AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.5.1.1

Energy transfer during exothermic and endothermic reactions

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**76**
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.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 01 · Mark scheme March 2007 | CHY1A | Original Q7 | Legacy

Seven	**3**	**2**	**4**	**2**

Answer 02 · Mark scheme November 2007 | CHY1B | Original Q8 | Legacy

Eight	**1**	**2**	**2**	**3**

Answer 03 · Mark scheme January 2008 | CHY2H | Original Q1 | Legacy

Question 1

question	answers	extra information	mark
(a)	sensible line of best fit which goes through or close to all the points **except** the anomalous point	allow wobbly / short double lines ± ½ square	1
(b)	loss of gas / loss of CO_2	idea of gas produced / formed	1

Answer 04 · Mark scheme January 2008 | CHY2H | Original Q5 | Legacy

The full source mark scheme begins on page 169. Follow original question 5 in that document.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 05 · Mark scheme January 2008 | CHY2H | Original Q7 | Legacy

(c)	7		1
(d)(i)	steeper line from around the same starting point and left of the points levelling off at 99	allow crosses if they are fully correct for **1** mark accept short level line at 99 ± ½ square	1 1
(d)(ii)	any **three** from: • particles / molecules / atoms/ ions have more energy • move faster • collide <u>more</u> often **or** <u>more</u> chance of collisions **or** bump into each other <u>more</u> • collide with <u>more</u> force / energy **or** <u>more</u> particles have the activation energy **or** <u>more</u> collisions result in reaction **or** <u>more</u> collisions are successful	 allow given / gain / get energy ignore move about more ignore vibrate more / faster ignore collide quicker / faster	3
total			8

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 2

question	answers	extra information	mark
(a)	any **one** from: • they are made of layers • atoms / ions / particles / layers (of atoms) can slide over each other	do **not** accept line / rows / lattice	1
(b)	any **one** from: • smaller / tiny **or** very small • correct size range 1 to 100 nanometres • a few hundred atoms in size	do **not** allow small alone if they state smaller and give a size outside range ignore size if it is less than 20,000	1
(c)	harder plus **one** from: • so does not wear as quickly / erode as quickly • less vulnerable to damage owtte • because they have a high surface area to volume ratio **or** stronger (1) plus **one** from: (1) • less likely to break / do not break • not as vulnerable to damage owtte • do not bend out of shape • because they have a high surface area to volume ratio	 ignore corrode harder to wear down = **1** mark accept withstand pressure harder and stronger alone gains **1** mark	1 1
total			4

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 3

question	answers	extra information	mark
(a)	N_2O		1
(b)	13.8 to 14	gains full marks without working if answer incorrect 13 gains **1** mark **or** 14/101 × 100 gains **1** mark	2
total			3

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

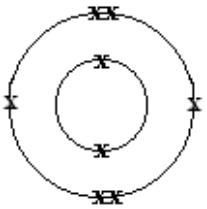
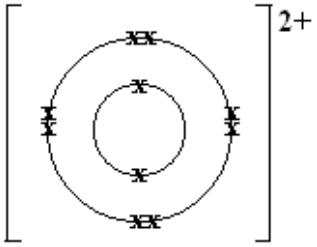
Question 4

question	answers	extra information	mark
(a)	electric current / electricity		1
	plus **one** from:		1
	• is passed through ionic compound / substance / electrolyte • passed through molten/aqueous compound / substance	must be linked to electricity allow liquid compound / substance do **not** allow solution / liquid alone	
	• causing decomposition	accept split up / breakdown / breaking up owtte ignore separated accept elements are formed ignore new substances form	
(b)	hydrogen	accept H_2 do **not** accept H / H^2	1
(c)	one electron from each atom	accept each carbon is bonded to three other carbon atoms leaving one (unbonded) electron owtte	1
	is delocalised / free (to move)	must be linked to electrons answers of delocalised / free electrons only, gains **1** mark accept each carbon is bonded to three other carbon atoms leaving delocalised / free electrons = **2** marks **maximum 1** mark if graphite described as a metal / giant ionic lattice	1
total			5

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 5

question	answers	extra information	mark
(a)	any **one** from: • gives out heat / energy • transfers energy from a substance to the surroundings • ΔH / energy change / enthalpy change is negative	accept releases / gives off owtte ignore references to light	1
(b)	$2Mg + O_2 \rightarrow 2MgO$	accept correct multiples / fractions	1
(c)		electrons do not need to be paired accept dots / circles / e instead of crosses do **not** allow 2.6 without diagram	1
(d)		electrons do not need to be paired allow without brackets must have the charge accept dots / circles / e instead of crosses ignore extra empty outer shells ignore nucleus do **not** allow $[2.8]^{2+}$ without diagram	1

continued…

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 5 continued…

question	answers	extra information	mark
(e)	oppositely charged (ions / atoms)	allow positive and negative(ions / atoms)	1
	(they) attract	must be in correct context accept held by electrostatic forces ignore ionic bonding **maximum 1** if they refer to intermolecular forces / attractions / covalent bonds	1
(f)	magnesium chloride	accept $MgCl_2$ (if correctly written)	1
total			7

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 6

question	answers	extra information	mark
(a)	**Compound A** any **one** from: • sodium bromide • potassium bromide • ammonium bromide • hydrogen bromide • any metal bromide except silver and lead. **Compound B** silver nitrate	accept correct formulae accept silver sulfate	1 1
(b)	the silver compound will decompose / silver ions be reduced to silver (owtte)	accept film would darken owtte accept any idea of light changing silver bromide / silver ions / silver nitrate / silver sulfate allow 'forms a black solid' / it would turn black	1
(c)	precipitation	accept descriptions of precipitation reactions accept double decomposition accept precipitate do **not** allow displacement	1
(d)	electrons are gained	 the second mark **must** be linked to electrons accept it / silver / silver ions gains electrons for **both** marks ignore references to oxygen	1 1
total			6

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 7

question	answers	extra information	mark
(a)	1213.8 to 1214.3 correct answer not given then check working 1) moles of N_2 = $\frac{1000}{28}$ = 35.7 mol 2) moles of NH_3 = 2 × (answer from (1)) = 71.4 mol 3) mass of NH_3 = (answer from 2) × 17 = 71.4 × 17 = 1214 g **or** • 28g of N_2 → 34g of NH_3 • 1g of N_2 → $\frac{34}{28}$ = 1.214g NH_3 • 1000 g of N_2 → 1000 × 1.214 = 1214g **or** • $1000 \times \frac{34}{28}$ **or** **other correct methods**	gains **3** marks without working **1** mark for each correct step do **not** penalise rounding errors in this part **1** mark for each correct step do **not** penalise rounding errors in this part allow error carried forward eg gains **2** marks if correct answer not given $1000 \times \frac{28}{34}$ gains **1** mark, **2** marks if correctly calculated (823.5g) $1000 \times \frac{28}{17}$ gains **1** mark if calculated correctly (1647.05g) look for the key ideas in the methods above	3

continued…

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 7 continued…

question	answers	extra information	mark
(b)	25 / 25.035 **or** ecf from (a)	gains **2** marks even when there is no working incorrect answer then 304/(their answer from (a)) × 100 gains **1** mark	2
	or using figures from part (b) **27.6 / 28**	gains **2** marks even when there is no working accept 27 for **1** mark if answers incorrect then304/1100 × 100 gains **1** mark	
(c)(i)	increase yield reaction is exothermic **or** allow decreased yield because rate of reaction is slower / fewer collisions for **2** marks	**must** get both points for **2** marks	1 1
(c)(ii)	increase yield plus **one** from: • more (gaseous) reactant molecules than (gaseous) product molecules (owtte) • increased rate of reaction / more collisions	accept greater volume on the left than the right owtte	1 1

continued…

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 7 continued…

question	answers	extra information	mark
(d)	any **one** from: **economic** • large town provides workforce • workers do not have to travel far to the factory. (owtte) • transport infrastructure already in place for large town. (owtte) • factory brings prosperity to town (owtte) • factory provides employment • reduced tourism • reduction in local house prices • any other sensible economic factor linked to town		1
	any **one** from: **safety** • <u>escape</u> of dangerous / harmful chemicals / gases (owtte) • <u>danger</u> of increased traffic • risk of explosion.(owtte) /danger of high pressure • consequences of an accident could be severe if the town is close • any other sensible safety idea	do **not** allow polluting gases unqualified	1

continued…

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 7(d) continued…

question	answers	extra information	mark
	any **one** from: **environmental** • factory might be unsightly (owtte) • screening of factory (owtte) • loss of habitats (owtte) • plant trees/ hedges etc on and around plant site • pollution of water / air / soil could harm plants / animals **or** noise pollution • CO_2 is produced by burning fuels / heating • CO_2 causes global warming / any effect of global warming • eye sore • any other sensible environmental factor	must be explained	1
total			12

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 06 · Mark scheme

June 2008 | CHY1H | Original Q1 | Legacy

question	answers	extra information	mark
1(a)(i)	calcium oxide / CaO carbon dioxide / CO_2	products can be in either order ignore chemical names other than calcium oxide **or** carbon dioxide	1 1
1(a)(ii)	(thermal) decomposition	accept endothermic	1
1(b)(i)	(chemical) reaction / react energy / heat released / exothermic	accept calcium hydroxide / slaked lime produced ignore incorrect products ignore gets hot / heats up if neither mark awarded then allow 'mixing the chemicals heats up the coffee' for **1** mark	1 1
1(b)(ii)	any **two** from: • foil has been broken • ring pull used • quicklime and / or water mixed / reacted	if neither mark awarded accept 'cannot / difficult to repair' for **1** mark ignore button pushed accept reaction not reversible accept cannot / difficult to replace quicklime / water / chemicals	2
Total			**7**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 06 · Mark scheme

June 2008 | CHY1H | Original Q1 | Legacy

COMPONENT NUMBER: CHY1H

COMPONENT NAME: Science B / Chemistry

STATUS: Final

DATE: June 2008

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 07 · 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 × 435) + 498 = 1368 bonds made: (2 × 805) + (2 × 464) = 2538 energy change: 1368 – 2538 = (–)1170	 allow: (8 × 435) + 498 = 3978 allow: (6 × 435) + (2 × 805) + (2 × 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**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 07 · Mark scheme June 2008 | CHY3H | Original Q7 | Legacy

COMPONENT NUMBER: CHY3H

COMPONENT NAME: Chemistry

STATUS: Final

DATE: June 2008

Answer 08 · Mark scheme March 2009 | CHY1AP | Original Q7 | Legacy

Seven	**3**	**3**	**4**	**4**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 09 · Mark scheme

June 2009 | CHY2H | Original Q3 | Legacy

Question 3

question	answers	extra information	mark
3(a)	to speed up the reaction **or** it is a catalyst	allow higher level answers such as to reduce the activation energy ignore cost or yield	1
3(b)(i)	reaction is exothermic	accept reverse reaction is endothermic **or** high temperature causes decomposition of ammonia ignore reference to rate	1
3(b)(ii)	more (gaseous) reactant molecules than (gaseous) product molecules	accept 4 volumes / moles of reactant and 2 volumes / moles of product accept lower volume of products **or** volume lower on right hand side accept 'favours the reaction which produces fewer molecules' ignore incorrect number of moles ignore reference to' amount' of product / reactant ignore reference to rate	1
3(c)	(rate is) too slow / slower owtte	allow catalyst would not work accept at higher temperature the rate is quicker accept at lower temperatures particles do not collide as often **or** fewer particles have the activation energy **or** particles do not have the activation energy ignore reaction would not work ignore optimum / compromise type answers	1

Question 3 continues on the next page…

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 3 Continued

question	answers	extra information	mark
3(d)	cooled	allow ammonia / it is turned into a liquid **or** is condensed ignore references to boiling point	1
3(e)	nitric (acid)	allow HNO_3 ignore hydrogen nitrate	1
Total			**6**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 09 · Mark scheme

June 2009 | CHY2H | Original Q3 | Legacy

CHY2H

Answer 10 · Mark scheme

November 2009 | CHY1AP | Original Q1 | Legacy

Question	Key		
One	**A**	Calcium (Ca)	**2**
	B	Lithium (Li)	**3**
	C	Gold (Au)	**1**
	D	Iron (Fe)	**4**

Answer 11 · Mark scheme

November 2009 | CHY1BP | Original Q7 | Legacy

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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 12 · Mark scheme January 2010 | CHY2H | Original Q5 | Legacy

Question 5

question	answers	extra information	mark
5(a)(i)	0.2	correct answer gains **2** marks with or without working accept answer in table if answer incorrect 5/25 gains **1** mark	2
5(a)(ii)	any **one** from: • wider range of temperatures (owtte) • (repeat at the same temperature) to improve accuracy / reliability • reveal anomalous results (owtte) • so you can get an average / better average	 allow to make it reliable / accurate allow to eliminate random / human errors / to check results owtte ignore to make it a fair test / to get better results ignore precision and validity	1
5(b)	any **two** from: • particles gain energy / have more energy • particles move faster • particles collide more • more of the particles have the activation energy **or** more of the collisions are successful (owtte) **or** particles <u>collide</u> with more force / harder / more energy	allow atoms / molecules / they instead of particles throughout ignore increases particles activation energy ignore move more / vibrate more ignore increases / decreases activation energy allow more successful collisions alone for **1** mark	2
Total			**5**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 12 · Mark scheme

January 2010 | CHY2H | Original Q5 | Legacy

CHY2H

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 13 · Mark scheme January 2010 | CHY2H | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)	any **two** from: • heat water / make steam / boil water **or** heat / steam used in stage 1 • carbon dioxide from stage 3 used in stage 7 / to make urea • nitrogen and / or hydrogen recycled (owtte) • ammonia and / or carbon dioxide <u>recycled</u> (owtte)	allow reused instead of recycled in correct context allow unreacted material / gas recycled from stage 5 (to 4) allow unreacted material / gas recycled from stage 8 (to 7) NB if neither of the last two points are awarded unreacted material recycled = **1** mark	2
6(b)	any **one** from: • fertiliser / fertilise / fertile • provide nitrogen • any idea of faster / better / helps growth of crop • greater yield of crop • helps proteins / amino acids to form in plants owtte	ignore cost ignore neutralisation / minerals / to treat plants / photosynthesis allow give plants nutrients allow provides nitrate	1
6(c)	3	allow correct multiples eg $2CH_4 + 2H_2O \rightarrow 2CO + 6H_2$	1
6(d)(i)	(forward reaction is) exothermic / gives out heat	accept Le Chatelier based answers accept reverse argument eg because at high temperature the ammonia would decompose	1

Question 6 continues on the next page...

CHY2H

Question 6 continued

question	answers	extra information	mark
6(d)(ii)	reaction is too slow / takes too long **or** to make the reaction fast(er)	allow answers that imply increased rate eg more collisions / particles have more energy allow catalyst works better ignore optimum condition / compromise type answers ignore yield	1
6(e)	sulfuric / H_2SO_4	accept sulphuric	1
6(f)(i)	3400	correct answer gains all **3** marks with or without working if answer incorrect: 1700 with or without working or 6000 × (34/60) gains **2** marks **or** 6800 gains **2** marks with or without working **or** moles of urea = 6000/60 = 100 gains **1** mark moles of ammonia needed = 200 gains **1** mark **or** 6000 × (17/60) gains **1** mark **or** (2×17) → 60 gains **1** mark **or** 34 → 60 gains **1** mark	3

Question 6 continueson the next page

CHY2H

Question 6 continued

question	answers	extra information	mark
6(f)(ii)	76.9	correct answer gains **2** marks with or without working. allow 77 or 76.923… allow 76 **or** 0.77 **or** 0.76923 for **1** mark if answer incorrect allow **1** mark for **either** identifying the mass of the useful product **or** the total M_r of reactants – this can be awarded from the numbers in the calculation: M_r of useful product = 60 M_r of reactants = 78 **or** (2×17)+44 **or** 60 +18 60/78 × 100 gains **1** mark	2
Total			**12**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 14 · 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**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 14 · Mark scheme

January 2010 | CHY3H | Original Q6 | Legacy

CHY3H

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 15 · Mark scheme

June 2010 | CHY2H | Original Q2 | Legacy

Question 2

question	answers	extra information	mark
2(a)(i)	(different) properties	allow ideas of different property / behaviour / element	1
2(a)(ii)	any **one** from: • they had high status **or** they were lecturers / doctors / professors / famous scientists • other scientists repeated experiments • they had proof **or** lots of / strong / conclusive / enough / clear evidence	they = Crawford + Cruikshank allow experiment could be repeated allow other scientists showed they had different properties ignore evidence unqualified	1
2(a)(iii)	other scientists obtained similar results / proved it **or** experiments were repeated		1

Question 2 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY 2H

Question 2 continued

question	answers	extra information	mark
2(b)(i)	any **one** from: • mass of solid / strontium (chloride) / barium (chloride) • volume of water • type of container	allow amount / volume allow amount / mass allow initial / starting temperature (of water) ignore room temperature / time / concentration ignore reference to hydrochloric acid	1
2(b)(ii)	2 **and** takes in heat / energy **or** 2 **and** temperature goes down (owtte)		1
2(b)(iii)	temperature increased for one experiment and decreased for the other (owtte) **or** one was exothermic and one was endothermic (owtte)	accept experiment 1 was exothermic	1
2(c)	any **one** from • positive / + (charge) • opposite (charges) attract	do **not** accept incorrect further qualification eg electrons / atoms / electrodes	1
Total			**7**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 15 · Mark scheme

June 2010 | CHY2H | Original Q2 | Legacy

CHY 2H

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 16 · Mark scheme

June 2010 | CHY2H | Original Q4 | Legacy

Question 4

question	answers	extra information	mark
4(a)(i)	84 / 84.5 / 83.98	correct answer with or without working gains **3** marks (moles of NaN_3 =) 130/65 (1) moles of nitrogen = 3 (1) mass of nitrogen = 3 x 28 = 84 (1) **or** 2 x (23 + (3 x 14)) (1) 3 x (2 x14) (1) **or** $2NaN_3$ = 130 (1) $3N_2$ = 84 (1) if answer is incorrect then look for evidence of correct working. allow ecf from previous stage **1** mark lost for each mistake in the working if they do not have the correct answer.	3
4(a)(ii)	72 / 72.24 / 72.2 **or** 69 **or** 68.8	allow ecf from part (i) × 0.86 ignore working	1
4(b)(i)	2 **and** 5		1
4(b)(ii)	any **one** from: • corrosive / burns • alkaline / basic • attacks / destroys / damages living tissue / cells	do **not** accept acidic allow irritant ignore reference to reactivity ignore reference to silicates ignore harmful / toxic	1
Total			**6**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 16 · Mark scheme

