AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.4.2.4

The pH scale and neutralisation

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.

5.4.2.4 The pH scale and neutralisation

Answer 01 · Mark scheme

June 2018 | 8464/C/1H | Original Q7

Question	Answers	Mark	AO / Spec. Ref.
07.1	**Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO3
	Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	AO3
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	AO1 AO2
	No relevant content	0	
	Indicative content: A is sodium oxide B is phosphorus oxide C is magnesium oxide D is silicon dioxide **linked statements:** A is sodium oxide because it has highest pH **or** pH = 14 **or** is a strong alkali B is phosphorus oxide because it has lowest pH **or** pH = 3 **or** is an acid C is magnesium oxide because it has 2nd highest pH **or** pH = 9 **or** is a (weak) alkali D is silicon dioxide because it is neutral **or** pH = 7 **or** A and B are sodium oxide **or** phosphorus oxide because both soluble **or** no solid remains C is magnesium oxide because it will be the colourless solution with solid remaining D is silicon dioxide because it will be the colourless liquid with solid remaining for **level 3** the solids must be correctly identified		5.1.2.3 5.4.2.4

5.4.2.4 The pH scale and neutralisation

Answer 01 · Mark scheme

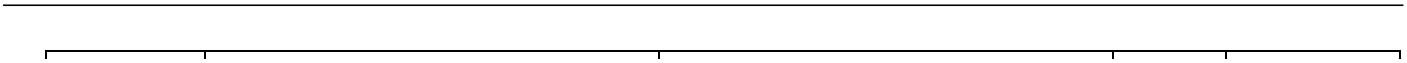
June 2018 | 8464/C/1H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2		an answer of (pH=) 5 gains **2** marks		
	dilution by a factor of 100	allow pH changes by 1 when solution is diluted by factor of 10 **or** allow pH changes by 2	1	AO1 5.4.2.5
	(pH=) 5		1	AO3 5.4.2.5
Total			**8**	

5.4.2.4 The pH scale and neutralisation

Answer 01 · Mark scheme

June 2018 | 8464/C/1H | Original Q7



5.4.2.4 The pH scale and neutralisation

Answer 02 · Mark scheme June 2019 | 8464/C/1H | Original Q2

02.1	(aq)	allow aq ignore aqueous ignore formulae	1	AO1 5.2.2.2
02.2	HNO_3		1	AO1 5.1.1.1 5.4.2.2
02.3	red purple **or** blue	allow orange or yellow do **not** accept green allow shades of purple eg violet	1 1	AO1 5.4.2.4
02.4	D		1	AO3 5.4.2.4
02.5	 3 × 16 **or** 48 $\frac{48}{80}$ (×100) 60 (%)	an answer of 60 (%) scores **3** marks an answer of 20 (%) scores **2** marks for: $\frac{16}{80}$ (× 100) (1) = 20 (%) (1)	 1 1 1	AO2 5.3.1.2

5.4.2.4 The pH scale and neutralisation

Answer 02 · Mark scheme

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

Question	Answers	Mark	AO/ Spec. Ref
02.6	**Level 3:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	5–6	AO3 AO2
	Level 2: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.	3–4	5.5.1.1
	Level 1: The design/plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content **Steps** • use a suitable container eg test tube • use insulation • add water • measure the initial water temperature (with a thermometer) • add stated mass eg 1g **or** 1 spatula • stir (to dissolve the solid) • measure the final (allow lowest or highest) temperature of the solution • calculate the temperature difference **or** determine graphically • repeat with different masses • repeat with the same volume of water to access level 3 there must be an indication of how the temperature change is determined using different masses dissolved in the same quantity of water		

Total			14

5.4.2.4 The pH scale and neutralisation

Answer 02 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.4.2.4 The pH scale and neutralisation

