AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.4.2.1

Reactions of acids with metals

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**12**
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.

5.4.2.1 Reactions of acids with metals

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 × $\frac{2}{3}$	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)			

5.4.2.1 Reactions of acids with metals

Answer 01 · Mark scheme

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**	

5.4.2.1 Reactions of acids with metals

Answer 02 · Mark scheme June 2019 | 8464/C/1H | Original Q1

01.1	Ca Mg Zn Cu		1	AO3 5.4.1.2

01.2	any **two** from: • mass (of metal / element) • surface area (of metal / element) • concentration (of acid) • volume (of acid) • temperature (of acid)	 allow weight ignore size ignore length ignore pH ignore strength ignore room temperature	2	AO3 5.4.1.2

01.3	(type of) metal / element		1	AO2 5.4.1.2

5.4.2.1 Reactions of acids with metals

Answer 02 · Mark scheme

01.4	(beryllium is) less reactive any **one** from: • greater attraction between nucleus and outer electrons • more energy is needed to remove electrons • loss of electrons is more difficult • outer electrons closer to nucleus • less shielding	allow converse answers for magnesium MP2 only if MP1 is correct allow higher in group allow reactivity increases down the group ignore reactivity series	1 1	AO3 5.1.2.3 5.1.2.5 5.4.1.2

5.4.2.1 Reactions of acids with metals

Answer 02 · Mark scheme

June 2019 | 8464/C/1H | Original Q1

01.5	$\frac{50}{1000}$ (dm^3) = 0.05 (dm^3) ($\frac{3.2}{0.05}$) = 64 (g per dm^3) **alternative approach:** $\frac{3.2}{50}$ (1) = 0.064 (1) (× 1000) = 64 (g per dm^3) (1) **alternative approach**: $\frac{1000}{50}$ (1) = 20 (1) (× 3.2) = 64 (g per dm^3) (1)	an answer of 64 (g per dm^3) scores **3** marks an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps an answer of 0.16 / 0.064 / 0.64 / 6.4 / 6.4 × 10^{-5} (g per dm^3) gains **2** marks	1 1 1	AO2 5.3.2.5
Total			**9**	

5.4.2.1 Reactions of acids with metals

Answer 02 · Mark scheme

June 2019 | 8464/C/1H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.4.2.1 Reactions of acids with metals

Answer 03 · Mark scheme June 2019 | 8464/C/2H | Original Q5

05.1	$Mg + 2H^+ \rightarrow Mg^{2+} + H_2$		1	AO2 5.6.1.2 5.1.1.1
05.2	electron transfer		1	AO2 5.11
05.3	all points correctly plotted	allow a tolerance of ± ½ a small square allow **1** mark for at least 4 points correctly plotted	2	AO2 5.6.1.1
	line of best fit		1	
05.4	(rate) decreases	allow (rate is) fastest at the beginning	1	AO3 5.6.1.1
	(rate decrease) more slowly as time increases (in rate)		1	AO3 5.6.1.1
	(rate) becomes zero at time read from graph	allow reaction stops at time read from graph	1	AO3 5.6.1.1
05.5		Incorrect reference to energy scores **max. 1**		AO2 5.6.1.3
	(rate decreases because) fewer particles (of acid / magnesium) as reaction progresses	allow (rate decreases because) concentration of acid decreases as reaction progresses	1	AO1 5.6.1.3
	(so) less frequent collisions	allow collisions less likely ignore less / fewer collisions	1	AO2 5.6.1.3
	reaction stops due to limiting factor / reagent	allow reaction stops because a reactant is used up	1	5.3.2.4
Total			**11**	

5.4.2.1 Reactions of acids with metals

Answer 03 · Mark scheme

June 2019 | 8464/C/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.4.2.1 Reactions of acids with metals

Answer 04 · 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

5.4.2.1 Reactions of acids with metals

Answer 04 · 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 → 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**	

5.4.2.1 Reactions of acids with metals

Answer 04 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.4.2.1 Reactions of acids with metals

