AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.5.1.2

Reaction profiles

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**5**
Available paper years	**2018–2024**

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.

5.5.1.2 Reaction profiles

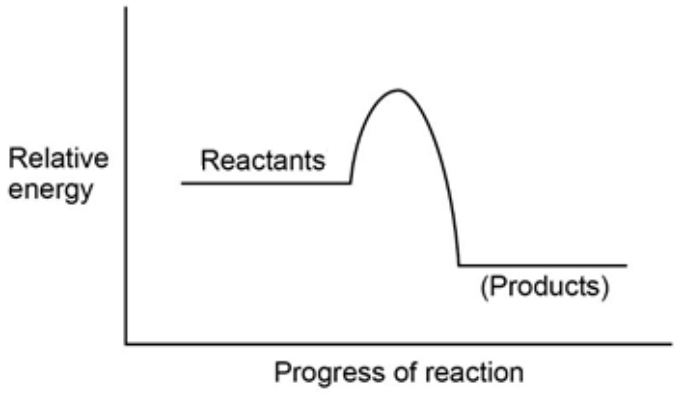
Answer 01 · Mark scheme June 2018 | 8464/C/1H | Original Q2

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		

5.5.1.2 Reaction profiles

Answer 01 · Mark scheme

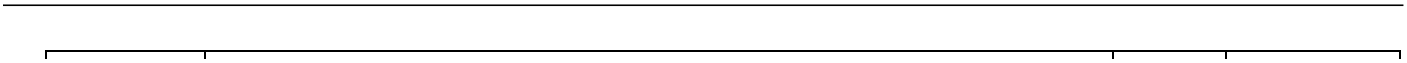
June 2018 | 8464/C/1H | Original Q2

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**	

5.5.1.2 Reaction profiles

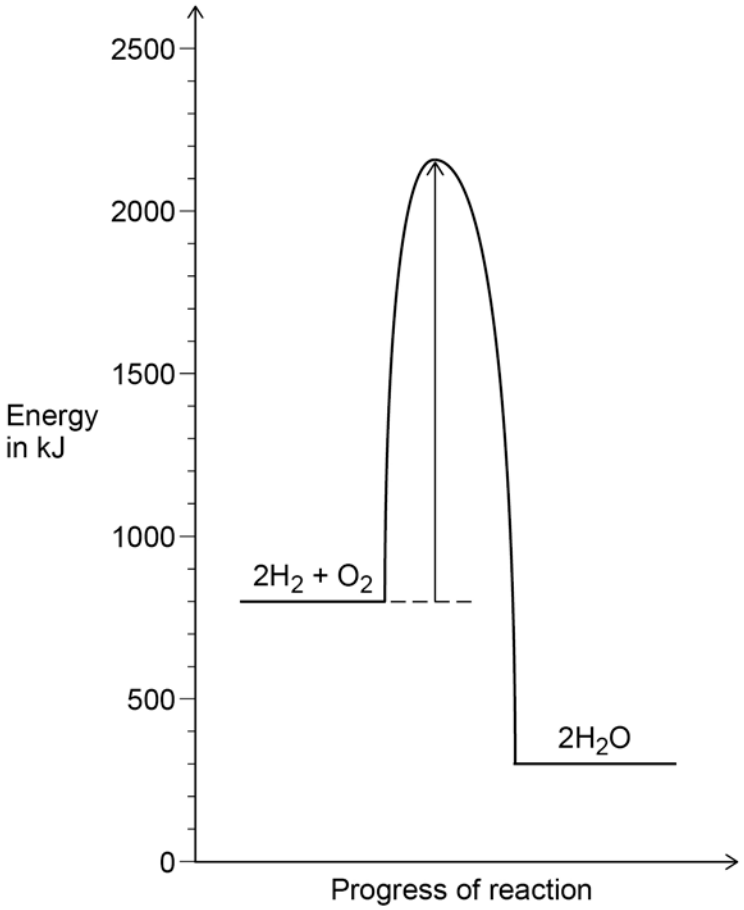
Answer 01 · Mark scheme

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



5.5.1.2 Reaction profiles

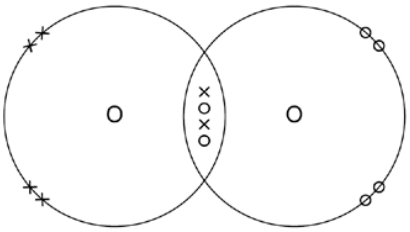
Answer 02 · Mark scheme June 2019 | 8464/C/1H | Original Q3