Answer 03 · Mark scheme November 2020 | 8464/C/1H | Original Q4

04.1	ZnO (**s**) + HCl (**aq**) → $ZnCl_2$ (**aq**) + H_2O (**l**)	allow **1** mark for 2/3 correct state symbols	2	AO2 5.2.2.2 5.4.2.3 RPA8
04.2	any **one** from: • warm / heat the mixture • increase the concentration of the (hydrochloric) acid	ignore add a catalyst ignore stir ignore powder ignore add more zinc oxide do **not** accept volume / amount of (hydrochloric) acid do **not** accept increase the surface area	1	AO1 5.4.2.2 5.4.2.3 RPA8
04.3	zinc oxide remains **or** solid remains	ignore colour allow zinc oxide is added until in excess	1	AO1 5.3.2.4 5.4.2.2 5.4.2.3 RPA8
04.4	filtration / filter		1	AO1 5.4.2.2 5.4.2.3 RPA8
04.5	heat leave to crystallise / cool	do **not** accept heat to dryness allow leave to evaporate some water	1 1	AO1 5.4.2.2 5.4.2.3 RPA8

5.4.2.4 The pH scale and neutralisation

Answer 03 · Mark scheme

04.6	(at start) value in range 12–14 (at end) value in range 0–3	must be in this order	1 1	AO1 AO2.2 5.4.2.2 5.4.2.4

04.7	$2\ NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2\ H_2O$	allow 1 mark for Na_2SO_4 **and** H_2O	2	AO2 5.1.1.1 5.4.2.2

04.8	0.10 mol/dm^3		1	AO3 5.4.2.2 5.4.2.4

Total			**12**

5.4.2.4 The pH scale and neutralisation

Answer 03 · Mark scheme

November 2020 | 8464/C/1H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.4.2.4 The pH scale and neutralisation

Answer 04 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	green to red		1	AO1 5.4.2.4
02.2	decreases		1	AO1 5.4.2.4
02.3	(aq)	allow aq ignore aqueous ignore HNO_3	1	AO1 5.2.2.2
02.4	any **two** from: • (white) solid disappears • fizzing **/** bubbles / effervescence • (then) stops fizzing • (white) solid left at the end / bottom	 allow a gas is produced ignore colourless solution	2	AO3 5.4.2.2 5.4.2.3
02.5	$Zn(NO_3)_2$		1	AO2 5.1.1.1 5.4.2.2

5.4.2.4 The pH scale and neutralisation

Answer 04 · Mark scheme

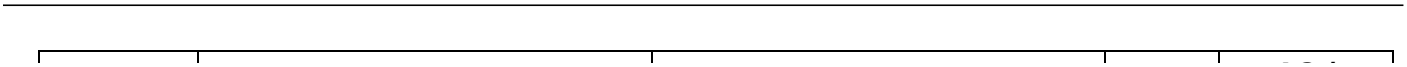
November 2021 | 8464/C/1H | Original Q2

Question	Answers	Mark	AO / Spec. Ref.
02.6	**Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6	AO1 5.4.2.2 5.4.2.3 RPA8
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative Content: • react hydrochloric acid • (with) copper oxide • in a suitable container • warm (hydrochloric) acid • add copper oxide • until is in excess **or** until solid remains • stir • filter excess copper oxide • pour solution / filtrate into evaporating basin • use of water bath **or** use of electric heater • to heat gently **or** partially evaporate • leave to cool / crystallise For level 3 the correct chemicals must have been selected.		
Total		**12**	

5.4.2.4 The pH scale and neutralisation

Answer 04 · Mark scheme

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



5.4.2.4 The pH scale and neutralisation

Answer 05 · Mark scheme

June 2022 | 8464/C/1H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	any **three** from: • green solid / powder • colourless solution • blue solution formed • copper carbonate disappears • fizzing / effervescence **or** bubbles (of gas) • stops fizzing • solid / powder left at the end **or** copper carbonate left at the end	 ignore green copper carbonate allow colour (of solution) changes allow solid disappears ignore gas allow fizzing slows down allow (container) gets hot **or** allow temperature increases	3	AO2 AO3 5.4.2.2 5.4.2.3 RPA8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	filtration **or** filter		1	AO1 5.4.2.3 RPA8