Answer 05 · 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

5.4.2.1 Reactions of acids with metals

Answer 05 · Mark scheme

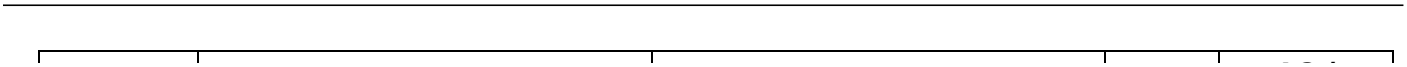
November 2021 | 8464/C/1H | Original Q2

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**	

5.4.2.1 Reactions of acids with metals

Answer 05 · Mark scheme

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



5.4.2.1 Reactions of acids with metals

Answer 06 · Mark scheme

November 2021 | 8464/C/2H | Original Q1

Question	Answers	Extra information	Mark	AO / Spec.
01.1	**independent** concentration (of hydrochloric acid) **control** any **one** from: • temperature (of hydrochloric acid) • volume of (hydrochloric) acid • length of magnesium • surface area of magnesium	 allow same mass of magnesium allow same form of magnesium ignore amount	1 1	AO1 5.6.1 RPA11
01.2	all points correctly plotted line of best fit	allow a tolerance of ± ½ a small square allow 1 mark for 4 or 5 points correctly plotted must include 0,0	2 1	AO2 5.6.1 RPA11
01.3	the rate decreases		1	AO3 5.6.1 RPA11
01.4	the magnesium reacted more quickly		1	AO3 5.6.1.2

5.4.2.1 Reactions of acids with metals

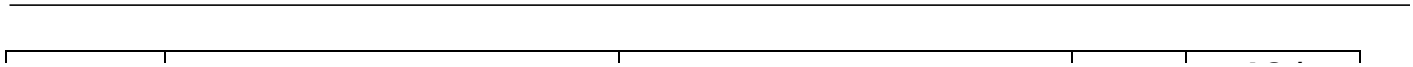
Answer 06 · Mark scheme

01.5	rate increases (because) particles have more energy (so) more frequent collisions	allow reaction happens faster allow (because) particles move faster allow (because) more particles have energy greater than the activation energy	1 1 1	AO1 5.6.1.2 5.6.1.3
Total			**10**	

5.4.2.1 Reactions of acids with metals

Answer 06 · Mark scheme

November 2021 | 8464/C/2H | Original Q1



5.4.2.1 Reactions of acids with metals

Answer 07 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	production of copper is increasing at an increasing rate		1 1	AO2 5.10.1.1
04.2	increase in population / demand	allow more uses for copper	1	AO3 5.10.1.1
04.3	any **one** from: • more use of recycling • copper is a finite resource and may run out • alternative metals may be used in future	ignore only an estimate	1	AO3 5.10.1.1
04.4	**B**, **D**, **C**, **A**, **E**		1	AO1 5.10.1.4
04.5	any **two** from: • (phytomining is) slower to produce copper • large area of land required • insufficient yield to meet demand	ignore reference to cost ignore references to carbon dioxide ignore references to global warming allow plants grow slowly	2	AO3 5.10.1.4

5.4.2.1 Reactions of acids with metals

Answer 07 · Mark scheme

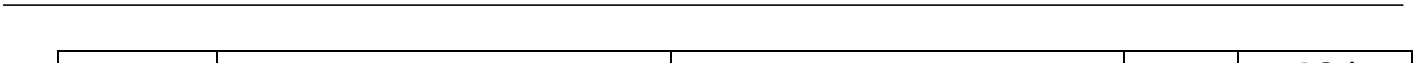
November 2021 | 8464/C/2H | Original Q4

04.6	(energy use through recycling = $27.2 \times 8.89 \times 10^9 \times \frac{41}{100}$) $= 9.914 \times 10^{10}$ (energy use through extraction = $70.4 \times 8.89 \times 10^9 \times \frac{59}{100}$) $= 3.693 \times 10^{11}$ (total consumption today = $9.914 \times 10^{10} + 3.693 \times 10^{11}$) $= 4.6844 \times 10^{11}$ (energy use if only recycling used = $27.2 \times 8.89 \times 10^9$) $= 2.418 \times 10^{11}$ (energy saving = $4.6844 \times 10^{11} - 2.418 \times 10^{11}$) $= 2.27 \times 10^{11}$ (MJ)	allow correct use of an incorrect energy use determined in MP1 and/or MP2 allow an answer correctly calculated to 3 significant figures which uses the values in the question	1 1 1 1 1 1	AO2 5.10.2.2
Total			**12**	

