AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.2.2.2

State symbols

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**6**
Available paper years	**2018–2025**

Using this booklet

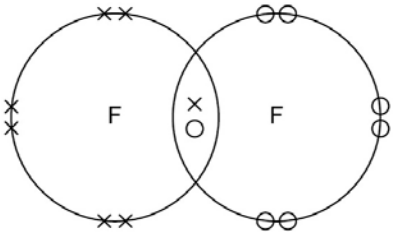
1. Booklet answer numbers match the question booklet.
2. Use the original question number within marking tables.
3. Examiner comments are included where available.

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.

5.2.2.2 State symbols

Answer 01 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	g	do **not** accept upper case (G) do **not** accept gas	1	AO1 5.1.2.6
04.2		one shared pair anywhere in overlap between two circles **or** on intersection 6 other electrons on each atom allow dots **or** crosses **or** mixture for all marks ignore any inner shell electrons	1 1	AO1 5.1.2.6 5.2.1.4 AO2 5.1.2.6 5.2.1.4
04.3	18		1	AO2 5.1.1.5 5.1.2.6
04.4	$AlBr_3$ **2** Al + **3** Br_2 (→ 2 $AlBr_3$)	ignore state symbols ignore charges ignore brackets as eg $Al(Br)_3$ allow **1** mark for balancing their equation with an incorrect product	 1 1	AO2 5.1.1.1 5.1.2.6

5.2.2.2 State symbols

Answer 01 · Mark scheme

June 2018 | 8464/C/1H | Original Q4

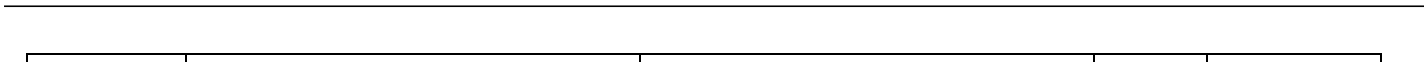
04.5		**max 2** if outer shell / level not mentioned 'it' refers to chlorine allow converse reasons for bromine being less reactive		
	chlorine is a smaller atom **or** has fewer energy levels **or** outer shell closer to nucleus	ignore chlorine has fewer electrons	1	AO1 5.1.2.6
	chlorine has less shielding **or** has the greater attraction between the nucleus and the outer shell **or** incoming electron		1	AO1 5.1.2.6
	therefore chlorine can gain an electron (into the outer shell) more easily		1	AO2 5.1.2.6
		if no other marks awarded allow **1** mark for correct trend in reactivity in Group 7 do **not** accept reference to incorrect particles eg chloride atom		

Total			**9**

5.2.2.2 State symbols

Answer 01 · Mark scheme

June 2018 | 8464/C/1H | Original Q4



5.2.2.2 State symbols

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

5.2.2.2 State symbols

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

5.2.2.2 State symbols

Answer 02 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.2.2.2 State symbols

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

5.2.2.2 State symbols

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 → 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**	

5.2.2.2 State symbols

Answer 03 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.2.2.2 State symbols

Answer 04 · Mark scheme

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

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

5.2.2.2 State symbols

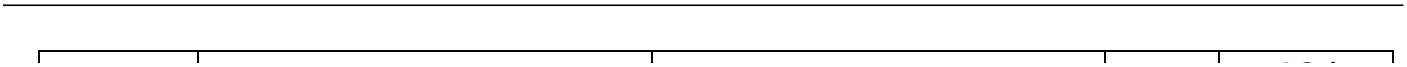
Answer 04 · Mark scheme

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**	

5.2.2.2 State symbols

Answer 04 · Mark scheme

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



5.2.2.2 State symbols

Answer 05 · Mark scheme

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	halogens		1	AO1 5.1.2.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	all have 7 electrons in <u>outer</u> shell **or** all have 7 <u>outer</u> electrons	allow energy level for shell allow same number of <u>outer</u> electrons allow one electron required to complete the <u>outer</u> shell	1	AO1 5.1.2.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	Cl_2O_7		1	AO2 5.2.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	*y*-axis scale correct from –100 to –250 °C bar correctly plotted at –220 °C	 allow a tolerance of ± ½ a small square	1 1	AO2 5.1.2.6