5.4.2.4 The pH scale and neutralisation

Answer 05 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	7		1	AO1 5.4.2.3 5.4.2.4 RPA8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	neutralisation	allow exothermic	1	AO1 5.4.2.2 5.4.2.4 RPA8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	83 (g at 80 °C)	allow a value in range 82–84 (g at 80 °C)	1	AO2
	32 (g at 20 °C)	allow a value in range 32–33 (g at 20 °C)	1	AO2
	(83–32 =) 51 (g)	allow a correct calculation using incorrectly read values for mass at 80 °C and/or 20 °C	1	AO3 5.4.2.3

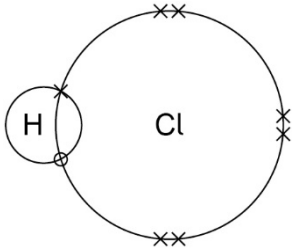
Total Question 1		**9**

5.4.2.4 The pH scale and neutralisation

Answer 06 · Mark scheme

June 2022 | 8464/C/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	one shared pair in overlap 6 non-bonding electrons in outer shell of chlorine	allow any combination of circles, dots, crosses or $e^{(-)}$ do **not** accept extra electron(s) on outer shell of hydrogen ignore any inner shell electrons an answer of  scores **2** marks	1 1	AO1 5.1.2.6 5.2.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	completely ionises in aqueous solution	allow completely dissociates in aqueous solution	1	AO1 5.4.2.5

5.4.2.4 The pH scale and neutralisation

Answer 06 · Mark scheme

June 2022 | 8464/C/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	fizzing / effervescence **or** magnesium disappears		1	AO3 5.4.2.5
	at a greater rate with a strong acid	allow converse with weak acid allow for **2** marks strong acid has a greater temperature increase	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	(pH) decreases	allow pH is lower	1	AO1
	by (a unit of) 2		1	AO2 5.4.2.5

5.4.2.4 The pH scale and neutralisation

Answer 06 · Mark scheme

June 2022 | 8464/C/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	(bonds broken = (4 × 413) + C=C + 431 =) 2083 + **C=C**		1	AO2 5.5.1.3
	(bonds made = (346 + 339 + (5 × 413) =) 2750		1	
	(energy released = bonds made – bonds broken =) 56 = 2750 – [2083 + C=C]	allow correct use of incorrect value(s) from step 1 and / or step 2	1	
	(C=C) = 611 (kJ/mol)		1	

Total Question 6		**11**

5.4.2.4 The pH scale and neutralisation

Answer 07 · Mark scheme June 2023 | 8464/C/1H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	hydrogen / H^+		1	AO1 5.4.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2		MP2 is dependent upon MP1 being awarded		AO1 5.4.2.4
	(indicator) universal	ignore pH meter	1	
	(result) (green to) red / orange / yellow		1	
	OR			
	(indicator) (blue) litmus (1)			
	(result) (turns) red (1)			
	OR			
	(indicator) methyl orange (1)			
	(result) (turns) red (1)			

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	the solubility decreases		1	AO3 5.3.2.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	pH of the solution increases		1	AO3 5.3.2.5 5.4.2.4

5.4.2.4 The pH scale and neutralisation

Answer 07 · Mark scheme

June 2023 | 8464/C/1H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	(I)		1	AO2 5.2.2.2