June 2010 | CHY2H | Original Q4 | Legacy

CHY 2H

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 17 · Mark scheme

June 2010 | CHY2H | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)	same number of (gaseous) molecules / moles / volume on both sides of the equation	allow particles for molecules do **not** accept atoms ignore amount	1
6(b)	(forward) reaction is exothermic	accept reverse answer	1
6(c)	any **three** from: • particles gain energy • particles move faster • particles collide more **or** more collisions • more of the collisions are successful **or** more of the particles have the activation energy **or** particles collide with more force / energy	 allow particles collide faster / quicker ignore move more / vibrate more	3

Question 6 continues on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY 2H

Question 6 continued

question	answers	extra information	mark
6(d)	any **two** from: • more product (obtained in shorter time) • less fuel needed **or** lower fuel costs • less pollution caused by burning fuels **or** less specified type of pollution caused by producing heat / burning fuels • using less fuel conserves resources	 accept better yield (of product) accept less energy / heat / electricity needed ignore cheaper unqualified allow correct specified pollutants caused by burning fossil fuels eg CO_2 / greenhouse gases **or** correct effect of burning fossil fuels eg global warming accept thermal / heat pollution accept sustainable accept fossil fuels are non-renewable	2
Total			**7**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 18 · Mark scheme

November 2010 | CHY1AP | Original Q8 | Legacy

Eight	**3**	**2**	**2**	**2**

Answer 19 · Mark scheme

November 2010 | CHY1BP | Original Q8 | Legacy

Eight	**1**	**4**	**1**	**3**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 20 · Mark scheme

January 2011 | CHY2H | Original Q4 | Legacy

Question 4

question	answers	extra information	mark
4(a)	gives out heat / energy **or** energy / heat transferred to the surroundings	allow release / loses allow the products have less energy ignore temperature rises allow more energy given out in forming bonds than taken in to break bonds	1
4(b)(i)	speed up the reaction (owtte)	accept changes the rate accept lowers activation energy accept increases successful collisions accept allows reaction to take place at a lower temperature	1
4(b)(ii)	nitrogen (N_2) / oxygen (O_2) / products are safe **or** not harmful / pollutant / toxic / dangerous / damaging **or** (harmful) nitrogen monoxide / NO is not released into the air.	ignore releases nitrogen / oxygen unless qualified accept prevents / less acid rain ignore greenhouse gas / ozone layer	1
4(b)(iii)	2 and 2	accept correct multiples or fractions	1
4(b)(iv)	idea of catalyst not being used up	allow not changed by reaction ignore catalyst does not take part ignore catalyst not used in the reaction	1

Question 4 continues on the next page

CHY2H

Question 4 contd

question	answers	extra information	mark
4(b)(v)	idea of different reactions (require different catalysts)	accept catalysts work for specific reactions allow different gases	1
4(c)	• smaller / very small / or any indication of very small / 1–100 nanometres / a few (hundred) atoms • big(ger) surface area • less (catalyst) needed / small amount of catalyst needed	ignore just small ignore size of the converter	1 1 1
Total			**9**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 20 · Mark scheme

January 2011 | CHY2H | Original Q4 | Legacy

CHY2H

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 21 · Mark scheme

January 2011 | CHY2H | Original Q6 | Legacy

Question 6

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

Question 6 continued on the next page

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 6 contd

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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 6 contd

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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 22 · Mark scheme

January 2011 | CHY3H | Original Q7 | Legacy

Question 7

question	answers	extra information	mark
7(a)		correct answer with or without working = **3** marks	
	M1: (bonds broken) = 2148 (kJ)		1
	M2: (bonds made) = 2354 (kJ)		1
	M3: change in energy = (–) 206 (kJ)	ecf ignore sign	1
7(b)	energy released from forming new bonds is greater than energy needed to break existing bonds	allow the energy needed to break bonds is less than the energy released in forming bonds do **not** accept energy needed to form bonds	1
Total			**4**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 23 · Mark scheme

March 2011 | CHY1AP | Original Q8 | Legacy

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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 24 · Mark scheme

June 2011 | CHY2H | Original Q3 | Legacy

Question 3

question	answers	extra information	mark
3(a)	particles move faster **or** particles have more energy so they collide more often / frequently **or** more of the collisions are successful / have the activation energy	accept molecules / atoms / ions instead of particles ignore move / vibrate more allow particles collide harder / with more force ignore collide quicker ignore collide more / more collisions	1 1
3(b)	any **one** from: • increase surface area (of the rock) • increase the concentration (of the acid) • add a catalyst • stir / mix the mixture	 accept crush / powder the rock ignore increase the pressure / temperature	1
Total			**3**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 24 · Mark scheme

June 2011 | CHY2H | Original Q3 | Legacy

CHY2H

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 25 · Mark scheme

June 2011 | CHY2H | Original Q4 | Legacy

Question 4

question	answers	extra information	mark
4(a)	gives out heat / energy **or** energy / heat transferred to surroundings	allow more energy given out in making bonds than is used in breaking bonds ignore light	1
4(b)	activation	allow phonetic spelling	1
4(c)(i)	2 crosses on inner circle **and** 8 crosses on outer circle	accepts dots / e / — for electrons	1
4(c)(ii)	opposite charges (attract)	allow electrostatic forces (attract) do **not** accept intermolecular attraction / shared electrons	1
Total			**4**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 25 · Mark scheme

June 2011 | CHY2H | Original Q4 | Legacy

CHY2H

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 26 · Mark scheme

June 2011 | CHY2H | Original Q7 | Legacy

Question 7

question	answers	extra information	mark
7(a)(i)	nitrogen – air hydrogen – north sea gas / natural gas / methane / CH_4	accept atmosphere accept water / (crude) oil / coal / hydrocarbons / brine	1 1
7(a)(ii)	• high temperature gives a low yield • because reaction is exothermic • but at low temperatures the rate is (too) slow	allow converse throughout must be linked to first bullet point if no other marks awarded accept 450°C is a compromise between yield and rate **or** 450°C gives a reasonable yield in a reasonable time for **1** mark	1 1 1
7(a)(iii)	nitric (acid)	accept HNO_3	1
7(b)	Ammonia / Haber process can be used to make fertiliser with a specified economical reason eg raw materials for Haber process readily available eg transport costs are lower or no need to import eg Haber process is a continuous process	 ignore employment / labour costs	1 1
Total			**8**

The AQA UMS Conversion Calculator is available on the Results statistics page of the AQA Website

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 27 · 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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

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**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 27 · Mark scheme June 2011 | CHY3H | Original Q4 | Legacy

CHY3H

Answer 28 · Mark scheme November 2011 | CHY1AP | Original Q7 | Legacy

Seven	**1**	**2**	**2**	**3**

Answer 29 · Mark scheme November 2011 | CHY1BP | Original Q6 | Legacy

Six	**2**	**1**	**4**	**4**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 30 · Mark scheme

June 2012 | CH2HP | Original Q3 | Legacy

Question 3

question	answers	extra information	Mark
3(a)	gives out energy **or** heat		1
3(b)(i)		accept qualified answers in terms of volume of gas related to time	
	fast initially		1
	slows down		1
	reaction stops	accept reaction is now very slow	1
3(b)(ii)	21		1
3(b)(iii)	84	correct answer with or without working = **2** marks allow ecf from 3(b)(ii) correctly calculated for **2** marks allow evidence of 21/25 **or** 3(b)(ii)/25 for **1** mark	2
3(c)	because they / particles have more energy / move faster	ignore particles move more / vibrate	1
	(and so) particles collide more often / more frequently **or** particles more likely to collide	ignore collide faster ignore more collisions	1
	(and) more of the collisions are successful **or** particles collide with more energy / harder **or** more of the particles have the activation energy	accept more successful collisions	1
Total			10

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 30 · Mark scheme

June 2012 | CH2HP | Original Q3 | Legacy

CH2HP

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 31 · Mark scheme

June 2013 | CH2HP | Original Q1 | Legacy

Question 1

question	Answers	extra information	Mark
1(a)(i)	the more sodium hydrogencarbonate the greater the temperature change up to 8 spatula measures then the temperature change is constant	accept examples from the table accept any correct indication of when change occurs if no marks awarded allow **1** mark for: the more sodium hydrogencarbonate the lower the final temperature	1 1 1
1(a)(ii)	energy is taken in from the surroundings **or** endothermic		1
1(b)(i)	gas / carbon dioxide / steam / water is produced	accept carbon dioxide is a gas **or** steam / water is a gas allow gas / air expands when heated	1
1(b)(ii)	no, because (reaction) is exothermic **or** yes, to start the reaction	allow no, because (reactants) were formed by heating ignore references to cooling	1
1(c)(i)	84	correct answer with or without working gains **2** marks if no answer or incorrect answer then evidence of 23 +1 + 12 + (3 × 16) gains **1** mark	2
1(c)(ii)	14.29	accept rounding to 14.3 or 14 allow ecf from (c)(i)	1
Total			**9**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 32 · 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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 33 · 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		

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 33 · Mark scheme

June 2014 | CH2HP | Original Q3 | Legacy

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**		

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 33 · Mark scheme

June 2014 | CH2HP | Original Q3 | Legacy



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 34 · Mark scheme June 2014 | CH2HP | Original Q4 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
4(a)(i)	so ions can move (and carry charge)	accept so current can flow *allow so it can conduct (electricity)* *allow so charged particles can move* *do **not** accept so electrons can move*	1	1 / 2.7.1a/b	E
4(a)(ii)	because zinc ions gain electrons 2 (electrons) zinc is formed	accept because zinc ions are reduced *accept correct half equation for **3** marks* *if no mark gained allow* *positive ions go to negative electrode **or*** *opposites attract **or*** *reduction (of zinc) **or*** *(zinc) gains electrons for **1** mark*	1 1 1	1 + 2 / 2.7.1b/c/e	E
4(a)(iii)	**2** Cl^- ⟶ Cl_2 + **2** e^-	must be completely correct	1	1 / 2.7.1g	E
4(b)(i)	because the magnesium is *a gas*	*allow magnesium goes from solid to gas*	1	2 / 2.6.1a	E
4(b)(ii)	(a reaction which) takes in energy (from the surroundings)	*accept more energy needed to break bonds than released by forming bonds* *accept correct reference to energy level diagram* *allow (a reaction which) takes in heat (from the surroundings)*	1	1 / 2.5.1a/b	E

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 34 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
4(b)(iii)	(M_r MgO =) 40	*accept* ($2\ M_r$ MgO =) 80	1	2 / 2.3.3c	E
	1.2/24 (x40) **or** 0.05 (x40) **or** 40/24 (x1.2) **or** 1.67 (x1.2)	allow ecf from step 1	1		
	2(.0)	allow ecf carried through from step 1 correct answer with or without working gains **3** marks	1		
4(b)(iv)	75(%)		1	2 / 2.3.3e	E
4(b)(v)	any **one** from: • the reaction is reversible • *some lost /escaped/ released (when* separated) • some of the reactant may react in different ways from the expected reaction • *impure reactant(s)*	*accept incomplete reaction* *ignore equilibrium not reached* *ignore measurement and calculation errors*	1	1 / 2.3.3d/f	E
Total			**12**		

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 34 · Mark scheme

June 2014 | CH2HP | Original Q4 | Legacy



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 35 · 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**		

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 35 · Mark scheme

June 2014 | CH3HP | Original Q6 | Legacy



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 36 · Mark scheme

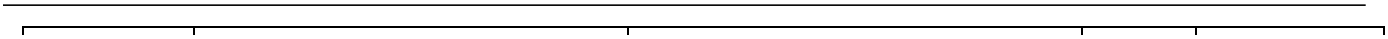
June 2015 | CH2HP | Original Q1 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
1(a)(i)	the higher the temperature, the greater the rate **or** at 40 °C rate is faster than at 20 °C	accept the higher the temperature, the faster the reaction	1	**AO3** 2.4.1c
1(a)(ii)	40 °C curve is steeper **or** correct comparison of data from the graph	accept the 40 °C line becomes horizontal sooner accept at higher temperatures the reaction finishes sooner accept reaction finishes sooner at 40 °C accept at higher temperatures the gas is produced faster	1	**AO3** 2.4.1c
1(a)(iii)	2		1	**AO2** 2.4.1a
1(b)(i)	Concentration of acid Mass of marble chips		2	**AO3** 2.4.1e
1(b)(ii)	increases rate (because of) more frequent collisions (between particles)	incorrect reference to energy = max **1** accept particles are more likely to collide ignore more collisions ignore more successful collisions	1 1	**AO1** 2.4.1f
1(c)	any **one** from: • increases rate of reaction • reduces energy required • lower temperature can be used • catalyst is not used up		1	**AO1** 2.4.1g,h
Total			**8**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 36 · Mark scheme

June 2015 | CH2HP | Original Q1 | Legacy



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 37 · Mark scheme June 2015 | CH2HP | Original Q2 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
2(a)	any **one** from: • solution becomes colourless or colour fades • zinc becomes bronze / copper coloured • zinc gets smaller • bubbles or fizzing	 allow copper (forms) or a solid (forms) allow zinc dissolves ignore precipitate	1	**AO2** 2.5.1
2(b)	improvement: use a plastic / polystyrene cup or add a lid reason - must be linked reduce / stop heat loss **OR** improvement: use a digital thermometer reason - must be linked more accurate or easy to read or stores data	 accept use lagging/insulation allow use a data logger allow more precise or more sensitive ignore more reliable ignore improvements to method, eg take more readings	1 1	**AO3** 2.5.1a,b

Question 2 continues on the next page

Question 2 continued

2(c) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5, and apply a 'best-fit' approach to the marking.	**AO2/AO3** 2.5.1a,b

0 marks	Level 1 (1–2 marks)	Level 2 (3–4 marks)	Level 3 (5–6 marks)
No relevant content.	There is a statement about the results.	There are statements about the results. These statements may be linked or may include data.	There are statements about the results with at least one link and an attempt at an explanation.

Examples of chemistry points made in the response:

Description:

Statements
Concentration of copper sulfate increases
Temperature change increases
There is an anomalous result
The temperature change levels off
Reaction is exothermic

Linked Statements
Temperature change increases as concentration of copper sulfate increases
The temperature change increases, and then remains constant
After experiment 7 the temperature change remains constant

Statements including data
The trend changes at experiment 7
Experiment 3 is anomalous

Attempted Explanation:
Temperature change increases because rate increases
Temperature change levels off because the reaction is complete

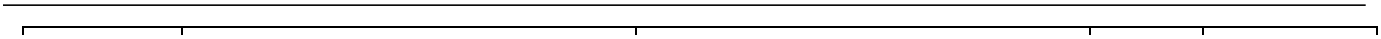
Explanation:
As more copper sulfate reacts, more heat energy is given off
Once copper sulfate is in excess, no further heat energy produced

Total			**9**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 37 · Mark scheme

June 2015 | CH2HP | Original Q2 | Legacy



4.5.1.1 Energy transfer during exothermic and endothermic reactions

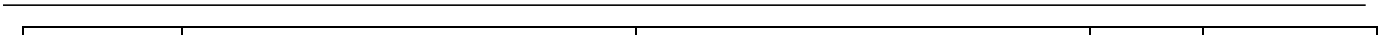
Answer 38 · Mark scheme June 2015 | CH3HP | Original Q6 | Legacy

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**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 38 · Mark scheme

June 2015 | CH3HP | Original Q6 | Legacy



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 39 · Mark scheme June 2015 | CH3HP | Original Q8 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
8(a)(i)	any **one** from • incorrect measurement of temperature or volume • incorrect recording of temperature • failure to stir • heat loss	ignore faulty equipment	1	**AO3** 3.1.3.c
8(a)(ii)	32 - 33		1	**AO2** 3.1.3.c
8(a)(iii)	55		1	**AO2** 3.1.3.c
8(a)(iv)	20		1	**AO2** 3.1.3.c
8(a)(v)	4620 J / joules	allow 4.62 kJ for **2 marks** allow kJ if evidence of dividing by 1000 mark independently, but if a numerical answer has been divided by 1000 must be kJ. allow ecf from their answers to 8(a)(iii) and 8(a)(iv)	1 1	**AO2** 3.3.1.b/c
8(b)	twice as much energy released but twice as much water to heat	allow more energy released but more water to heat for **2 marks** if no other mark awarded, allow twice the amount of hydrochloric acid used for **1 mark**	1 1	**AO3** 3.3.1.c
Total			**8**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 40 · Mark scheme

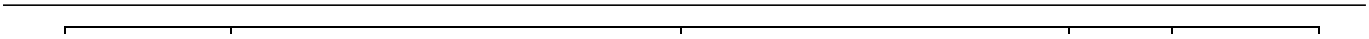
June 2016 | CH2HP | Original Q1 | Legacy

Question	Answers	Extra information	Mark	AO / SpecRef
1(a)(i)	5.75 **or** 5.8	correct answer with or without working gains **2** marks correct working showing addition of any four results and division by 4 gains **1** mark **OR** 6(.04) for **1** mark	2	AO2/AO3 2.5.1a,c
1(a)(ii)	use a polystyrene cup **or** lid to prevent energy/heat gain **OR** use a digital thermometer easier to read (to 0.1°C)	accept insulate the beaker accept to prevent energy/heat transfer do **not** accept energy/heat loss allow use a data logger	1 1	AO3 2.5.1a,c
1(b)	(as mass increases) the final temperature increases then stays constant correct reference to a value above 8 g up to and including 10 g as mass when the trend changes		1 1 1	2AO2 / 1AO3 2.5.1b
Total			**7**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 40 · Mark scheme

June 2016 | CH2HP | Original Q1 | Legacy



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 41 · Mark scheme June 2016 | CH2HP | Original Q2 | Legacy

Question	Answers	Extra information	Mark	AO / SpecRef
2(a)	endothermic		1	AO1 2.5.1d
2(b)	82 (%)	correct answer with working gains **3** marks if 17 or 34 not shown in working **max 2** marks accept 82.4 accept 82.35 to full calculator display (82.35294...) correctly rounded to at least 2 sf if no answer or incorrect answer, then (M_r =) 17 gains **1** mark **or** 14/17 gains **2** marks **OR** ($2M_r$ =) 34 gains **1** mark **or** 28/34 gains **2** marks **OR** 14/their M_r shown gains **1** mark **or** correct calculation of 14/their M_r gains **2** marks	3	AO2 2.3.3a, 2.3.1f
2(c)(i)	7 / seven		1	AO1 2.6.2d
2(c)(ii)	$H^+ + OH^- \rightarrow H_2O$		1	AO1 2.6.2e
2(c)(iii)	ammonium chloride	allow NH_4Cl ignore an incorrect formula	1	AO1 2.6.2b

Question 2 continues on the next page

Question 2 continued

Question	Answers	Extra information	Mark	AO / SpecRef
2(d)			6	2AO2 / 4AO3 2.6.2c

Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5 and apply a 'best-fit' approach to the marking.

