AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.5.1.2

Reaction profiles

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**20**
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.

4.5.1.2 Reaction profiles

Answer 01 · Mark scheme January 2008 | CHY3H | Original Q1 | Legacy

Question 1

question	answers	extra information	mark
(a)	either: calculations: all correct (ethanol = 6, methanol = 3, peanut oil = 10, vegetable oil = 15) **or** implication of correct calculation (vegetable oil) gives largest temperature / heat increase <u>per gram</u> (owtte)	ignore repetition of data from table unqualified allow 'produced most heat in proportion to the fuel used' owtte for **1** mark	2
(b)	any **one** from: • smoke • soot • carbon • carbon monoxide • carbon dioxide • global warming / climate change / greenhouse gases • (air) pollution • harmful / poisonous scrub / wash the gases owtte	owtte ignore references to crops/food filter / remove (gases / fumes / appropriate named substance) owtte (add extra oxygen) can burn more efficiently owtte use a cleaner fuel owtte plant more trees or similar linked to CO_2 any sensible answer 'don't burn so much fuel' insufficient alone ignore extractor fans / air conditioning	1 1

continued…

4.5.1.2 Reaction profiles

CHY3H

Question 1 continued…

question	answers	extra information	mark
(c)(i)	A		1
(c)(ii)	B		1
total			6

4.5.1.2 Reaction profiles

Answer 01 · Mark scheme January 2008 | CHY3H | Original Q1 | Legacy

CHY3H

Answer 02 · Mark scheme June 2008 | CHY3H | Original Q7 | Legacy

question	answers	extra information	mark
7(a)(i)	energy / heat of products less than energy of reactants	owtte allow products are lower than reactants allow more energy / heat given out than taken in allow methanol is lower allow converse allow energy / heat is given out / lost allow ΔH is negative	1
7(a)(ii)	lowers / less activation energy	owtte allow lowers energy needed for reaction **or** it lowers the peak/ maximum do **not** allow just 'lowers the energy'	1
7(b)(i)	bonds broken: $(2 \times 435) + 498 = 1368$ bonds made: $(2 \times 805) + (2 \times 464) = 2538$ energy change: $1368 - 2538 = (-)1170$	 allow: $(8 \times 435) + 498 = 3978$ allow: $(6 \times 435) + (2 \times 805) + (2 \times 464) = 5148$ allow: $3978 - 5148 = (-)1170$ ignore sign allow ecf correct answer (1170) = **3** marks	1 1 1
7(b)(ii)	energy released forming new bonds is greater than energy needed to break existing bonds owtte	allow converse do **not** accept energy needed to form new bonds greater than energy needed to break existing bonds	1
Total			**6**

4.5.1.2 Reaction profiles

Answer 02 · Mark scheme June 2008 | CHY3H | Original Q7 | Legacy

COMPONENT NUMBER: CHY3H

COMPONENT NAME: Chemistry

STATUS: Final

DATE: June 2008

4.5.1.2 Reaction profiles

Answer 03 · Mark scheme

January 2010 | CHY3H | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)	energy of product greater than energy of reactants	allow converse allow energy = heat do **not** accept temperature for energy allow product / nitrogen oxide is higher than reactants allow less energy / heat given out than taken in allow energy / heat is taken in / gained allow ΔH is positive	1
6(b)	(minimum) energy needed to start the reaction / overcome energy barrier	accept (minimum) energy needed for a collision to be successful	1
6(c)(i)	bonds broken = 945 + 498 = 1443 (kJ) bonds made = 2 × 630 = 1260 (kJ) energy change = 1443 – 1260 = (+) 183	correct answer with or without working = **3** marks ignore sign allow ecf	1 1 1
6(c)(ii)	energy released forming new bonds is less than energy needed to break existing bonds owtte	allow converse accept energy change(ΔH) is + / positive do **not** accept energy <u>needed to form new bonds</u> is less than energy needed to break existing bonds	1
Total			**6**

4.5.1.2 Reaction profiles

Answer 03 · Mark scheme

January 2010 | CHY3H | Original Q6 | Legacy

CHY3H

4.5.1.2 Reaction profiles

Answer 04 · Mark scheme

June 2011 | CHY3H | Original Q4 | Legacy

Question 4

question	answers	extra information	mark
4(a)	energy released from making (new) bonds is greater than the energy needed to break (existing) bonds	accept the energy needed to break (existing) bonds is less than the energy released in making (new) bonds do **not** accept energy needed to make bonds	1
4(b)(i)	energy / heat of products less than energy of reactants	accept products are lower than reactants **or** reactants higher than products accept more energy / heat given out than taken in **or** less energy / heat taken in than given out accept energy / heat is given out / lost (to the surroundings) allow produce heat ignore produce energy accept △H is negative **or** energy change / **A** is negative **or B** is less than **C**	1
4(b)(ii)	**B** is (very) high / large	it = **B** ignore energy change **C** is high	1
4(b)(iii)	(MnO_2) catalyst (is added) **or** reaction catalysed (by MnO_2) which lowers activation energy **or** which lowers (energy change) **B**	it = MnO_2 accept it is a catalyst do **not** accept MgO / magnesium oxide accept provides alternative / lower energy pathway if hydrogen peroxide is given as a catalyst instead of MnO_2 penalise once only in question	1 1

Question 4 continues on the next page

Question4 continued

question	answers	extra information	mark
4(c)	any **two** from: • (chemicals) not mixed / stirred • heat / energy lost (from apparatus) • (apparatus) not insulated **or** no lid • low amount / mass / not enough MnO_2 **or** low concentration H_2O_2 • thermometer read incorrectly	ignore other experimental error	2
Total			**7**