03.1	line from reactants to top of curve (i.e. from 800 to 2160)  ignore arrowheads	1	AO1 5.5.1.2

03.2		an answer of (–) 500 (kJ) scores **2** marks ignore sign		AO2 AO3 5.5.1.2
	reads levels of reactants (800 kJ) and products (300 kJ)		1	
	(800 – 300) = 500 (kJ)	allow correct subtraction of one incorrect value determined for the energy change	1	

5.5.1.2 Reaction profiles

Answer 02 · Mark scheme

03.3	two shared pairs in overlap all non-bonding electrons in outer shell (4 electrons on each O atom)	allow combination of circles, dots, crosses or e(–) ignore any inner shell electrons  diagram scores 2 marks	 1 1	AO2 5.2.1.4

5.5.1.2 Reaction profiles

Answer 02 · Mark scheme

03.4	(bonds broken) ((4×463) + (2×138) =) **2128** (bonds made) ((4×463) + (496) =) **2348** (energy change = bonds broken – bonds made) (2128 – 2348 =) (–) **220** (kJ) **alternative approach:** (bonds broken) (2× (O–O) = (2×138) =) **276** (1) (bonds made) (1× (O=O) =) **496** (1) (energy change = bonds broken – bonds made) (276 – 496 =) (–) **220** (kJ) (1)	an answer of (–) 220 (kJ) scores **3** marks an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps ignore energy change sign allow correct calculation using incorrect values from step 1 and/or step 2	1 1 1	AO2 5.1.1.1 5.5.1.1 5.5.1.3

Total			**8**

5.5.1.2 Reaction profiles

Answer 02 · Mark scheme

June 2019 | 8464/C/1H | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.5.1.2 Reaction profiles

Answer 03 · Mark scheme June 2019 | 8464/C/2H | Original Q4

04.1	growing plants (on low-grade ore) plants are burnt (to produce ash) (ash dissolved in acid to produce) solution of a copper compound electrolysis (of solution of a copper compound) **or** displacement (by adding scrap iron to a solution of a copper compound)	allow named plant allow named copper compound allow addition of scrap iron (to a solution of a copper compound)	1 1 1 1	AO1 5.10.1.4
04.2	 M_r $CuSO_4$ = 159.5 $\frac{0.319}{159.5}$ = 0.002 (mol)	an answer of 0.002 **or** 2×10^{-3} (mol) scores **3** marks allow correct use of incorrectly calculated value for M_r allow 2×10^{-3} (mol)	 1 1 1	AO2 5.3.2.1 5.3.2.5
04.3	both reaction profiles start at the same energy level and end at the same energy level.		1	AO3 5.6.1.4

5.5.1.2 Reaction profiles

Answer 03 · Mark scheme

04.4	the amount of carbon dioxide used to produce the ethanol is the same as the amount of carbon dioxide given off when the ethanol is burned	**alternative approach** there is sufficient carbon dioxide (in the atmosphere) (1) because carbon dioxide is constantly produced from burning fossil fuels (1) if no other mark awarded allow for **1** mark burning ethanol produces carbon dioxide	1 1	AO3 5.9.2.2 5.9.3.1

5.5.1.2 Reaction profiles

Answer 03 · Mark scheme

04.5	meets needs of current generation without compromising needs of future generations	 allow so there are enough resources for future generations ignore references to harming / damaging planet / environment	1 1	AO1 5.10.1.1

Total			**12**

5.5.1.2 Reaction profiles

Answer 03 · Mark scheme

June 2019 | 8464/C/2H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.5.1.2 Reaction profiles