0 marks	Level 1 (1–2 marks)	Level 2 (3–4 marks)	Level 3 (5–6 marks)
No relevant content.	Suggestion with a reference to a graph.	Suggestion with reasons referring to more than one graph.	Suggestion with reasons from all three graphs, and linking of ideas which may explain a compromise.

Examples of chemistry points made in response:
A reasonable suggested amount of fertiliser would be in the region of 200 kg (per ha). Accept any suggestion from about 180 kg (per ha) to 500 kg (per ha).

Yield:
- Using fertiliser improves yield.
- Yield improved most up to about 200 kg (per ha) of fertiliser.
- Yield only increased slightly above about 200 kg (per ha).

Profit:
- About 200 kg of fertiliser gives the most profit.
- Above about 200 kg (per ha) of fertiliser profit declines.

Run off:
- Run off is at low levels until about 300 kg (per ha) of fertiliser.
- Above about 300 kg (per ha) of fertiliser, run off increases.

Examples of linking of ideas:
- Overall 200 kg gives high crop yield and most profit.
- In conclusion 200 kg gives high crop yield and low run off.
- 200 kg gives most profit and low run off.

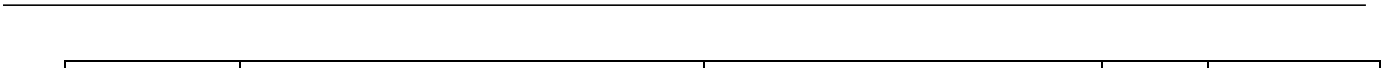
Examples of compromise:
- Profits go down after about 200 kg (per ha) of fertiliser because cost of fertiliser is not covered by increased yield.
- 200 kg gives the highest profit although it is not the highest yield.
- 500 kg gives the best yield but has the most runoff.

Total			13

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 41 · Mark scheme

June 2016 | CH2HP | Original Q2 | Legacy



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 42 · Mark scheme June 2016 | CH2HP | Original Q4 | Legacy

Question	Answers	Extra information	Mark	AO / SpecRef
4(a)	because sulfur / S (forms) (which) is solid / insoluble / a precipitate/ a suspension		1 1	AO2 2.6.1a
4(b)	any **two** from: • volume of sodium thiosulfate • volume of (hydrochloric) acid • concentration of sodium thiosulfate • concentration of (hydrochloric) acid	ignore amount of sodium thiosulfate ignore amount of (hydrochloric) acid if no other mark, allow **1** mark for same cross **or** same flask **or** unspecified volume **or** unspecified concentration ignore same person do **not** accept references to temperature	2	AO3 2.4.1
4(c)	rate increases because particles move faster so frequency of collisions increases more particles/ collisions have energy greater than (or equal to) the activation energy	 accept particles have more energy accept particles are more likely to collide **or** more chance of collisions ignore more collisions	1 1 1 1	AO1 2.4.1b,c
4(d)	cool **or** decrease the temperature (of the solutions)	accept refrigerate **or** method to decrease temperature	1	AO3 2.4.1c
Total			**9**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

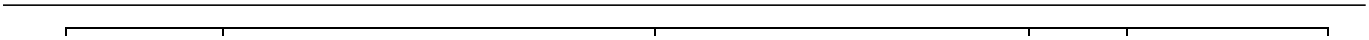
Answer 43 · Mark scheme June 2016 | CH3HP | Original Q5 | Legacy

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**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 43 · Mark scheme

June 2016 | CH3HP | Original Q5 | Legacy



Answer 44 · Mark scheme

June 2017 | CH2HP | Original Q6 | Legacy

The full source mark scheme begins on page 184. Follow original question 6 in that document.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 45 · Mark scheme June 2017 | CH3HP | Original Q5 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
5(a)(i)	high temp increases rate	allow converse for low temperature	1	AO1 AO2 AO3 3.5.1d,e,f,h
	but decreases yield	allow shifts equilibrium to the left	1	
	because (forward) reaction is exothermic **or** so this (temperature) is a compromise	this mark dependent on M2 this mark dependent on both M1 and M2	1	
5(a)(ii)	high pressure increases yield	allow converse for low pressure allow shifts equilibrium to the right	1	AO1 AO2 3.5.1d,g,h
	(because) more moles / molecules of gas on LHS	allow (because) greater volume of gas on LHS If no other mark gained, allow 1 mark for high pressure increase rate because molecules closer together **or** increased frequency of collisions.	1	
5(a)(iii)	any **one** from: • less risk of explosion/safer • less energy required • less likely to leak.	allow converse for high pressure ignore cost / strength of plant	1	AO3 3.5.1g

4.5.1.1 Energy transfer during exothermic and endothermic reactions

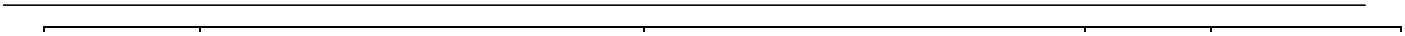
Answer 45 · Mark scheme

5(b)	white precipitate (forms) with aluminium, the ppt dissolves in excess **or** with magnesium, the ppt does not dissolve in excess		1 1	**AO1** 3.4.1b
Total			**8**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 45 · Mark scheme

June 2017 | CH3HP | Original Q5 | Legacy



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 46 · Mark scheme June 2017 | CH3HP | Original Q6 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
6(a)(i)	natural gas or water / steam	allow methane / crude oil / petroleum ignore processes	1	**AO1** 3.5.1a
6(a)(ii)	cool to any temp in the range -33 to -196 °C because (at this temperature) ammonia becomes a liquid **or** ammonia condenses		1 1	**AO1** **AO3** 3.5.1b
6(b)(i)	81(kJ)	ignore sign ((4 x 391 + 160) =) 1724 for 1 mark, and ((2 x 432 + 941) =) 1805 for 1 mark correct subtraction using one correct value for 1 mark	3	**AO2** 3.3.1f
6(b)(ii)	because energy taken in to break bonds is less than energy given out when bonds form	allow converse	1 1	**AO1** 3.3.1e,f
Total			**8**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 47 · 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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 47 · 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			

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 47 · Mark scheme

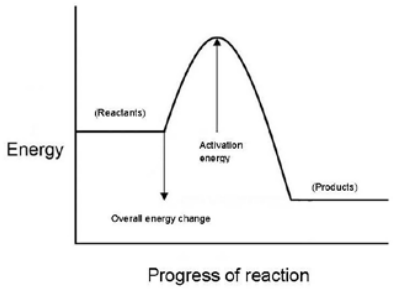
June 2018 | 8462/1H | Original Q5

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			

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 47 · Mark scheme

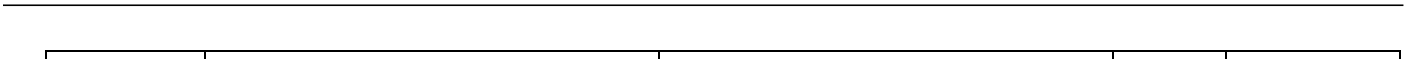
June 2018 | 8462/1H | Original Q5

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**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 47 · Mark scheme

June 2018 | 8462/1H | Original Q5



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 48 · Mark scheme June 2018 | 8462/1H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	potassium chloride **and** iodine	either order allow KCl for potassium chloride and I_2 for iodine	1	AO1 4.1.2.6
07.2		allow converse statements allow energy levels for shells throughout		AO1 4.1.2.6
	(chlorine's) outer electrons / shell closer to the nucleus	allow chlorine has fewer shells allow chlorine atom is smaller than iodine atom ignore chlorine has fewer outer shells	1	
	(so) the chlorine nucleus has greater attraction for outer electrons / shell	allow chlorine has less shielding do **not** accept incorrect types of attraction	1	
	(so) chlorine gains an electron more easily	 **maxf 2** marks can be awarded if the answer refers to chloride / iodide instead of chlorine / iodine	1	
07.3	hydrogen chloride is made of small molecules	allow hydrogen chloride is simple molecular	1	AO1 4.1.2.6 4.2.1.4
	(so hydrogen chloride) has weak intermolecular forces	do **not** accept reference to bonds breaking unless applied to intermolecular bonds	1	4.2.2.4
	(intermolecular forces) require little energy to overcome		1	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 48 · Mark scheme

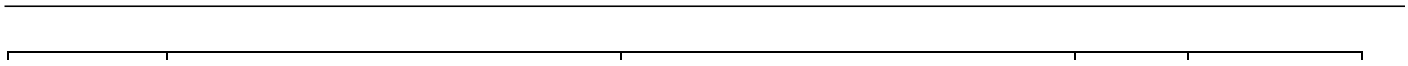
June 2018 | 8462/1H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4		an answer of 290 (kJ/mol) scores **4** marks an answer of 188 (kJ/mol) scores **3** marks an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps		AO2 4.5.1.3
	(bonds broken = 4(412) + 193 =)1841		1	
	(bonds formed = 3(412) + 366 + **X** =) 1602 + **X**		1	
	−51 = 1841 − (1602 + **X**)	allow use of incorrectly calculated values of bonds broken and / or bonds formed from steps 1 and 2 for steps 3 and 4	1	
	(X =) 290 (kJ/mol)	allow a correctly calculated answer from use of −51 = bonds formed – bonds broken	1	
	OR alternative method ignoring the 3 unchanged C–H bonds (412 + 193 =) 605 (1) 366 + **X** (1) −51 = 605 − (366 + **X**) (1) (**X** =) 290 (kJ/mol) (1)			
Total			**11**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 48 · Mark scheme

June 2018 | 8462/1H | Original Q7



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 49 · Mark scheme June 2018 | 8462/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	chlorine is toxic	allow carbon monoxide is toxic allow poisonous for toxic ignore harmful / deadly / dangerous allow a poisonous gas is used / produced allow titanium chloride is corrosive	1	AO3 4.1.2.6 4.4.1.3
08.2	any **one** from: • very exothermic reaction • produces a corrosive solution • produces hydrogen, which is explosive / flammable	allow explosive allow violent reaction ignore vigorous reaction ignore sodium is very reactive allow caustic for corrosive ignore alkaline allow flames produced ignore sodium burns	1	AO3 4.1.2.5 4.4.1.3
08.3	argon is unreactive / inert oxygen (from air) would react with sodium / titanium **or** water vapour (from air) would react with sodium / titanium	allow argon will not react (with reactants / products / elements) allow elements / reactants / products for sodium / titanium	1 1	AO3 4.1.2.4 4.1.2.5 4.4.1.1 4.4.1.3

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 49 · Mark scheme

June 2018 | 8462/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.4	metal chlorides are usually ionic	allow titanium chloride is ionic	1	AO1 4.1.2.6 4.1.3.1
	(so)(metal chlorides) are solid at room temperature **or** (so)(metal chlorides) have high melting points	allow titanium chloride for metal chlorides	1	4.2.1.2 4.2.2.3 4.2.2.4
	(because) they have strong (electrostatic) forces between the ions **or** (but) must be a small molecule or covalent	ignore strong ionic bonds allow molecular allow alternative approach: titanium chloride must be covalent **or** has small molecules (1) with weak forces between molecules do **not** accept bonds unless intermolecular bonds(1) (but) metal chlorides are usually ionic (1)	1	
08.5	sodium (atoms) lose electrons	do **not** accept references to oxygen	1	AO1 4.4.1.4
08.6	$Na \rightarrow Na^+ + e^-$	do **not** accept e for e^-	1	AO2 4.1.1.1 4.4.1.4

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 49 · Mark scheme

June 2018 | 8462/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.7	(M_r of $TiCl_4$ =) 190 (moles Na) = $\frac{20\,000}{23}$ =) 870 (mol $\left(\text{moles } TiCl_4 = \frac{40\,000}{190} =\right)$ 211 (mol) **either** (sodium is in excess because) 870 mol Na is more than the 844 mol needed **or** (because) 211 mol $TiCl_4$ is less than the 217.5 mol needed	an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps allow **1** mark for 0.870 mol Na **and** 0.211 mol $TiCl_4$ allow use of incorrectly calculated M_r from step 1 the mark is for correct application of the factor of 4 other correct reasoning showing, with values of moles or mass, an excess of sodium or insufficient $TiCl_4$ is acceptable allow use of incorrect number of moles from steps 2 and / or 3 alternative approaches: **approach 1:** (M_r of $TiCl_4$ =) 190(1) (40 kg $TiCl_4$ needs) $\frac{40}{190} \times 4 \times 23$ (kg Na) (1) (=) 19.4 (kg) (1) so 20 kg is an excess (1) **approach 2:** (M_r of $TiCl_4$ =) 190(1) (20 kg Na needs) $\frac{20}{4 \times 23} \times 190$ (kg $TiCl_4$) (1) (=) 41.3 (kg) (1) so 40 kg is not enough (1)	1 1 1 1	AO2 4.3.1.2 4.3.2.1 4.3.2.2 4.3.2.4

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 49 · Mark scheme

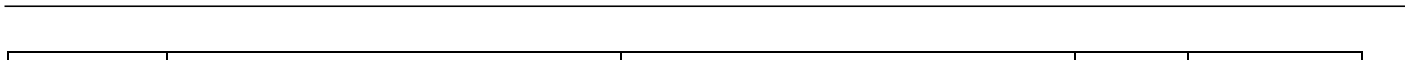
June 2018 | 8462/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.8	(actual mass =) $\frac{92.3}{100} \times 13.5$ **or** (actual mass =) 0.923×13.5 = 12.5 (kg)	an answer 12.5 (kg) scores **2** marks allow 12 / 12.46 / 12.461 / 12.4605 (kg)	1 1	AO2 4.3.3.1
Total			**15**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 49 · Mark scheme

June 2018 | 8462/1H | Original Q8



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 50 · Mark scheme

June 2018 | 8462/2H | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	hydrogen	allow H_2	1	AO1 4.10.4.1
03.2	450 °C 200 atm / atmospheres	allow values in the range 400– 500 °C allow values in the range 150– 250 atm / atmospheres allow **1** mark if both values within range but no units given	1 1	AO1 4.10.4.1
03.3	ammonia has a higher boiling point	allow the other gases have lower boiling points ignore references to melting point	1	AO3 4.10.4.1

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 50 · Mark scheme

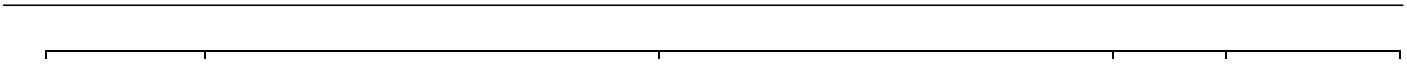
June 2018 | 8462/2H | Original Q3

Question	Answers		Mark	AO / Spec. Ref.
03.4	**Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.		5–6	AO2
	Level 2: Relevant points (reasons / causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.		3–4	AO1
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.		1–2	AO1
	No relevant content		0	
	Indicative content **changes** • carbon dioxide has decreased • oxygen has increased **processes** • volcanic activity released water vapour • the water vapour condensed to form oceans • carbon dioxide dissolved in oceans • carbonates produce sediments • carbon locked up in sedimentary rocks • algae and plants evolved / appeared • algae / plants absorbed carbon dioxide • by photosynthesis • which also released oxygen • carbon locked up in fossil fuels			4.9.1.2 4.9.1.3 4.9.1.4
03.5	any **one** from: • occurred 4.6 billion years ago • limited or no evidence	allow any indication of billions of years allow limited or no proof ignore there was nobody there	1	AO1 4.9.1.2
Total			**11**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 50 · Mark scheme

June 2018 | 8462/2H | Original Q3



4.5.1.1 Energy transfer during exothermic and endothermic reactions

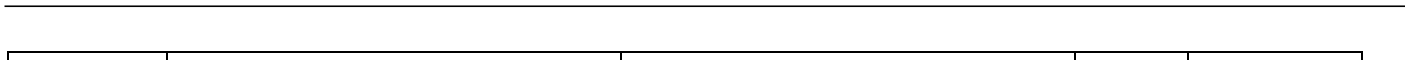
Answer 51 · Mark scheme June 2018 | 8462/2H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	a gas is produced	allow carbon dioxide is produced do **not** accept an incorrect gas	1	AO2 4.3.1.3 4.6.1.1
	(which) escapes	**max 1** mark if evaporation mentioned	1	
08.2	all eight points plotted correctly	allow a tolerance of ± half a small square. allow six or seven points plotted correctly for **1** mark	2	AO2 4.6.1.1
	line of best fit		1	
08.3		an incorrect answer for one step does not prevent allocation of marks for subsequent steps		AO2 4.6.1.1
	correctly drawn tangent at 0.95 g		1	
	correct value for x step **and** y step from tangent	allow evidence of use of two points on tangent either on the graph or in the text	1	
	(rate =) $\frac{\text{value for y step}}{\text{value for x step}}$		1	
	correctly evaluated and rounded to 2 sig figs	allow (rate =) $\frac{\text{value for x step}}{\text{value for y step}}$ (ie inverted division) correctly evaluated and rounded to 2 sig figs	1	
Total			**9**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 51 · Mark scheme

June 2018 | 8462/2H | Original Q8



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 52 · Mark scheme June 2018 | 8462/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	enzyme		1	AO2 4.6.1.4
09.2	2.0×10^3 moles		1	AO2 4.3.2.1
09.3	smaller yield (because) favours endothermic reaction	allow less methanol is produced allow (because) favours reverse reaction allow equilibrium / reaction shifts to the left allow equilibrium / reaction shifts to reduce the temperature ignore reference to forward reaction is exothermic ignore references to rate	1 1	AO2 4.6.2.4 4.6.2.6

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 52 · Mark scheme

June 2018 | 8462/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.4	(yield) equilibrium position moves to the product side	allow converse arguments allow equilibrium / reaction moves to the right allow equilibrium / reaction shifts to reduce the pressure	1	AO2 4.6.1.3 4.6.2.4 4.6.2.7
	(because) fewer molecules / moles / particles on product side	allow (because) fewer molecules / moles / particles on the right allow (because) smaller volume on product side	1	
	(rate) more collisions per unit time	allow increases collision frequency / rate ignore more collisions alone ignore faster collisions do **not** accept any indication of more energetic / forceful collisions	1	
	(because) more molecules / particles per unit volume	allow (gas) molecules / particles closer together ignore more molecules / particles alone	1	
09.5	provides different reaction pathway (which has a) lower activation energy	allow provides a different mechanism / route ignore references to collisions	1 1	AO1 4.6.1.4

