AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.1.1.7

Electronic structure

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.

5.1.1.7 Electronic structure

Answer 01 · Mark scheme

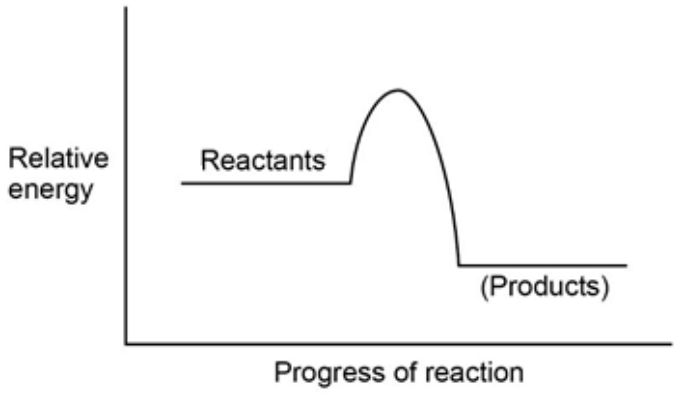
June 2018 | 8464/C/1H | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	(difference) sodium has one and chlorine has seven electrons in outer level / shell **or** number of electrons	number of electrons must be correct if quoted	1	AO2 5.1.1.7 5.1.2.1
	(similarity) both have three / same number of levels / shells **or** have electrons in third level / shell **or** both have incomplete (outer) levels / shells	allow both have 2 electrons in inner shell **or** both have 8 electrons in second shell **or** both are one electron away from full outer level / shell	1	
02.2		allow marks from suitable diagram(s)		AO1 5.2.1.2
	sodium (atom) loses	allow moves / transfers for loses do **not** accept sodium ion loses	1	
	one (outer shell electron)		1	
	chlorine (atom) gains	do **not** accept chloride	1	
	one (electron)		1	
		transfer of 1 electron from chlorine to sodium **max 2** marks		
		reference to sharing **or** covalent bonding **max 3** marks		

5.1.1.7 Electronic structure

Answer 01 · Mark scheme

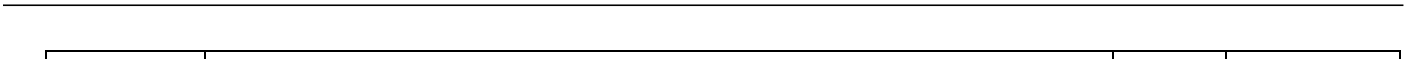
June 2018 | 8464/C/1H | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3		ignore labels any curve / line going up and then down products line below reactants allow curve to start / finish anywhere along reactant / product lines	1 1	AO1 5.5.1.2
Total			8	

5.1.1.7 Electronic structure

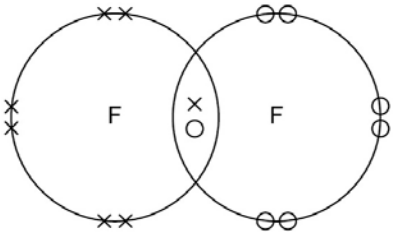
Answer 01 · Mark scheme

June 2018 | 8464/C/1H | Original Q2



5.1.1.7 Electronic structure

Answer 02 · Mark scheme June 2018 | 8464/C/1H | Original Q4

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

5.1.1.7 Electronic structure

Answer 02 · Mark scheme

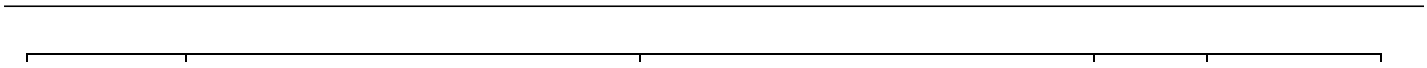
04.5		**max 2** if outer shell / level not mentioned 'it' refers to chlorine allow converse reasons for bromine being less reactive		
	chlorine is a smaller atom **or** has fewer energy levels **or** outer shell closer to nucleus	ignore chlorine has fewer electrons	1	AO1 5.1.2.6
	chlorine has less shielding **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**

5.1.1.7 Electronic structure

Answer 02 · Mark scheme

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



5.1.1.7 Electronic structure

Answer 03 · Mark scheme June 2019 | 8464/C/1H | Original Q4

04.1	atomic weight	do **not** accept atomic mass or A_r	1	AO1 5.1.2.2

04.2	left gaps / spaces **or** changed the order based on atomic weights	 allow placed them in correct groups according to properties do **not** accept reference to atomic number	1	AO1 5.1.2.2