4.5.1.2 Reaction profiles

Answer 04 · Mark scheme

June 2011 | CHY3H | Original Q4 | Legacy

CHY3H

4.5.1.2 Reaction profiles

Answer 05 · Mark scheme

June 2013 | CH3HP | Original Q6 | Legacy

Question 6

question	Answers	extra information	Mark
6(a)	air		1
6(b)	recycle (unreacted) nitrogen and hydrogen	allow re-use allow N_2 and H_2	1 1
6(c)	$N_2 + 3H_2 \rightarrow 2NH_3$	allow correct multiples	1
6(d)	 because a higher temperature would reduce (equilibrium) yield because a lower temperature would reduce rate	allow converse arguments ignore references to compromise allow higher temperature favours backward reaction	 1 1
6(e)(i)	(energy of) reactants greater than (energy of) products	allow converse allow (overall) energy decreases allow energy required to break bonds is less than the energy released making bonds	1
6(e)(ii)	line starting and finishing at same levels but with lower peak		1
Total			8

4.5.1.2 Reaction profiles

Answer 06 · Mark scheme June 2014 | CH2HP | Original Q3 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
3(a)	O_2 in correct space		1	2 / 2.4	E
	correct balancing	accept multiples	1		
3(b)(i)		*incorrect reference to energy = max **2***		1 / 2.4.1d	E
		ignore references to equilibrium			
	rate increases		1		
	because particles are closer together	accept because there are more particles (per unit volume)	1		
		allow particles have less space / room to move around			
	so frequency of collisions increases	*accept particles are more likely to collide*	1		
		ignore more collisions			
		ignore more successful collisions			
3(b)(ii)	has a greater surface area		1	3 / 2.4.1f/g	E
	so the reaction is faster	*accept so more frequent collisions*	1		
3(c)	the (minimum) amount of energy (particles must have) to react ***or*** *to start a reaction*	accept the energy needed to break bonds	1	1 / 2.4.1b	E
		ignore references to heat			
3(d)(i)	(potassium is) too / *very* reactive	*ignore potassium is a Group 1 / alkali metal*	1	1 + 2 / 2.6.1b	E
	so dangerous / *violent reaction*	accept hydrogen produced rapidly	1		
3(d)(ii)		accept products in either order		2 / 2.6.2b	E
		ignore names of substances			
		*do **not** accept brackets or charges in the formulae*			
	$ZnSO_4$		1		
	H_2		1		

4.5.1.2 Reaction profiles

Answer 06 · Mark scheme

3(d)(iii)	any **one** from: • increase concentration (of sulfuric acid) • increase temperature **or** heat it • increase surface area of zinc		1	1 / 2.4.1	E
Total			**13**		

4.5.1.2 Reaction profiles

Answer 06 · Mark scheme

June 2014 | CH2HP | Original Q3 | Legacy



4.5.1.2 Reaction profiles

Answer 07 · 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		

4.5.1.2 Reaction profiles

Answer 07 · Mark scheme

June 2014 | CH3HP | Original Q6 | Legacy



4.5.1.2 Reaction profiles

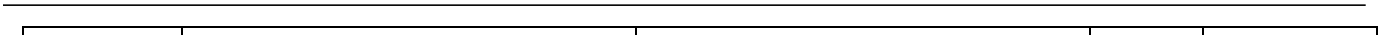
Answer 08 · Mark scheme June 2015 | CH3HP | Original Q6 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
6(a)(i)	nothing can enter **and** nothing can leave the reaction	allow sealed reaction vessel	1	**AO1** 3.5.1.c
6(a)(ii)	forward and backward reactions have same rate so there is no (overall) change in quantities of reactants and products	 allow concentrations of reactants and products	1 1	**AO1/ AO2** 3.5.1.c
6(b)(i)	natural gas	allow methane / CH_4 allow fossil fuels / hydrocarbons allow water	1	**AO1** 3.5.1.a
6(b)(ii)	provides an alternative reaction pathway which has a lower activation energy	 ignore references to collisions	1 1	**AO1** 3.3.1.h
6(b)(iii)	the amount (of ammonia) increases the equilibrium moves to the side (of the equation) with fewer (gaseous) molecules / moles	allow yield increases allow it favours the forward reaction	1 1	**AO1/ AO2** 3.5.1.d/g
6(c)(i)	vertical arrow from reactants to maximum		1	**AO2** 3.3.1.e
6(c)(ii)	(energy of) products higher than (energy of) reactants	allow converse	1	**AO2** 3.3.1.d
6(c)(iii)	amount of hydrogen iodide decreases equilibrium moves in the direction of the endothermic reaction	 allow it favours the forward reaction	1 1	**AO1/ AO2** 3.5.1.d/e
Total			**12**	

4.5.1.2 Reaction profiles

Answer 08 · Mark scheme

June 2015 | CH3HP | Original Q6 | Legacy



4.5.1.2 Reaction profiles

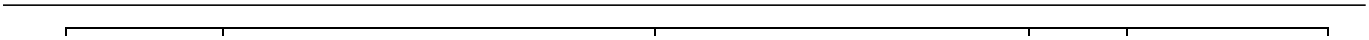
Answer 09 · Mark scheme June 2016 | CH3HP | Original Q5 | Legacy

Question	Answers	Extra information	Mark	AO / SpecRef
5(a)	CH_4 + $2O_2$ → CO_2 + $2H_2O$	allow multiples	1	AO2 3.3.1a
5(b)	3444 J	if answer incorrect: one mark for temperature increase = 16.4 °C one mark for mass of water = 50 g ecf for one incorrect value gains two marks for correct calculation no ecf for two incorrect values	3	AO2 3.3.1a
5(c)(i)	1276 (kJ per mole)	ignore + or - if answer incorrect: [(5 x 413) + 347 + 358 +467] + [(3 x 495)] = 4722 (1 mark) [(4 x 799) + (6 x 467)] = 5998 (1 mark) correct subtraction of calculated energy values (1 mark)	3	AO2 3.3.1f
5(c)(ii)	because energy released when bonds form is greater than energy used when bonds broken	allow converse if no mark awarded allow one mark for energy is used to break bonds or one mark for energy is released when bonds form	2	AO1 3.3.1e,f
5(c)(iii)	products line lower than reactants activation energy labelled overall energy change labelled		1 1 1	2AO2 / 1AO3 3.3.1d
Total			**12**	