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 52 · Mark scheme

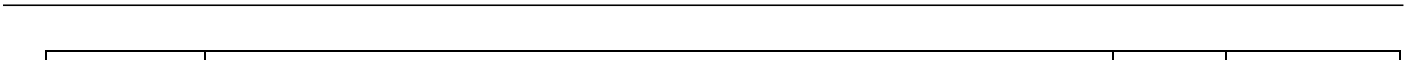
June 2018 | 8462/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.6	less energy is needed	allow reduces the temperature required allow reduces costs ignore references to pressure ignore references to rate or time	1	AO2 4.6.1.4
09.7	no effect / change		1	AO3 4.6.1.4 4.6.2.3
Total			**12**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 52 · Mark scheme

June 2018 | 8462/2H | Original Q9



4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 53 · Mark scheme

June 2019 | 8462/1H | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	any **one** from: • so elements / iodine / tellurium were in groups with similar properties • iodine has similar properties to Br / Cl / F / Group 7 • iodine has different properties to Se / S / O / Group 6	ignore reference to atomic structure ignore references to Cr, Mn and Mo allow corresponding argument in terms of tellurium	1	AO1 4.1.2.2
01.2	Mendeleev had predicted properties of missing elements elements were discovered (that filled the spaces / gaps) properties (of these elements) matched Mendeleev's predictions	ignore reference to atomic structure allow atomic weights (of these elements) fitted in the spaces / gaps if no other mark awarded, allow **1** mark for in previous versions of the periodic table the pattern of similar properties broke down	1 1 1	AO1 4.1.2.2
01.3	relative atomic mass		1	AO1 4.1.1.6
01.4	(increasing) atomic / proton number	ignore (increasing) electron number do **not** accept relative atomic / proton number	1	AO1 4.1.2.1
01.5	(formula) At_2 (state) solid	ignore incorrect state symbol allow (s) ignore s	1 1	AO1 4.1.2.6

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 53 · Mark scheme

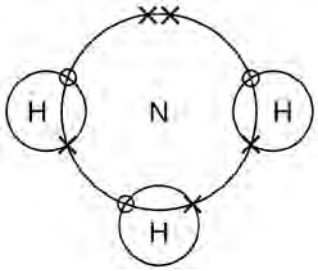
01.6	any **two** from: • flame • (white) solid forms • colour of gas / chlorine disappears / fades	allow burns allow (white) smoke forms	2	AO1 4.1.2.5
Total			**10**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 54 · 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	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 54 · Mark scheme

June 2019 | 8462/1H | Original Q5

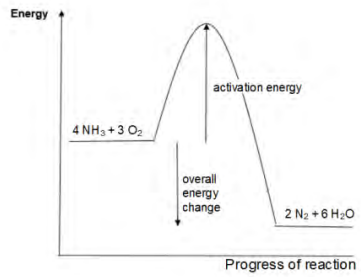
05.4	Cr_2O_3		1	AO2 4.1.3.2
05.5	(for bonds broken) ((12 x 391) + (3 x 498) =) 6186 (for bonds made) ((2 x 945) + (12 x 464) =) 7458 (overall energy change = 6186-7458 =) (-)1272 (kJ)	an answer of (-)1272 (kJ) scores **3** marks allow correct calculation using incorrectly calculated values from step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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 54 · 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**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 55 · Mark scheme

June 2019 | 8462/1H | Original Q9

Question 9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	polystyrene is a better (thermal) insulator (so) reduces energy exchange (with the surroundings)	allow polystyrene is a poorer (thermal) conductor allow (so) reduces energy / heat loss (to the surroundings)	1 1	AO3 4.5.1.1
09.2	all six points plotted correctly line of best fit through points plotted from Table 6 both lines of best fit extrapolated correctly until they cross	allow a tolerance of ± ½ a small square allow **1** mark for at least 3 points plotted correctly	2 1 1	AO2 4.5.1.1
09.3	11 (cm^3)	allow ecf from question **09.2** allow answers in the range 10.75 to 11.25 (cm^3) allow a tolerance of ± ½ a small square	1	AO2 4.5.1.1
09.4	(27.5 – 18.9) = 8.6 (°C)	allow ecf from question **09.2** allow answers in the range 8.5 to 8.7 (°C) allow a tolerance of ± ½ a small square	1	AO2 4.5.1.1

Question 9 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.5		an answer of 0.62 (mol/dm^3) for concentration in mol/dm^3 scores **4** marks an answer of 0.31 (mol/dm^3) for concentration in mol/dm^3 scores **3** marks		AO2/2 4.3.1.2 4.3.2.5 4.3.4 4.4.2.5
	(moles H_2SO_4 = 0.500 × $\frac{15.5}{1000}$) = 0.00775		1	
	(moles KOH = 2 x moles H_2SO_4 = 2 x 0.00775) = 0.0155	allow correct calculation using incorrectly calculated value of moles of H_2SO_4	1	
	(conc KOH = moles KOH x $\frac{1000}{25.0}$) = 0.0155 x $\frac{1000}{25.0}$	allow correct calculation using incorrectly calculated value of moles of KOH	1	
	= 0.62 (mol/dm^3)	allow correct answer using incorrectly calculated value of moles of KOH	1	
	(M_r KOH =) 56		1	
	(conc = M_r x conc in mol/dm^3 = 56 x 0.62) = 34.7 (g/dm^3)	allow 35 or 34.72 (g/dm^3) allow correct answer using incorrectly calculated value of concentration in mol/dm^3 and/or incorrect M_r	1	
	alternative approach for step 1 to step 4 $\frac{2}{1} = \frac{25 \times \text{conc KOH}}{15.5 \times 0.500}$ (2) (conc KOH) = $\frac{2 \times 15.5 \times 0.500}{25.0}$ (1) = 0.62 (mol/dm^3) (1)	allow **1** mark if mole ratio is incorrect		

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 55 · Mark scheme

June 2019 | 8462/1H | Original Q9

Total			**14**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 56 · Mark scheme

June 2019 | 8462/2H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	(aq)	allow aqueous / aq	1	AO1 4.2.2.1 4.2.2.2
03.2	(gas) syringe stopclock / stopwatch	allow measuring cylinder (and water trough) allow balance allow timer / clock / watch	1 1	AO1 4.6.1.1
03.3	all points plotted correctly line of best fit	allow a tolerance of ± ½ a small square allow at least 3 points plotted correctly for **1** mark. allow correctly drawn line of best fit for incorrectly plotted points	2 1	AO2 4.6.1.1
03.4	(rate) decreases (rate decreases) more slowly as time increases (rate) becomes zero at 60 s	allow slows down allow (rate decreases) at a non-linear rate allow the reaction stops at 60 s allow ecf from question **03.3**	1 1 1	AO3 4.6.1.1
03.5	more bubbles were produced in the first 10 seconds the magnesium was used up more quickly		1 1	AO2 4.6.1.2
Total			**11**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 57 · Mark scheme

June 2019 | 8462/2H | Original Q10

Question 10

Question	Answers	Extra information	Mark	AO / Spec. Ref.
10.1	$\frac{6}{34} \times 100$	an answer of 17.6470588 (%) correctly rounded to at least 2 significant figures scores **2** marks	1	AO2 4.3.3.2
	= 17.6 (%)	allow 17.6470588 (%) correctly rounded to at least 2 significant figures	1	
10.2	higher yield (of hydrogen or carbon monoxide or product)	allow converse arguments in terms of higher pressure ignore references to rate allow more hydrogen or more carbon monoxide or more product allow equilibrium moves to the right allow equilibrium moves in the forward direction	1	AO2 4.6.2.4 4.6.2.7
	(because) fewer moles / molecules / particles on left hand side **or** (because) more moles / molecules / particles on right hand side	allow (because) the reverse reaction produces fewer moles / molecules / particles **or** allow (because) the forward reaction produces more moles / molecules / particles do **not** accept fewer / more atoms	1	
10.3	no effect (on yield of hydrogen)	allow position of equilibrium unaffected by pressure ignore references to rate of reaction	1	AO2 4.6.2.7

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 57 · Mark scheme

June 2019 | 8462/2H | Original Q10

10.4	an answer of 2.25 scores **3** marks 350 (°C) and 285 (atmospheres) = 63 (%) **and** 450 (°C) and 200 (atmospheres) = 28 (%) $\frac{63}{28}$ = 2.25 (times greater)	 allow a value between 62 (%) and 64 (%) inclusive allow a correct expression using incorrectly determined value(s) for percentage yield allow a correct calculation using incorrectly determined value(s) for percentage yield correctly evaluated and rounded to at least 2 significant figures	 1 1 1	AO2 4.10.4.1
10.5	any **one** from: • the energy costs would be high(er) • the equipment would need to be strong(er) • high(er) pressures are (more) dangerous	allow converse arguments in terms of low(er) pressure ignore energy / cost unqualified allow the equipment would be (more) expensive (to build / maintain) allow (more) dangerous because (greater) risk of explosion	1	AO1 4.10.4.1
10.6	higher temperatures produce a lower (percentage) yield (of ammonia)	allow converse allow correct reference to shift in equilibrium ignore references to pressure	1	AO2 4.6.2.6 4.10.4.1
10.7	world population has increased any **one** from: • demand for fertiliser has increased • increased demand for other specified ammonia-based products e.g. nitric acid, drugs, dyes, explosives	 allow more food needed	1 1	AO3 AO1 4.10.4.1 4.10.4.2
Total			**12**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 58 · 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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 58 · 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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 59 · Mark scheme

November 2020 | 8462/1H | Original Q9

Question 9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	didn't stir (the solution enough)	allow measured the temperature before the temperature stopped falling allow measured the temperature too soon	1	AO3 4.5.1.1 RPA 4
09.2	the temperature decreases (initially) because energy is taken in (by the reaction from the solution)	allow temperature decreases (initially) because the reaction is endothermic	1	AO2 AO3 4.5.1.1 RPA 4
	when 1.5 g (of citric acid) is added the sodium hydrogencarbonate has all reacted **or** from 1.5 g the citric acid is in excess **or** when 1.5 g (of citric acid) is added the reaction is complete	allow when the temperature reaches 11.6 °C the sodium hydrogencarbonate has all reacted allow after the temperature reaches 11.6 °C the citric acid is in excess allow when the temperature reaches 11.6 °C the reaction is complete	1	
	(so) the temperature increases as energy is transferred from the room to the solution	allow (so) the temperature increases as energy is transferred from the excess citric acid to the solution	1	

Question 9 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.3	less steep line starting at 16.8 °C **and** reaching 1.00 g (of citric acid)	ignore any part of the line drawn beyond 1.00 g	1	AO3 4.2.2.8 4.5.1.1 RPA 4
	(as) metal is a better conductor	allow (as) polystyrene is a better insulator	1	
	(so) more energy is absorbed (from the surroundings)	allow (so) more heat is absorbed (from the surroundings)	1	
09.4	(M_r citric acid =) 192		1	AO2 4.3.2.5 4.3.4
	(moles = $\frac{250}{1000}$ × 0.0500) = 0.0125		1	
	(mass = 0.0125 × 192 =) 2.4 (g)	allow correct use of an incorrectly calculated M_r allow correct use of an incorrectly calculated number of moles	1	
	alternative approach:			
	(M_r citric acid =) 192 (1)			
	(concentration = 0.0500 × 192) = 9.6 (g/dm^3) (1)	allow correct use of an incorrectly calculated M_r		
	(mass = $\frac{250}{1000}$ × 9.6 =) 2.4 (g) (1)	allow correct use of an incorrectly calculated concentration in g/dm^3		

Question 9 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.5	add the citric acid (to the flask) until there is a (permanent) colour change	ignore colours of indicator	1	AO1 4.4.2.5 RPA 2
	measure / record the volume (of citric acid) added	allow take the final (and initial) burette reading	1	
	any **one** from: • swirl • use a white tile • add the citric acid dropwise (near the end-point) • repeat **and** calculate a mean	allow add the citric acid slowly (near the end-point)	1	
09.6	any **two** from: • can add (the citric acid) in small increments	allow can add (the citric acid) drop by drop allow can add (the citric acid) slowly	2	AO1 4.4.2.5 RPA 2
	• can measure variable volumes	allow has a scale		
	• more accurate than a measuring cylinder			

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question 9 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.7	(moles citric acid = $\frac{13.3}{1000}$ × 0.0500) = 0.000665		1	AO2 4.3.4 4.4.2.5 RPA 2
	(moles NaOH = 3 × 0.000665) = 0.001995	allow correct use of an incorrectly calculated number of moles of citric acid	1	
	(conc = $\frac{1000}{25}$ × 0.001995) = 0.0798 (mol/dm^3)	allow 0.08 or 0.080 (mol/dm^3) allow correct use of an incorrectly calculated number of moles of NaOH	1	
	alternative approach: $\frac{25.0 \times \text{conc NaOH}}{13.3 \times 0.0500} = \frac{3}{1}$ (1) (conc NaOH =) 3 × $\frac{13.3 \times 0.0500}{25.0}$ (1) = 0.0798 (mol/dm^3) (1)	allow $\frac{13.3 \times 0.0500}{25.0 \times \text{conc NaOH}} = \frac{1}{3}$ allow 0.08 or 0.080 (mol/dm^3)		
Total			**18**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 60 · Mark scheme

November 2020 | 8462/2H | Original Q10

Question 10

Question	Answers	Extra information	Mark	AO / Spec. Ref.
10.1	water	allow H_2O	1	AO1 4.2.2.2
10.2	becomes (more) red		1	AO2 4.6.2.4 4.6.2.5
	(because the position of) equilibrium moves to the right	allow (because) the concentration of $FeSCN^{2+}$ (ions) increases allow (because) the forward reaction is favoured	1	
	(so that) the (increase in the) concentration of thiocyanate (ions) is reduced	allow (so that) the increase in the concentration of thiocyanate (ions) is counteracted	1	
10.3	(the position of) equilibrium moves to the left	allow the concentration of Fe^{3+} (ions) increases allow the reverse reaction is favoured	1	AO2 4.6.2.4 4.6.2.6
	(so that) the (increase in the) temperature is reduced	allow (so that) the increase in the temperature is counteracted	1	
	(therefore) the forward reaction is exothermic	allow (therefore) the forward reaction releases energy (to the surroundings)	1	

Question 10 (continued)

Question	Answers	Extra information	Mark	AO / Spec. Ref.
10.4	no change in equilibrium position (because) no gases are present	 allow (because) only aqueous solutions are present	1 1	AO2 4.6.2.7
10.5	Co^{2+}		1	AO2 4.1.3.2 4.6.2.5
Total			**10**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

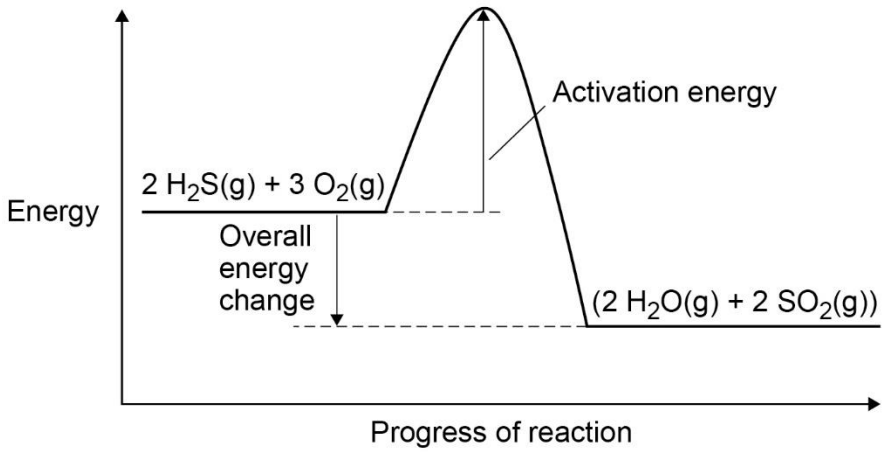
Answer 61 · Mark scheme

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**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 62 · Mark scheme

November 2021 | 8462/2H | Original Q10

Question 10

Question	Answers	Extra information	Mark	AO / Spec. Ref.
10.1	(steam / catalytic) cracking	allow thermal decomposition	1	AO1 4.7.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
10.2	high temperature steam / catalyst	allow a temperature in the range 300 – 900 °C	1 1	AO1 4.7.1.4

Question 10 continued

Question	Answers	Mark	AO/ Spec. Ref
10.3	**Level 3:** Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO2 4.6.1.3 4.6.2.4 4.6.2.6 4.6.2.7 4.7.2.2
	Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	
	No relevant content	0	
	Indicative content **Rate** • higher temperature gives higher rate • because more frequent collisions • higher pressure gives higher rate • because more frequent collisions • a catalyst can be used to give a higher rate • because the activation energy is reduced **Yield** • higher temperature gives lower yield • because the reaction is exothermic • higher pressure gives higher yield • because there are more molecules on left hand side **Other factors** • higher temperatures use more energy so costs increase • higher pressures use more energy so costs increase • higher pressures require stronger reaction vessels so costs increase **Compromise** • chosen temperature is a compromise between rate and yield • chosen temperature is a compromise between rate and cost (of energy used) • chosen pressure is a compromise between rate and cost (of energy used) • chosen pressure is a compromise between yield and cost (of energy used)		

Question 10 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
10.4	fermentation	allow ferment(ing)	1	AO1 4.7.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
10.5	warm anaerobic (conditions)	allow a value in the range 25 °C to 45 °C allow without oxygen / air	1 1	AO2 4.7.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
10.6	(conversion) 200 km = 200,000 m (moles =) $\frac{200000 \times 1.95 \text{ (mol)}}{1300}$ = 300 (mol)	 allow correct use of incorrect / no conversion for distance	1 1 1	AO2 4.7.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
10.7	$C_4H_9OH + 6\,O_2 \rightarrow 4\,CO_2 + 5\,H_2O$	allow $C_4H_{10}O$ for C_4H_9OH allow multiples allow **1** mark for $C_4H_9OH + O_2 \rightarrow CO_2 + H_2O$ with incorrect / no multipliers ignore state symbols	2	AO2 4.1.1.1 4.3.1.1 4.7.2.3

Total			17

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 63 · 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		

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 63 · Mark scheme

June 2022 | 8462/1H | Original Q2

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)			

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 63 · Mark scheme

June 2022 | 8462/1H | Original Q2

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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 64 · Mark scheme

June 2022 | 8462/1H | Original Q7

Question 7

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

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

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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 64 · Mark scheme

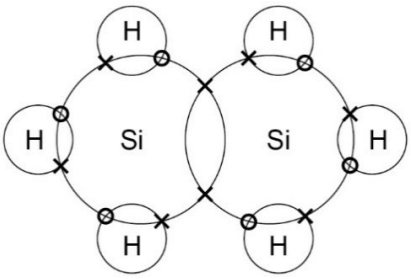
June 2022 | 8462/1H | Original Q7

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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 64 · Mark scheme