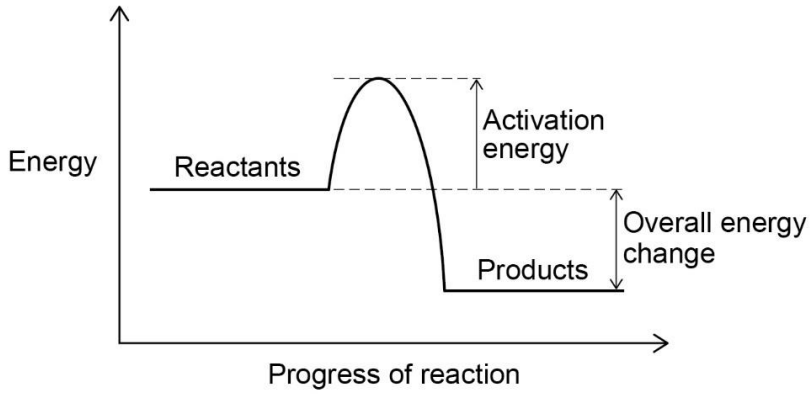
Answer 04 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	temperature (of solution)	allow temperature change	1	AO1 5.5.1.1
03.2	any **three** from: • insulate the beaker **or** use polystyrene cup • add a lid • stir more (times) • repeat the experiment **and** calculate the mean (ignoring anomalous results) • use smaller volume (of water) • use larger mass of ammonium nitrate • more accurate balance • use digital thermometer **or** use a more accurate thermometer		3	AO3 5.5.1.1
03.3	(from 0 to 1.5 minutes the) temperature decreases (because) ammonium nitrate dissolving is endothermic (then) after 1.5 minutes the temperature increases (because) energy transfers to the solution from the surroundings	allow the temperature decreases (from 21.4 ºC to 15.4 ºC) (then) after 15.4 ºC the temperature increases	1 1 1 1	AO3 5.5.1.1

5.5.1.2 Reaction profiles

Answer 04 · Mark scheme

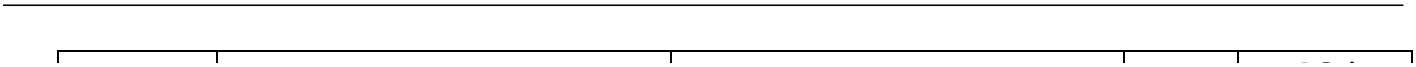
November 2021 | 8464/C/1H | Original Q3

03.4	labelled horizontal lines for reactants and products, with the product line below the level of the reactant line		1	AO1 5.5.1.2
	reaction pathway	allow curve to start / finish anywhere along reactant / product lines	1	
	line from reactants to maximum labelled activation energy		1	
	line from reactants to products labelled overall energy change		1	
	the diagram below scores 4 marks  			
Total			**12**	

5.5.1.2 Reaction profiles

Answer 04 · Mark scheme

November 2021 | 8464/C/1H | Original Q3

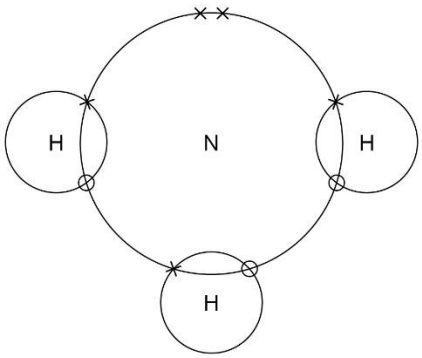


5.5.1.2 Reaction profiles

Answer 05 · Mark scheme

June 2024 | 8464/C/1H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1		allow any combination of circles, dots, crosses or $e^{(-)}$ ignore any inner shell electrons on nitrogen		AO1 5.2.1.4
	one shared pair of electrons in each overlap		1	
	2 non-bonding electrons on the outer shell of nitrogen	do **not** accept non-bonding electrons on hydrogen an answer of  scores **2** marks	1	

5.5.1.2 Reaction profiles

Answer 05 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	(M_r NH_3 = 14 + (3 × 1) =) 17		1	AO2 5.3.1.1 5.3.2.2
	$\left(\text{moles } NH_3 = \frac{25}{17}\right)$ = 1.47 (mols)	allow correct use of incorrectly determined M_r of NH_3	1	
	(moles H_2 = 1.47 × $\frac{3}{2}$) = 2.205 (mols)	allow correct use of an incorrectly calculated value of moles of NH_3	1	
	(mass H_2 = 2.205 × 2) = 4.41 (g)	allow 4.4117647 (g) correctly rounded to at least 2 significant figures allow correct use of an incorrectly calculated value of moles of H_2	1	
	alternative approach (2 × M_r NH_3 = 17 × 2 =) 34 (1)			
	6 g H_2 → 34 g NH_3 (1)	allow correct use of an incorrectly calculated value of 2 × M_r NH_3		
	$\frac{6}{34}$ × 25 (g) H_2 → 25 g NH_3 (1)			
	4.41 (g H_2 → 25 g NH_3) (1)			

