AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.2.1.4

Covalent bonding

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**12**
Available paper years	**2008–2025**

Using this booklet

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

Name: _____ **Date:** _____

Where a precise marking extract is unavailable, the full source document is included in an appendix. Any missing mark scheme is explicitly identified.

4.2.1.4 Covalent bonding

Answer 01 · Mark scheme June 2008 | CHY1H | Original Q7 | Legacy

question	answers	extra information	mark
7(a)	any **two** from:	asks for cause therefore no marks for just describing the change must link reason to a correct change in a gas	2
	carbon dioxide has decreased due to: • plants / micro organisms / bacteria / vegetation / trees	accept idea of 'used' to indicate a decrease	
	• photosynthesis	ignore respiration	
	• 'locked up' in (sedimentary) rocks / carbonates / fossil fuels		
	• dissolved in oceans	ignore volcanoes	
	oxygen has increased due to: • plants / bacteria / micro organisms / vegetation / trees	accept idea of 'given out / produced'	
	• photosynthesis	ignore respiration	
	nitrogen increased due to: • ammonia reacted with oxygen	accept idea of 'given out / produced'	
	• bacteria / micro organisms	ignore (increase in) use of fossil fuels / deforestation	
7(b)	(because methane's) boiling point is greater than the average / surface temperature **or** Titan's (average / surface) temperature is below methane's boiling point	ignore references to nitrogen **or** water	1
	any methane that evaporates will condense	accept boils for evaporates accept cooling and produce rain for condensing	1

Question 7 continued on next page…

4.2.1.4 Covalent bonding

Answer 01 · Mark scheme

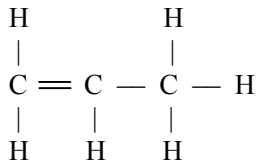
COMPONENT NUMBER: CHY1H

COMPONENT NAME: Science B / Chemistry

STATUS: Final

DATE: June 2008

Question 7 continued…

question	answers	extra information	mark
7(c)(i)		bonds must be displayed correctly ignore bond angles	1
7(c)(ii)	poly(propene) / polypropene / polypropylene any **two** from: • double bonds open up / break / become single • propene molecules / monomers / they join / undergo addition polymerisation • form chains / long molecules	do **not** allow polypropane correct chemical equation gains **2** marks ignore large using monomer incorrectly max **2** marks	1 2
Total			**8**

4.2.1.4 Covalent bonding

Answer 02 · Mark scheme

November 2009 | CHY1BP | Original Q4 | Legacy

No matching mark scheme was available in the supplied archive for this question.

4.2.1.4 Covalent bonding

Answer 03 · Mark scheme

June 2010 | CHY1H | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)	it is a mixture (of hydrocarbons) **or** contains hydrocarbons with different boiling points	accept 'to separate (crude) oil (into fractions) **or** obtain the naphtha (fraction) accept to get useful products ignore removal of impurities	1
6(b)(i)	heat / vaporise	mention of hydrogen = max **1** accept thermal (decomposition) for heat allow boil do not allow temperatures below 100°C ignore steam	1
	catalyst	allow alumina / porous pot ignore other catalysts	1
6(b)(ii)	4 × C – H **and** C = C	ignore brackets with or without an 'n' before them do not allow poly(ethene)	1

Question 6 continues on the next page

4.2.1.4 Covalent bonding

Answer 03 · Mark scheme

June 2010 | CHY1H | Original Q6 | Legacy

question	answers	extra information	mark
6(c)	any **four** from: **must** be at least **one** advantage and **one** disadvantage for all four marks <u>crops</u> advantages eg: • renewable (resource) / sustainable • low / less energy / fuel needed for process **or** lower temperature [ignore heat or quoted temperatures] • can use waste plant / crop material • carbon neutral • low safety risk (processes) • low technology disadvantages eg: • batch process / process is slow • many steps in the process • ethanol is impure / may contain water • food shortages • need very large areas of (arable) land to grow crops **or** can only grow in certain areas / climates • destruction of woodland / habitat • slow growth of crops • labour intensive a conclusion with a reasoned argument based on	ignore ideas about carbon dioxide formation / photosynthesis or cost / economics / environmentally friendly candidates are only awarded **1** mark if they use equivalent pairs of bulleted points <u>crude oil</u> disadvantages eg: • *non*-renewable (resource) / finite / running out • high / more energy needed for process **or** higher temperature • not carbon neutral **or** releases locked up carbon • high safety risk (process) • high technology • risk of major oil spillage • can be used to make other products advantages eg: • continuous process / process is fast • few steps in the process • ethanol is pure • 'conserves' food • can accept reverse arguments there must be at least one advantage and one disadvantage, however, a	4

4.2.1.4 Covalent bonding

	valid advantages **and** disadvantages	matched pair, although only awarded one mark would allow the conclusion mark to be awarded	1
Total			**9**

4.2.1.4 Covalent bonding

Answer 04 · Mark scheme

January 2011 | CHY2H | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)(i)	less drying time **and/or** less soaking time	allow it is quicker / faster allow converse if they state water	1
6(a)(ii)	forces of attraction / bonds between molecules are weak (owtte) **or** intermolecular forces / bonds are weak (owtte)	do not accept intramolecular forces / covalent bonds are weak forces of attraction are weak (without specifying between molecules / intermolecular) gains **1** mark (accept easily broken / not much energy needed to break instead of weak) bonds are weak without specifying intermolecular would **not** gain a mark and would be ignored. made of small molecules / simple molecular gain **1** mark an answer such as, it is made of small molecules with weak forces of attraction, would gain **2** marks	2
6(b)(i)	exothermic reaction (owtte)	accept answers based on Le Chatelier eg when temperature is low the reaction moves to increase the temperature accept reverse argument	1