June 2022 | 8462/1H | Original Q7

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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 64 · Mark scheme

June 2022 | 8462/1H | Original Q7

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

Total Question 7		15

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 65 · Mark scheme

June 2022 | 8462/2H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	(nitrogen) air (hydrogen) natural gas	allow atmosphere allow methane allow water / steam	1 1	AO1 4.10.4.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	there is only one product		1	AO2 4.3.3.2 4.10.4.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	(mixture is) cooled (so that only) ammonia liquefies	 allow (so that only) ammonia condenses	1 1	AO1 4.10.4.1

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 65 · Mark scheme

June 2022 | 8462/2H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	scale labelled at 100, 200, 300 and 400 (atm)	allow scale labelled at 50, 150, 250 and 350 (atm)	1	AO2 4.10.4.1
	all five points plotted correctly	allow a tolerance of ± ½ a small square allow **1** mark for three / four points plotted correctly	2	
	line of best fit		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5 View with Figure 5	extrapolation to 500 atmospheres		1	AO2 4.10.4.1
	percentage value at 500 atmospheres	allow a tolerance of ± ½ a small square	1	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 65 · Mark scheme

June 2022 | 8462/2H | Original Q7

Question	Answers	Mark	AO / Spec. Ref.
07.6	**Level 3**: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO1 4.6.1.3 4.6.1.4 4.6.2.6 4.6.2.7 4.10.4.1
	Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	
	No relevant content	0	
	Indicative content **rate** • higher temperature gives higher rate because of more frequent collisions • higher temperature gives higher rate because more particles have the activation energy • higher pressure gives higher rate because of more frequent collisions • use of catalyst gives higher rate because the activation energy is lowered **equilibrium** • higher temperature shifts the position of equilibrium to the left because reaction is exothermic • higher pressure shifts the position of equilibrium to the right because more molecules on left-hand side • use of catalyst has no effect on the position of equilibrium **other factors** • higher temperature (than 450°C) uses more energy so increases costs • higher pressure (than 200 atmospheres) uses more energy so increases costs • higher pressure (than 200 atmospheres) requires stronger reaction vessels so increases costs • use of a catalyst reduces energy costs **compromise** • the temperature chosen is a compromise between rate of reaction and position of equilibrium • the temperature chosen is a compromise between rate and cost • the pressure chosen is a compromise between yield / rate and cost		

Total Question 7		**17**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 66 · Mark scheme

June 2023 | 8462/1H | Original Q2

Question 2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	(independent variable) mass (of ammonium nitrate) (dependent variable) (lowest) temperature (reached by solution)	 allow change in temperature (of solution)	1 1	AO1 4.5.1.1 RPA4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	all 6 points plotted correctly line of best fit	allow a tolerance of ± ½ a small square allow **1** mark for 4 or 5 points plotted correctly	2 1	AO2 AO3 4.5.1.1 RPA4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	line extrapolated to *y*-axis (initial temperature) value for temperature where extrapolated line meets *y*-axis	 allow a tolerance of ± ½ a small square	1 1	AO3 AO2 4.5.1.1 RPA4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	temperature decreased	ignore correct references to energy transfer	1	AO1 4.5.1.1 RPA4

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 66 · Mark scheme

June 2023 | 8462/1H | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.5	(0.3 °C) is the uncertainty (because 0.3 °C) is the range about the mean value	 allow values are (a maximum of) 0.3 (°C) either side of the mean allow (because) 16.8 = 16.5 + 0.3 **and** 16.2 = 16.5 – 0.3	1 1	AO2 4.3.1.4 4.5.1.1 RPA4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.6	random error		1	AO3 4.5.1.1 RPA4

Total Question 2	11

Answer 67 · Mark scheme

Question 9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	(mass of water in 4.68 g = 4.68 - 2.99) = 1.69 (g)		1	AO2 4.6.2.2
	(mass of water in 11.7 g =) $\frac{11.7}{4.68} \times 1.69$	allow correct use of an incorrectly determined mass of water in 4.68 g	1	
	= 4.23 (g)	allow 4.2 / 4.225 (g)	1	
	alternative approach: $\left(\text{mass of anhydrous compound} = \frac{11.7}{4.68} \times 2.99\right)$ = 7.475 (g) (1)			
	(mass of water =) 11.7 – 7.475 (1)	allow correct use of an incorrectly determined mass of anhydrous compound		
	= 4.23 (g) (1)	allow 4.2 / 4.225 (g)		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.2	(energy =) $\frac{15.0}{2.99} \times 1.47$		1	AO2 4.6.2.2
	= 7.37 (kJ)	allow 7.37458194 correctly rounded to at least 2 significant figures	1	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 67 · Mark scheme

June 2023 | 8462/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.3	shifts to the left		1	AO2 4.6.2.1 4.6.2.4 4.6.2.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.4	the mixture is a lighter shade of brown		1	AO2 4.6.2.4 4.6.2.7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.5	no effect (on equilibrium position) (because) there are equal numbers of (gas) moles / molecules on each side (of the equation)	allow (equilibrium position) stays the same	1 1	AO2 4.6.2.4 4.6.2.7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.6	no effect (on equilibrium position)	allow (equilibrium position) stays the same	1	AO2 4.6.2.3 4.6.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.7	add more hydrochloric acid		1	AO2 4.6.2.4 4.6.2.5

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 67 · Mark scheme

June 2023 | 8462/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.8	(because the) forward and reverse reactions are taking place at (exactly) the same rate	ignore references to closed systems allow for **1** mark (because) the reactions are taking place at (exactly) the same rate	2	AO1 4.6.2.3

Total Question 9	**13**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 68 · Mark scheme

June 2024 | 8462/1H | Original Q4

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	line of best fit using the first five points	max **1** mark if the lines do not intersect	1	AO3 4.5.1.1 RPA4
	line of best fit using the last four points		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	the temperature rises because the reaction is exothermic **or** the temperature rises because energy is transferred to the surroundings	allow heat for energy	1	AO2
	until 0.8 g (zinc) is added	allow a tolerance of ± ½ a small square allow until the temperature reaches 47 °C allow a correctly determined value for mass of zinc or temperature from the intersection of drawn lines of best fit	1	AO2
	(so) there is no additional reaction	allow (when) the reaction has finished	1	AO3
	(because) zinc is in excess **or** (because) copper sulfate is used up		1	AO3 4.5.1.1 RPA4

Answer 68 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	polystyrene is a better (thermal) insulator (so) there is less energy transfer to the surroundings	allow converse statements for glass allow (so) less energy is lost (to the surroundings) allow heat for energy	1 1	AO1 4.5.1.1 RPA4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$ allow **1** mark for $Zn^{2+} + Cu$		2	AO2 4.1.1.1 4.2.2.2 4.4.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	(mean highest temperature =) $\frac{37.6 + 37.2 + 37.8 + 37.4}{4}$ = 37.5 (°C) 37.5 (°C) ± 0.3 (°C)	allow (mean highest temperature =) $\frac{150}{4}$	1 1 1	AO2 4.3.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	any **one** from: • starting temperature may be different • inconsistent stirring	ignore room temperature allow inconsistent use of a lid	1	AO3 4.5.1.1 RPA4

Total Question 4	14

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 69 · Mark scheme

June 2024 | 8462/1H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	(thermal) energy is transferred by delocalised electrons	allow heat is transferred	1 1	AO1 4.2.1.5 4.2.2.8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2		allow (positive / metal) ions for atoms throughout		AO1 4.2.2.7
	(the alloy / mixture has) different sized atoms		1	
	(so the) layers are distorted		1	
	(so the) layers cannot easily slide	allow (so the) atoms cannot slide over each other	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	$2\,Fe + 3\,Cl_2 \rightarrow 2\,FeCl_3$		1	AO2 4.3.1.1 4.3.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	$1\ Fe^{2+} : 2\ Fe^{3+} : 4\ O^{2-}$		1	AO2 4.4.2.2

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 69 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5	(M_r Fe_3O_4 =) 232		1	AO2 4.3.1.2
	(% Fe =) $\frac{3 \times 56}{232} \times 100$	allow $\frac{168}{232} \times 100$ allow correct use of an incorrectly determined M_r using the values of A_r given in the question	1	
	= 72.4 (%)	allow 72.41379 correctly rounded to at least 2 significant figures	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.6		a maximum of **4** marks can be awarded for a method which determines and uses the volume of iron oxide as a gas		AO2 4.3.2.1 4.3.2.2
	(40.0 kg =) 40 000 (g)		1	
	(moles Fe_2O_3 = $\frac{40\,000}{160}$ =) 250	allow correct use of an incorrectly converted or unconverted mass	1	
	(moles CO_2 = 250 × $\frac{3}{2}$ =) 375	allow correct use of an incorrectly determined number of moles of Fe_2O_3	1	
	(volume of CO_2 =) 375 × 24	allow correct use of an incorrectly determined number of moles of CO_2	1	
	= 9000 (dm^3)		1	

Total Question 7	15

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 70 · 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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 70 · 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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 71 · Mark scheme

June 2024 | 8462/2H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1		ignore (hydrochloric / nitric / sulfuric) acid		AO1 4.8.3.5
	(test) add barium chloride (solution)	allow add barium nitrate (solution)	1	
	(result) white precipitate		1	
		MP2 is dependent upon MP1 being awarded		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	the yield is smaller at higher temperatures because the reaction is exothermic		1	AO2 4.6.2.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3		allow converse		AO2 4.6.2.7
	there are more moles / molecules (of gas) on the left	ignore particles	1	
	(so the position of) equilibrium shifts to the right		1	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 71 · Mark scheme

June 2024 | 8462/2H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	any **two** from: • the yield is already high • more energy required • risk of explosion is increased • higher income from increased yield is outweighed by the extra expenditure • increased cost of safety precautions	allow requires stronger vessels allow requires thicker walls	2	AO3 4.6.2.7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5	vanadium (V)		1	AO3 4.1.3.2

Total Question 7	**8**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 72 · Mark scheme

June 2024 | 8462/2H | Original Q9

Question 9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	(some) hydrogen / gas escapes (from the flask) (because the reaction starts) before the stopper is put in	 allow (because) stopper cannot be inserted instantly allow for **1** mark some air (from the conical flask) is collected **or** allow some hydrogen remains in the conical flask **or** allow some hydrogen remains in the delivery tube	1 1	AO3 4.6.1.2 RPA5

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 72 · Mark scheme

June 2024 | 8462/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.2	(volume = 39 − 25 =) 14 (cm^3)		1	AO2 4.3.5
	(14 cm^3 =) 0.014 (dm^3)	allow correct use of an incorrectly determined volume	1	4.6.1.1 RPA5
	(moles of hydrogen =) $\frac{0.014}{24}$	allow correct use of an incorrectly determined volume allow correct use of an incorrect / no conversion of volume	1	
	= 5.8 x 10^{-4} (mol)	allow 5.833333 x 10^{-4} correctly rounded to at least 2 significant figures allow 0.00058 (mol)	1	
	alternative approach 1:			
	(24 dm^3 =) 24 000 (cm^3) (1)			
	(volume = 39 − 25 =) 14 (cm^3) (1)			
	(moles of hydrogen =) $\frac{14}{24000}$ (1)	allow correct use of an incorrectly determined volume allow correct use of an incorrect / no conversion of volume		
	= 5.8 x 10^{-4} (mol) (1)	allow 5.833333 x 10^{-4} correctly rounded to at least 2 significant figures allow 0.00058 (mol)		

	alternative approach 2: (24 dm^3 =) 24 000 (cm^3) (1) (moles of hydrogen at 100 s = $\frac{39}{24000}$ =) 0.001625 **and** (moles of hydrogen at 40 s = $\frac{25}{24000}$ =) 0.00104 (1) (moles 100 s – moles 40 s =) 0.001625 – 0.00104 (1) = 5.8 x 10^{-4} (mol) (1) **alternative approach 3:** (39 cm^3 =) 0.039 (dm^3) **and** (25 cm^3 =) 0.025 (dm^3) (1) (moles of hydrogen at 100 s = $\frac{0.039}{24}$ =) 0.001625 **and** (moles of hydrogen at 40 s = $\frac{0.025}{24}$ =) 0.00104 (1) (moles 100 s – moles 40 s =) 0.001625 – 0.00104 (1) = 5.8 x 10^{-4} (mol) (1)	allow correct use of an incorrect / no conversion of volume allow correct use of an incorrectly determined number of moles allow 5.833333 x 10^{-4} correctly rounded to at least 2 significant figures allow 0.00058 (mol) allow correct use of an incorrect / no conversion of volume allow correct use of an incorrectly determined number of moles allow 5.833333 x 10^{-4} correctly rounded to at least 2 significant figures allow 0.00058 (mol)		

Answer 72 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.3	tangent drawn at 45 s		1	AO2 4.6.1.1 RPA5
	correct values for *y* step **and** *x* step from tangent	allow correct use of an incorrectly drawn tangent allow a tolerance of ± ½ a small square for each coordinate	1	
	(rate =) $\frac{\text{value for } y \text{ step}}{\text{value for } x \text{ step}}$	allow correct use of incorrectly determined value(s) from the tangent for *y* step and/or *x* step	1	
	correct calculation of rate (mol/s)		1	
	rate given in standard form (mol/s)	allow a correctly calculated answer in standard form from an incorrect attempt at rate determination	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.4	line starting at 0,0.000 and less steep than existing line		1	AO2 4.3.2.4 4.3.4 4.6.1.1 RPA5
	becomes level at 0.0084 mol	allow a tolerance of ± ½ a small square	1	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 72 · Mark scheme

June 2024 | 8462/2H | Original Q9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.5	(increasing the temperature) increases the rate of reaction		1	AO1 4.6.1.2 4.6.1.3
	(because) particles have more energy	allow (because) particles move faster	1	
	(so) the frequency of collisions increases	allow (so) a greater proportion of collisions have enough energy to react ignore successful	1	

Total Question 9	16

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 73 · Mark scheme

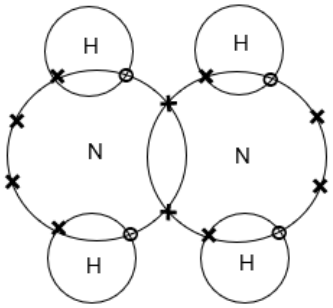
June 2025 | 8462/1H | Original Q7

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		

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 73 · Mark scheme

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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 73 · Mark scheme

June 2025 | 8462/1H | Original Q7

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	

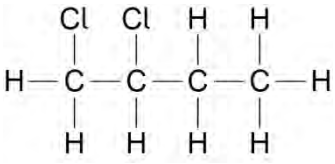
Total Question 7	11

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	– 6 (°C)	allow a value in the range (+)4 to –16 (°C)	1	AO2 4.7.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	ethanol	allow C_2H_5OH	1	AO2 4.7.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	(test) damp litmus paper (result) litmus paper is bleached **or** litmus paper turns white	 ignore litmus paper turns red ignore litmus paper turns red	1 1	AO1 4.8.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4			1	AO2 4.7.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	propene		1	AO1 4.7.2.1

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 74 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.6	(because of) incomplete combustion	ignore insufficient oxygen	1	AO1 4.7.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.7	(conversion 24 dm^3 =) 24 000 cm^3	allow conversion of volume anywhere in method	1	AO2 4.3.1.2 4.3.2.1 4.3.5 4.7.2.1
	(M_r = (3 × 12) + (6 × 1) =) 42		1	
	(moles = $\frac{2.1}{42}$ =) 0.05	allow correct use of an incorrectly determined M_r	1	
	(volume =) 24 000 × 0.05	allow correct use of an incorrectly determined number of moles allow correct use of an incorrect / no conversion of volume	1	
	= 1200 (cm^3)		1	
	alternative approach			
	(conversion 24 dm^3 =) 24 000 cm^3 (1)	allow conversion of volume anywhere in method		
	(M_r = (3 × 12) + (6 × 1) =) 42 (1)			
	(ratio of mass = $\frac{42}{2.1}$ =) 20 (1)	allow correct use of an incorrectly determined M_r		
	(volume =) $\frac{24\,000}{20}$ (1)	allow correct use of an incorrect / no conversion of volume		
	= 1200 (cm^3) (1)			

Total Question 5	**12**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 75 · 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	

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 76 · Mark scheme

Question 9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	the forward reaction is endothermic		1	AO2 4.6.1.3 4.6.2.4 4.6.2.6
	(so high temperature) shifts the equilibrium (position) to the right		1	
	(which) increases the yield (of products)	allow (and a high temperature) increases the rate of reaction	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.2		allow converse		AO2 4.6.2.4 4.6.2.7
	(low pressure) shifts the equilibrium (position) to the right		1	
	(because) there are more moles on the right	allow (because) there are more molecules on the right	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.3	no effect on equilibrium position		1	AO3 4.6.1.4 4.6.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.4	(volume ~) $\frac{50 \times 100}{80}$	allow a value in the range 78.0 to 80.0 for percentage of nitrogen	1	AO2 4.9.1.1 4.10.4.1
	~ 62.5 (dm^3)		1	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 76 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.5	(the reaction mixture is) cooled		1	AO1 4.10.4.1
	(so that) ammonia condenses / liquefies		1	
	(but) nitrogen **and** hydrogen are gases		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.6	any **three** from: • nitrogen is an abundant gas (in the air) • the use of nitrogen releases fewer greenhouse gases • the nitrogen released replaces that used to make ammonia • natural gas is a finite resource • (the use of hydrogen / methane releases) carbon dioxide which contributes to climate change	allow nitrogen is renewable allow (the use of hydrogen / methane releases) carbon dioxide contributes to global warming	3	AO3 4.10.1.1 4.10.4.1

Total Question 9	14

Version 1.0: 0108

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Secondary Education

Additional Science 4463 / Chemistry 4421

CHY2H Unit 2 Chemistry

Mark Scheme

2008 examination – January series

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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4.5.1.1 Energy transfer during exothermic and endothermic reactions

MARK SCHEME

Information to Examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the Examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following lines is a potential mark.

2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.

2.3 Alternative answers acceptable for a mark are indicated by the use of **or**. (Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.)

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which candidates have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error/contradiction negates each correct response. So, if the number of error/contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (indicated as * in example 1) are not penalised.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Example 1: What is the pH of an acidic solution? (1 mark)

Candidate	Response	Marks awarded
1	4,8	0
2	green, 5	0
3	red*, 5	1
4	red*, 8	0

Example 2: Name two planets in the solar system. (2 marks)

Candidate	Response	Marks awarded
1	Pluto, Mars, Moon	1
2	Pluto, Sun, Mars, Moon	0

3.2 Use of chemical symbols / formulae

If a candidate writes a chemical symbol / formula instead of a required chemical name, full credit can be given if the symbol / formula is correct and if, in the context of the question, such action is appropriate.