4.5.1.2 Reaction profiles

Answer 09 · Mark scheme

June 2016 | CH3HP | Original Q5 | Legacy



4.5.1.2 Reaction profiles

Answer 10 · Mark scheme June 2018 | 8462/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	all 4 metals labelled and suitable scale on *y*-axis all bars correctly plotted	magnesium value must be at least half the height of the grid allow a tolerance of ± ½ a small square ignore width and spacing of bars allow **1** mark if copper not included and other 3 bars plotted correctly	1 1	AO2 4.4.1.2 4.5.1.1
05.2	temperature increases **or** temperature does not decrease	ignore because it is exothermic ignore references to copper allow (because) energy / 'heat' is transferred to the surroundings allow energy / 'heat' is given out allow energy / 'heat' is not taken in (from the surroundings) allow the energy of the products is less than the energy of the reactants	1	AO3 4.5.1.1

4.5.1.2 Reaction profiles

Answer 10 · Mark scheme

June 2018 | 8462/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	suitable method described		1	AO3 4.4.1.2
	the observations / measurements required to place in order	dependent on a suitable method	1	4.5.1.1
	an indication of how results would be used to place the unknown metal in the reactivity series		1	
	a control variable to give a valid result		1	
	approaches that could be used **approach 1:** add the unknown metal to copper sulfate solution (1) measure temperature change (1) place the metals in order of temperature change (1) any **one** from (1): • same volume of solution • same concentration of solution • same mass / moles of metal • same state of division of metal **approach 2:** add the metal to salt solutions of the other metals **or** heat the metal with oxides of the other metals (1) measure temperature change (only if salt solutions used) **or** observe whether a chemical change occurs (1) place the metals in order of temperature change **or** compare whether there is a reaction to place in correct order (1) any **one** from (1): • same volume of salt solutions • same concentration of salt solutions • same (initial) temperature of salt solutions • same mass / moles of metal **or** metal oxide • same state of division of metal **or** metal oxide			

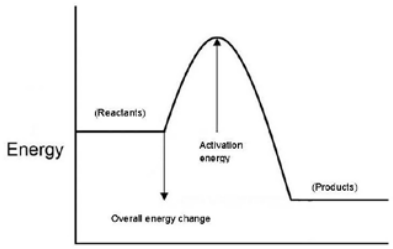
4.5.1.2 Reaction profiles

Answer 10 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3 cont.	**approach 3:** add all of the metals to an acid (1) measure temperature change or means of comparing rate of reaction (1) place the metals in order of temperature change or rate of reaction (1) any **one** from (1): • same volume of acid • same concentration of acid • same (initial) temperature of acid • same mass / moles of metal • same state of division of metal **approach 4:** set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1) measure the voltage of the cell (1) place the metals in order of voltage (1) any **one** from (1): • same electrolyte • same concentration of electrolyte • same temperature of electrolyte			

4.5.1.2 Reaction profiles

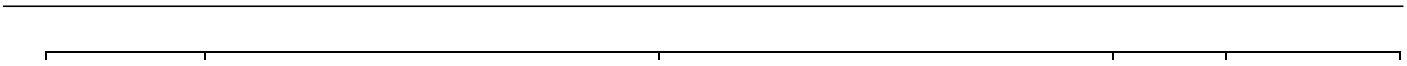
Answer 10 · Mark scheme June 2018 | 8462/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4		an answer of:  scores **3** marks		AO1 4.5.1.2
	correct shape for exothermic reaction	the reactant and product lines needed not be labelled do **not** accept incorrectly labelled reactant and product lines	1	
	labelled activation energy		1	
	labelled (overall) energy change	ignore arrow heads	1	
Total			**10**	

4.5.1.2 Reaction profiles

Answer 10 · Mark scheme

June 2018 | 8462/1H | Original Q5

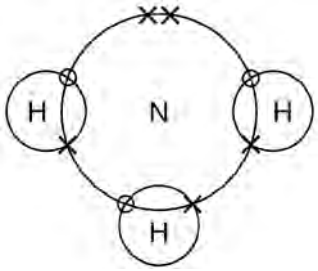


4.5.1.2 Reaction profiles

Answer 11 · 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	

4.5.1.2 Reaction profiles

Answer 11 · Mark scheme

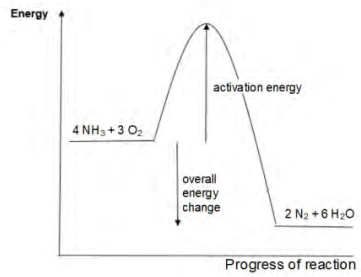
June 2019 | 8462/1H | Original Q5

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

Answer 11 · Mark scheme

June 2019 | 8462/1H | Original Q5

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**	

4.5.1.2 Reaction profiles

Answer 12 · Mark scheme

November 2020 | 8462/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	the (minimum) energy needed for particles to react **or** the (minimum) energy needed for a reaction to occur	allow the (minimum) energy needed to start a reaction	1	AO1 4.5.1.2
06.2	(M_r of Fe_2O_3 =) 160		1	AO2 4.3.1.2 4.3.2.1 4.3.2.2 4.3.2.4
	(moles $Fe_2O_3 = \frac{3000}{160}$ =) 18.75 (mol)	allow correct use of incorrectly calculated M_r	1	
	(moles Al $= \frac{1000}{27}$ =) 37.0 (mol)	allow 37.037037 (mol) correctly rounded to at least 2 significant figures if both MP2 and MP3 are not awarded allow **1** mark for 0.01875 mol Fe_2O_3 **and** 0.037 mol Al	1	
	(aluminium is limiting because) 37.0 mol is less than the (2 x 18.75 =) 37.5 mol (aluminium needed) **or** iron oxide is in excess because 18.75 mol is more than the ($\frac{37.0}{2}$ =) 18.5 mol (iron oxide needed)	allow correct use of incorrect number of moles from steps 2 and/or 3	1	

