AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.5.2.2

Fuel cells

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**10**
Available paper years	**2007–2025**

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.

4.5.2.2 Fuel cells

Answer 01 · Mark scheme

June 2007 | CHY1A | Original Q9 | Legacy

Nine	**2**	**3**	**2**	**3**

Answer 02 · Mark scheme

June 2008 | CHY1AP | Original Q8 | Legacy

Eight	**1**	**1**	**2**	**2**

4.5.2.2 Fuel cells

Answer 03 · Mark scheme

Question 5

question	answers	extra information	mark
5(a)(i)	any **one** from: • they are positive / cations • they are H^+ • opposite charges attract	ignore atom	1
5(a)(ii)	potassium is more reactive (or reverse)	assume 'it' refers to hydrogen allow potassium reacts <u>with</u> water allow potassium is very reactive **or** most reactive metal / element allow hydrogen gains electrons more easily / is reduced more easily accept potassium is higher up the reactivity series	1
5(b)	6 **and** 2	accept correct multiples and fractions	1
5(c)(i)	the reaction / it is reversible **or** a description of a reversible reaction	allow 'it is an equilibrium' allow reversible symbol drawn correctly allow 'the reverse / back reaction'	1

Question 5 continues on the next page…

CHY2H

Question 5 Continued

question	answers	extra information	mark
5(c)(ii)	**lithium nitride** assume that 'it' or if they do not specify means lithium nitride assume lithium / lithium nitrate refers to lithium nitride • hydrogen is bonded / held / absorbed / has formed a compound / reacted with lithium nitride plus **one** of: • does not explode / cause a fire • is not free / less hydrogen • is not under pressure • does not leak • is only released slowly • compound of hydrogen with lithium nitride / product is (more) stable / less reactive / less chance of a reaction	accept converse for hydrogen as below assume that gas / hydrogen means gas in the cylinder • hydrogen (in cylinder) / gas is not bonded / held / absorbed / in a compound / reacted with lithium nitride plus **one** of: • can explode / cause a fire • is free • is under pressure • can leak • releases quickly	1 1
5(d)(i)	smaller **or** correct indication of size **or** higher surface area	allow very / really small **or** tiny accept few (100) atoms in size allow 1 to 100 nanometres or 10^{-9} metres allow absorption and / or release of hydrogen more quickly allow have different properties allow 'more particles in each volume / area' do not allow reacts more quickly	1

Question 5 continues on the next page…

4.5.2.2 Fuel cells

CHY2H

Question 5 Continued

question	answers	extra information	mark
5(d)(ii)	greater surface area		1
5(e)(i)	loss of an electron **or** loses electrons	do not accept any ref. to oxygen	1
5(e)(ii)	full outer shell of 8 electrons on circle	need not be paired can be ×, dot or e do **not** accept if extra electrons added to inner shell	1
Total			**10**

4.5.2.2 Fuel cells

Answer 03 · Mark scheme June 2009 | CHY2H | Original Q5 | Legacy

CHY2H

Answer 04 · Mark scheme November 2011 | CHY1AP | Original Q9 | Legacy

Nine	**2**	**3**	**1**	**4**

The AQA UMS Conversion Calculator can be found at the following web address:

http://www.aqa.org.uk/umsconversion

4.5.2.2 Fuel cells

Answer 05 · Mark scheme

June 2014 | CH3HP | Original Q6 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
6(a)	electrical		1	1 / 3.3.1i	G
6(b)	using hydrogen saves petrol / diesel / *crude oil* *using hydrogen (in fuel cells) does not cause pollution*	allow crude oil is non-renewable *ignore hydrogen is renewable* accept no carbon dioxide produced *allow less carbon dioxide produced* *allow hydrogen produces only water*	1 1	3 / 3.3.1i	E
6(c)(i)	(–)486	correct answer with or without working gains **3** marks if answer is incorrect: (2 x 436) + 498 **or** 1370 gains **1** mark 4 x 464 **or** 1856 gains **1** mark *correct subtraction of ecf* gains **1** mark	3	2 / 3.3.1f	E
6(c)(ii)	products lower than reactants *reaction curve correctly drawn* activation energy labelled		1 1 1	1 + 2 / 3.3.1d	E
Total			9		