Question	Answers	Mark	AO / Spec. Ref.
01.6	**Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	5–6	AO3 5.3.1.3 5.4.2.2
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.	3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative Content: • measure a (stated) mass of calcium carbonate • use a balance • add calcium carbonate into a conical flask • measure a (stated) volume of hydrochloric acid • use a measuring cylinder • add hydrochloric acid to the conical flask • immediately place the stopper (and delivery tube) in the conical flask • record the total volume of carbon dioxide gas **or** record volume of carbon dioxide collected in set time **or** time taken to collect fixed volume of gas • collected in the gas syringe • repeat • repeat method with different masses of calcium carbonate		

Total Question 1	12

5.4.2.4 The pH scale and neutralisation

Answer 08 · 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

5.4.2.4 The pH scale and neutralisation

Answer 08 · Mark scheme

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

Total Question 5	**9**

5.4.2.4 The pH scale and neutralisation

Answer 09 · Mark scheme

June 2024 | 8464/C/1H | Original Q4

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	completely ionised in aqueous solution	allow completely ionised (when dissolved) in water allow fully dissociated in aqueous solution	1	AO1 5.4.2.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	low concentration of (nitric) acid dissolved in water	allow low concentration of solute / solid / gas dissolved in water	1	AO1 5.4.2.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	decreases by a factor of 100		1	AO2 5.4.2.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	$H^+ + OH^- \rightarrow H_2O$	ignore state symbols	1	AO1 5.4.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	1 : 2		1	AO2 5.3.2.3

5.4.2.4 The pH scale and neutralisation

Answer 09 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	red		1	AO3 5.3.2.4 5.4.2.2 RPA10

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.7	(for each mass of magnesium carbonate) repeat the experiment (discard anomalous results) **and** calculate the mean		1	AO3 5.5.1.1 RPA10
	measure the highest temperature		1	

Total Question 4	**8**

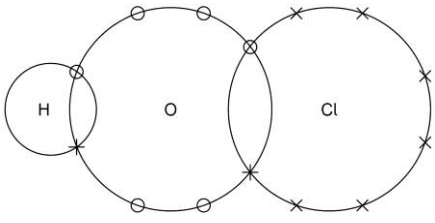
5.4.2.4 The pH scale and neutralisation

Answer 10 · Mark scheme June 2025 | 8464/C/1H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	(hydrogen chloride) g / (g) **and** (water) l / (l) **and** (hydrochloric acid) aq / (aq)		1	AO2 5.2.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	3.16×10^{-4} (mol/dm^3)		1	AO2 5.4.2.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3		allow any combination of x, O, $e^{(-)}$, ● for electrons		AO2 5.2.1.1 5.2.1.4
	1 pair of electrons in both overlaps		1	
	4 non-bonding electrons on oxygen atom **and** 6 non-bonding electrons on chlorine atom	do **not** accept non-bonding electrons on hydrogen	1	
		an answer of  scores **2** marks		

5.4.2.4 The pH scale and neutralisation

Answer 10 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	a weak acid partially ionises in an aqueous solution (so) produces a lower concentration of hydrogen ions		1 1	AO1 5.4.2.4 5.4.2.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	(bonds broken = (4 × 413) + 243 =) 1895 (bonds made = (3 × 413) + 346 + 432 =) 2017 (energy change = 1895 − 2017 =) (−) 122 (kJ/mol) **alternative approach** (bonds broken = 413 + 243 =) 656 (1) (bonds made = 346 + 432 =) 778 (1) (energy change = 656 − 778 =) (−) 122 (kJ/mol) (1)	allow correct use of an incorrectly determined value for bonds broken and / or bonds made allow correct use of an incorrectly determined value for bonds broken and / or bonds made	1 1 1	AO2 5.5.1.3

Total Question 5	9

5.4.2.4 The pH scale and neutralisation

Answer 01 · Examiner comments

June 2018 | 8464/C/1H | Original Q7

Question 7 (standard / high & high demand)

07.1 In this 'extended response' question many students used the information effectively and gave very good explanations. 73% of students were able to achieve at least one mark, while 18% of students gave answers sufficient enough to meet the demands of the level 3 descriptor.