5.5.1.2 Reaction profiles

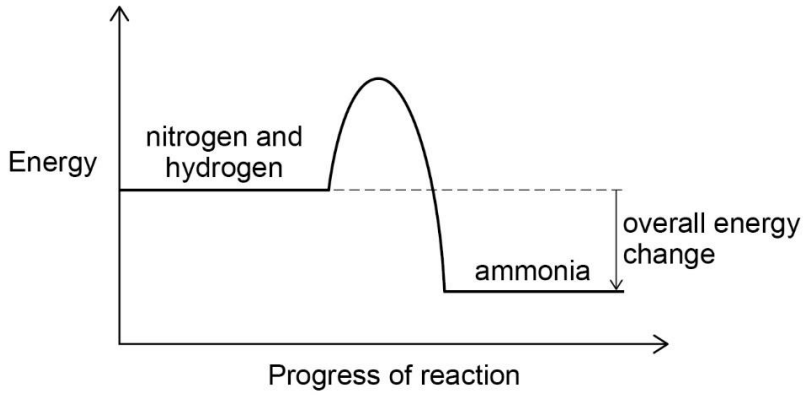
Answer 05 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	(bonds broken =) 945 + 3**X**		1	AO2 5.5.1.1 5.5.1.3
	(bonds made = 6 × 391 =) 2346		1	
	(energy released = bonds made – bonds broken =) 93 = 2346 – [945 + 3**X**]	allow correct use of incorrectly determined value(s) of bonds broken and/or bonds formed	1	
	(3**X** =) 1308 (kJ/mol)		1	
	(**X** =) 436 (kJ/mol)	allow correct use of an incorrectly determined value for 3**X**	1	

5.5.1.2 Reaction profiles

Answer 05 · Mark scheme

June 2024 | 8464/C/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	correct shape for exothermic reaction with the product line below the level of the reactants line		1	AO2
	labelled horizontal lines for reactants and product	labelled horizontal lines for nitrogen and hydrogen and ammonia	1	AO1
	labelled overall energy change		1	AO1 5.5.1.2
	an answer of  scores **3** marks			

Total Question 5	14

5.5.1.2 Reaction profiles

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.

5.5.1.2 Reaction profiles

Answer 02 · Examiner comments — June 2019 | 8464/C/1H | Original Q3

Question 3

This was the first question not common with the Foundation tier. There was a ramping of demand through the question from standard demand (03.1) to standard/high demand (03.2) then to high demand (03.3 and 03.4).

03.1 A good proportion of students correctly identified the activation energy. Common errors included arrows pointing to the maximum of the energy diagram or to a section of the line leading to the peak.

03.2 Students were very good at determining the overall energy change; nearly three-quarters of all students gained full marks. Those students who selected one value of either the reactants or products from the graph gained credit for a correct subtraction of their values.

03.3 Students provided a wide range of responses for the dot-and-cross diagram of oxygen. Half of all students appreciated the number of electrons involved in bonding and non-bonding. A number of students did not appreciate that oxygen always has two sharing pairs of electrons; in this case a double bond results between the two atoms. Others who added 4 electrons for a double bond often still added 3 other non-bonding pairs on each O atom.

03.4 This question discriminated very well where two-fifths of students gained all three marks for an answer of (–) 220 kJ.

Many students presented their working clearly. This allowed examiners to identify where any errors had been made which allowed access to the final marking point (MP3); a subtraction of bonds made (their MP2) from bonds broken (their MP1).

Answer 02 · Examiner comments — June 2019 | 8464/C/1H | Original Q3

Common mistakes centred on using an O-O value when an O=O bond strength should have been used and not taking into account the stoichiometry of the equation.