5.4.2.1 Reactions of acids with metals

Answer 07 · Mark scheme

November 2021 | 8464/C/2H | Original Q4



5.4.2.1 Reactions of acids with metals

Answer 08 · Mark scheme

June 2022 | 8464/C/1H | Original Q3

Question 3

Question	Answers	Mark	AO / Spec. Ref.
03	**Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	5–6	AO3
	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	AO3
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	AO1
	No relevant content.	0	
	Indicative Content • measure volume of (hydrochloric) acid • into a suitable container eg polystyrene cup • measure the initial temperature (of hydrochloric acid) • with a thermometer • add stated mass of one metal • stir • measure the highest temperature reached of the solution **or** measure temperature reached after a set time period • determine the temperature difference • repeat • repeat for each metal • with same mass • in same physical state (powder, lump, etc) • with the same volume and / or concentration of (hydrochloric) acid • use results to arrange metals in order of reactivity • most reactive metal has the largest temperature change to access level 3 there must be an indication of how the temperature change is determined with the same mass of the 3 different metals reacted with the same volume of (hydrochloric) acid		5.1.4.2 RPA2

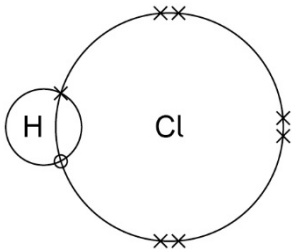
Total Question 3		**6**

5.4.2.1 Reactions of acids with metals

Answer 09 · 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	allow any combination of circles, dots, crosses or $e^{(-)}$	1	AO1 5.1.2.6 5.2.1.4
	6 non-bonding electrons in outer shell of chlorine	do **not** accept extra electron(s) on outer shell of hydrogen ignore any inner shell electrons	1	
		an answer of  scores **2** marks		

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

5.4.2.1 Reactions of acids with metals

Answer 09 · Mark scheme

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

5.4.2.1 Reactions of acids with metals

Answer 09 · Mark scheme

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**

5.4.2.1 Reactions of acids with metals

Answer 10 · Mark scheme

June 2023 | 8464/C/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	filter (to remove excess magnesium) (then) crystallisation (of magnesium chloride solution)	 allow (then) evaporation (of water from magnesium chloride solution)	1 1	AO1 5.1.1.2 5.4.2.1 5.4.2.3 RPA8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	(magnesium atoms are) oxidised (because the atoms) lose (two) electrons		1 1	AO2 5.4.1.4 5.4.2.1 5.4.2.3 RPA8

5.4.2.1 Reactions of acids with metals

Answer 10 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	(moles Mg =) $\frac{0.72}{24}$		1	AO2 5.3.1.1 5.3.2.2 5.4.2.1 5.4.2.3 RPA8
	= 0.03		1	
	(moles Mg = moles $MgCl_2$) (so mass $MgCl_2$ =) 0.03 × 95	allow a correct calculation using an incorrectly calculated value of moles of magnesium allow a correct calculation using an incorrectly calculated value of moles of magnesium chloride	1	
	= 2.85 (g)		1	
	(100.0 cm^3 = 0.100 dm^3 concentration = $\frac{\text{mass}}{\text{volume}}$)			
	= $\frac{2.85}{0.100}$	allow correct use of incorrectly calculated mass of magnesium chloride	1	
	= 28.5 (g/dm^3)		1	

Total Question 6	10

5.4.2.1 Reactions of acids with metals

Answer 11 · 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

5.4.2.1 Reactions of acids with metals

Answer 11 · 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**

5.4.2.1 Reactions of acids with metals

Answer 12 · Mark scheme

June 2025 | 8464/C/2H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	time taken (for the cross to be no longer visible)		1	AO1 5.6.1.2 RPA11

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	sulfur (is produced)		1	AO2 5.2.2.2 5.6.1.2
	(which is a) solid	allow (which is) insoluble allow (which is) a precipitate	1	RPA11

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3		allow converse throughout		AO1 5.6.1.2 5.6.1.3
	increasing the concentration increases the rate of reaction		1	
	(because) there are more particles in the same volume (of solution)	allow (because) the particles are closer together do **not** accept the particles have more energy	1	
	(so) there are more frequent collisions		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	to reduce loss of gas	allow to reduce loss of hydrogen do **not** accept to stop loss of gas / hydrogen	1	AO3 5.6.1.2 RPA11

5.4.2.1 Reactions of acids with metals

Answer 12 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	(test) add a burning splint (result) (hydrogen burns with) a pop sound	do **not** accept glowing splint MP2 is dependent upon MP1 being awarded	1 1	AO1 5.8.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.6	tangent drawn at 75 s value of *x*-step **and** *y*-step from tangent (rate=) $\frac{\text{value for y-step}}{\text{value for x-step}}$ correct calculation of rate	 allow evidence of use of two points on tangent either on the graph or in the text allow a tolerance of ± ½ a small square allow correct use of incorrectly determined value(s) for *x*-step and/or *y*-step from a drawn tangent 	1 1 1 1	AO2 5.6.1.1 RPA11

Total Question 5	13

5.4.2.1 Reactions of acids with metals

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 ($\times$ 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.