4.5.2.2 Fuel cells

Answer 05 · Mark scheme

June 2014 | CH3HP | Original Q6 | Legacy



4.5.2.2 Fuel cells

Answer 06 · Mark scheme

June 2018 | 8462/1H | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	copper, zinc, sodium chloride solution		1	AO2 4.5.2.1
03.2	a reactant is used up	allow the reaction stops allow electrolyte / electrode / ions / metal / metal hydroxide / alkali for reactant	1	AO1 4.5.2.1
03.3	the reaction is not reversible		1	AO1 4.5.2.1
03.4	$2H_2 + O_2 \rightarrow 2H_2O$	allow fractions / multiples allow **1** mark for O_2	2	AO1 AO2 4.1.1.1 4.5.2.2

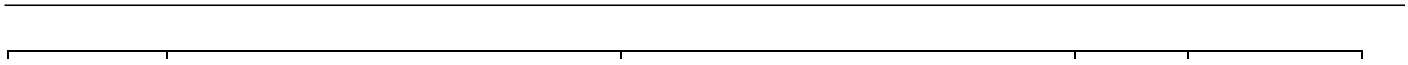
<table>
<tr><th>Question</th><th>Answers</th><th>Mark</th><th>AO / Spec. Ref.</th></tr>
<tr><td rowspan="5">03.5</td><td>Level 3: A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.</td><td>5–6</td><td>AO3</td></tr>
<tr><td>Level 2: Some logically linked reasons are given. There may also be a simple judgement.</td><td>3–4</td><td>AO3</td></tr>
<tr><td>Level 1: Relevant points are made. This is not logically linked.</td><td>1–2</td><td>AO2</td></tr>
<tr><td>No relevant content</td><td>0</td><td></td></tr>
<tr><td>Indicative content

reasons why fuel cells could be judged as better
<table>
<tr><th>from the table</th><th>from other knowledge</th></tr>
<tr><td>• time for refuelling a fuel cell is faster than recharging
or
a fuel cell does not need to be recharged
• a fuel cell has a greater range</td><td>• hydrogen can be renewable if made by electrolysis using renewable energy
• lithium-ion batteries can catch fire
• produces only water
or
no pollutants produced
• lithium-ion batteries may release toxic chemicals on disposal
• lithium-ion batteries (eventually cannot be recharged so) have a finite life</td></tr>
</table>
reasons why the lithium-ion battery could be judged as better
<table>
<tr><th>from the table</th><th>from other knowledge</th></tr>
<tr><td>• lithium-ion uses energy more efficiently
• cost of lithium-ion car much less
• cost of recharging much less than refuelling with hydrogen</td><td>• hydrogen is often made from fossil fuels so is not renewable
• charging points are more widely available than hydrogen filling stations
• hydrogen takes up a lot of space
or
is difficult to store
• hydrogen can be highly flammable / explosive
• no emissions produced
• (catalyst in the hydrogen fuel-cell eventually becomes poisoned so) have a finite life</td></tr>
</table></td><td></td><td>4.4.3.4
4.5.2.1
4.5.2.2</td></tr>
<tr><td>Total</td><td></td><td></td><td>11</td><td></td></tr>
</table>

4.5.2.2 Fuel cells

Answer 06 · Mark scheme

June 2018 | 8462/1H | Original Q3



4.5.2.2 Fuel cells

Answer 07 · Mark scheme

June 2019 | 8462/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	any **two** from: • temperature (of solution) • concentration of electrolyte / solution • compound / ions in electrolyte / solution	ignore room temperature allow volume of electrolyte / solution allow size of electrode allow distance between electrodes do **not** accept electrode **X** unqualified do **not** accept (measured) voltage	2	AO3 4.5.2.1
06.2	order: (most reactive) magnesium cobalt nickel tin copper (least reactive) silver justification: the higher the (positive) voltage, the more reactive (the metal) silver has a negative voltage because silver is less reactive than copper	allow **1** mark for magnesium, cobalt, nickel, tin in order at top allow **1** mark for copper and silver in order at the bottom allow the most reactive (metal) has the highest voltage	2 1 1	AO3 4.4.1.2 4.5.2.1
06.3	magnesium and tin		1	AO3 4.5.2.1