3.3 Marking procedure for calculations

Full marks can be given for a correct numerical answer, as shown in the column 'answers', without any working shown.

However if the answer is incorrect, mark(s) can be gained by correct substitution / working and this is shown in the 'extra information' column;

3.4 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.5 Errors carried forward

Any error in the answers to a structured question should be penalised once only.

Papers should be constructed in such a way that the number of times errors can be carried forward are kept to a minimum. Allowances for errors carried forward are most likely to be restricted to calculation questions and should be shown by the abbreviation e.c.f. in the marking scheme.

3.6 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited **unless** there is a possible confusion with another technical term.

3.7 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.8 Unexpected Correct Answers not in the Mark Scheme

The Examiner should use professional judgement to award credit where a candidate has given an unexpected correct answer which is not covered by the mark scheme. The Examiner should consult with the Team Leader to confirm the judgement. The Team Leader should pass this answer on to the Principal Examiner with a view to informing all examiners.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 1

question	answers	extra information	mark
(a)	sensible line of best fit which goes through or close to all the points **except** the anomalous point	allow wobbly / short double lines ± ½ square	1
(b)	loss of gas / loss of CO_2	idea of gas produced / formed	1
(c)	7		1
(d)(i)	steeper line from around the same starting point and left of the points levelling off at 99	allow crosses if they are fully correct for **1** mark accept short level line at 99 ± ½ square	1 1
(d)(ii)	any **three** from: • particles / molecules / atoms/ ions have more energy • move faster • collide <u>more</u> often **or** <u>more</u> chance of collisions **or** bump into each other <u>more</u> • collide with <u>more</u> force / energy **or** <u>more</u> particles have the activation energy **or** <u>more</u> collisions result in reaction **or** <u>more</u> collisions are successful	 allow given / gain / get energy ignore move about more ignore vibrate more / faster ignore collide quicker / faster	3
total			8

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 2

question	answers	extra information	mark
(a)	any **one** from: • they are made of layers • atoms / ions / particles / layers (of atoms) can slide over each other	 do **not** accept line / rows / lattice	1
(b)	any **one** from: • smaller / tiny **or** very small • correct size range 1 to 100 nanometres • a few hundred atoms in size	 do **not** allow small alone if they state smaller and give a size outside range ignore size if it is less than 20,000	1
(c)	harder plus **one** from: • so does not wear as quickly / erode as quickly • less vulnerable to damage owtte • because they have a high surface area to volume ratio **or** stronger (1) plus **one** from: (1) • less likely to break / do not break • not as vulnerable to damage owtte • do not bend out of shape • because they have a high surface area to volume ratio	 ignore corrode harder to wear down = **1** mark accept withstand pressure harder and stronger alone gains **1** mark	1 1
total			4

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 3

question	answers	extra information	mark
(a)	N_2O		1
(b)	13.8 to 14	gains full marks without working if answer incorrect 13 gains **1** mark **or** 14/101 × 100 gains **1** mark	2
total			3

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

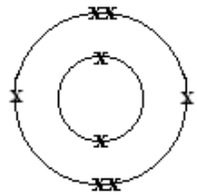
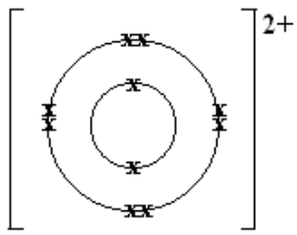
Question 4

question	answers	extra information	mark
(a)	electric current / electricity		1
	plus **one** from:		1
	• is passed through ionic compound / substance / electrolyte • passed through molten/aqueous compound / substance	must be linked to electricity allow liquid compound / substance do **not** allow solution / liquid alone	
	• causing decomposition	accept split up / breakdown / breaking up owtte ignore separated accept elements are formed ignore new substances form	
(b)	hydrogen	accept H_2 do **not** accept H / H^2	1
(c)	one electron from each atom	accept each carbon is bonded to three other carbon atoms leaving one (unbonded) electron owtte	1
	is delocalised / free (to move)	must be linked to electrons answers of delocalised / free electrons only, gains **1** mark accept each carbon is bonded to three other carbon atoms leaving delocalised / free electrons = **2** marks **maximum 1** mark if graphite described as a metal / giant ionic lattice	1
total			5

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 5

question	answers	extra information	mark
(a)	any **one** from: • gives out heat / energy • transfers energy from a substance to the surroundings • ΔH / energy change / enthalpy change is negative	accept releases / gives off owtte ignore references to light	1
(b)	$2Mg + O_2 \rightarrow 2MgO$	accept correct multiples / fractions	1
(c)		electrons do not need to be paired accept dots / circles / e instead of crosses do **not** allow 2.6 without diagram	1
(d)		electrons do not need to be paired allow without brackets must have the charge accept dots / circles / e instead of crosses ignore extra empty outer shells ignore nucleus do **not** allow $[2.8]^{2+}$ without diagram	1

continued…

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 5 continued…

question	answers	extra information	mark
(e)	oppositely charged (ions / atoms)	allow positive and negative(ions / atoms)	1
	(they) attract	must be in correct context accept held by electrostatic forces ignore ionic bonding **maximum 1** if they refer to intermolecular forces / attractions / covalent bonds	1
(f)	magnesium chloride	accept $MgCl_2$ (if correctly written)	1
total			7

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 6

question	answers	extra information	mark
(a)	**Compound A** any **one** from: • sodium bromide • potassium bromide • ammonium bromide • hydrogen bromide • any metal bromide except silver and lead. **Compound B** silver nitrate	accept correct formulae accept silver sulfate	1 1
(b)	the silver compound will decompose / silver ions be reduced to silver (owtte)	accept film would darken owtte accept any idea of light changing silver bromide / silver ions / silver nitrate / silver sulfate allow 'forms a black solid' / it would turn black	1
(c)	precipitation	accept descriptions of precipitation reactions accept double decomposition accept precipitate do **not** allow displacement	1
(d)	electrons are gained	 the second mark **must** be linked to electrons accept it / silver / silver ions gains electrons for **both** marks ignore references to oxygen	1 1
total			6

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 7

question	answers	extra information	mark
(a)	1213.8 to 1214.3 correct answer not given then check working 1) moles of N_2 = $\frac{1000}{28}$ = 35.7 mol 2) moles of NH_3 = 2 × (answer from (1)) = 71.4 mol 3) mass of NH_3 = (answer from 2) × 17 = 71.4 × 17 = 1214 g **or** • 28g of N_2 → 34g of NH_3 • 1g of N_2 → $\frac{34}{28}$ = 1.214g NH_3 • 1000 g of N_2 → 1000 × 1.214 = 1214g **or** • 1000 × $\frac{34}{28}$ **or** **other correct methods**	gains **3** marks without working **1** mark for each correct step do **not** penalise rounding errors in this part **1** mark for each correct step do **not** penalise rounding errors in this part allow error carried forward eg gains **2** marks if correct answer not given 1000 × $\frac{28}{34}$ gains **1** mark, **2** marks if correctly calculated (823.5g) 1000 × $\frac{28}{17}$ gains **1** mark if calculated correctly (1647.05g) look for the key ideas in the methods above	3

continued…

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 7 continued…

question	answers	extra information	mark
(b)	25 / 25.035 **or** ecf from (a)	gains **2** marks even when there is no working incorrect answer then 304/(their answer from (a)) × 100 gains **1** mark	2
	or using figures from part (b)		
	27.6 / 28	gains **2** marks even when there is no working accept 27 for **1** mark if answers incorrect then304/1100 × 100 gains **1** mark	
(c)(i)	increase yield		1
	reaction is exothermic		1
	or		
	allow decreased yield because rate of reaction is slower / fewer collisions for **2** marks	**must** get both points for **2** marks	
(c)(ii)	increase yield		1
	plus **one** from: • more (gaseous) reactant molecules than (gaseous) product molecules (owtte) • increased rate of reaction / more collisions	accept greater volume on the left than the right owtte	1

continued…

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 7 continued…

question	answers	extra information	mark
(d)	any **one** from: **economic** • large town provides workforce • workers do not have to travel far to the factory. (owtte) • transport infrastructure already in place for large town. (owtte) • factory brings prosperity to town (owtte) • factory provides employment • reduced tourism • reduction in local house prices • any other sensible economic factor linked to town		1
	any **one** from: **safety** • escape of dangerous / harmful chemicals / gases (owtte) • danger of increased traffic • risk of explosion.(owtte) /danger of high pressure • consequences of an accident could be severe if the town is close • any other sensible safety idea	do **not** allow polluting gases unqualified	1

continued…

4.5.1.1 Energy transfer during exothermic and endothermic reactions

CHY2H

Question 7(d) continued…

question	answers	extra information	mark
	any **one** from: **environmental** • factory might be unsightly (owtte) • screening of factory (owtte) • loss of habitats (owtte) • plant trees/ hedges etc on and around plant site • pollution of water / air / soil could harm plants / animals **or** noise pollution • CO_2 is produced by burning fuels / heating • CO_2 causes global warming / any effect of global warming • eye sore • any other sensible environmental factor	must be explained	1
total			12

4.5.1.1 Energy transfer during exothermic and endothermic reactions

GCSE

Additional Science / Chemistry

CH2HP
Final Mark scheme

4408 / 4402
June 2017

Version/Stage: v1.0

4.5.1.1 Energy transfer during exothermic and endothermic reactions

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4.5.1.1 Energy transfer during exothermic and endothermic reactions

Information to Examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the Examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded
- the Assessment Objectives and specification content that each question is intended to cover.

The extra information is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.
At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.
In general the right-hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

2. Emboldening and underlining

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.

2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.

2.3 Alternative answers acceptable for a mark are indicated by the use of **or**.
Different terms in the mark scheme are shown by a / ; eg allow smooth/free movement.

2.4 Any wording that is underlined is essential for the marking point to be awarded.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which students have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error/contradiction negates each correct response. So, if the number of error/contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (indicated as * in example 1) are not penalised.

Example 1: What is the pH of an acidic solution?

[1 mark]

Student	Response	Marks awarded
1	green, 5	0
2	red*, 5	1
3	red*, 8	0

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Example 2: Name two planets in the solar system.

[2 marks]

Student	Response	Marks awarded
1	Pluto, Mars, Moon	1
2	Pluto, Sun, Mars, Moon	0

3.2 Use of chemical symbols/formulae

If a student writes a chemical symbol/formula instead of a required chemical name, full credit can be given if the symbol/formula is correct and if, in the context of the question, such action is appropriate.

3.3 Marking procedure for calculations

Full marks can be given for a correct numerical answer, without any working shown. However, if the answer is incorrect, mark(s) can be gained by correct substitution/working and this is shown in the 'extra information' column or by each stage of a longer calculation.

3.4 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.5 Errors carried forward

Any error in the answers to a structured question should be penalised once only. Papers should be constructed in such a way that the number of times errors can be carried forward are kept to a minimum. Allowances for errors carried forward are most likely to be restricted to calculation questions and should be shown by the abbreviation 'ecf' in the marking scheme.

3.6 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited **unless** there is a possible confusion with another technical term.

3.7 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.8 Accept/allow

Accept is used to indicate an equivalent answer to that given on the left-hand side of the mark scheme. Allow is used to denote lower-level responses that just gain credit.

3.9 Ignore/Insufficient/Do not allow

Ignore or insufficient is used when the information given is irrelevant to the question or not enough to gain a marking point. Any further correct amplification could gain the marking point.
Do **not** allow means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

4 Quality of Written Communication and levels marking

In Question 2 students are required to produce extended written material in English, and will be assessed on the quality of their written communication as well as the standard of the scientific response.

Students will be required to:
- use good English
- organise information clearly
- use specialist vocabulary where appropriate.

The following general criteria should be used to assign marks to a level:

Level 1: Basic

- Knowledge of basic information.
- Simple understanding.
- The answer is poorly organised, with almost no specialist terms and their use demonstrating a general lack of understanding of their meaning, little or no detail.
- The spelling, punctuation and grammar are very weak.

Level 2: Clear

- Knowledge of accurate information.
- Clear understanding.
- The answer has some structure and organisation, use of specialist terms has been attempted but not always accurately, some detail is given.
- There is reasonable accuracy in spelling, punctuation and grammar, although there may still be some errors.

Level 3: Detailed

- Knowledge of accurate information appropriately contextualised.
- Detailed understanding, supported by relevant evidence and examples.
- Answer is coherent and in an organised, logical sequence, containing a wide range of appropriate or relevant specialist terms used accurately.
- The answer shows almost faultless spelling, punctuation and grammar.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question	Answers	Extra information	Mark	AO / Spec. Ref.
1(a)(i)	a smooth curve through or close to all points except (30,12)		1	AO2 2.4
1(a)(ii)	correct reading from the curve in 1(a)(i) (cm^3)	allow a tolerance of +/- 0.5 cm^3	1	AO2 2.4
1(a)(iii)	45-50 (seconds)		1	AO3 2.4
1(a)(iv)	line becomes less steep because gas is produced more slowly	ignore line levels out or plateaus allow examples with figures, eg 12 cm^3 gas from 0 to 20s but 1.5 cm^3 gas in last 20s ignore reaction has stopped or no more gas produced	1 1	AO3 2.4
1(a)(v)	0.6 (cm^3 per second)	allow 0.55 to 0.65	1	AO2 2.4
1(b)(i)	 temperature volume (of hydrogen peroxide)	concentration of hydrogen peroxide = max **1** ignore amount (of hydrogen peroxide)	 1 1	AO3 2.4
1(b)(ii)	 rate increases because more particles (in the same volume) so frequency of collisions increases	incorrect reference to energy = max **2** accept particles closer together allow greater chance of collisions ignore more collisions	 1 1 1	AO1 2.4.1e

4.5.1.1 Energy transfer during exothermic and endothermic reactions

1(c)	(increasing the amount of catalyst) increases rate same final volume of gas	accept steeper graph or graph levels off earlier	1 1	**AO2** 2.4.1g
Total			**13**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

<table>
<tr><th>Question</th><th>Answers</th><th>Extra information</th><th>Mark</th><th>AO / Spec. Ref.</th></tr>
<tr><td>2</td><td></td><td></td><td>6</td><td rowspan="6">AO1
2.1.1h
2.2.4b,c
2.2.5a,b</td></tr>
<tr><td colspan="4">Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5 and apply a ‘best-fit’ approach to the marking.</td></tr>
<tr><td colspan="4"><table>
<tr><th>0 marks</th><th>Level 1
(1–2 marks)</th><th>Level 2
(3–4 marks)</th><th>Level 3
(5–6 marks)</th></tr>
<tr><td>no relevant information given</td><td>a statement about the structure or a property of a metal
or
a statement about the structure or a property of a polymer</td><td>a statement about the structure or a property of a metal
and
a statement about the structure or a property of a polymer</td><td>a statement about the structure or a property of a metal
and
a statement about the structure or a property of a polymer
and
at least one statement linking structure and property</td></tr>
</table></td></tr>
<tr><td colspan="4">Statements shown as HT only are credited on both FT and HT.
However, HT only means that these statements are not expected in a FT answer.</td></tr>
<tr><td colspan="4">Examples of chemistry points made in response

Metal:

Properties
shiny
hardness
(tensile) strength
melting point/boiling point
density
malleable/flexible
ductile
conduct electricity or thermal energy</td></tr>
</table>

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Structure • metals contain atoms /((positive) ions HT only) • (the atoms/(positive) ions/particles are) closely packed / in a regular pattern / in a giant structure/in layers / in a lattice • strong bonds/(electrostatic attractions HT only) • (metal has delocalised electrons HT only) **Polymer:** **Properties** • flexible • melting/boiling point • density • can be shaped/moulded • poor conductor of electricity or thermal energy **Structure** • polymer consists of chains • polymer chains may be tangled • polymer has no cross links. • (polymer has weak intermolecular forces HT only) **Level 3:** **Examples of linked statements:** • metal can be bent and shaped because the layers can slide • some metals are soft because layers can slide • some metals are hard because they have strong bonds and/ or (the atoms/(positive) ions/particles) are closely packed / in a regular pattern / in a giant structure/ in a lattice • metal has high melting/boiling point because they have strong bonds and/ or (the atoms/(positive) ions/particles) are closely packed / in a regular pattern / in a giant structure / in a lattice • metal is strong because of strong bonds • some metals are dense because the atoms are closely packed • (metal can conduct thermal energy and electricity because metal has delocalised electrons HT only) • thermosoftening polymer melts when heated because it has no cross-links (or has weak intermolecular forces HT only) • thermosoftening polymer is flexible because the chains can move over each other	

Total			**6**

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question	Answers	Extra Information	Mark	AO / Spec. Ref
3(a)(i)	2 bonding pairs 4 unbonded electrons on each atom	accept dots, crosses, e, - or any combination ignore any electrons on any inner shells if no other mark awarded allow **1** mark for 1 bonding pair and 6 unbonded electrons on each atom	1 1	**AO2** 2.1.1g
3(a)(ii)	covalent	allow convalent and covelant ignore single or double ignore shared, shared bond or sharing	1	**AO1** 2.1.1g
3(a)(iii)	weak intermolecular forces require little energy to overcome	reference to weak covalent or weak ionic bonds = **0** accept weak intermolecular bonds MP2 dependent on MP1 if no other mark awarded allow 1 mark for simple/small molecules	1 1	**AO1** **AO2** 2.2.1a,b

4.5.1.1 Energy transfer during exothermic and endothermic reactions

3(b)(i)	**2** Mg + O_2 → **2** MgO	accept multiples	1	**AO2** 2.2.2
3(b)(ii)		reference to incorrect particles **or** incorrect bonding **or** incorrect structure = max **2**		**AO1** **AO2** 2.1.1a,b,c,f
	magnesium loses (electrons) **and** oxygen gains (electrons)		1	
	two (electrons transferred)		1	
	noble gas structure **or** 8 electrons in outer shells **or** (electrostatic) attraction between ions **or** forms ionic bonds	accept full outer shell (of electrons)	1	
3(b)(iii)	particles 1-100 nm in size	accept contain a few hundred atoms/ions accept have a high surface area to volume ratio ignore reference to (very) small particles do **not** accept smaller than an atom/ion	1	**AO1** 2.2.6a