5.4.2.1 Reactions of acids with metals

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.

5.4.2.1 Reactions of acids with metals

Answer 02 · Examiner comments June 2019 | 8464/C/1H | Original Q1

Question 1

This question was common with the Foundation paper and each item was at standard demand.

01.1 The decreasing reactivity of the metals was deduced from the amount of effervescence in each reaction. Most students selected the correct order.

01.2 Although most students had a good understanding of the control variables in this situation, the way they described the variable sometimes lacked the correct terminology. 'Amount of acid' was often used instead of 'volume of acid'.

01.3 This question to identify the independent variable was well answered, although it was common to see other incorrect variables mentioned, such as reactivity of the metals or number of bubbles.

01.4 This question comparing the reactivity of beryllium to magnesium was reasonably well answered. A number of students gained no credit as they stated that beryllium was more reactive. Some students stated that magnesium has more 'outer shells'; all elements only have one outer shell. Trends in reactivity had to refer to the group (as the question stated to use the periodic table) and not the periodic table or reactivity series. The word 'outer' was frequently omitted, so responses such as the electrons in magnesium are further from the nucleus were insufficient.

01.5 A quarter of students used a variety of methods to correctly calculate the concentration. Just under a half of the students scored 2 of the 3 marks, usually failing to correctly convert cm^3 to dm^3

Answer 03 · Examiner comments June 2019 | 8464/C/2H | Original Q5

Question 5 (standard/high demand)

05.1 Around 6% of students gained this mark. The third option was the most popular incorrect response.

5.4.2.1 Reactions of acids with metals

Answer 03 · Examiner comments June 2019 | 8464/C/2H | Original Q5

05.2 About 65% of students gained this mark. Most students gave the correct symbol equation rather than the ionic equation.

05.3 This question produced a good spread of marks, with only 2.5% of students failing to gain any credit for their answer. Around 27% of students gained all three marks. Most students gained 2 marks and just below a third gained one mark.

Common errors included:

- failing to plot the point at the origin
- incorrectly plotting the points (particularly 35, 36.0 and 95, 59.0), lines of best fit that were sketched
- drawing a straight line of best fit rather than a curved line of best fit
- lines of best fit that extended too far above the plateau
- 'double lines' drawn as part of the curve.

Points plotted as 'crosses' are easier to see and mark as opposed to those points plotted as 'dots', though large, heavy crosses make it difficult for examiners to determine whether the plotted points are within tolerance and risk losing credit.

05.4 Few students gained any credit on this question. Many responses incorrectly described the change in volume of gas evolved rather than the change in the rate of the reaction. Those students who gained one mark usually did so by identifying the point at which the rate of reaction became zero (read from their graph). However, some students used the figure from Table 2 (120 seconds) to identify when the reaction stopped, which did not reflect the time indicated by their graph, so consequently gained no credit.

05.5 In this question more than a third of students gained some credit for their response, however, only about 1% of students obtained all 3 marks. Very often students would answer in terms of the reaction getting faster (rather than slower), 'the particles gain more energy and move about faster causing more frequent collisions' or would give a detailed answer covering all aspects of the collision theory rather than explaining the rate changes for the reaction given in the question.

Some students did not gain the last marking point because they referred to both reactants being 'used up' at the end of the reaction rather than just one reactant or it being a limiting factor.

Answer 05 · 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.

5.4.2.1 Reactions of acids with metals

Answer 05 · 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.

Answer 06 · Examiner comments November 2021 | 8464/C/2H | Original Q1

Question 1 (standard demand)

The variables were rarely correctly identified. Well over half of the students did not score any marks. No credit was given for the use of “amount” in place of volume or mass or for simply stating magnesium or hydrochloric acid unqualified.

The graphs were accurately plotted and a reasonable line of best fit drawn which needed to include the given plot at (0.0)

The effect of temperature upon the rate of reaction was well known, and many scored highly on this question. When explaining how the rate of reaction is affected credit is given for the frequency of particle collisions not simply more collisions.

5.4.2.1 Reactions of acids with metals

Answer 07 · Examiner comments — November 2021 | 8464/C/2H | Original Q4

Question 4 (standard, standard / high and high demand)

Most students were successfully able to describe the general trend in the graph and account for the changes. In question 04.1, however, many failed to gain the second mark point as they did not recognise that the increase was not the same throughout the graph.