5.5.1.2 Reaction profiles

Answer 03 · Examiner comments — June 2019 | 8464/C/2H | Original Q4

Question 4 (standard/high demand)

04.1 The majority of students who obtained marks on this question did so from the first 2 marking points, although then many continued to describe the next process incorrectly as 'electrolysing the copper metal from the ash'. Converting the copper compounds found in the ash into a suitable copper solution or electrolyte, was rarely seen in the student responses. A significant minority of students who gained no marks on this question did not seem familiar with the process of phytomining, and gave answers based around normal mining, or heating the rock until the copper melted.

04.2 Around 73% of students gained some credit on this question, predominantly for correctly calculating the M_r of copper sulfate (159.5), although 111.5 (addition of all the A_r given in the question) was given regularly. The most common mistake was to multiply the figures (0.319 x 159.5) rather than divide ($\frac{0.319}{159.5}$). 15% of students scored all three marks, many giving their answers in standard form (2×10^{-3}), which, although not asked for, was accepted.

04.3 About 84% of students gained this mark with no pattern seen in the incorrect responses.

04.4 Only a few students achieved both marks by correctly linking the idea that the amount of CO_2 used to produce ethanol would be the same as would be released when the ethanol was burned. The vast majority of correct answers for both marks were based on the large amount of CO_2 in the air, and its regular replacement by burning fossil fuels. About 23% of students achieved 1 mark for highlighting that there was sufficient carbon dioxide in the atmosphere or that it is produced from the combustion of ethanol.

04.5 Around 17% of students gained credit on this question by recalling the definition of sustainability from the specification or were able to give an equivalent statement. Most students answered in terms of environmental issues or renewable routes, including 'long lasting' and 'won't run out'.

Answer 04 · Examiner comments — November 2021 | 8464/C/1H | Original Q3

Question 3 (standard and standard / high demand)

03.1 In this investigation the temperature of the solution is measured (the independent variable is changed and the dependent variable measured). Just under two fifths of students gained the mark.

03.2 This question was based on the required practical activity of investigating the variables that affect temperature changes. Students had difficulty in identifying more than one improvement from the method or from the diagram of the apparatus.

03.3 Students were good at describing the trends in the graph, although a few misread the minimum point (1.5, 15.4); approximately half of students gained two marks. However, students struggled to explain the trends. The temperature of the solution decreased because the dissolving process is endothermic. Then when the energy change due to dissolving finishes, the temperature of the solution increases from the minimum back to room temperature as energy transfers to the solution from the surroundings.

03.4 More than two thirds of students scored at least one mark with approximately one sixth of students gaining all four marks. A small number incorrectly drew the reaction profile for an endothermic reaction and some labels were not clearly drawn.

5.5.1.2 Reaction profiles

Answer 05 · Examiner comments

June 2024 | 8464/C/1H | Original Q5

Question 5 (standard/high & high demand)

05.1 Around two-thirds of students were able to complete the dot and cross diagram for an ammonia molecule.

Some students gained just 1 mark for correctly adding either three shared pairs of electrons or two non-bonding electrons on the outer shell of nitrogen, or included non-bonding electrons on hydrogen, so were not able to access mark point 2.

05.2 In this reacting mass calculation students were asked to calculate the mass of hydrogen needed to produce 25 g of ammonia. As always, a number of approaches were taken and students who showed their working often gained credit even after making errors. More than half of students scored at least 1 mark.

Those who answered with a moles method usually scored 4 marks for the correct answer, 3 marks for 2.94 g (because they missed the molar ratio) or 1 mark for determining the M_r of ammonia.

Those who used a ratio method usually either scored 4 marks for the correct answer or 1 mark for $2 \times M_r$ of ammonia; few showed clear working to gain either marking point 2 or marking point 3.

05.3 In this question students were asked to calculate the bond energy for the H—H bond. The working for breaking bonds needed to show that the values 945 and 3*X* have been added together.

Many students were good at calculating the energy changes for bonds broken but went on to simply subtract the bond breaking value from the bond making value without taking into account the H—H bond energy. In the reaction more energy was released than was needed to break existing bonds so this value, 93 kJ/mol, needed to be correctly used in the next stage of the calculation before the H—H bond energy was determined by dividing by 3.

This question differentiated well, with higher-attaining students showing clear working where they equated the energy released to the difference between the bonds made and the bonds broken.