Question 6 continued on the next page

Question 6 contd

question	answers	extra information	mark
6(b)(ii)	fewer product molecules / particles (than reactants molecules) (owtte)	accept three molecules / particles / volumes / moles on the left and one on the right (numbers given must be correct) accept answers based on Le Chatelier eg when pressure is high, reaction moves to the side with fewest molecules / smaller volume **or** when pressure is high, reaction moves to reduce the pressure do **not** accept reference to atoms do not accept more reactants than products unless qualified	1
6(b)(iii)	any **two** from: • molecules / particles / they move faster • collide more (often) / quicker • more of the collisions are successful **or** more have the activation energy (owtte) **or** more energetic collisions	 ignore move / vibrate more allow harder collisions allow collide with more force	2
6(c)(i)	16	correct answer with or without working accept correct rounding if the answer is incorrect then check the working. for **1** mark look for correct method in one line of the working. Moles of CO = 14/28 **or** 0.5 **or** Mass of CH_3OH = 0.5 × 32 **or** 28 → 32 **or** 14 → 32/2 **or** $\frac{32}{28}\times 14$	2

4.2.1.4 Covalent bonding

Question 6 contd

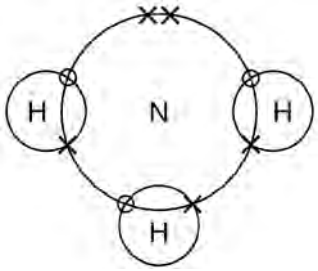
question	answers	extra information	mark
6(c)(ii)	75	correct answer with or without working allow correct answer with ecf from (c)(i) for **2** marks if the answer is incorrect $\frac{12}{16}\times 100$ **or** $\frac{12}{\text{their (c)(i)}}\times 100$ gains **1** mark **OR if working from 18 g** 66.6 recurring or correctly rounded to a max of 67 = **2** marks incorrect rounding eg 66 = **1** mark **or** $\frac{12}{18}\times 100$ gains **1** mark	2
6(c)(iii)	reversible reaction **or** not all reactants converted to product (owtte) **or** other sensible reason such as: loss of product / reactant **or** impurities in reactants **or** side reactions / other products **or** temperature too high / pressure too low	 allow 'it did not all react' allow gas is lost ignore mass lost ignore some is lost	1
Total			**12**

4.2.1.4 Covalent bonding

Answer 05 · Mark scheme

June 2019 | 8462/1H | Original Q5

Question 5

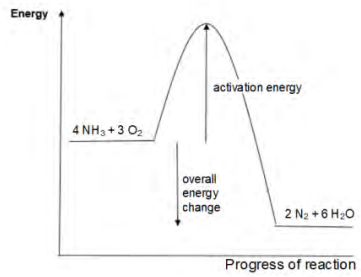
Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1		 scores **2** marks allow dots, crosses, circles or $e^{(-)}$ for electrons		AO1 4.2.1.4
	1 bonding pair of electrons in each overlap		1	
	2 non-bonding electrons on nitrogen	do **not** accept non-bonding electrons on hydrogen ignore inner shell electrons drawn on nitrogen	1	
05.2	does not show the shape **or** only two-dimensional	allow is not three-dimensional	1	AO1 4.2.1.4
05.3	(ammonia has) small molecules	allow (ammonia has) a simple molecular (structure)	1	AO1 4.2.2.1 4.2.2.4
	(ammonia has) weak intermolecular forces	allow (ammonia has) weak intermolecular bonds do **not** accept weak covalent bonds	1	
	(so) little energy is needed to overcome the intermolecular forces	allow (so) little energy is needed to break the intermolecular bonds allow (so) little energy is needed to separate the molecules do **not** accept references to breaking covalent bonds	1	

4.2.1.4 Covalent bonding

Answer 05 · Mark scheme

05.4	Cr_2O_3		1	AO2 4.1.3.2
05.5	(for bonds broken) ((12 x 391) + (3 x 498) =) 6186 (for bonds made) ((2 x 945) + (12 x 464) =) 7458 (overall energy change = 6186-7458 =) (-)1272 (kJ)	an answer of (-)1272 (kJ) scores **3** marks allow correct calculation using incorrectly calculated values from step 1 and/or step 2	 1 1 1	AO2 4.5.1.3

Question 5 continued

05.6	7458 (kJ) (released in making bonds) is greater than 6186 (kJ) (used in breaking bonds) **or** the products have 1272 (kJ) less energy than the reactants	allow ecf from question **05.5** allow the (overall) energy change is -1272 (kJ)	1	AO2 4.5.1.3
	(so) energy is released (to the surroundings)	dependent on MP1 being awarded allow (so) heat is released (to the surroundings) if no values given, allow **1** mark for more energy released in making bonds than used in breaking bonds	1	
05.7		 scores **2** marks allow discontinuous lines ignore arrow heads		AO1 4.5.1.2
	activation energy labelled		1	
	(overall) energy change labelled		1	
Total			**14**	

4.2.1.4 Covalent bonding

Answer 06 · Mark scheme

November 2020 | 8462/1H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	poly(ethene) water		1 1	AO2 4.2.1.4 4.2.2.4 4.2.2.5