The disadvantages of phytomining compared to traditional mining tended to focus on pollution, carbon dioxide emissions and global warming as a result of the combustion of the plants. This did not gain credit as traditional mining methods also lead to a similar increase in the gas.

Students approached the calculation in question 04.6 using a variety of methods, which is to be encouraged. A significant number merely calculated the difference in mass rather than energy. Marking point 5 was awarded for an answer to a calculation using the data provided, given to 3 significant figures.

Answer 08 · Examiner comments — June 2022 | 8464/C/1H | Original Q3

Question 3 (Standard demand)

03 This question discriminated well with nearly 60% of students achieving level two or above. It was based upon Required Practical Activity 10. Students needed to plan an investigation to find the order of reactivity of three metals using the temperature change recorded when each metal reacts with hydrochloric acid.

To access level 3, the method would lead to a valid outcome. This required students controlling variables such as the mass of metal and the volume of acid reacting, determining a temperature change having recorded the initial and final temperatures and repeating the method for each metal.

To access level 2 the method would not necessarily lead to a valid outcome. Students were generally good at providing practical details. The main oversights that prevented a valid outcome were the measurement of starting temperature and/or controlling the mass of metal. Students should be encouraged to state volumes and masses as most creditworthy

Answer 08 · Examiner comments — June 2022 | 8464/C/1H | Original Q3

responses regarding the control of volume and mass did so by stating a value and then repeating with the other metals. Weaker responses gained credit for either correctly identifying apparatus or for explaining the link between expected results and the reactivity of the metal.

5.4.2.1 Reactions of acids with metals

Answer 09 · 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 10 · Examiner comments June 2023 | 8464/C/1H | Original Q6

Question 6 (standard/high and high demand)

06.1 Students found difficulty in describing how to obtain magnesium chloride from the reaction solution. Just over one third of students gained at least one mark. A number of students did not filter out the excess magnesium before crystallising the solution and many referred to magnesium displacing hydrogen.

06.2 A common response was that magnesium displaces the hydrogen without any explanation; many students did not appreciate that this is a redox reaction. Students should realise that metals always undergo oxidation which can be related to dot and cross diagrams in ionic bonding. In this question identifying what is oxidised (ie the metal) is easier than identifying what is reduced ie H+ ion (not hydrogen). Magnesium is oxidised during the reaction with hydrochloric acid as magnesium atoms lose two electrons. Students found it challenging to describe what happens to the magnesium atoms with only a quarter gaining more than one mark. Many students who stated that magnesium atoms were oxidised then went on to state it was because they gained oxygen. A common mistake was to say that atoms (not electrons) were lost.

06.3 Students found this calculation challenging but the question proved to be a good discriminator. A third of students gained at least one mark for initially calculating the number of moles of magnesium. About 20% went on to calculate the mass of magnesium chloride produced as 2.85 grams. Only a small percentage of students then went on to determine the concentration of the magnesium chloride solution produced; students struggled with the conversion of 100 cm^3 into dm^3 so a wide variety of answers were seen where a mass of 2.85 grams had been multiplied by ‘some factor of 10’.

Answer 11 · 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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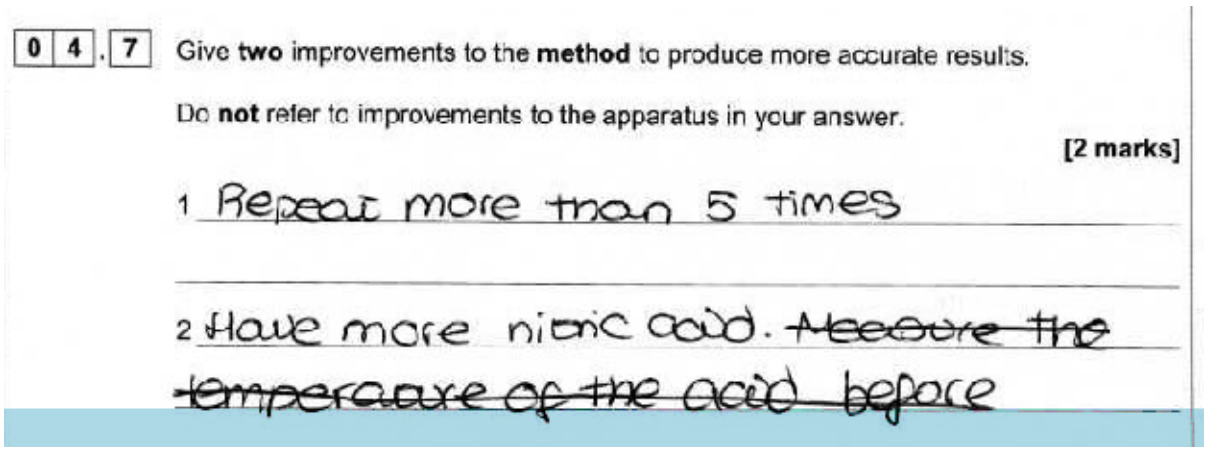
5.4.2.1 Reactions of acids with metals