Some misunderstood the solubility data and gave SiO_2 as the most soluble. Many understood how pH related to acid, alkali and neutral. Although a common error was the confusion between whether sodium oxide was alkaline or acidic so many gave C and D correct from the solubility data but A and B incorrect.

In long descriptions, students would often contradict chemical identification or properties due to a lack of organisation within their response. A number gave the identity of the substances as elements instead of oxides. Some did not link the letters with any of the four substances listed in the question, choosing others compounds.

07.2 Students struggled with the concept that is if an acid is diluted by a factor of 10 then the pH increases by 1. Very few showed any attempt at the correct method, with 12% of students achieving one or two marks. Most students simply multiplied the 3 by 100 to give an answer of 300.

5.4.2.4 The pH scale and neutralisation

Answer 02 · Examiner comments — June 2019 | 8464/C/1H | Original Q2

Question 2

This question was common with the Foundation paper and included an extended response question based around Required Practical Activity 10. Each item was at standard demand.

02.1 This question was poorly answered where only a quarter of students gained the mark. A wide range of incorrect responses were seen. Many students wrote a chemical formula of ammonium nitrate instead of the state symbol. Students should know that state symbols are lower case only which are written in brackets.

02.2 Around two-thirds of students identified the correct formula of nitric acid. The next most common response was the alkali NH_4OH

02.3 This recall question was generally well answered with more than half the students gaining both marks. Two colours were often listed eg red/orange or blue/purple when only one colour was required. The most common incorrect responses included green, black and colourless.

Answer 02 · Examiner comments — June 2019 | 8464/C/1H | Original Q2

02.4 Approximately one-third of students identified the correct pH change when nitric acid was added to ammonia solution. The three incorrect responses were selected in approximately equal amounts. A large number of students did not follow the rubric of the question which required them to tick one box only.

02.5 This question discriminated well. Two-thirds of students gained all three marks for an answer of 60%. A very common error was to carry out the calculation for only one oxygen atom, leading to an answer of 20%, which gained two marks. Some students started the calculation correctly by calculating 48 for three oxygen atoms, but then subtracted that from the given relative formula mass to give 32, which was then used in a percentage calculation.

02.6 Most students had a good understanding of the requirements of this question which was based upon Required Practical Activity 10. They could appreciate the need to control variables, although the most common errors were to not mention a constant volume of water when starting each experiment or not taking the temperature of the water before the ammonium nitrate was added. The descriptions were often poorly organised with statements relating to a constant volume of water or measuring the starting temperature appearing at the end of the response. Some students carried out the experiment in one container, adding successive masses to the same beaker in the same way they could have done a heat of neutralisation experiment. This question discriminated well with approximately a fifth of students achieving level 3 and a half achieving level 2.

5.4.2.4 The pH scale and neutralisation

Answer 04 · Examiner comments — November 2021 | 8464/C/1H | Original Q2

Question 2 (standard demand)

02.1 Just under half of students correctly choose ‘green to red’ as the colour change observed when nitric acid is added to a mixture of universal indicator and water.

02.2 Just over one half of students knew that the pH of water decreases when nitric acid was added.

Answer 04 · Examiner comments — November 2021 | 8464/C/1H | Original Q2

02.3 Few students were able to give (aq) as the state for a substance dissolved in water.

02.4 The required practical activity of making a soluble salt starts by reacting either an insoluble metal oxide or metal carbonate with an acid. The word equation was provided to help students with this question although many students found difficulty in making links between this and the resulting observations. Since carbon dioxide is produced, initial observations would be fizzing and white solid disappearing. Excess zinc carbonate would result in all the nitric acid reacting; fizzing would stop and excess solid would collect at the bottom. Very few students scored two marks.

02.5 Students found difficulty in determining the formula for zinc nitrate. Just over one third of students gained the mark.