Question 1 continued

Question	Answers	Mark	AO/ Spec. Ref
01.2	**Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar/different is made clear and (where appropriate) the magnitude of the similarity/difference is noted.	4–6	AO1 4.2.1.2 4.2.1.3 4.2.1.4
	Level 1: Relevant features are identified and differences noted.	1–3	
	No relevant content	0	
	Indicative content • (both) carbon dioxide and silicon dioxide are made up of atoms • (but) magnesium oxide is made up of ions • (both) silicon dioxide and magnesium oxide are giant structures • (but) carbon dioxide is small molecules • with weak intermolecular forces • all three compounds have strong bonds • (both) carbon dioxide and silicon dioxide are formed from two non-metals • (so) bonds formed are covalent • (so) electron (pairs) are shared (between atoms) • (but) magnesium oxide is formed from a metal and a non-metal • (so) bonds in magnesium oxide are ionic • (so) electrons are transferred • from magnesium to oxygen • two electrons are transferred • bonds in silicon dioxide are single bonds • (where) each silicon forms four bonds • (and) each oxygen forms two bonds • (but) in carbon dioxide the bonds are double bonds • (where) carbon forms two double bonds • (and) oxygen forms one double bond ignore properties e.g. melting point, electrical conductivity		

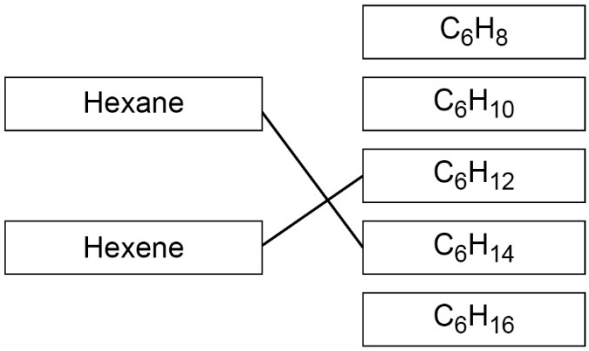
Total			8

4.2.1.4 Covalent bonding

Answer 07 · Mark scheme

November 2020 | 8462/2H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	 additional line from a box on the left negates the mark for that box		1 1	AO2 4.7.1.1 4.7.2.1
03.2	(remains) orange (becomes) colourless	must be in this order allow no (colour) change ignore initial colour ignore clear	 1 1	AO2 4.7.1.4

Question 3 (continued)

Question	Answers	Mark	AO/ Spec. Ref
03.3	**Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar/different is made clear and (where appropriate) the magnitude of the similarity/difference is noted.	4–6	AO1 AO2
	Level 1: Relevant features are identified and differences noted.	1–3	
	No relevant content	0	4.7.1.1 4.7.1.3 4.7.1.4 4.7.2.1 4.7.2.2 4.9.3.1
	Indicative content **Structure and bonding** • both are hydrocarbons • both contain two carbon atoms (per molecule) • ethane contains six hydrogen atoms (per molecule) • (but) ethene contains four hydrogen atoms (per molecule) • both have covalent bonds • ethane contains a single C—C bond • (but) ethene contains a double bond • both contain C—H bonds • both small molecules **Reactions** • both react with oxygen in complete combustion reactions • to produce water and carbon dioxide • both react with oxygen in incomplete combustion reactions • to produce water, carbon monoxide and carbon • incomplete combustion is more likely with ethene • ethene decolourises bromine water • (but) ethane does not decolourise bromine water • ethene is more reactive (than ethane) • ethene can react with hydrogen (to produce ethane) • ethene can react with water (to produce ethanol) • ethene can react with halogens (to produce halogenoalkanes) • ethene can undergo addition reactions • ethene can polymerise (to produce poly(ethene)) ignore physical properties ignore references to flammability		

Total			10

4.2.1.4 Covalent bonding

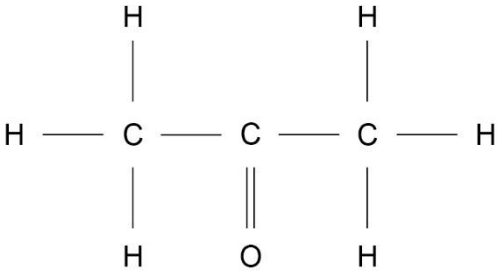
Answer 08 · Mark scheme

November 2021 | 8462/1H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	spherical	allow ball-shaped ignore round / circular	1	AO1 4.2.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	any **one** from: • drug delivery (round the body) • hydrogen storage • anti-oxidants • reduction of bacterial growth • catalysts • (cylindrical fullerenes for) strengthening materials • (spherical fullerenes for) lubricants		1	AO1 4.2.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3			1	AO2 4.2.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	C_3H_6O	allow CH_3COCH_3 allow elements in any order	1	AO2 4.2.1.4

Question 1 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	the intermolecular forces are weak		1	AO1 4.2.2.1 4.2.2.4

Question	Answers	Mark	AO/ Spec. Ref
01.6	**Level 3**: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO1 4.2.2.6 4.2.3.2
	Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	
	No relevant content	0	
	Indicative content • bonds are covalent • giant / macromolecular structure • three (covalent) bonds per carbon atom **or** only three electrons per carbon atom used in (covalent) bonds • so one electron per carbon atom (is delocalised) • these delocalised electrons • can move through the structure • carrying (electrical) charge • so graphite conducts electricity • layered structure • of (interlocking) hexagonal rings • with weak (intermolecular) forces between layers **or** no (covalent) bonds between layers • so the layers can slide over each other • so graphite is soft and slippery		