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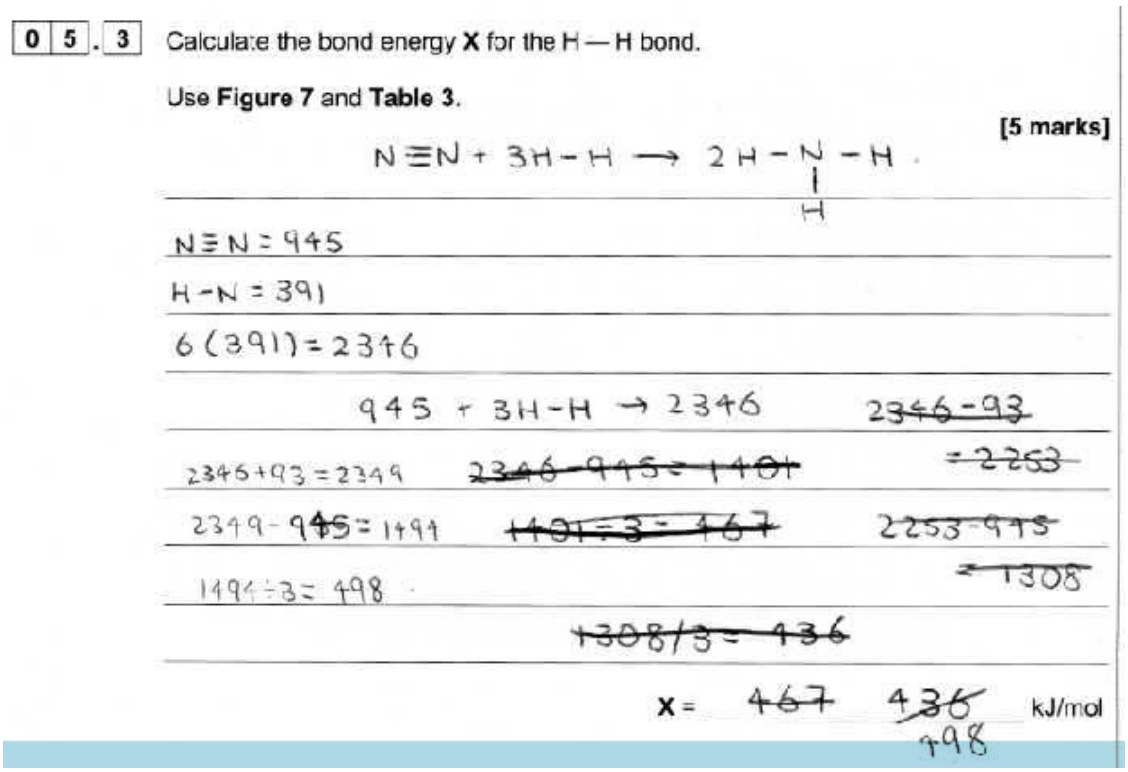
5.5.1.2 Reaction profiles

Answer 05 · Examiner comments June 2024 | 8464/C/1H | Original Q5

0 5 . 3 Calculate the bond energy **X** for the H — H bond.

Use **Figure 7** and **Table 3**. **[5 marks]**



This student gained 3 marks for 498 kJ/mol. They gained the first 2 marks for calculating the energy to break bonds and the energy released when bonds are made but did not then include the value of 93 so were unable to gain the next 2 marks. They then correctly divided 1494 by 3 to determine the average H—H bond energy so gained the final mark.

The student has made three attempts at the calculation, two of which they have crossed out. In the middle they did not use the value of 93, which gave a common incorrect answer of 436; this answer would have also scored 3 marks. On the right (also crossed out) they used the value of 93 correctly to give the correct answer of 436, which would have scored all 5 marks.

05.4 This question was well answered with approximately 20% of students gaining 3 marks, 40% gaining 2 marks and 20% of students gaining 1 mark.

Those students who gained 2 marks usually either drew the arrow indicating the overall energy change incorrectly or completed a correct profile for an endothermic reaction.

When 1 mark was scored this was usually for the correct shape for an exothermic reaction but labels for reactants and/or product were omitted and the arrow indicating the overall energy change was incorrect. On this occasion any sort of arrow was allowed accompanied with the label for the overall energy change, and ΔH is an equivalent response for the label.

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