02.6 Students had difficulty in describing the essential steps of the required practical activity of making a soluble salt from an insoluble metal oxide and an acid. Many failed to select the correct chemicals, copper oxide and hydrochloric acid; without these the method would not lead to a valid outcome. Very few students got into level three. Approximately four fifths of students produced a level one answer.

5.4.2.4 The pH scale and neutralisation

Answer 05 · Examiner comments June 2022 | 8464/C/1H | Original Q1

Question 1 (Standard demand)

01.1 Students were asked to state observations when copper carbonate is added to sulfuric acid. 30% of students gave at least two correct observations. The most common responses were ‘colour changes’ or ‘fizzing’. Many students appeared to misunderstand what an observation is and instead either wrote instructions on how to carry out the preparation of copper sulfate or gave vague comments such as ‘there was a reaction’, or ‘it stopped reacting’, along with describing the reaction with comments such as carbon dioxide gas was given off. Some students referred to copper carbonate as either copper or copper oxide which are different chemicals.

01.2 Nearly three quarters of students knew that filtration is used to separate unreacted copper carbonate after a reaction between sulfuric acid and excess copper carbonate.

01.3 Just under half the students knew the pH of the solution at the end of the reaction between sulfuric acid and excess copper carbonate.

01.4 Just over a third of students knew that the reaction between sulfuric acid and copper carbonate was neutralisation.

Answer 05 · Examiner comments June 2022 | 8464/C/1H | Original Q1

01.5 The question required students to read the masses of ammonium nitrate that dissolve at 80 °C and 20 °C from a graph and to then carry out a subtraction to determine the mass of solid that crystallises on cooling. Just over 40% of students were able to gain all 3 marks. There were a minority of students who failed to show any working except for small crosses on the graph.

5.4.2.4 The pH scale and neutralisation

Answer 06 · Examiner comments June 2022 | 8464/C/1H | Original Q6

Question 6 (Standard, standard/high and high demand)

06.1 Two third of students correctly drew a dot and cross diagram for hydrogen chloride. The most common mark was for the two shared electrons in the overlap between the atoms. Many did not show that there are six unshared electrons.

06.2 Less than 10% were able to state what is meant by the term strong acid. Many omitted 'in aqueous solution'.

06.3 40% of students gained 1 mark usually for referring to an observation when magnesium reacts with a strong acid and a weak acid. The second mark was for a comparison of the rates of reaction between magnesium and the two acids, with few students being able to develop their response to give this.

06.4 Nearly 40% of students gained 1 mark usually for stating that the pH decreases when the concentration was increased. However very few recognised that pH was related to the power of 10, so when the concentration of hydrochloric acid is increased by a factor of 100 then the pH will decrease by 2.

06.5 Many students were good at calculating the energy changes for bonds broken and bonds made, however then went on to simply subtract these two numbers without taking into account the C=C bond energy. Many students kept their working to a minimum which often did not help them score. This question discriminated well with better responses showing clear working where the energy released was equated to the difference between the bonds made and the bonds broken.

Answer 07 · Examiner comments June 2023 | 8464/C/1H | Original Q1

Question 1 (standard demand)

01.1 Students were asked to state which ion makes a solution acidic. 30% of students correctly identified the ion as H^+. Carbon was a very common incorrect response.

01.2 More than half the students named an indicator that could be used to test if a solution is acidic and most of these then gave the correct colour in the acid solution. The majority of students listed universal indicator.

01.3 More than three-quarters of students deduced that the solubility of carbon dioxide decreases as the temperature of water increases. The solubility increases proved to be the most common distractor.

5.4.2.4 The pH scale and neutralisation

Answer 07 · Examiner comments June 2023 | 8464/C/1H | Original Q1

01.4 Just over a third of students deduced that the pH of the solution increases as the temperature of water increases. More students selected the pH of the solution decreases.

01.5 More than three-quarters of students knew that the state symbol of water is (l). The most popular distractor was (aq).