Total			**11**

4.2.1.4 Covalent bonding

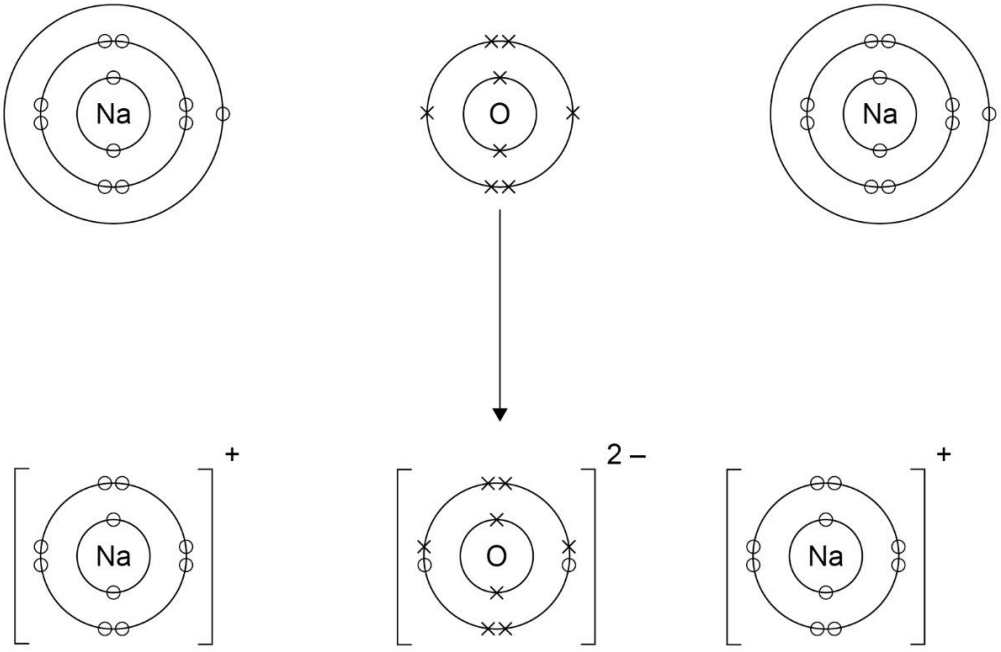
Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	any **two** from: • (potassium) floats • (potassium) melts • (potassium) moves around • potassium becomes smaller • (lilac) flame • effervescence	 allow potassium disappears allow fizzing	2	AO1 4.1.2.5 4.4.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	$2K + 2H_2O \rightarrow 2KOH + H_2$	allow multiples allow **1** mark for KOH **and** H_2	2	AO1 AO2 4.1.1.1 4.1.2.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	reactivity increases (going down the group) (because) the outer electron / shell is further from the nucleus (so) there is less attraction between the nucleus and the outer electron / shell (so) the atom loses an electron more easily	 allow (because) there are more shells allow (because) the atoms get larger allow (so) there is more shielding from the nucleus do **not** accept incorrect attractions	1 1 1 1	AO1 4.1.2.5 4.4.1.2

Question 4 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	(dot and cross diagram to show) sodium atom **and** oxygen atom	allow use of outer shells only	1	AO2 4.2.1.1 4.2.1.2
	two sodium atoms to one oxygen atom	allow two sodium ions to one oxide ion	1	
	(to produce) sodium ion with a + charge		1	
	(to produce) oxide ion with a 2– charge		1	
	 scores **4** marks			

4.2.1.4 Covalent bonding

Question 4 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	(oxygen) gains electrons		1	AO1 4.4.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	giant structure	allow (giant ionic) lattice	1	AO1 4.2.1.3 4.2.2.1
	(with) strong (electrostatic) forces of attraction between (oppositely charged) ions		1	4.2.2.3
	(so) large amounts of energy are needed to break the bonds / forces	allow (so) large amounts of energy are needed to separate the ions	1	

Total			**16**

4.2.1.4 Covalent bonding

Answer 10 · Mark scheme

June 2022 | 8462/1H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	silicon is less reactive than carbon (because) carbon displaces silicon (from silicon dioxide)	ignore references to hydrogen allow converse allow silicon is below carbon (in the reactivity series) ignore (because) carbon reduces silicon dioxide	1 1	AO3 4.4.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	more energy is needed (to obtain aluminium) (because) aluminium is obtained (from aluminium oxide) by electrolysis	ignore references to electricity	1 1	AO3 4.4.1.3 4.4.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	both products are solid		1	AO3 4.4.1.3

4.2.1.4 Covalent bonding

Answer 10 · Mark scheme

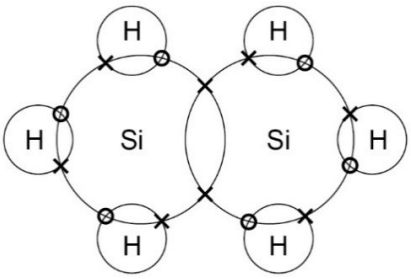
June 2022 | 8462/1H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	(M_r of SiO_2 = 28 + (2 × 16)) = 60		1	AO2 4.3.1.2 4.3.2.1 4.3.2.2
	(conversion 1.2 kg =) 1200 (g)		1	
	(number of moles of SiO_2 = $\frac{1200}{60}$) = 20	allow correct use of an incorrectly converted or unconverted mass of SiO_2 allow correct use of an incorrectly calculated M_r of SiO_2	1	
	(number of moles of Mg = 20 × 2) = 40	allow correct use of an incorrectly calculated number of moles of SiO_2	1	
	(mass of Mg = 40 × 24) = 960 (g)	allow correct use of an incorrectly calculated number of moles of Mg	1	
	alternative approach:			
	(M_r of SiO_2 = 28 + (2 × 16)) = 60 (1)			
	48 g Mg reacts with 60 g SiO_2 (1)	allow correct use of an incorrectly calculated M_r of SiO_2		
	(conversion 1.2 kg =) 1200 (g) (1)			
	48 × $\frac{1200}{60}$ (g Mg reacts with 1200 g SiO_2) (1)	allow correct use of an incorrectly calculated mass of Mg and / or incorrectly converted or unconverted mass of SiO_2		
	= 960 (g) (1)			