Answer 11 · 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.


0 4 . 7 Give **two** improvements to the **method** to produce more accurate results.

Do **not** refer to improvements to the apparatus in your answer.

[2 marks]

1 Repeat more than 5 times

2 Have more nitric acid. ~~Measure the temperature of the acid before~~

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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5.4.2.1 Reactions of acids with metals

Answer 12 · Examiner comments

June 2025 | 8464/C/2H | Original Q5

Question 5 (Standard, Standard/High and High demand)

05.1 This question was answered well by half of all students. The most common incorrect link to time taken was 'time taken for reaction to go cloudy'.

05.2 Although a significant number of students recognised that sulfur was formed and is a solid, they often then linked sulfur dioxide bubbling through the solution as a contributory factor causing the cross to become obscured thus not accessing full marks. Another common error was mistaking S for sodium rather than sulfur.

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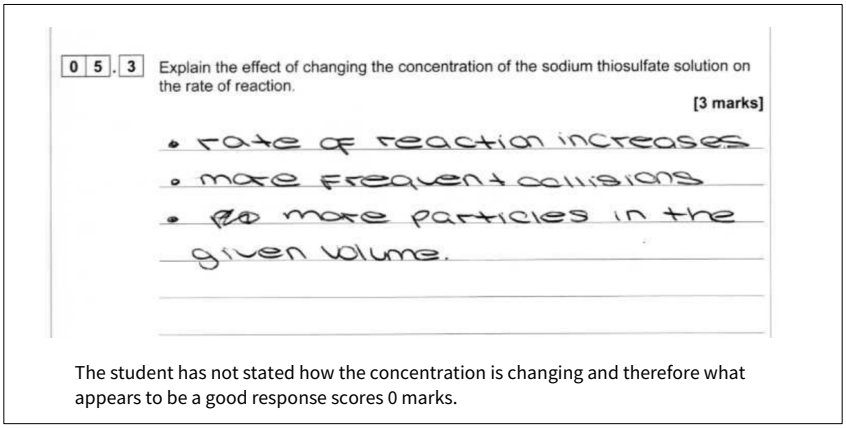
5.4.2.1 Reactions of acids with metals

Answer 12 · Examiner comments June 2025 | 8464/C/2H | Original Q5

05.3 Several students misinterpreted this question and simply stated 'changing the concentration' without clarifying whether they meant 'increasing' or 'decreasing'. This resulted in them not having access to any of the marks.
Those who did achieve credit mainly did so by correctly linking the directional change in concentration to a directional change in rate of reaction and then linking this to an appropriate description of frequency of collisions. Descriptions of 'more particles per unit volume/ in the same volume' were rarely seen, with many students simply stating 'more particles'.


0 5 . 3 Explain the effect of changing the concentration of the sodium thiosulfate solution on the rate of reaction.

[3 marks]

- rate of reaction increases
- more frequent collisions
- more particles in the given volume.

The student has not stated how the concentration is changing and therefore what appears to be a good response scores 0 marks.

05.4 The majority of students did not recognise that the reaction would start immediately and that some gas would inevitably escape from the conical flask. They therefore answered in terms of an absolute such as 'to stop gas escaping' or 'to prevent the gas escaping' rather than expressing the fact that the insertion of the bung would 'minimise' or 'reduce' the volume of gas lost. Consequently, very few students gained this mark.

05.5 Over half of students answered this question well, however there was a significant number who mixed up the standard tests for hydrogen and oxygen giving perfect answers but for the wrong gas.

05.6 More students attempted this question than in previous years. Where a tangent was drawn further marks were nearly always achieved.
Common errors included misreading the scales to calculate the *x*-step or *y*-step, using these figures incorrectly (change in *x*/change in *y*), or simply trying to calculate the gradient from a single point (often 56,75).