4.5.1.1 Energy transfer during exothermic and endothermic reactions

3(c)	has a high melting point	allow will not melt allow a lot of energy needed to melt ignore boiling point reference to incorrect particles or incorrect bonding or incorrect structure = max **1** from MP2 and MP3	1	**AO1** **AO2** 2.2.3a
	because all atoms linked to other atoms	allow giant structure/lattice ignore many bonds	1	
	by covalent bonds	allow strong bonds allow a lot of energy needed to break bonds accept giant covalent structure for MP2 and MP3	1	
Total			**13**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question	Answers	Extra Information	Mark	AO / Spec. Ref
4(a)	add copper oxide and (sulfuric) acid		1	**AO1** **AO2** 2.6.1b,c
	excess (copper oxide)		1	
	filter (to remove excess)	ignore impurities	1	
	heat /boil / evaporate / leave (to crystallise)	do **not** accept to dryness	1	
4(b)	(M_r CuO =) 79.5		1	**AO2** 2.3.3c
	24.95/249.5 **or** 0.1 **OR** 79.5/249.5 **or** 0.3186…	allow ecf for M_r CuO from step 1 allow correct rounding to min 2SF	1	
	(24.95/249.5 x 79.5=) 7.95	allow ecf for M_r CuO from step 1 allow ecf from step 2 of incorrect calculation/ rounding of correct ratio allow correct rounding to min 2SF correct answer with or without working gains 3 marks	1	
4(c)(i)	as wealth decreases, ethene production decreases (with the exception of country C or D)	accept converse	1	**AO2** **AO3** 2.6
	sulfuric acid production is not linked to wealth		1	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

4(c)(ii)	use of products of ethene has increased	allow use of polymers / plastics / ethanol / poly(ethene) has increased ignore use of ethene as a (bio)fuel ignore cost	1	**AO3** 2.2.5
Total			**10**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question	Answers	Extra Information	Mark	AO / Spec. Ref
5(a)(i)	draw line on paper put (dots of) inks on line place (bottom of) paper in solvent / water any **one** from: line drawn in pencil allow dots of ink to dry line above solvent lid		1 1 1 1	**AO1** 2.3.2b
5(a)(ii)	any **two** from: • A has 3 colours **and** B has 4 colours • 2 colours are the same • **A** has 1 colour not in **B and B** has 2 colours not in **A**	accept 3 colours are different if no other mark awarded allow **one** more colour in ink **B** than in ink **A** (or converse)	2	**AO3** 2.3.2b
5(b)(i)	substances carried by gas through column / tube / coil (packed with solid) (different substances move through the column) at different speeds	 accept (different) substances come out at different times or have different retention times	1 1 1	**AO1** 2.3.2c
5(b)(ii)	(relative) molecular mass	allow (relative) formula mass allow RFM, RMM, M_r	1	**AO1** 2.3.2c
Total			**10**	

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Question	Answers	Extra Information	Mark	AO / Spec. Ref
6(a)(i)	tick (✓) by: the initial temperature reading was too low		1	**AO3** 2.5
6(a)(ii)	the reaction is exothermic	allow energy is given out	1	**AO3** 2.5.1b
6(b)(i)	(positive/hydrogen) ions gain electrons hydrogen is below sodium in the reactivity series so hydrogen / H_2 is produced	accept (positive/hydrogen) ions are reduced accept reference to high reactivity of sodium If no other mark awarded allow hydrogen (and sodium) ions **or** positive ions are attracted to negative electrode for **1** mark	1 1 1	**AO1** **AO2** 2.7.1c,f,i
6(b)(ii)	**2** (Cl^-) → **Cl_2 + 2e^-**	must be completely correct allow multiples	1	**AO1** 2.7.1g
6(b)(iii)	solution is alkaline because sodium hydroxide / NaOH is produced **or** sodium hydroxide / NaOH is left over	accept hydroxide (ions) / OH^- is produced **or** hydroxide (ions) / OH^- is left over	1 1	**AO1** **AO2** 2.7.1i; 2.6.2d
Total			**8**	

Answer 47 · 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.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 47 · 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 48 · Examiner comments

June 2018 | 8462/1H | Original Q7

Question 7 (standard / high and high demand)

07.1 This question was answered well by the majority of students, with 68% giving a correct answer. The most common error was to give only one of the products, usually potassium chloride.

07.2 Although this historically is a well-known area of the specification, lack of precision in answers cost some students greatly. 16% of students achieved all three marks, with 72% gaining some credit.

The electrons are not (all) closer to the nucleus in chlorine – the **outer** electrons are. The relevant force of attraction is between the **outer** electrons and the **nucleus**, and is not intermolecular, magnetic or gravitational. Attracting another electron is not the same as **gaining** it.

07.3 This was another difficult question with 51% of students gaining no marks at all. 9% of students achieved all three. Few described the structure correctly. 'Simple covalent' only refers to the bonding; the structure needed to be described as small molecules, as in the specification, or as simple molecular (to distinguish it from large molecules or giant structures).

Some answers started well, referring to weak intermolecular forces, but then moved into talking about breaking bonds, for example 'it has weak intermolecular forces so little energy is needed to break the bonds'. Again, language was an issue, with statements such as 'hydrogen chloride is a covalent bond' failing to gain any credit. Some students stated that hydrogen chloride is ionic (but often then referred to intermolecular forces), or did not refer to hydrogen chloride at all, instead couching their answer in terms of hydrogen and chlorine.

07.4 This question was answered well, with 73% students achieving three or four marks.

It was often difficult to give partial credit as working was difficult to follow. Many students worked out the sum of the bonds broken as 1841 kJ/mol, but then said that the sum of the bonds made was 1602 kJ/mol rather than (1602 + X) kJ/mol. Many students then calculated their final answer based on energy change = bonds made – bonds broken, rather than the other way round.

Some students missed out on putting brackets around their (1602 + X) in their overall expression, making it incorrect. A decent number divided the bond enthalpies by 2 then subtracted one from another to get the difference, which they then added to another halved bond energy. This perhaps shows a misconception that the bond energy is associated with an atom rather than a bond.

Answer 49 · Examiner comments

Question 8 (standard / high and high demand)

08.1 42% of students could answer this correctly. A hazard was asked for, and it was expected that students would use the correct chemical term for such a hazard; hence the idea that chlorine or carbon monoxide is **toxic** was required. Many did not use the correct term, referring instead to it being harmful (incorrect – it can kill, not merely make one ill), or dangerous or deadly (in what way?). Some students misread the equation and referred to carbon dioxide.

08.2 40**%** of students achieved the mark here. Many did not realise that their observations of a vigorous reaction with a small piece of sodium in the lab would be magnified enormously on an industrial scale. Hence the reaction would be **very** violent or explosive, not just vigorous.

08.3 There were many good attempts at this question, with 73% of students scoring at least one mark. Many students referred to the lack of reactivity of the metals with argon, but some forgot to refer to air. Then some students did not express themselves clearly, referring to one or both metals reacting with air in general, or even with gases not present in the air, such as hydrogen.

08.4 There were some excellent attempts at this difficult question, which discriminated well. 8% of students achieved full marks with 43% achieving at least one mark. Full credit could be gained by those who started with the premise that titanium chloride must be ionic so should have a high melting point; very few started from the true situation, which is that titanium chloride must exist as small molecules as its melting point is low.

The mark that was scored least often was for the explanation of the bonding and how it leads to the actual, or predicted, melting point. Some spoiled an otherwise good description of ionic bonding by also referring to ‘strong intermolecular forces’. Many referred to ‘strong electrostatic forces’ but failed to mention that those forces were between ions.

A significant number of students answered solely in terms of the separate elements, particularly titanium, rather than the compound.

08.5 51% of students achieved the mark for this question. Whilst the definition of oxidation in terms of electrons is well known, the question asked why **this** reaction is oxidation. So, it was necessary to refer to the sodium atoms losing electrons rather than giving a generalised answer. Some students referred to ‘it’ losing electrons, without specifying what ‘it’ referred to, while others referred to oxygen, which is not present.

08.6 54% of students achieved the mark here. It was not uncommon to see ‘$-e^-$’ on the right hand side. A significant number of incorrect responses showed the formation of a doubly charged sodium ion.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 49 · Examiner comments June 2018 | 8462/1H | Original Q8

08.7 This difficult unstructured calculation tested a new area of the specification, and discriminated very well. 74% of students were able to achieve at least one mark, usually for calculating the M_r of $TiCl_4$. 7% of students achieved all four marks, with 12% achieving at least three marks and there were some valiant efforts.

Common errors were:

- using 92 instead of 23 to calculate the number of moles of Na
- omitting the unit conversion from kg to g for the mole calculations
- using the 1:4 mole ratio incorrectly or not at all.

Also, it is not appropriate to leave answers in the form of a fraction, even if this is the default on their calculator. Answers should always be converted to decimal form.

08.8 This was well answered, with 74% of students achieving both marks. A few forgot the 100 in their expression and didn't realise they were making about 1000 kg more than the theoretical maximum.

Answer 50 · Examiner comments

June 2018 | 8462/2H | Original Q3

Question 3 (standard demand)

03.1 80% of students realised that the other gas used in the Haber process is hydrogen.

03.2 44% of the students knew the temperature and pressure used in the process. This was made even more challenging as they had to give the correct units as well.

03.3 32% of students could explain why only the ammonia, and not the other gases, turn into a liquid: because its boiling point is higher.

03.4 This was an 'extended response', 'level marked' question. There were three levels and the command word was 'explain'. The question was marked holistically. Students were given information about the current atmosphere of Venus, believed to be similar to that on the early Earth, and the Earth's atmosphere today.

Generally, a level 1 response used the percentages given to say in which direction the amounts of these gases had moved. Level 2 moved beyond this, giving an explanation in terms of one process, such as photosynthesis or dissolving in oceans. Level 3 responses usually gave more than one process, for example both of the processes mentioned above.

Many students talked only about the changes in the last few centuries, which was not what the question was asking. 47% of students were able to provide a level 3 response.

03.5 39% of students seemed aware of the timescale under consideration here, namely the atmosphere of billions of years ago, or that there was a lack of evidence or proof. Many merely asserted that there was no-one there (to make measurements).

Answer 51 · Examiner comments

June 2018 | 8462/2H | Original Q8

Question 8 (standard / high & high demand)

08.1 Most students recognised that a gas is given off by the reaction. Sometimes it was incorrectly identified as hydrogen.

The 'escape' mark was less commonly awarded either because the students thought it was sufficient to state that a gas is given off or because they thought that the gas 'evaporated'.

43% of students achieved full marks.

08.2 The points on the graph were almost invariably correctly drawn within tolerance. Most found the question easy although there were a significant number who omitted the point at 0,0.

The line of best fit was problematic for a number of students. A significant number assumed that the line of best fit was a straight line rather than a curve. Other students were penalised for 'double lines' or not extending the curve over the whole range of points.

83% of students were able to achieve at least two marks here.

08.3 A significant number of students did not draw a tangent at 0.95 g but used 0.95 g to calculate the **mean** rate over the first 0.95 g lost. Such students were able to score the third and fourth marking points. A small number of students drew the tangent in the wrong place choosing the other number (50) quoted in the question.

Some students had difficulty with the scales on the graph either by:

- forgetting that the *y*-axis intervals were 0.1 and calculating the difference as a whole number rather than the actual difference eg 18 rather than 0.18
- counting the number of squares on the *y*-axis or the *x*-axis eg 1.00 − 0.8 = 10 (squares) rather than 0.2

Many students were able to state that the gradient of the tangent is calculated by the *y* value divided by the *x* value and calculate a value correctly. But some students neglected to quote their answer to two significant figures. 25% of students achieved full marks.

Answer 52 · Examiner comments

June 2018 | 8462/2H | Original Q9

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

09.1 88% of students could identify an enzyme as a (biological) catalyst.

09.2 64% of students could use the equation to work out that 2.0×10^3 moles of carbon monoxide would react.

09.3 The endothermic nature of the backwards reaction was often identified as the reason the equilibrium position moved to the left; however many made no comment about the yield of methanol. Many students thought there would be a higher yield. 39% of students achieved both marks.

09.4 While many students did well, there were many others who demonstrated partial knowledge or who did not express themselves clearly. Many thought that an increase in pressure caused an increased yield of methanol because it was an exothermic reaction, rather than because the equilibrium moved to the position of fewer moles / molecules / particles.

The increased rate of reaction was better understood; students usually gave some indication that the particles are closer or there are **more particles** in a **fixed** volume or there are the **same number of particles** in a **smaller** volume. Simply saying there were more particles was insufficient.

In addition, students needed to link collisions **and** time to gain credit, usually by saying that the particles collide more often or there are more frequent collisions. Simply saying **more collisions** alone was insufficient. The idea that an increase in pressure supplied energy (and therefore increased the speed of the particles) was discounted.

73% of students were able to achieve some credit, with 12% of students achieving full marks.

09.5 Higher-attaining students achieved both marks for stating that catalysts reduce the activation energy by providing an alternative route or pathway, though the second point was less well known than the first. Sometimes one or other of these points was omitted. A popular incorrect idea was that catalysts supply energy.

09.6 47% of students knew that catalysts reduce costs, save energy or allow lower temperatures to be used. Others just mentioned that catalysts can be reused or that they speed up the reaction.

09.7 The effect of a catalyst on the equilibrium yield of methanol was not well understood. It was widely thought that a catalyst increased the yield of methanol because the reaction was faster and would, therefore, produce more of the product. 24% of students answered correctly.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 53 · Examiner comments

June 2019 | 8462/1H | Original Q1

Question 1 (standard demand)

01.1 Approximately 40% of students scored this mark which required an appropriate reference to the properties of tellurium and/or iodine.

Most correct answers referred to iodine having similar properties to other Group 7 elements.

References to atomic structure were quite common, for example, iodine has 7 electrons in the outer shell so fits in Group 7. This was not creditworthy since this detail of atomic structure would not have been known by Mendeleev.

01.2 Students found this question difficult with almost half scoring 0 marks.

The most commonly awarded mark was for the idea that the missing elements were eventually discovered.

The ideas that Mendeleev predicted the properties of the missing elements and that when discovered the actual properties matched his predictions were not often stated.

01.3 Approximately three-quarters of students correctly identified relative atomic mass as the modern name for atomic weight.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 53 · Examiner comments

June 2019 | 8462/1H | Original Q1

01.4 Approximately 70% of students scored this mark with the most common response being 'atomic number'.

The most common responses seen that were not credited:

- reactivity
- relative atomic mass
- mass
- number of electrons in the outer shell.

01.5 Almost 70% of students scored at least 1 mark.

To gain the mark for the formula, At_2, the correct casing for the letters needed to be used; also, a subscript for the number. This mark was scored more often than the mark for the state.

01.6 Students found this question difficult and were often unable to give the observations associated with the reaction between sodium and chlorine.

The few students that gained credit mostly did so for the formation of a solid or for a flame.

Many students gave observations that would be expected from adding sodium to water, for example, a vigorous reaction or fizzing.

Other common non-scoring responses referred to:

- a precipitate being formed
- salt or sodium chloride being produced
- transfer of electrons.

Answer 54 · 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.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 54 · 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 55 · Examiner comments June 2019 | 8462/1H | Original Q9

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

09.1 Almost a half of students scored 0 marks.

The mark scheme required the use of comparatives.

Common correct responses were:

- Better insulator
- Less heat loss

Common responses seen that were not credited included:

- good insulator
- no heat loss.

09.2 This graph question was well answered with approximately half of students scoring full marks.

Some students attempted to draw a straight line of best fit. In most cases, this was inappropriate.

Some students did not draw their line so that the two lines of best fit crossed. Instead, they drew a curved peak.

Answer 55 · Examiner comments

09.3 Approximately 60% of students were able to determine the neutralisation point from their graph.

In some cases, students misunderstood the scale of the x-axis, for example, reading 11 cm^3 as 10.1 cm^3.

09.4 Only approximately a third of students correctly determined the overall temperature change for the reaction from their graph.

A common incorrect answer was 8.2 °C (from subtraction of the highest and lowest temperature values in the table).

09.5 Students found this titration calculation difficult and approximately a third of students scored 0 marks.

The marks for calculating the number of moles of sulfuric acid and for calculating the relative formula mass of potassium hydroxide were the most scored. Even when these values were incorrect, this did not prevent students from gaining marks in subsequent steps.

The correct answer for the concentration in mol/dm^3 was achieved more often than the subsequent conversion to g/dm^3. A common error was to use a conversion factor of 112 (2 × M_r(KOH)) rather than 56.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 55 · Examiner comments

June 2019 | 8462/1H | Original Q9

Use of statistics

Statistics used in this report may be taken from incomplete processing data. However, this data still gives a true account on how students have performed for each question.

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 58 · 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

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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.

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November 2020 | 8462/1H | Original Q9

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

09.1 A third of students scored this mark; some realised that the most likely error was lack of stirring; fewer suggested that the temperature was measured too early, before the temperature had stopped falling. Many suggestions contradicted the information given.

09.2 Students had great difficulty in expressing their answers using correct terminology, often using energy and temperature interchangeably. They generally find endothermic reactions difficult; they do not seem to realise that the energy taken in is not staying as thermal energy but is being converted to chemical energy. Some students gained the mark for saying that the temperature initially falls because energy is being taken in, showing an endothermic reaction. A few noted that when 1.5 g of citric acid had been added the reaction had finished and that the citric acid was in excess from there on. However, it was very rare for a correct explanation for the subsequent rise in temperature to be given. Some thought the reaction suddenly became exothermic, or that it suddenly reversed (showing a lack of understanding of reversible reactions).

09.3 Many students realised that the difference was due to the better thermal conductivity of the metal. However, many of those merely referred to the metal as a good conductor, without comparing the metal to polystyrene. The majority of students drew a steeper line, stating that the metal would lose heat more quickly. Of those who drew the correct shallower line, few could explain that the metal would conduct thermal energy in from the surroundings more quickly, reducing the temperature drop in this endothermic reaction.

09.4 Many students were able to score all three marks. Common errors were to confuse concentration with number of moles and to fail to convert 250 cm^3 to 0.25 dm^3 correctly. The symbol ‘m’ for number of moles was commonly seen instead of ‘n’ – students consequently became confused between mass and number of moles. Students who set out their working step by step were able to gain partial credit, but those who simply had a jumble of numbers, with no explanation as to what the numbers represented, were not.

09.5 Most students scored at least two marks Some students referred to ‘amount’ of acid added rather than volume, and many failed to take any burette readings at all. It was not uncommon to see a conical flask placed ‘under’ a white tile rather than on one.

09.6 This was not well answered. Most students who scored a mark did so for stating that the acid could be added drop by drop, or that the rate of flow could be controlled. Few stated that the burette could measure variable volumes (unlike a pipette). Many stated that a burette was ‘more accurate’ but did not say what they were comparing it to. Of those who

did, most said it was more accurate than a pipette, which is not true. Some students confused a volumetric pipette with a dropping pipette.