5.2.2.2 State symbols

Answer 05 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5		allow converse explanation in terms of decreasing melting point		
	(the) molecules increase in size going down the group	allow atoms increase in size going down the group allow increase in number of electron shells going down group	1	AO3
	(so the) forces between the molecules increase **or** (so the) intermolecular forces increase		1	AO1
	(so the) melting points increase going down the group **or** (so the) melting points increase with increasing relative atomic mass	allow (so) more energy is needed to separate the molecules	1	AO1 5.1.2.6 5.2.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	(s)		1	AO3 5.1.2.6 5.2.2.1 5.2.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.7	condensation	allow condensing ignore evaporating and boiling	1	AO1 5.2.2.1

Total Question 4		10

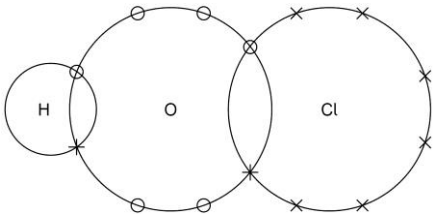
5.2.2.2 State symbols

Answer 06 · Mark scheme

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		

5.2.2.2 State symbols

Answer 06 · 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

5.2.2.2 State symbols

Answer 01 · Examiner comments

June 2018 | 8464/C/1H | Original Q4

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

04.1 Students did not answer this question as well as expected. They were either not aware that chlorine was a gas or were not familiar with state symbols, as answers other than (s), (l) (g) or (aq) were frequently seen. Some wrote the word 'gas' in the space. 36% of students answered correctly.

04.2 This question was very well answered with 64% of students achieving full marks. Students showed a good understanding of the number of electrons involved in this example of covalent bonding, by ensuring that they had two electrons in the overlap area and six other electrons in the energy level of each fluorine.

A common mistake was to include two electrons in the overlap, but still included the seven electrons each fluorine originally contained in the level outside the overlap.

04.3 48% of students selected the correct answer to this question. The question followed the diagram of a fluorine (F_2) molecule in question **04.2** and focussed on this species.

A significant number of students incorrectly selected '9' as their response, which is the number of electrons in one fluorine atom.

04.4 Students are expected to represent the electronic structures of the first 20 elements of the periodic table and to predict and explain reactions of elements from their position in the periodic table.

A small number of students were able to state the correct formula, $AlBr_3$, with AlBr and $AlBr_2$ being the most common incorrect formulae. But, students did show a good understanding of balancing equations, in this case based upon their wrong formula for aluminium bromide. 68% of students achieved a single mark.

04.5 This question was not answered well, with 8% of students achieving three marks for the explanation that included:

- comparative size of atoms
- comparative difference in attraction
- the ease of which an electron was gained.

This last point was the one that was seen the least and the word 'outer' (shell or level) was omitted in a lot of answers.

Often students would repeat the question stem in terms of chlorine and bromine's reactivity without relating it to the whole of Group 7 and in many instances referring to the reactivity series (of metals).

5.2.2.2 State symbols

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.

5.2.2.2 State symbols

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.

5.2.2.2 State symbols

Answer 05 · Examiner comments

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

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

04.1 Approximately 70% of students could correctly identify Group 7 elements as the halogens.

04.2 Just over half of students stated that Group 7 elements react in similar ways because they all have 7 electrons in their outer shell. Many omitted the word outer which was a requirement for the mark.

04.3 Just under a third of students were able to deduce the molecular formula of Cl_2O_7 from the diagram of a molecule of a chlorine oxide. Students need to ensure that subscript numbers can be distinguished as such.

04.4 Nearly 70% students of students were able to gain both marks for completing the scale of the *y*-axis and drawing a bar at –220 °C for the melting point of fluorine. A significant minority failed to score the first marking point as the scale was not completed to minus 250 °C.

04.5 Very few students gained 3 marks. More than 60% gained 1 mark, usually for stating that the melting points increase going down Group 7. However students were unable to explain that this is because the molecules increase in size going down the group and the intermolecular forces increase, with only a small number of students gaining any further marks.

04.6 Just over 40% of the students deduced that bromine is a solid at –220 °C. Liquid proved to be a popular distractor.

04.7 Just under 40% of students knew that condensation happens at the surface of bromine at its boiling point.

5.2.2.2 State symbols

Answer 06 · 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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5.2.2.2 State symbols

Answer 06 · 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

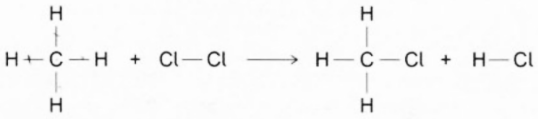


Table 4 shows the bond energies.

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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