04.3	weak forces between the molecules **or** weak intermolecular forces	allow weak intermolecular bonds do **not** accept incorrect references to covalent bonds	1	AO1 AO3 5.1.2.6 5.2.2.4
	(so) little energy required to overcome / break the forces between molecules **or** (so) little energy required to overcome / break the intermolecular forces	allow (so) little energy required to separate the molecules allow (so) little energy required to overcome / break the intermolecular bonds ignore less energy	1	

04.4	(the) molecules get larger going down the group (so the) forces between the molecules increase **or** (so the) intermolecular forces increase (so the) boiling points increase going down the group **or** (so the) boiling points increase with increasing relative atomic mass	allow converse explanation in terms of boiling point allow (so) more energy is needed to separate the molecules	1 1 1	AO1 AO3 5.1.2.6 5.2.2.4

04.5	2,8 (so) stable arrangement of electrons **or** (so) full outer shell	allow diagram or description	1 1	AO1 5.1.2.4

04.6	$\frac{1}{40} \times 6.02 \times 10^{23}$ **or** $0.025 \times 6.02 \times 10^{23}$ 1.51×10^{22}	an answer of 1.51×10^{22} scores **2** marks allow 1.505×10^{22}	 1 1	AO2 5.3.2.1

Total			**11**

5.1.1.7 Electronic structure

Answer 03 · Mark scheme

June 2019 | 8464/C/1H | Original Q4

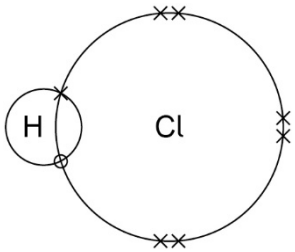
Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.1.1.7 Electronic structure

Answer 04 · 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

5.1.1.7 Electronic structure

Answer 04 · 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

5.1.1.7 Electronic structure

Answer 04 · 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

Answer 05 · Mark scheme

June 2023 | 8464/C/1H | Original Q4

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	electron → proton → neutron		1	AO1 5.1.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	(times heavier =) $\frac{1.673 \times 10^{-27}}{9.109 \times 10^{-31}}$ = 1837	 allow 1836.645076 correctly rounded to at least 3 significant figures	1 1	AO2 5.1.1.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	46		1	AO2 5.1.1.5

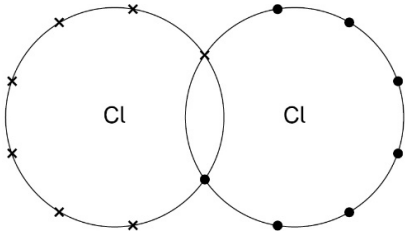
Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	36		1	AO2 5.1.1.4 5.1.1.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	(A_r =) $\frac{(35 \times 75.77) + (37 \times 24.23)}{100}$ = 35.4846 = 35.48	 allow an answer correctly calculated to 2 decimal places from an incorrect calculation which uses the values in the question	1 1 1	AO2 5.1.1.6

5.1.1.7 Electronic structure

Answer 05 · Mark scheme

June 2023 | 8464/C/1H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6		allow any combination of circles, dots, crosses, $e^{(-)}$ for electrons		AO1 5.1.2.6 5.2.1.1
	one shared pair in overlap		1	5.2.1.4
	each chlorine atom with 6 non-bonded electrons (on outer shell)	ignore any inner shell electrons	1	
		the diagram below scores 2 marks  		

Total Question 4	10

5.1.1.7 Electronic structure

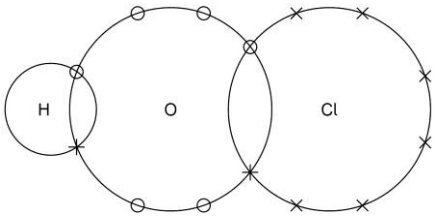
Answer 06 · Mark scheme

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		

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

5.1.1.7 Electronic structure

Answer 01 · Examiner comments

June 2018 | 8464/C/1H | Original Q2

Question 2 (standard demand)

02.1 73% of students achieved at least a mark on this question. Many could clearly see the most obvious difference and similarity in the electronic structures of sodium and chlorine. These correct answers were described in a variety ways eg different number of electrons or by stating the correct number of electrons in the outer shell. Examples of similarities related to the number of shells or completed inner energy levels.