Question 6 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2 ctd	**alternative approaches:** **approach 1:** **(finding required mass of aluminium by moles method)** (M_r of Fe_2O_3 =) 160 (1) (moles $Fe_2O_3 = \frac{3000}{160}$ =) 18.75 (mol) (1) (moles Al needed =18.75 × 2 =) 37.5 (mol) **and** (mass Al needed = 37.5 × 27 =) 1012.5 (g) **or** 1.0125 kg (1) (so) 1.00 kg of aluminium is not enough (1) **approach 2:** **(finding required mass of aluminium by proportion method)** (M_r of Fe_2O_3 =) 160 (1) (3.00 kg Fe_2O_3 needs) $\frac{3.00}{160}$ × 2 × 27 (kg Al) (1) (=) 1.0125 (kg) (1) (so) 1.00 kg of aluminium is not enough (1)	allow correct use of incorrectly calculated M_r allow correct use of incorrectly calculated moles of iron oxide allow correct use of incorrectly calculated moles of aluminium needed dependent on calculated mass of aluminium needed being greater than 1.00 (kg) allow correct use of incorrectly calculated M_r dependent on calculated mass of aluminium needed being greater than 1.00 (kg)		AO2 4.3.1.2 4.3.2.1 4.3.2.2 4.3.2.4

Question 6 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2 ctd	**alternative approaches:** **approach 3:** **(finding required mass of iron oxide by moles method)** M_r of Fe_2O_3 =) 160 (1) (moles Al $= \frac{1000}{27}$ =) 37.0 (mol) (1) (moles Fe_2O_3 needed) $= \frac{37.0}{2}$) = 18.5 (mol) **and** (mass Fe_2O_3 needed = 18.5 × 160 =) 2960 (g) **or** 2.96 (kg) (1) (so) 3.00 kg of iron oxide is an excess (1) **approach 4:** **(finding required mass of iron oxide by proportion method)** (M_r of Fe_2O_3 =) 160 (1) (1.00 kg Al needs) $\frac{1.00}{2 \times 27} \times 160$ (kg Fe_2O_3) (1) (=) 2.96 (kg) (1) (so) 3.00 kg of iron oxide is an excess (1)	allow 37.037037 (mol) correctly rounded to at least 2 significant figures allow correct use of incorrectly calculated moles of aluminium allow correct use of incorrectly calculated moles of iron oxide needed allow correct use of incorrectly calculated M_r dependent on calculated mass of iron oxide needed being less than 3.00 (kg) allow correct use of incorrectly calculated M_r dependent on calculated mass of iron oxide needed being less than 3.00 (kg)		AO2 4.3.1.2 4.3.2.1 4.3.2.2 4.3.2.4

Question 6 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	$Mg(s) + Zn^{2+}(aq) \rightarrow Mg^{2+}(aq) + Zn(s)$	allow multiples allow **1** mark for $Mg^{2+} + Zn$ with missing or incorrect state symbols	2	AO2 4.1.1.1 4.2.2.2 4.4.1.4
06.4	magnesium (atoms) are oxidised because they lose electrons (and) zinc (ions) are reduced because they gain electrons	 if no other marks awarded allow **1** mark for magnesium (atoms) lose electrons and zinc (ions) gain electrons	1 1	AO2 4.4.1.4
Total			**9**	

4.5.1.2 Reaction profiles

Answer 13 · 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

4.5.1.2 Reaction profiles

Answer 13 · Mark scheme

November 2020 | 8462/1H | Original Q7

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

4.5.1.2 Reaction profiles

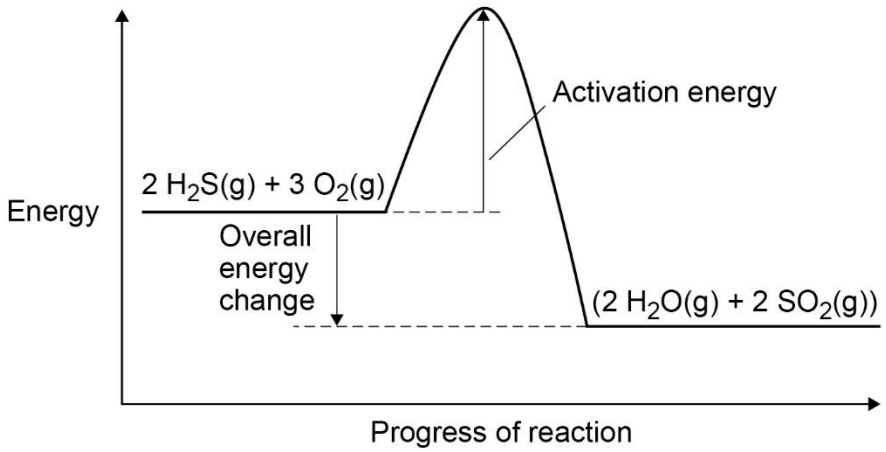
Answer 14 · Mark scheme

November 2021 | 8462/1H | Original Q8

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	water vapour	allow steam allow gaseous water	1	AO1 4.1.1.1 4.2.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.2	75 (cm^3)		1	AO2 4.3.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.3	product level below reactants activation energy drawn and labelled overall energy change drawn and labelled  scores **3** marks	ignore labelling of products if endothermic profile drawn allow corresponding overall energy change	1 1 1	AO1 4.5.1.2