4.2.1.4 Covalent bonding

Answer 10 · Mark scheme

June 2022 | 8462/1H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5		allow any combination of x, •, o, $e^{(-)}$ for electrons	1	AO2 4.2.1.4

4.2.1.4 Covalent bonding

Answer 10 · Mark scheme

June 2022 | 8462/1H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.6	(volume of oxygen for 30 cm^3 Si_2H_6 = 3.5 × 30) = 105 (cm^3)		1	AO2 4.3.2.4 4.3.5
	(volume of excess oxygen = 150 – 105) = 45 (cm^3)	allow correct use of an incorrectly calculated volume of oxygen for 30 cm^3 Si_2H_6	1	
	(volume of water (vapour) = 3 × 30) = 90 (cm^3)		1	
	(volume of gases = 45 + 90) = 135 (cm^3)	allow correct use of incorrectly calculated volumes of excess oxygen and / or water vapour	1	
	allowed alternative approach: (moles Si_2H_6 = $\frac{0.03}{24}$ =) 0.00125 (1)			
	(moles water vapour formed = 3 × 0.00125 =) 0.00375 **and** (moles oxygen used = 3.5 × 0.00125 =) 0.004375 (1)	allow correct use of an incorrectly calculated number of moles of Si_2H_6		
	(moles excess oxygen = $\frac{0.15}{24}$ - 0.004375 =) 0.001875 (1)	allow correct use of an incorrectly calculated number of moles of oxygen used		
	(volume of gases = 24 × (0.00375 + 0.001875) = 0.135 dm^3 =) 135 (cm^3) (1)	allow correct use of an incorrectly calculated number of moles of excess oxygen and / or moles of water vapour formed		

Total Question 7		15

4.2.1.4 Covalent bonding

Answer 11 · Mark scheme

June 2023 | 8462/1H | Original Q4

Question 4

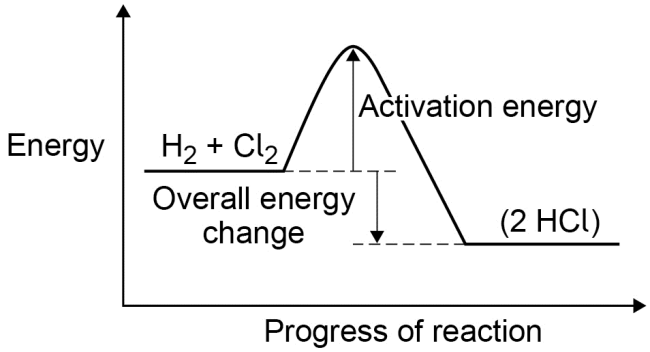
Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	436 + 346 − (2 × 432) kJ/mol		1	AO2 4.5.1.3

Question	Answers	Extra	Mark	AO / Spec. Ref.
04.2	energy is needed to break bonds **and** energy is released when bonds form		1	AO1 4.5.1.3
	(and) the energy released is greater than the energy needed	allow the energy transferred in bond making is greater than the energy transferred in bond breaking allow 2 x 432 (kJ/mol) is greater than 436 + 346 (kJ/mol) allow the overall energy change is negative	1	

4.2.1.4 Covalent bonding

Answer 11 · Mark scheme

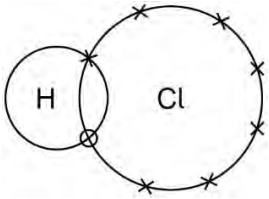
June 2023 | 8462/1H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3		ignore arrow heads		
	profile completed with product energy below reactant energy		1	AO1
	activation energy labelled from reactant energy to top of curve		1	AO1
	overall energy change labelled from reactant energy to product energy		1	AO2
				4.5.1.2
	an answer of 			
	scores **3** marks			

4.2.1.4 Covalent bonding

Answer 11 · Mark scheme

June 2023 | 8462/1H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4		allow any combination of x, o, $e^{(-)}$, • for electrons do **not** accept molecules containing more than 2 atoms		AO1 4.2.1.4
	bonded pair of electrons in the overlap		1	
	chlorine with 6 non-bonded electrons	do **not** accept if extra electrons on H an answer of  scores **2** marks **or** an answer of  scores **2** marks	1	

4.2.1.4 Covalent bonding

Answer 11 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	(methane) methane has (much) smaller molecules		1	AO1 4.2.2.4 4.2.2.5
	(so) has weaker intermolecular forces	do **not** accept reference to weak(er) covalent bonds	1	
	(so the intermolecular forces) need less energy to overcome	do **not** accept reference to breaking covalent bonds	1	
	(so) the boiling / melting point is lower (and methane is a gas)		1	
	OR			
	(poly(ethene))			
	poly(ethene) has (much) larger molecules (1)			
	(so) has stronger intermolecular forces (1)	do **not** accept reference to weak(er) covalent bonds		
	(so the intermolecular forces) need more energy to break (1)	do **not** accept reference to breaking covalent bonds		
	(so) the melting / boiling point is higher (and poly(ethene) is a solid) (1)			