4.5.2.2 Fuel cells

Answer 07 · Mark scheme

June 2019 | 8462/1H | Original Q6

06.4	(in a fuel cell) hydrogen is oxidised (to produce water) water is produced / released as gas / vapour / steam	allow (in a fuel cell) hydrogen reacts with oxygen (to produce water) if no other mark awarded, allow **1** mark for fuel cells produce water	1 1	AO3 4.5.2.2
Total			**9**	

4.5.2.2 Fuel cells

Answer 08 · Mark scheme

November 2020 | 8462/1H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	the activation energy should be from the reactants (line to the peak) the products (line) should be below the reactants (line) **or** the products should have less energy than the reactants	ignore description of where the activation energy is on the diagram allow the product (line) is above the reactants (line) allow the products have more energy than the reactants allow the profile shows an endothermic reaction ignore the arrow for the overall energy change should point downwards	1 1	AO3 4.5.1.2
07.2	any **two** from: (hydrogen fuel cells) • no toxic chemicals to dispose of at the end of the cell's life • take less time to refuel (than to recharge rechargeable cells) • travel further before refuelling (than before recharging rechargeable cells) • no loss of efficiency (over time)	allow converse arguments for a rechargeable cell allow has a greater range allow does not lose capacity / range in cold weather	2	AO1 4.5.2.2

Question 7 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	any **one** from: • $H_2 \rightarrow 2H^+ + 2e^-$ • $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ • $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$ • $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$	allow multiples allow $H_2 - 2e^- \rightarrow 2H^+$ allow $H_2 + 2OH^- - 2e^- \rightarrow 2H_2O$	1	AO1 4.5.2.2
07.4	any **two** from: • hydrogen is not shown as H_2 / molecules • particles are shown as spheres • particles are shown as solid • does not show the (weak) forces (between particles) • does not show the movement / speed (of particles) • is only two-dimensional		2	AO1 4.2.2.1
07.5	any **one** from: • under (higher) pressure • cool • absorb / adsorb in a solid	allow increase concentration allow condense allow store as a liquid / solid allow develop more efficient engines	1	AO3 4.2.2.1 4.5.2.2

Question 7 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.6	(58 MJ =) 58 000 kJ **or** (290 kJ =) 0.290 MJ	allow (58 MJ =) 58 000 000 J **and** (290 kJ =) 290 000 J	1	AO2 4.3.2.1 4.3.5 4.5.2.2
	(moles = $\frac{58000}{290}$ **or** $\frac{58}{0.290}$ =) 200	allow correct use of an incorrectly converted or unconverted value of energy	1	
	(volume =) 200 × 24	allow correct use of an incorrectly calculated number of moles of hydrogen	1	
	= 4800 (dm^3)		1	
	alternative approach: (58 MJ =) 58 000 kJ (1) (energy released per dm^3 = $\frac{290}{24}$ =) 12.08333 (kJ/dm^3) (1) (volume =) $\frac{58000}{12.08333}$ (1) = 4800 (dm^3) (1)	allow correct use of an incorrectly converted or unconverted value of energy allow correct use of an incorrectly calculated energy released per dm^3		

Total			12

4.5.2.2 Fuel cells

Answer 09 · Mark scheme

June 2024 | 8462/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	(most reactive) Mg Zn Ni Cu Ag (least reactive) (justification) the higher the (positive) voltage the more reactive the metal	allow name of metal for symbol allow **1** mark for (most reactive) Mg Zn Ni **or** Ni Cu Ag (least reactive) allow the most reactive (metal) has the highest (positive) voltage allow the least reactive (metal) has the most negative voltage allow the greater the difference in reactivity the greater the (magnitude of the) voltage	2 1	AO3 4.4.1.2 4.5.2.1