Question 8 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.4	(bonds broken = 4(364) + 3(498) =) 2950		1	AO2 4.5.1.3
	(bonds formed = 2950 + 1034 =) 3984	allow correct use of incorrectly calculated values of bonds broken	1	
	4**X** + 4(464) = 3984	allow correct use of incorrectly calculated values of bonds formed	1	
	4**X** = **(**3984 – 1856 =) 2128		1	
	X = 532 (kJ/mol)		1	
	alternative approach: (bonds broken = 4(364) + 3(498) =) 2950 (1)			
	(bonds formed = 4(464) + 4**X** =) 1856 + 4**X** (1)			
	(1856 + 4**X**) – 2950 = 1034 (1)	allow correct use of incorrectly calculated values of bonds broken and/or bonds formed		
	4**X** = (1034 + 2950 – 1856 =) 2128 (1)			
	X = 532 (kJ/mol) (1)			

Total			10

4.5.1.2 Reaction profiles

Answer 15 · Mark scheme

November 2021 | 8462/2H | Original Q9

Question 9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	(delivery) tube is in (sulfuric) acid		1	AO3 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.2	reaction has stopped (because a) reactant is used up	allow no more gas produced allow named reactants	1 1	AO2 4.6.1.1 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.3	any **one** from: • the line (for 0.05 mol/dm^3 sulfuric acid) is less steep • (0.05 mol/dm^3 sulfuric acid) produces less gas in a fixed time • the reaction (using 0.05 mol/dm^3 sulfuric acid) takes longer to finish	allow converse statements about 0.10 mol/dm^3 sulfuric acid ignore produces less gas do **not** accept produces less gas in total	1	AO1 4.6.1.1 RPA5

Question 9 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.4	tangent drawn at 80 s on 0.05 mol/dm^3 curve (from tangent) value for *x*-step **and** value for *y*-step (rate =) $\frac{\text{value for } y\text{-step}}{\text{value for } x\text{-step}}$ calculation of rate answer to 2 significant figures	 allow a tolerance of ± ½ a small square allow correct use of incorrectly determined values from tangent for *x*-step and/or *y*-step allow an answer correctly calculated to 2 significant figures from an incorrect calculation of rate	1 1 1 1 1	AO2 4.6.1.1 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.5	Cu^{2+}		1	AO2 4.1.3.2 4.6.1.4

Total			10

4.5.1.2 Reaction profiles

Answer 16 · Mark scheme

June 2022 | 8462/1H | Original Q2

Question 2

Question	Answers	Mark	AO/ Spec. Ref
02.1	**Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6	AO1 4.5.1.1 RPA 4
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the plan 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 • **measure volume of (hydrochloric) acid** • with a measuring cylinder • pour (hydrochloric) **acid into a suitable container** eg polystyrene cup • measure the initial temperature (of hydrochloric acid) • with a thermometer • **add a known mass of sodium carbonate** • measured with a balance • stir • **measure the highest temperature reached** • **repeat with different masses of sodium carbonate or add successive masses of sodium carbonate to the same mixture** • repeat the whole investigation • use the same starting temperature • use the same volume of (hydrochloric) acid each time • use the same concentration of (hydrochloric) acid each time		

4.5.1.2 Reaction profiles

Answer 16 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2 View with Figure 3	change in highest temperature	allow a tolerance of ± ½ a small square	1	AO2 4.5.1.1 RPA 4
	corresponding change in mass	allow a tolerance of ± ½ a small square	1	
	(gradient =) $\frac{\text{change in highest temperature}}{\text{change in mass}}$	allow correct use of an incorrectly determined change in highest temperature and / or change in mass	1	
	(gradient =) 1.6		1	
	°C/g	allow °C/gram(s)	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3 View with Figure 3	extrapolates line to the *y*-axis		1	AO2 4.5.1.1 RPA 4
	20.6 (°C)	allow a tolerance of ± ½ a small square allow a correctly determined value from an incorrectly extrapolated line	1	
	alternative approach:			
	(highest temperature at 1.0 g – change in highest temperature per gram =) 22.2 – 1.6 (1)	allow correct use of value determined for gradient in question **02.2**		
	= 20.6 (°C) (1)			

4.5.1.2 Reaction profiles

Answer 16 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	C		1	AO3 4.5.1.1 RPA 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.5	(**X**) energy (**Y**) (overall) energy change		1 1	AO1 4.5.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.6	(level of) products is below (level of) reactants	allow the energy decreases (overall) allow energy is transferred to the surroundings ignore references to bond making / breaking	1	AO1 4.5.1.2

Total Question 2		17

4.5.1.2 Reaction profiles

Answer 17 · Mark scheme

June 2023 | 8462/1H | Original Q4

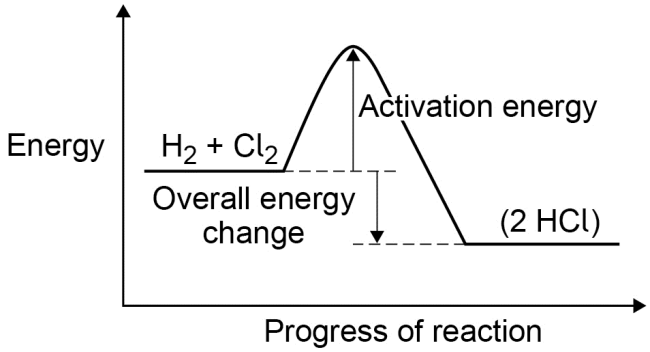
Question 4

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	

4.5.1.2 Reaction profiles

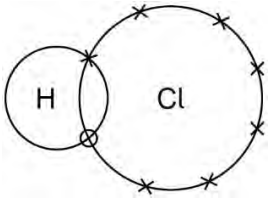
Answer 17 · Mark scheme June 2023 | 8462/1H | Original Q4