Total Question 4	12

4.2.1.4 Covalent bonding

Answer 12 · Mark scheme

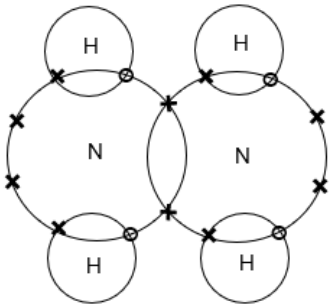
June 2025 | 8462/1H | Original Q7

Question 7

Question	Answers	Mark	AO / Spec. Ref.
07.1	**Level 2:** A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.	3–4	AO3 4.5.2.2
	Level 1: Some logically linked reasons are given. There may also be a simple judgement.	1–2	
	No relevant content	0	
	Indicative content • hydrazine is liquid so easier to store / transport o because takes up less space • both have significant dangers • both produce harmless products • hydrazine produces a higher voltage so fewer cells will be needed (to produce the same voltage) o so the battery would be lighter • hydrazine needs no catalyst so costs may be less • hydrogen uses platinum as a catalyst which is a rare metal • judgement		

4.2.1.4 Covalent bonding

Answer 12 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	bonded pair of electrons in each overlap	allow any combination of x, o, $e^{(-)}$, ● for electrons	1	AO2 4.2.1.4
	each nitrogen atom with 2 non-bonded electrons	do **not** accept if extra electrons on hydrogen atom(s) MP2 is dependent upon the award of MP1 an answer of  scores **2** marks	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	(the ball and stick model) shows the shape (of the molecule) **or** (the ball and stick model) is 3-D		1	AO1 4.2.1.4

4.2.1.4 Covalent bonding

Answer 12 · Mark scheme

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Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	(bonds broken = (4 × 391) + 498 + **X** =) 2062 + **X**		1	AO2 4.5.1.3
	(bonds formed = 945 + (4 × 464) =) 2801		1	
	581 = 2801 - (2062 + **X**)	allow correct use of incorrectly determined values of bonds broken and / or bonds made	1	
	(X =) 158 (kJ/mol)		1	

Total Question 7	11

4.2.1.4 Covalent bonding

Answer 05 · Examiner comments

June 2019 | 8462/1H | Original Q5

Question 5 (standard, standard / high and high demand)

05.1 Approximately three-quarters of students were able to complete the dot and cross diagram correctly.

The mark for the bonding electrons was scored more often than the mark for the non-bonding electrons.

05.2 Only a small proportion of students were able to give a limitation of a dot and cross diagram.

The most common correct response was that the molecule was not shown in 3 dimensions.

Common responses seen that were not credited included:

- only shows the outer electrons
- does not show the structure
- does not show the intermolecular forces.

05.3 Students found this question difficult.

The mark for indicating the presence of weak intermolecular forces was most often awarded. However, some students referred to 'intermolecular forces' incorrectly, for example, weak intermolecular forces between the atoms / bonds.

A common misconception was that covalent bonds are weak and that it is these bonds that are broken when ammonia boils.

Ammonia consisting of small molecules was the mark least often awarded.

05.4 Students found identification of a metal oxide most likely to be used as a catalyst difficult.

The correct answer, the transition metal oxide, Cr_2O_3, was the most common choice of catalyst but the other 3 options were all chosen in significant numbers, especially MgO.

05.5 Approximately two-thirds of students correctly calculated the overall energy change.

The most common error was to incorrectly determine, or not determine, the number of each type of bond from the given equation.

05.6 Students found this question challenging. In particular, students did not always use values from their previous calculation as instructed in the question. A common non-scoring response was simply to define an exothermic reaction.

Few students compared their calculated values for bond breaking and bond making as was intended. Some referred in general terms to these processes but often used incorrect terms, for example, more energy was <u>needed</u> for making bonds than used for breaking bonds.

4.2.1.4 Covalent bonding

Answer 05 · Examiner comments June 2019 | 8462/1H | Original Q5

05.7 The completion of the energy profile was often done well with almost two-thirds of students scoring both marks.

Some students were imprecise with the positioning of their lines.

Other common errors included:

- Not drawing a line for activation energy, just labelling the peak.
- Drawing a line from the peak to the products line for ‘overall energy change’.

Answer 06 · Examiner comments November 2020 | 8462/1H | Original Q1

Question 1 (standard demand)

01.1 Few students scored both marks. Diamond and sodium chloride were both commonly seen incorrect responses.

01.2 Many students were unable to reach the higher marks because they did not make direct comparisons. Instead, they gave separate descriptions of the three compounds. Many also referred to the properties of the compounds, which were not required. The phrase ‘intermolecular forces’ was used indiscriminately to describe interactions between ions or in giant covalent structures, as well as between molecules.

4.2.1.4 Covalent bonding

Answer 07 · Examiner comments

November 2020 | 8462/2H | Original Q3

Question 3 (standard demand)

03.1 The vast majority of students scored both marks here. Again some reversed the responses and there was no pattern in the selection of the distractors.

03.2 Quite well answered, with the majority of students gaining at least one mark. A very wide range of colours for bromine water were seen in addition to orange, including red, yellow, brown and intermediate shades. A common error was to assert that the bromine water **becomes** orange upon addition to hexane. The difference between colourless and clear is now well understood by most.

03.3 This part was not very well answered by many, usually because they focused exclusively on structure and bonding at the expense of reactions, which could indicate that they didn't read the question carefully enough or didn't refer back to the question when constructing their response. Structure and bonding were well understood, but few of the reactions were mentioned. Additionally, students often reversed their answers because they confused ethane and ethene or the formation of their handwriting made it unclear whether a compound name ended 'ane' or 'ene'. The command word 'compare' demands that students mention both compounds to access level 2 and there were some imprecise comparisons such as 'ethane undergoes complete combustion whereas ethene undergoes incomplete combustion'. Because of these points, rather fewer than half of students were able to access level 2.