01.6 This question proved accessible for the vast majority of students and discriminated well with over 80% of students achieving level two or above. Students needed to plan a method to investigate the volume of carbon dioxide produced when different masses of calcium carbonate react with hydrochloric acid. To access level 3, the method would lead to a valid outcome. To access level 2 the method would not necessarily lead to a valid outcome. Common reasons for students not accessing level 3 was the use of incorrectly named equipment or the use of a beaker to carry out the reaction as the gas syringe would not be able to be attached to a beaker so the gas could not be collected and measured. Details of when to read the gas syringe was the common omission. Students should be encouraged to state volumes and masses as most creditworthy responses regarding the control of volume and mass did so by stating a value and then repeated with other masses. Students working at level 1 usually gained credit for either mixing the reagents or attempting to collect and measure the gas produced.

Answer 08 · 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.

5.4.2.4 The pH scale and neutralisation

Answer 08 · 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 09 · Examiner comments

Question 4 (standard & standard/high demand)

04.1 Many students stated that strong acids completely ionise but omitted to include that this happens in water or in aqueous solution. 10% of students gave the correct definition.

04.2 Less than 5% of students gave a correct explanation for 'dilute aqueous solution'. Very few students made reference to being dissolved in water or used the term (low) concentration.

Common incorrect responses made reference to reducing the concentration of the acid or stating that there would be a small volume of acid per unit volume or small volume of acid in aqueous solution. A number of students stated that a high concentration of substance/acid had been dissolved.

04.3 This question proved challenging. To deduce the change in the hydrogen ion concentration students need to know that as the pH decreases by one unit, the hydrogen ion concentration of the solution increases by a factor of 10. A third of students gained the mark with approximately equal numbers choosing the alternative responses.

04.4 Nearly one-fifth of students were able to recall an ionic equation to represent the neutralisation between an acid and an alkali. This question had the highest not attempted rate at 12.5%, which was nearly double that of any other question. A common response was 'acid + alkali → salt' suggesting that students were not familiar with the ions present in acid or alkaline solutions or that this involved neutralisation to produce water.

04.5 Most students were able to deduce the correct ratio of moles from the equation. The most common distractor was 2:1 where the correct ratio was reversed.

04.6 Just over half of students recognised that universal indicator would turn red in the acidic solution produced when magnesium carbonate and excess nitric acid were reacted. Green was the most common distractor which was not correct as excess acid was used in the reaction.

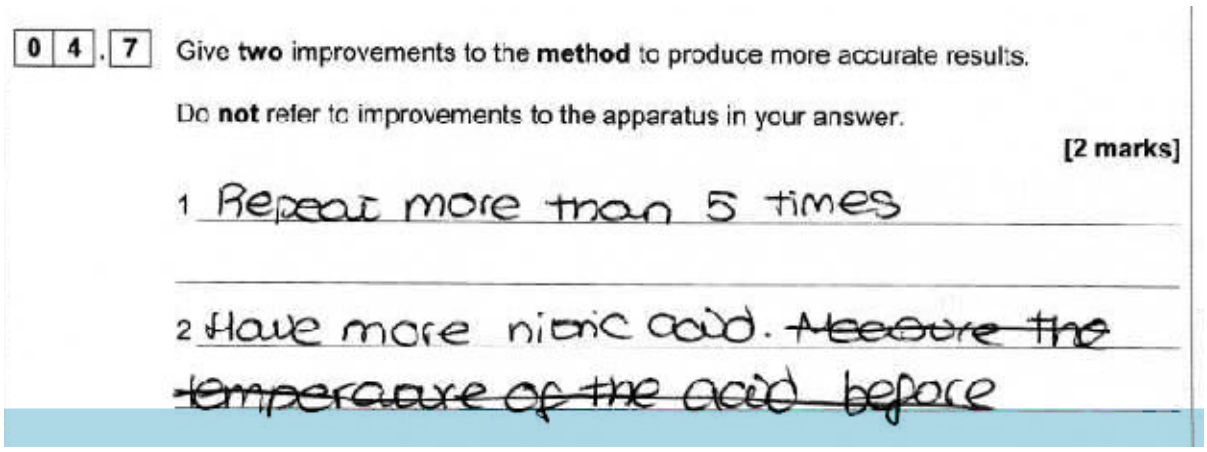
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5.4.2.4 The pH scale and neutralisation