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			

4.5.1.2 Reaction profiles

Answer 17 · 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	

4.5.1.2 Reaction profiles

Answer 17 · Mark scheme

June 2023 | 8462/1H | Original Q4

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) **OR** (poly(ethene)) poly(ethene) has (much) larger molecules (1)		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

4.5.1.2 Reaction profiles

Answer 18 · Mark scheme

June 2024 | 8462/1H | Original Q8

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	propane is a small molecule	allow propane is a simple molecule	1	AO1 4.2.1.4 4.2.2.1 4.2.2.4
	(so) the forces between molecules are weak **or** (so) the intermolecular forces are weak	do **not** accept covalent bonds are weak	1	
	(which) require little energy to overcome	do **not** accept answers in terms of breaking covalent bonds	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.2	**B**		1	AO1 4.5.1.2

4.5.1.2 Reaction profiles

Answer 18 · Mark scheme

June 2024 | 8462/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.3	(bonds broken = 2(347) + 8**X** + 5(498) =) 3184 + 8**X**		1	AO2 4.5.1.3
	(bonds made = 6(805) + 8(464) =) 8542		1	
	(energy released = bonds made – bonds broken =) 2219 = 8542 – (3184 + 8**X**)	allow correct use of incorrectly determined values of bonds broken and/or bonds made	1	
	(8**X** =) 3139 (kJ/mol)	allow correct evaluation of the expression energy released = bonds broken – bonds made	1	
	(**X** =) 392 (kJ/mol)	allow 392.375 correctly rounded to at least 3 significant figures allow correct use of an incorrectly determined value for 8**X**	1	

Total Question 8	9

4.5.1.2 Reaction profiles

Answer 19 · Mark scheme

June 2024 | 8462/2H | Original Q2

Question 2

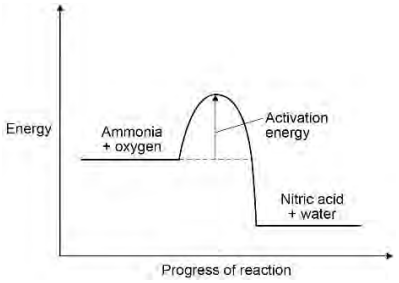
Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	to recycle (remaining) nitrogen and hydrogen	allow to recycle unreacted gases allow to return nitrogen and hydrogen to the reactor	1	AO1 4.10.4.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	iron	allow Fe	1	AO1 4.6.1.4 4.10.4.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	(test) glowing splint (result) (splint) relights	 MP2 is dependent upon MP1 being awarded	 1 1	AO1 4.8.2.2

4.5.1.2 Reaction profiles

Answer 19 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	labelled vertical arrow from dotted line to peak ammonia **and** oxygen on left **and** nitric acid **and** water on right	ignore arrow heads allow NH_3 for ammonia allow O_2 for oxygen allow HNO_3 for nitric acid allow H_2O for water an answer of  scores **2** marks	1 1	AO2 4.6.1.4 4.10.4.1 4.10.4.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.5	the line would reach a higher peak		1	AO1 4.6.1.4 4.10.4.1 4.10.4.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.6	fertilisers	allow explosives allow sports injury packs	1	AO3 4.10.4.1 4.10.4.2

Total Question 2	8

4.5.1.2 Reaction profiles

Answer 20 · Mark scheme

June 2025 | 8462/2H | Original Q8

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	a gas was produced	allow oxygen for gas	1	AO2 4.3.1.3 4.6.1.4
	(and the gas) escaped from the flask		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.2	catalysts provide a different pathway for the reaction		1	AO3 4.6.1.3 4.6.1.4
	(and) the activation energy using **B** is lower	allow converse	1	
	(so) the rate of reaction is higher using **B**	allow converse allow (so) the reaction using **B** has more particles with an energy exceeding the activation energy	1	

Answer 20 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.3	tangent at 60 s		1	AO2 4.6.1.1
	value for *x* step **and** *y* step from tangent	allow a tolerance of ± ½ a small square allow correct use of an incorrect tangent	1	
	(rate =) $\frac{\text{value for } y \text{ step}}{\text{value for } x \text{ step}}$	allow correct use of incorrectly determined *x* and / or *y* step from a drawn tangent	1	
	correct calculation of rate		1	
	answer in standard form	allow an answer correctly given in standard form from an incorrect calculation which uses values determined from the graph	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.4		allow converse		AO1 4.6.1.2 4.6.1.3
	the rate (of decomposition / reaction) increases at higher temperatures		1	
	(because) particles have more energy	allow (because) particles move faster	1	
	(so) collide more frequently	allow (and) a greater proportion collide with sufficient energy to exceed the activation energy	1	

Total Question 8	13

Answer 10 · Examiner comments

June 2018 | 8462/1H | Original Q5

Question 5 (standard and standard / high demand)

05.1 This question was done very well, with 94 % of students achieving both marks. The few that did not score both marks usually omitted to label their bars.

05.2 This question was very well answered, with 77% of students achieving both marks. The most common error was suggesting that the reactions were not endothermic because the copper experiment did not increase in temperature. This seems to suggest an unclear understanding of exothermic and endothermic reactions. Other common errors were in the use of language, such as the 'heat increases' (for temperature), or 'temperature is given out'.

05.3 It was expected that students would simply repeat the same experiment with the unknown metal, giving details of variables to be controlled in order to produce valid results. However, many students decided to go down a different track, and full marks could be achieved from methods involving:

- adding all of the five metals to an acid
- adding the unknown metal to salt solutions of the other four
- measuring either the temperature change or some measure of the rate of reaction
- heating the unknown metal with oxides of the other four
- using the unknown metal as one electrode in a series of electrochemical cells and measuring the voltage produced.