4.2.1.4 Covalent bonding

Answer 08 · Examiner comments

November 2021 | 8462/1H | Original Q1

Question 1 (standard demand)

01.1 There were many good answers but some focused on the hexagonal arrangement of bonds rather than the molecule as a whole. Others did not appear to realise the shape is three dimensional and described the molecule as a circle.

01.2 Many students knew the uses as catalysts, for drug delivery round the body, as lubricants' and for strengthening other materials. There were, however, some vague answers such as 'in medicine'.

01.3 This was well done. A few students drew double bonds between all the atoms. Some students did not appear to realise that all they had to do was copy the positions of the atoms and replace each shared pair of electrons with a line.

01.4 This was answered well, although a number of students had two oxygen atoms in their formula. A few appeared to misunderstand the question and gave the relative formula mass.

01.6 Some students gave full, detailed accounts of both properties. The reasons for the slipperiness of graphite were better understood than its electrical conductivity, though many did not refer to the weakness of the forces between the layers. There was some poor use of language in the description of the structure, with atoms, molecules and ions being used interchangeably. A fairly common misconception is that there are gaps between the layers, allowing 'electricity' to somehow slip through. Many students did not seem to appreciate that the electric current is delocalised electrons themselves flowing through the structure.

4.2.1.4 Covalent bonding

Answer 09 · Examiner comments

November 2021 | 8462/1H | Original Q4

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

04.1 Many students remembered that effervescence would be seen, but there were many vague descriptions such as ‘vigorous reaction’ which did not gain credit. Students often gave the same observation twice, eg, ‘effervescence’ and ‘bubbles’. Many students incorrectly mentioned a colour change, perhaps remembering a demonstration where an indicator had been added. Very few mentioned the potassium melting.

04.2 Very few students could write the formulae for the correct products. Those who could were usually able to balance the equation. Many students approached the question from the wrong direction, trying to balance the equation by inventing fictitious products.

04.3 This was not well answered, with only a small number of students scoring full marks. Many incorrectly tried to link reactivity to melting and boiling point. Many referred to the distance and / or attraction between the nucleus and electrons in general, rather than the outer electrons. Others failed to mention the nucleus at all.

04.4 The electron arrangements of both atoms and ions were required for full marks, as well as the ratio of sodium ions to oxide ions and the correct charges on the ions. Few students scored all the marks as they did not draw the atoms of sodium and oxygen before reaction. Many tried to draw covalent structures. The ratio of 2 atoms of sodium to one of oxygen was well known. Students should be aware that electrons cannot be in two places at the same time and should not be drawn as if they are. Some students drew both ionic and covalent structures, thereby contradicting themselves and losing the marks for a correct ionic structure. A great deal of time and effort would be saved by drawing the outer electrons only, as in the specification.

04.6 Students found this question very difficult, with many referring incorrectly to intermolecular forces, even when mentioning ions. Many also referred to covalent bonds or forces between atoms. Of those who did refer correctly to the large amounts of energy required to break the strong attractions between ions, very few referred to the giant structure of the compound.

4.2.1.4 Covalent bonding

Answer 10 · Examiner comments

June 2022 | 8462/1H | Original Q7

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

07.1 This was well answered, with more than half of students scoring both marks. There was, however, some ambiguous use of the word ‘it’ such as ‘it shows that it is below carbon because it displaces it’. If it was not clear what ‘it’ referred to, credit was not given.

07.2 Only 10% of students were awarded both marks, although nearly 60% scored at least one mark. Many students realised that aluminium is extracted by electrolysis, although some stated that aluminium would be extracted by the use of a more reactive metal. Although many mentioned the high energy cost of electrolysis, few compared electrolysis to the lower energy cost of heating coal to obtain carbon. Other students did state that extracting aluminium requires more energy than forming carbon, but did not explain why.

07.3 Many students realised that the products both being solids would make their physical separation difficult. Some appeared to misunderstandd what ‘separate’ means, and described the difficulty of decomposing magnesium oxide; this did not gain credit. Another common incorrect approach was to say that magnesium is high in the reactivity series. Whilst true, this was not relevant to the question set.

07.4 Those students who adopted a systematic approach, either using moles or reacting masses by proportion, had little difficulty in scoring most or all of the marks. In a multi-step calculation it is essential that each step is shown in the working so that marks for working can be awarded. The most common error was to use 48, instead of 24, for the M_r of Mg, giving an answer that was twice the correct value. Nearly all students carried out the unit conversion correctly. Some students calculated the correct final answer (960 g) but used an incorrect method. Such responses did not score full marks.

4.2.1.4 Covalent bonding

Answer 10 · Examiner comments

June 2022 | 8462/1H | Original Q7

07.5 This was well answered. However, there were many blank responses.

07.6 This was a high demand calculation, and students found it difficult to analyse the correct approach to take. The gas molar volume was not provided, because it was not needed. Indeed, with the water being formed as a gas, a value of 24 dm^3/mol was not correct. Even so, those students who adopted the approach of converting gas volumes to moles were given full credit if they succeeded. Few did, as a four-step calculation with simple numbers was turned into a seven-step calculation with a unit conversion by electing to follow this approach.

