolve' but failed to identify the reagent. Others simply said, 'it' will redissolve, become clear, or turn colourless, which was insufficient. There was a misconception that the aluminium dissolves, rather than the precipitate.

06.3 Both the correct symbol and the charge on the ion were required to gain the mark for this item. A quarter of students did this. Many others wrote the name, or the symbol without a charge.

06.4 As with 06.3, both the symbol and the charge on the ion were needed to gain the mark. As with 06.3, a quarter of students answered this correctly. Similar mistakes, writing the name or a symbol without a charge were commonly seen.

06.5 Around two thirds of students gained both marks on this item. A small number of students described adding limewater to solution C, rather than bubbling the gas produced through limewater.

06.6 Around half of students identified ethanoic acid as a weak acid and stated that the rate of reaction was lower. Fewer students were able to describe a lower concentration of hydrogen ions, with some describing fewer hydrogen ions without making any reference to volume. Credit was given to those who described ethanoic acid as partially ionised, however, there was the misconception that less hydrogen ions were ionised. Only a minority of students made a correct reference to the frequency of collisions.