8% of students achieved full marks, and 53% achieved two or more.

The most common missed mark was for the control variable. Though some realised that a control variable was necessary, use of the ubiquitous 'amount' was all too frequently seen and did not gain credit.

The method involving displacement reactions was very common but not very successful, with vague references to adding the metal to unspecified solutions, or to metal oxides without heating, or to other metals. Some students wanted to add the metals to water, without recognising that these four metals would not react with water, so they would only be able to place the unknown if it were the most reactive. Other students placed the metal in relation to carbon or hydrogen rather than to the other four metals as required by the question.

There was some confusion between making results valid (by using control variables to give a fair test) as opposed to accurate (by cutting down energy exchange with the surroundings), which did not gain credit.

4.5.1.2 Reaction profiles

Answer 10 · Examiner comments June 2018 | 8462/1H | Original Q5

05.4 Many excellent answers were seen, although there were some very sloppy diagrams. 54% of students achieved two or three marks.

- A significant number had drawn an endothermic curve, but then went on to label it correctly so were able to access two of the three available marks.
- A small number drew the correct curve, but then did not put on the labels.
- Some labelled reactant and product lines incorrectly as start and end temperature.
- Some attempted labels by, for example, drawing a line / arrow from the right to point at the top of the curve and labelling it incorrectly as activation energy.

Answer 11 · 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.

4.5.1.2 Reaction profiles

Answer 11 · 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 12 · Examiner comments November 2020 | 8462/1H | Original Q6

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

06.1 Most students were able to express the idea that activation energy is the minimum energy required to start a reaction. One common error was to say that it is the energy needed to make particles collide.

06.2 A variety of approaches was seen. The majority of students calculated the number of moles of both aluminium and of iron oxide and then attempted with varying degrees of success to explain why the number of moles of aluminium was insufficient for the iron oxide. Common errors were to omit to convert the mass from kilograms to grams, and/or using 54 as the 'M_r' of aluminium. Of those who did correctly calculate the number of moles of each reactant, some had difficulty in expressing clearly the idea of 2 moles of aluminium being needed to react with 1 mole of iron oxide, and therefore 37.0 moles of aluminium is less than the 37.5 moles required, or that 18.75 moles of iron oxide is more than the 18.5 moles required. Other students started with the mass of one reagent and calculated the required mass of the other, either by the moles method or by proportion. These students found it easier to express why there was insufficient aluminium or excess iron oxide.

06.3 Few students scored both marks. Aqueous zinc was often seen as a response. Many students did not understand the idea of an ionic equation and tried to include the sulfate ion.

06.4 Only a third of students scored both marks, but a lot of students were confused about which species gained electrons and which lost them. Definitions of oxidation and reduction in terms of gain and loss of oxygen were not appropriate here and were not credited.

4.5.1.2 Reaction profiles

Answer 13 · 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

Answer 13 · 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.

4.5.1.2 Reaction profiles

Answer 14 · Examiner comments

November 2021 | 8462/1H | Original Q8

Question 8 (standard, standard / high and high demand)

08.3 Whilst there were many excellent answers, many were very carelessly drawn, with arrows for activation energy and overall energy change being placed so that their start and end were only vaguely near the correct levels. Dotted lines should be drawn to clarify the energy gaps. Some drew the profile for an endothermic change, rather than exothermic, and some did not complete the profile, leaving out the energy level of the products. Some appeared to think that the activation energy is the energy at the peak, rather than the difference between the energy of the reactants and the peak.

08.4 A good number of students were successful with this calculation, although some failed to count all of the bonds correctly. Where students made a slip of this nature, or an arithmetic error, it was sometimes impossible to award marks for following through with the method, since there was often a jumble of numbers scattered over the page with no words to explain what was going on. ‘Bonds broken’ and ‘bonds made’ should be stated in calculations of this type. Many students did not use the value of 1034 kJ/mol provided.

Answer 15 · Examiner comments

November 2021 | 8462/2H | Original Q9

Question 9 (standard, standard / high and high demand)

09.1 Only around a third of students knew this, which may reflect a lack of practical experience.

09.2 Many students were able to say that the reaction had stopped but only a much smaller number could explain why.

09.3 Around half of the students were able to explain this in a valid way, usually by reference to the slope of the line.

09.4 There was a wide spread of marks here. There is still confusion between mean and instantaneous rate of reaction, so students who approached this as a mean reaction rate usually only scored one mark for giving an answer to 2 significant figures. Amongst the better responses, the first mark was sometimes dropped because the tangent was not close enough to 80 seconds. Some students were able to obtain all 5 marks.

09.5 Around one-third of students identified copper(II) as the only transition metal amongst the choices and therefore more likely to have a catalytic effect.

Answer 16 · Examiner comments

June 2022 | 8462/1H | Original Q2

Question 2 (Standard demand)

02.1 Many excellent answers were seen, with a workable method laid out clearly in a logical order, and with added detail such as the use of a beaker to support a polystyrene cup, or using lagging to insulate a beaker. Answers often included a list of suitable apparatus for measurement of volume and mass, and details of important control variables such as the volume and concentration of acid.

Some students, however, tried to measure the loss in mass during the reaction, or even the volume of gas produced. A few compromised the experiment by heating the mixture with a Bunsen burner. Some students measured and varied the volume of sodium carbonate rather than the mass, despite being informed that the sodium carbonate was a powder and to investigate the change in mass.

Although most candidates referred to the measurement of temperature, the key step in the method that was most often missing was the instruction to measure the highest temperature reached by the mixture.