Students needed to use the equation to realise that the SiO_2 formed is a solid, not a gas. They were also told that the oxygen is in excess; that means that the Si_2H_6 is the limiting reactant, and that the gases after reaction would therefore be the water vapour and the remaining oxygen. All that was therefore necessary was to multiply the volume of Si_2H_6 by 3 to find the volume of water vapour formed, and by 7/2 to find the volume of oxygen used. Subtracting that volume from 150 cm^3 would then give the volume of excess oxygen, and adding the volumes of the two appropriate gases together gave the final answer. Only one sixth of students scored at least one mark, which was usually for calculating the volume of water vapour produced.

4.2.1.4 Covalent bonding

Answer 11 · Examiner comments

June 2023 | 8462/1H | Original Q4

Question 4 (standard and standard/high demand)

04.1 The great majority of students gave the correct answer, with most of the rest split evenly between the first option (adding the three bond energies together) and the third (subtracting only one H—Cl bond).

04.2 This question discriminated well and there were some excellent answers that described the energy released in making new bonds being greater than the energy required to break old bonds. However, some implied that energy is required in both steps, and others only referred to the bond making process, omitting a consideration of the bond breaking process. There were misconceptions with some students referring to gases being lost and taking energy with them, and others responding that an exothermic reaction is one that loses matter, rather than energy.

04.3 This question discriminated well; half of the students were awarded all three marks, while nearly all scored one mark. Most students drew an exothermic profile, but fewer labelled the products. Those who drew an endothermic profile could still access the second and third marking points. A few did not complete the profile so were only able to access the mark for the activation energy. There were some arrows for the activation energy and overall energy change that were untidily drawn which made it impossible to judge whether they started and finished at the correct place. This is one example where using a ruler really does help the student. A few labelled the top of the curve as the activation energy, rather than the gap between the energy of the reactants and the top of the curve.

04.4 Nearly three quarters of students scored both marks. Many fully correct diagrams were seen. The majority of students chose to use the format with a ring around each atom, but answer without rings were equally acceptable. A few students drew an extra electron on either hydrogen or carbon, and some drew ions instead of a molecule.

04.5 This question proved to be difficult, with few students giving fully correct answers to gain all 4 marks and with a third of students gaining no credit.

To answer the question, students needed to compare the size of the molecules, hence the strength of the intermolecular forces, hence the energy required to break those forces and hence the boiling/melting points. However, many students did not mention molecules at all, seeming to believe that the polymer is a giant structure. There was much confusion between bonds and intermolecular forces. Students sometimes think that by including both intermolecular forces and covalent bonds they will cover all eventualities, but this often results in contradictions which lose marks. Students often thought intermolecular forces had to be broken in methane but bonds had to be broken in poly(ethene). Many did not refer to the energy requirement or to the melting or boiling point.

4.2.1.4 Covalent bonding

Answer 12 · Examiner comments

June 2025 | 8462/1H | Original Q7

Question 7 (standard/high and high demand)

07.1 Whilst the majority of students reached level 1, only one in eight gave sufficient linked reasons to reach level 2. This was a high demand extended response question with the command word 'evaluate'. Merely making comparisons from the information in the table was insufficient to gain credit. Consequences of those comparisons were necessary to count as linked reasons. An overall judgement or several individual judgements were necessary to reach Level 2, but many answers contained no judgement at all.

Many students were able to link the states at room temperature to a consequence such as hydrazine being easier to store or transport. Many were also able to link the need for

Answer 12 · Examiner comments

a catalyst to potential extra costs. However, they had difficulty with consequences of the other information in the table. Most students do not realise that when comparing data in an AO3 question, sometimes there is no real advantage of one option over the other and that is a valid point to make. Many tried to justify why being explosive was more dangerous than being toxic or vice versa, instead of simply deducing that both were dangerous in different ways. A large proportion of students seem to think that nitrogen is harmful in some way, rather than deducing that neither fuel cell produces harmful products. Few students deduced that the larger voltage from hydrazine means that fewer fuel cells would need to be used in a battery; instead, they merely stated that more power would be produced from a single hydrazine fuel cell. Some students tried to refer to atom economy, which is not relevant in this context as there is no 'desired product'.

07.2 More than half of students scored both marks, and nearly two thirds scored at least one. A common error was to draw two pairs of electrons in the overlap between the two N atoms, despite the ball and stick model above showing all single bonds. Some miscounted the electrons on the two N atoms because they used the same symbol for the electrons from both. Some avoided this by using a combination of dots, crosses and open circles or other symbols. The question was not attempted by some students, suggesting that they did not read the question because there were no answer lines and therefore did not realise, they had to do something.

07.3 The question asked for an advantage of the ball and stick model; those answers which referred only to a disadvantage of the dot and cross diagram did not gain credit. Fewer than half gave one of the expected answers, in terms of the ball and stick model being 3-D rather than 2-D or showing the shape of the molecule. Answers that did not gain credit included the idea that the ball and stick model shows: the structure (both do); the arrangement of atoms (both do); the relative sizes of the atoms (both do), or referred to showing the atoms, rather than the molecule, in 3-D. Other vague responses such as 'better visual representation' did not gain credit.

07.4 There were many fully correct answers, with working set out clearly; nearly a half scored full marks. Those who did not complete the calculation correctly could score partial credit for working out that the energy to break bonds is 2062 + **X** kJ/mol and / or that the energy involved in forming bonds is 2801 kJ/mol. Credit was also given for correct use of incorrect values of these totals. Common errors were: leaving out the **X** for the bonds broken; ignoring the overall energy change of 581 completely; adding the 581 to the bonds formed instead of subtracting it or adding it to the bonds broken.