Students often used the periodic table shown in the stem of the question to answer the question, but most of these referred to periods and groups and failed to gain marks. Students should note that there is only one 'outer' shell or level.

02.2 This question was well answered with 63% of students achieving all four marks, often with concise statements.

Some students contradicted their description by mentioning covalent, the incorrect type of bonding, or the sharing of electrons, which restricted the number of marks they could attain.

Students need to use scientific terminology accurately. Ionic bonding occurs when a metal transfers its electron(s) to a non-metal (loss and gain of electrons). Whereas covalent bonding involves non-metals sharing electrons, which results in the formation of covalent bonds.

02.3 67% of students achieved both marks, although it was common for students to have incomplete diagrams, by failing to include a horizontal for the products side. Some students confused the two types of energy changes (endothermic and exothermic), while others provided a wide range of incorrect diagrams.

Answer 02 · 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).

5.1.1.7 Electronic structure

Answer 03 · Examiner comments

Question 4

Most of this question was at standard/high demand.

04.1 Scientists' use of atomic weight to arrange elements in early periodic tables was not well known. Far too many students did not fully appreciate the historical nature of the question and provided concepts that were not known at the time, such as atomic number and electrons.

04.2 Over half the entry gave a correct reason. Large numbers of students appreciated that Mendeleev left gaps or grouped elements with similar properties. Changing the order based upon atomic weights was correct but less common.

04.3 Only the higher-attaining students were able to explain that halogens have low boiling points because of weak intermolecular forces. It is these forces that are overcome when a 'little energy' is applied; less energy did not gain this mark, as less does not necessarily equate to little. Many students answered this question incorrectly in terms of the covalent bonds within the halogens. A lot of students linked the listed values to reactivity within group 7.

5.1.1.7 Electronic structure

Answer 03 · Examiner comments June 2019 | 8464/C/1H | Original Q4

04.4 The concept of intermolecular forces and the fact that the intermolecular forces increase because the molecules got larger was rarely seen in explanations. Many students gained a mark for stating that the boiling points increased down the group; down the table or periodic table did not gain this mark. Students commonly tried to explain a trend in reactivity down the group and attempted to link that to boiling points. Some struggled with negative temperatures.

04.5 Most students were able to state that neon's outer shell was full. Many did not gain the second mark by not giving the electronic structure of neon.

04.6 A third of students calculated the correct answer for 2 marks. Many were confused by standard form, with only a few students making slight calculation errors.
Most wrong answers came from either dividing the Avogadro number by 0.025 (the number of moles) or from multiplying by 40; they did not appreciate that 1g of argon is less than 1 mole of argon so the answer to this question must be less than 6×10^{23}

Answer 04 · 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.

5.1.1.7 Electronic structure

Answer 05 · Examiner comments

June 2023 | 8464/C/1H | Original Q4

Question 4 (standard and standard/high demand)

04.1 Nearly half of the students correctly selected the order of discovery of the electron, proton and neutron. A third of students thought that the proton was discovered before the electron and chose the fourth option.

04.2 Just over a third of students calculated the number of times a proton is heavier than an electron. Most students were able to correctly round their answers to 3 significant figures although those who gained 1 mark invariably evaluated the ratio correctly but then incorrectly rounded the answer (1836.645076) usually by 'truncating' this to 1836. The most common error here was to invert the mathematical expression.

04.3 More than three-quarters of students deduced the number of neutrons in the bromine $^{81}_{35}Br$ atom.

04.4 Only 20% of students deduced the number of electrons in the bromide $^{81}_{35}Br^-$ ion. The majority gain the number of electrons in a bromine atom.

04.5 This question was a good discriminator. Just under a third of students gained all 3 marks with a few students gaining 2 of the 3 marks for not giving their answer to 2 decimal places.

04.6 More than three-quarters of students correctly drew a dot and cross diagram for chlorine. When only one mark was gained this was usually for the two shared electrons in the overlap between the atoms. Some failed to show that there are six unshared electrons on each chlorine atom.

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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5.1.1.7 Electronic structure

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

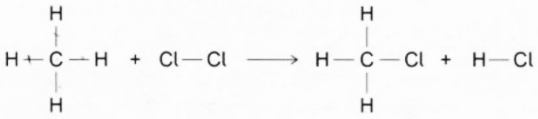


Table 4 shows the bond energies.

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 = 346 + 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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