Repeating the experiment with a different mass of sodium carbonate was the most common method used but a method which involved adding successive masses of sodium carbonate to the same container could also gain full credit provided that the highest temperature reached was measured after each addition of sodium carbonate.

02.2 Most students determined the gradient correctly, with many using the coordinates of the points at the limits of the printed line. Some appeared to misread the scale on the *y*-axis, reading 28.6 as 28.3 and 22.2 as 22.1. Many did not annotate their graph; those who read their coordinates incorrectly made it very difficult for examiners to judge whether the *x*-coordinates corresponded to the given *y*-coordinates. Students should always show their working in full, including annotating the graph. Units were usually given correctly, but g/°C was often seen. C° is not a correct representation of degrees Celsius.

02.3 The vast majority of students extrapolated the line to the *y*-axis correctly and read off the value of initial temperature. A handful of candidates gave a value for the initial temperature without annotating the graph so were not awarded any marks.

02.4 Nearly all students correctly identified **C** as the correct graph.

02.5 Fewer than half of students scored both marks, although nearly 80% scored at least one mark. Activation energy was a common incorrect response for either **X** or **Y**. Other incorrect answers included time for **Y** and temperature for **X**.

02.6 Most students referred correctly to the relative energies of the reactants and products, or to the loss of energy shown by those energies. A few students referred to temperature or heat rather than energy and were not given any credit.

4.5.1.2 Reaction profiles

Answer 17 · 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.

4.5.1.2 Reaction profiles

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Question 8 (standard, standard/high and high demand)

08.1 This question discriminated very well. Whilst more than a half of students scored at least one mark, only one in seven scored all three. Few students recognised that it is the structure of propane as small molecules that is important rather than it being a hydrocarbon with single bonds. Most did not mention the structure at all. Although many students used the term intermolecular forces, it was clear that many did not know what this phrase means as they referred to 'intermolecular forces between atoms' or 'between bonds.' These students did not gain credit for the forces being weak or needing little energy to overcome. Some, who correctly referred to intermolecular forces being weak, then described little energy being needed to break bonds rather than to break the intermolecular forces. This is a question where clear and precise use of language is absolutely critical.

08.2 Over three quarters of students identified the correct reaction profile. The most popular distractors were **A** and **D**.

08.3 Over a quarter of students gained full marks on this high demand question, with half of students gaining at least 4 marks. Sometimes working was very difficult to follow; there was a page full of additions and subtractions with no words to explain what these represented. Just the words 'broken' and 'made' would have clarified the working enormously. The students who scored 4 marks had usually failed to recognise that the reaction is exothermic and therefore 2219 (the magnitude of the energy change) is given by (bonds made – bonds broken) since the energy for bonds made must be the larger value in an exothermic reaction. It should be noted that ΔH and its sign convention are not in the GCSE specification. Other common errors included: not including the C—C bonds: counting 3 C—C bonds instead of 2; complete omission of the value of the energy change.

4.5.1.2 Reaction profiles

Answer 19 · Examiner comments June 2024 | 8462/2H | Original Q2

Question 2 (standard demand)

02.1 Around two-fifths of students gained credit on this question. Some students referred to both hydrogen and nitrogen gases being recycled or reused. A few referred to only one of the gases or unspecified unreacted gases.

A number of students referred to excess gases or gases alone. In addition, some students focused their answer on the condenser part of the flow chart and responded with the idea that uncondensed gases needed to be recycled.

02.2 This question was answered well by the majority of students, with roughly two-thirds of students gaining the mark.

02.3 Although this question was answered well, some students referred to a splint being lit initially and then blown out. These students did not often mention the splint was still glowing. The majority of students who stated glowing splint also gained the second marking point. Around three-quarters of students gained both marks; of those who did not, most described the test for hydrogen.

02.4 There were many variations of drawing the arrow for the activation energy. A number of students labelled the activation energy with abbreviations such as E_a. The majority of students correctly named the reactants and products and placed them above and below the lines, with a few using arrows to point out their positions. More than 60% of students gained both marks.

02.5 This multiple-choice question was well answered, with around 70% of students gaining credit. The most popular distractor was that the peak would be lower rather than higher.

02.6 This question was answered extremely well with fertiliser or NPK fertiliser. A small minority stated farming or agricultural use unqualified. Only a handful of students identified its use in explosives or sports injury packs.

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Answer 20 · Examiner comments June 2025 | 8462/2H | Original Q8

Question 8

08.1 Three quarters of students described correctly how gas escaped from the flask to cause the decrease in mass, however, students did not always say that the gas was a product of the reaction which was marking point 1. A few students incorrectly said that the gas evaporated, which was not accepted.

08.2 Three quarters of students described how catalysts provide an alternative pathway for the reaction. A description of a shorter pathway is not equivalent to an

4.5.1.2 Reaction profiles

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alternative pathway. Marking points 2 and 3 needed comparative statements between catalyst A and B. Some students just described in general how catalysts lower activation energy. This was not enough for these two marking points. Students needed to say the activation energy was lower using B. Saying catalyst B requires a lower activation energy was also not accepted, because a catalyst provides or allows a lower activation energy rather than requiring or needing one.

08.3 This style of question is becoming more familiar to students, with over 4 in 5 gaining at least 2 marks, which would require the drawing of a tangent. Over half of all students went on to correctly calculate the rate and give the answer in standard form. Answers were often well set out showing clearly which graph points had been used to calculate the gradient. Students could successfully quote the number in standard form. There were still quite a few students who just read the value of mass and time from the graph. Without a tangent, students could only gain the mark for an answer given in standard form.

08.4 Over 40% of students gave good answers that scored full marks. Students are well versed in describing how particles have more energy at higher temperatures. The idea of particles colliding more frequently was still a stumbling block for some; some students forgetting to include the word frequently. Very few students used the idea of a greater chance of collision that is not equivalent to frequency, which is a positive sign.