Question	Answers	Mark	AO / Spec. Ref.
06.2	**Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6	AO3 4.3.4 4.5.2.1
	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 • **set up cell with sodium chloride solution as the electrolyte** • **use two different metals as electrodes** • **measure voltage** • **repeat at different concentrations of electrolyte solution** • **by diluting the sodium chloride solution with water** • using measured volumes of sodium chloride solution and water • measure volumes with a measuring cylinder (allow pipette / burette) • use the same two metals each time • use the same volume of electrolyte solution		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3		ignore references to electrodes		AO1 4.5.2.2
	hydrogen is oxidised (electrochemically)	allow hydrogen loses electrons	1	
	to produce water		1	

Total Question 6	11

4.5.2.2 Fuel cells

Answer 10 · Mark scheme

June 2025 | 8462/1H | Original Q7

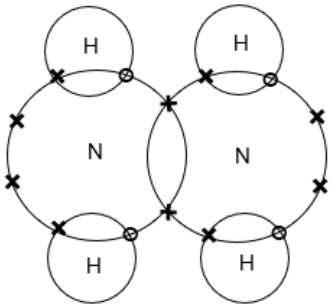
Question 7

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		

4.5.2.2 Fuel cells

Answer 10 · Mark scheme

June 2025 | 8462/1H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2		allow any combination of x, o, $e^{(-)}$, ● for electrons		AO2 4.2.1.4
	bonded pair of electrons in each overlap		1	
	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

4.5.2.2 Fuel cells

Answer 10 · Mark scheme

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

4.5.2.2 Fuel cells

Answer 06 · Examiner comments

June 2018 | 8462/1H | Original Q3

Question 3 (standard demand)

03.1 This was well answered with 67% of students recognising that there had to be two different metals, and that water alone would not be suitable as the electrolyte. A significant number of students incorrectly ticked more than one box.

03.2 62% of students answered this question on a new area of the specification correctly. Many, however, mixed up the answers to questions **03.2** and **03.3**. Many thought that charge, energy, or a product run out.

03.3 52% of students could answer in terms of the lack of reversibility of the chemical reaction in the cell.

03.4 This was well answered, with 70% of students able to give the formula for oxygen and then to balance the equation.

03.5 96% of students achieved three or more marks. However, many students limited themselves to level 2 as they just used the information from the table, without bringing in any of their own knowledge. Others failed to give a judgement on which method is better; a judgement is an essential part of a question where the command word is ‘evaluate’.

Some students wasted space and time requoting data from the table. A comment such as ‘you can go much further with a hydrogen fuel cell before having to stop to refuel’ is a better answer than ‘you can go 415 miles between refuelling with a hydrogen cell car but only 240 miles between recharges of a lithium-ion battery car’.

4.5.2.2 Fuel cells

Answer 07 · Examiner comments

June 2019 | 8462/1H | Original Q6

Question 6 (standard and standard / high demand)

06.1 Students found this question difficult and were quite often imprecise in their description of the control variables. The use of the word amount is unlikely to gain credit and students should be encouraged to use scientific terminology such as 'volume'.

The most common control variables given were volume of solution and concentration of solution.

Common responses seen that were not credited included:

- amount of solution
- the electrolyte
- the copper electrode.

06.2 Most students scored the 2 marks for the order of reactivity of the top four metals and the justification for this order.

The most common error was then to put silver above copper in the order of reactivity.

However, only a small proportion of students were able to explain the negative voltage for silver in terms of its reactivity compared with copper.

06.3 Approximately half of students correctly identified 'magnesium and tin' as the pair of metals to produce the greatest voltage.

'Magnesium and cobalt' was a strong distractor, presumably because it also contained the most reactive metal.

4.5.2.2 Fuel cells

Answer 07 · Examiner comments June 2019 | 8462/1H | Original Q6

06.4 Only a small proportion of students scored both marks. The mark for describing the reaction that produces water in a hydrogen fuel cell was the least frequently scored.

Often, students gained the compensation mark for the idea that hydrogen fuel cells produce water.

However a significant number of students gave incomplete responses indicating that hydrogen fuel cells produce steam (with no reference to water).

Some common misconceptions seen were:

- Hydrogen fuel cells release hydrogen gas.
- Hydrogen burns in a hydrogen fuel cell.