Answer 09 · Examiner comments June 2024 | 8464/C/1H | Original Q4

04.7 This question required improvements to the method, so references to changing the volume or concentration of solution were insufficient. Many students wrote that the experiment should be repeated but to be creditworthy they needed to include that the mean should be calculated. 'Measuring until the temperature stopped increasing' was taken as equivalent to 'measure the highest temperature'. However, 'measuring until the temperature is constant' is insufficient as this may not be the highest temperature or the mixture may have cooled to room temperature.

Just under a quarter of students gained 1 mark and 1% gained 2 marks.



This student did not gain any credit: repeating the experiment on its own is insufficient as the mean is not calculated (after anomalous results are discarded).

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Answer 10 · Examiner comments

Question 5 (Standard/High and High demand)

05.1 The state symbols for hydrogen chloride gas and water were well known but aqueous for hydrochloric acid was not. Some students mixed up l and aq. Most students correctly use lower case letters.

05.2 Few students gained this high demand mark. Those students who gained the mark often wrote down a few words next to the values given in the question, e.g. 'add 1, divide by 10' or 'concentration increases by factor of 10, pH decreases by 1'. Numerous students multiplied by 10 rather than dividing and many struggled to evaluate data in standard form.

05.3 More than half of students gained two marks for completing the dot and cross diagram. When 1 mark was gained it was usually for 1 pair of electrons in both overlaps with extra non-bonding electrons on hydrogen or incorrect numbers of non-bonding electrons on the oxygen atom and/or the chlorine atom.

05.4 Very few gained both marks. Students had to explain why a weak acid has a higher pH than a strong acid of the same concentration. Most answers were in terms of a pH comparison. Lots of students did not achieve MP1 by not using the full definition including in aqueous solution. For MP2 many students said there were less H^+ ions omitting reference to concentration or number per unit volume.

05.5 Many students were able to calculate the energy changes for bonds broken and for bonds made and then subtracted the latter value from the former. The value of bonds broken was less than bonds made so the overall energy change was a negative number. Those students who miscounted the bonds broken or made, could not gain MP1 and/or MP2 but were still able to access MP3 by evaluating their own figures correctly.

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5.4.2.4 The pH scale and neutralisation

Answer 10 · Examiner comments June 2025 | 8464/C/1H | Original Q5

0 5 . 5 Hydrogen chloride is produced in the reaction between methane and chlorine.

Figure 6 represents the equation for the reaction.

Figure 6

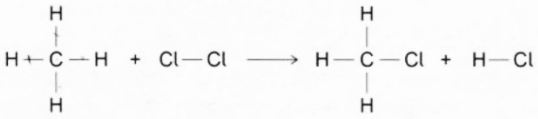


Table 4 shows the bond energies.

Table 4

Bond	C — H	Cl — Cl	C — Cl	H — Cl
Bond energy in kJ/mol	413	243	346	432

Calculate the overall energy change for the reaction.

[3 marks]

reactants	Products
413 x 4 = 1652	1 x 346 = 346
243 x 2 = 486	413 x 3 = 1239
total = 1652 + 486 =	432 x 1 = 432
2138 − 2017 = 121	total = 2346 + 1239 + 432
	= 2017

Overall energy change = 121 kJ/mol

This student has broken 2× Cl—Cl bonds (not 1×) for the reactants so is not awarded MP1. They then correctly subtract the correct value for bond making (2017) so MP2 and MP3 are credited.

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