Answer 08 · Examiner comments November 2020 | 8462/1H | Original Q7

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

07.1 Many students spotted that the curve was for an endothermic reaction rather than exothermic. Many also realised the activation energy was incorrect but could not always express correctly that activation energy should start at the energy of the reactants rather than the products.

07.2 Most students did not score well on this question. There were many vague references to 'better for the environment' without any justification for that statement. Many students referenced the fact that water is the only product, failing to realise that rechargeable cells produce no waste products at all. Others failed to realise that the infrastructure for recharging cells is actually better than that for refuelling with hydrogen. Some students

4.5.2.2 Fuel cells

Answer 08 · Examiner comments November 2020 | 8462/1H | Original Q7

were effectively giving advantages of hydrogen fuel cells over petrol engines, instead of answering the question. Others failed to express themselves clearly; saying that hydrogen fuels cells take less time to charge which did not gain credit, as the cells are refuelled, not recharged.

07.3 Many students did not realise that either hydrogen or oxygen had to be a reactant. Many impossible species such as e^{2-} or O_2^+ were seen.

07.4 Many students were able to score at least one mark but only one in six scored both. Many noted that the movement of the particles was not shown; many also noted that the particles are not shown as diatomic, or that the forces between them are not shown.

07.5 This was quite well answered, with most students favouring compressing the gas rather than cooling to condense the gas. A number of students incorrectly stated that hydrogen can be taken in from the atmosphere.

07.6 A third of students were able to score full marks. It was not possible to give partial credit for working when the students did not explain what they were doing; too often there was a jumble of numbers with various operators between them, with no words or units. No credit was given for multiplying a value by 24 unless that value was identified as a number of moles.

Answer 09 · Examiner comments June 2024 | 8462/1H | Original Q6

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

06.1 Over three fifths of students scored all three marks. Most students could list the metals in order of decreasing reactivity, although some ignored the sign and ordered the metals in order of absolute magnitude of voltage. A few tried to remember the reactivity series, even though nickel and silver are not listed in the specification. The best answers justified the order not only in terms of the most reactive metal producing the most positive voltage, but also that the negative voltages were produced by elements less reactive than nickel.

06.2 This extended response plan of a non-required practical discriminated very well. About a third of responses reached Level 3, with more than two thirds reaching level 2.

There were some excellent descriptions of a plan which would work, including details of how the different concentrations to be tested would be made. Some students thought the pure water was to be used as a control rather than for diluting the sodium chloride solution. The top mark in Level 3 was only available if there was detail about how the voltage could be linked quantitatively to the concentration of sodium chloride. This was often poorly expressed using terms such as

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4.5.2.2 Fuel cells

Answer 09 · Examiner comments June 2024 | 8462/1H | Original Q6

'amount' rather than 'volume,' and did not always mention both the sodium chloride solution provided and the water. The control variable 'use the same two metals each time' was essential to access a Level 3 mark, since the method must lead to a valid outcome. This was often implied in responses where a student named different metals, or stated they must be different, and then said, 'repeat using different concentrations of sodium chloride.' Many students, however, specified that all of the different metals should be used, which was completely unnecessary and possibly rendered the outcome invalid.

A common error was to use two electrodes of the same metal, or to refer simply to 'the electrodes' without specifying what type of electrodes to use. This restricted the answer to Level 2.

It was not uncommon to see reference to a power supply, which restricted the answer to Level 1; there is some confusion between an electrolytic cell and an electrochemical cell.

06.3 Only 1 in 25 students scored both marks by repeating the statement in the specification that hydrogen is oxidised electrochemically to produce water, and only a quarter of students scored one mark. There were a few excellent answers showing the half equations at both electrodes; as long as these showed hydrogen losing electrons, and water being a product, they gained full credit. Those who referred to hydrogen losing electrons in the fuel cell gained credit; however, students often thought that hydrogen ions were reacting, rather than hydrogen molecules. Other types of oxidation, such as combustion, were not accepted. Some students appear to believe that the water is produced as steam, which then drives a turbine generating electricity.

Answer 10 · 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 10 · 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.