09.7 This titration calculation was well done by many students. To gain full credit, working needed to be correct as well as the final answer. Students therefore need to show their working step by step in a way that can be followed by the examiner. Common errors were to omit to convert volumes to dm^3, to attempt to do so but incorrectly, or to omit the mole ratio of citric acid to sodium hydroxide. As with question 09.4, students who incorrectly used the symbol ‘m’ to mean moles often confused themselves; they should be encouraged to use ‘m’ only for mass, and ‘n’ for number of moles.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

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Question 10 (standard and high demand)

10.1 A minority of students identified water as the solvent.

10.2 The mark for describing the colour change was scored more often than the mark for the shift in the position of equilibrium that caused this colour change. The mark for the application of Le Chatelier's Principle was rarely scored by students.

10.3 Once again, the shift in equilibrium position and the identification of the forward reaction as exothermic were seldom justified in terms of Le Chatelier's Principle. The distribution of marks awarded to students was very similar to that for **10.2**.

10.4 Students answered this question poorly. A minority recognised that the position of equilibrium had not changed, but fewer still linked the non-effect of pressure with the absence of gases. A common error was to state that there there are equal numbers of moles on each side of the equation, as though this **were** a gaseous reaction.

10.5 A minority of students were able to identify cobalt as the only transition metal ion in the list.

Concluding Remarks

Many students gave responses which showed an excellent understanding while others had difficulty even with core chemical concepts.

The majority of students appeared to have sufficient time to complete the paper. A few used up a lot of time and space in practical and extended writing contexts by providing detailed additional information that did not contribute to a fully answered question.

Basic knowledge and understanding of how science works in everyday situations, including in the laboratory, were tested throughout this paper. This means that it was essential that students read and analysed the information provided, then read and understood the question before writing their response.

There is still some evidence that command words are misunderstood or ignored. This limits the marks awarded, especially in extended response questions. In this paper **compare** and **evaluate** were often too loosely interpreted.

Students seemed well prepared for questions based on Rate and Extent of Chemical Change and Organic Chemistry. In this series they seemed less equipped to deal with Chemical Analysis, Chemistry of the Atmosphere and some aspects of Using Resources.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 61 · 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 62 · Examiner comments November 2021 | 8462/2H | Original Q10

Question 10 (standard, standard / high and high demand)

10.2 More than two thirds of students knew one condition (high temperature) and more than one third knew two.

10.3 There was a very wide range of marks but many did not score above Level 1. The main failure to reach Level 2 was that the question focuses on economics so that an answer which fails to mention energy, cost or a compromise in reaction conditions does not meet the level descriptor for Level 2. Similarly, the requirements for Level 3 were not usually met if the references did not mention the impact of reaction conditions on both rate and yield. Only a handful of students gave a Level 3 answer.

Answer 62 · Examiner comments

10.4 Fermentation was well known.

10.5 Around half of students scored one mark by extending their knowledge of fermentation to this unfamiliar context, 'warm' was seen much more often than 'anaerobic'.

10.6 This was completely correct in the responses of nearly half of students. Where a mark was not obtained, this was usually caused by a failure to convert kilometres to metres.

10.7 A challenging concluding equation with no scaffolding which students found difficult.

Concluding Remarks

There is still some evidence that command words are misunderstood or ignored. This limits the marks awarded, especially in extended response questions. This is particularly true where a command word demands a reasoned judgement.

Students seemed well prepared for questions based on Organic Chemistry and Chemistry of the Atmosphere. In this series they seemed less equipped to deal with Chemical Analysis, Rate of Reaction and some aspects of Using Resources.

There were a number of instances of key reagents, techniques and colour changes still not being well known.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Mark Ranges and Award of Grades

Grade boundaries and cumulative percentage grades are available on the Results Statistics page of the AQA Website.

Answer 63 · 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.

Answer 64 · Examiner comments

June 2022 | 8462/1H | Original Q7

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

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

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

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

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

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 64 · Examiner comments June 2022 | 8462/1H | Original Q7

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

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

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

Answer 65 · Examiner comments June 2022 | 8462/2H | Original Q7

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

07.1 This was well answered with around half of the students scoring both marks. Incorrect responses included the atmosphere being a source of the hydrogen as well as the nitrogen. There were far fewer responses stating that biogas of any kind was suitable for the large-scale production of ammonia than in previous years.

07.2 About 25% of the students scored this mark. ‘No by-products’ was seen quite often and others stated there were the same number of atoms on both sides, which just means that the equation is balanced, not necessarily that there is only 1 product.

07.3 Roughly 1 in 10 students gained both marks. Many scored the second mark, but far fewer the first. This was often due to imprecise language rather than misunderstanding, but many stated that ‘ammonia is cooled’. The distinction between **all** the gases being cooled but only ammonia condensing is important. A large proportion did not mention cooling at all. Some negated the second mark by stating that ammonia has a lower boiling point than the other two gases.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 65 · Examiner comments

June 2022 | 8462/2H | Original Q7

07.4 Labelling the scale and the plotting of the given points was nearly always correct. Some did not label on the major gridlines, while a few got the scale completely wrong by labelling the major gridlines in multiples of 60 atmospheres, which did not match the pre-plotted points and therefore denied access to the plotting marks. Most students drew good best-fit curves, although some inappropriately drew a straight line. Over half of the students gained all four marks.

07.5 Most students extrapolated their line correctly and read off the value of the percentage at 500 atmospheres. About two-thirds of the students scored both marks.

07.6 This high demand extended response question gave students the opportunity to demonstrate their knowledge of collision theory, Le Chatelier's Principle and catalytic action in the context of the Haber Process.

More able students seemed to understand that they needed to consider cost implications. Explaining that a compromise is made in the choice of the temperature and the pressure was important in accessing Level 3.

The compromises made for temperature and pressure that were related to cost were more commonly stated than the compromise for temperature in relation to rate and position of equilibrium.

There was a high proportion of responses with additional material producing comprehensive, high-scoring responses. There were also a good number of weaker responses containing isolated statements, most commonly relating the conditions to rate, or more rarely position of equilibrium, but without explaining these relationships. Such responses were usually confined to Level 1. The ratio of Level 1:2:3 marks was roughly 40:20:20 with the remainder failing to gain any marks on this question.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 66 · Examiner comments

June 2023 | 8462/1H | Original Q2

Question 2 (standard demand)

02.1 This was answered very well, though a few students referred to amount rather than mass, or got the two variables the wrong way round. Nearly three quarters of students scored both marks.

02.2 Most students could plot the points accurately, though some found the scales difficult, particularly on the x-axis. The majority drew good straight lines of best fit, with a scatter of points either side of the line. However, some struggled with drawing a line of best fit when there is a scatter of points. Some drew 'point to point' lines, while others had a majority of points above (or below) the line.

Students should always plot their points in pencil, as well as using a pencil for the line of best fit. It is very difficult to amend a point plotted in ink, and in the case of ambiguity the examiners will not give the benefit of the doubt.

02.3 The great majority of students extrapolated the line correctly and read the correct value from the y-axis.

02.4 Nearly four fifths of students answered correctly in terms of the decrease of temperature. It was not necessary to refer to energy transfer as that is not shown in the results; however, those who did so usually referred correctly to energy being taken in. Those who contradicted their answer by giving an incorrect reference to energy being given out did not score the point.

02.5 This was not well answered, with fewer than half of students obtaining a mark. Many students were able to explain that the results ranged from 0.3 °C below the mean to 0.3 °C above the mean. However, few students said that 0.3 °C is the uncertainty in the results. Some students think that the uncertainty is half of the overall range (ie the range about the median) rather than the range about the mean as stated in the specification. In this particular question the median and the mean were numerically equal, but that is not always the case.

02.6 Fewer than a half of students gave the correct answer, random error, although this was the most popular answer. Systematic error was the second most popular response; however this would not have given a scatter of points.

4.5.1.1 Energy transfer during exothermic and endothermic reactions

Answer 67 · Examiner comments

June 2023 | 8462/2H | Original Q9

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

09.1 This question was well done by a large proportion of the students. There was an understanding of how to calculate the mass of water obtained from 4.68 g of hydrated copper(II) sulphate and use this to calculate the mass of water from 11.7 g hydrated copper(II) sulphate. The alternative method on the mark scheme was less popular with the students. Over two-thirds of students scored all three marks.

09.2 This question proved to be more difficult for many of the students. It was noticeable that rather than using the value 2.99 g in the calculation a large proportion of the students used 4.68 grams without understanding that the calculation was about the reverse reaction. Just under half of the students gained both marks.

09.3 Around two-thirds of the students gained this multiple-choice mark. Most who did not score selected 'shifts to the right' instead.

09.4 Around 40% of the students gained this multiple-choice mark. Most who did not score selected 'the mixture is a darker shade of brown' instead.

09.5 Large numbers of the students did not recognise that there were the same number of moles on each side of the equation. Quite a number of students stated that the equilibrium shifts to the side with the least moles and then said that the equilibrium shifts to either the left or the right showing a lack of understanding of the stoichiometry of written chemical equations. Around one-third of the students gained both marks.

09.6 There were a lot of answers relating to the effect of a catalyst on the rate of a chemical reaction without any mention of the effect on equilibrium position. There was a common misconception that increasing the rate of reaction increased the yield of products and therefore stated that the equilibrium shifts to the right. Around one-third of the students gained both marks.

09.7 More than 80% of the students gained this multiple-choice mark. 'Add more water' was occasionally seen but 'leave the reaction mixture for 30 minutes' was rarely seen.

09.8 This question was not well done. Students appear not to understand what is happening at equilibrium and responses did not relate to the rate of reaction. Around one-quarter of students gained this mark.

Question 4 (standard and standard/high demand)

04.1 Just over two fifths of students correctly drew two straight lines, with the ascending line having an even scatter either side of the points, and the horizontal line avoiding the anomaly. Some lines were doubled or feathered so did not gain credit. Some drew two different curves, each encompassing all the points, and made them cross somewhere. This gained no credit. Students should be aware of the sort of graph produced by this required practical.

04.2 This question discriminated well, with a quarter of students scoring 3 or 4 marks and the great majority scoring at least one mark. The question asked students to explain the results, but many simply described them. It was not sufficient just to describe the temperature increasing with the addition of more zinc; reference to the reaction being exothermic was also needed. The fact that the maximum temperature change occurred when 0.80 g of zinc was added was the mark scored most often, but many students were also able to explain this turning point in terms of no further reaction being possible because the zinc was now in excess. There were some excellent answers in terms of the zinc being the limiting reactant up to 0.8 g, after which the copper sulfate became the limiting reactant.

04.3 Some excellent answers were seen; however, fewer than a quarter of students scored both marks and only three fifths scored at all. The question asked why a polystyrene cup gives a more accurate result, so answers needed to be phrased in comparative terms. Polystyrene is a better insulator than glass, but it is not true that polystyrene is 'an insulator' and glass is 'a conductor,' since both materials insulate and conduct thermal energy to different extents. Similarly, many answers implied that no energy is lost from a polystyrene cup, which is not true.

04.4 Nearly two fifths of students were able to give the correct formulae of the products but the state symbols were sometimes incorrect. A common incorrect formula was Zn^{2-}. There was sometimes no clear distinction between upper and lower case letters; the n and u need to be discernibly smaller than the Z and the C. Many students tried to give formulae of compounds rather than just the ion or atom.

04.5 The vast majority of students were able to calculate the mean. Fewer than half were also able to express the mean and the uncertainty correctly. Some students only averaged the highest and lowest values, which calculates the median rather than the mean. Although the mean and the median are the same in this particular set of values, this method did not gain credit. Some students calculated the uncertainty by halving the range. This calculates the range about the median, rather than the definition in the specification which is the range about the mean. This method was given credit on this occasion, although it is not strictly correct.

04.6 Students found this question difficult, with fewer than a quarter scoring the mark. Despite the information that there were no measurement errors, many students gave a type of measurement error as their answer. Reading the method carefully would have pointed out that the starting temperature was neither measured nor controlled, so may have fluctuated, and that stirring is inherently inconsistent. Some students had evidently done the practical using a lid and referred to it being replaced at different times; this was given credit.

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Answer 69 · Examiner comments

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

07.1 Only a quarter of students gained both marks, and a third did not score. Many students described how solids in general conduct thermal energy, rather than answering the question which is specifically about conduction in a metal. Many students realised that the process has something to do with delocalised electrons. However, many described how electricity is conducted, rather than thermal energy. The idea of the delocalised electrons transferring thermal energy through the metal was not at all well known. As the question asked how thermal energy is conducted, repetition of the word 'conduct' did not help to explain the meaning of that word.

07.2 This question discriminated well, with over a half of students scoring 2 or 3 marks. There were many well-expressed, complete answers. Common errors often involved an attempt to describe some sort of stronger bonding (sometimes covalent or ionic) in the alloy. Some lost credit because of poor use of language; it is not 'metals' which are different sizes, but their atoms (or positive ions). A common error was to refer to different shapes of atoms. 'Particles' is also insufficient as it could refer to other types of particle than atoms. 'Intermolecular forces' were often referred to, although they are not present in either a pure metal or an alloy.

07.3 Just over a half of students identified the correct equation, spotting that the mole ratio of Fe:Cl_2 was 2:3. The most popular distractor was Fe + Cl_2 → $FeCl_2$, where the student had ignored the information provided about the reacting number of moles.

07.4 Only two fifths of students identified the correct response by working out the total charge of the various combinations and choosing the one with a net zero charge. $3Fe^{2+}$:$4O^{2-}$ was a very popular distractor, with $3Fe^{3+}$:$4O^{2-}$ not far behind.

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Answer 69 · Examiner comments

07.5 Over three quarters of students obtained full marks on this question. For those who did not, it was sometimes difficult to award any credit because the M_r had not been evaluated. Common errors were $56/M_r$ x 100 or $64/M_r$ x 100. Some students attempted to bring in the 0.12 and 0.18 from question **07.3**, which was about a different compound.

07.6 Those students who understand moles had little difficulty with this question; almost a half scored at least 4 marks. The most common error was a failure to convert the mass of Fe_2O_3 to grams. Some students attempted to calculate a volume of Fe_2O_3, not appreciating that it is a solid as shown by the state symbols in the equation. Some students unnecessarily calculated the mass of carbon dioxide before converting this to a volume. The mole ratio was sometimes applied incorrectly to the mass of Fe_2O_3. Despite being given the M_r of Fe_2O_3 as 160, many students used 320 instead. Whilst this sometimes led mathematically to the 'correct' answer, it is incorrect chemistry and full credit was therefore not awarded.

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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.

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

07.1 Around 40% of students scored two marks for this question. However, many students were not able to name the correct reagent for the test. White precipitate was often given as the result of the test, but this answer was not creditworthy unless the correct reagent had been named. Sodium hydroxide and silver nitrate were the most common incorrect reagents. A significant number of students left the answer space blank.

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4.5.1.1 Energy transfer during exothermic and endothermic reactions

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07.2 This multiple-choice question was well answered with two-thirds of students gaining the mark.

07.3 Around 30% of students scored both the marks on this question. Clear descriptions about the numbers of moles / molecules on each side of the equation and the resulting shift in the position of equilibrium at higher pressure were seen. A number of students failed to score the first marking point because they did not give a comparison of the number of moles or molecules of gas on each side of the equation. Answers that focused on changes in the rate of reaction or particle collisions were not creditworthy, nor were those which stated that the equilibrium shifted to the side with lower pressure.

07.4 This question was not well answered and only around 2% of students were awarded both marks. The most common creditworthy responses were based on the idea that a higher pressure is not used because the yield is already high or because more energy would be required to achieve a higher pressure. Many answers could not be given credit because they were not comparative. Higher risk of explosion or higher cost of safety precautions were creditworthy responses that focused on the consequences of using higher pressure compared to using a lower pressure.

07.5 This multiple-choice question was answered correctly by around a quarter of students who used their periodic table to locate and identify vanadium as a transition metal.

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

09.1 The idea that gas is lost was well understood but the reason why was less well known. Incorrect responses referred to the solubility of hydrogen in water and faulty apparatus. Around 15% of students gained both marks.

09.2 This question was awarded all four marks to around 20% of the students but a significant number of students did not recognise that the volume of the gas should be converted into dm^3. A small number of students believed that 1 cm^3 = 1000 dm^3 resulting in an answer 10^6 times too large.

09.3 Most students were able to construct a tangent at 45 s. The scale on the *y*-axis posed a problem for a significant number of the students. The calculation of the rate was well done, and most were able to convert their answer into standard form. A small number calculated the mean rate between 0 s and 45 s by drawing a single pair of construction lines which met the curve. Such students were only able to gain a mark for an answer correctly expressed in standard form. Just over half of the students scored five marks.

09.4 The vast majority of the students recognised that the curve started at 0,0 and rose less steeply than the curve shown, but only a minority were able to show that the curve levelled off at 0.0084 mol. Some students lost the first mark by shadowing the existing line for a significant time before becoming less steep. While around 20% of students scored both marks, more than four-fifths scored one.

09.5 This question was quite well done by a large proportion of the students, with nearly half of the students gaining all three marks. The idea that an increase in temperature increased the energy of the particles and therefore increased the rate of reaction was well understood by most students but the increase in collision frequency was less well known. A significant proportion of the students simply stated that there is an increase in the number of collisions with no reference

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to time. A ‘successful’ collision was considered insufficient to describe particles whose energy of collision exceeded the activation energy.

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4.5.1.1 Energy transfer during exothermic and endothermic reactions

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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

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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.

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Question 5

05.1 Over four fifths of students correctly estimated the boiling point. Those that did not gain the mark were often giving values that were just outside of the range given in the mark scheme.

05.2 Fewer than half of the students correctly identified ethanol as the product of the reaction between ethene and steam. Many of those who did not gain this mark gave the product as alcohol, which was insufficient.

05.3 Over half of students gained both marks on this item. Where students gained one mark, about 20%, it was because 'damp' was omitted from the test and only litmus paper was given.

05.4 The product of the chlorination of butene was well known by over 90% of students.

05.5 Around three quarters of students correctly identified propene. The most common incorrect response was butene. Very few students did not identify an alkene.

05.6 Around two fifths of students knew that alkenes burn with a smoky flame due to incomplete combustion. Many of the incorrect answers seen referred to there being a double bond present, or that there was insufficient oxygen.

05.7 This multi-step calculation was well answered by over 40% of students who gained all five marks. The most common error was the omission of the volume conversion from dm^3 to cm^3. Some students divided by the volume, rather than multiplying. Equally, a number multiplied by the M_r to calculate the number of moles. In both instances, marks were awarded where clear working was shown for correct

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additional steps. when one mark alone was awarded, it was for the correct determination of the M_r.

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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

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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.

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Question 9

09.1 Three quarters of students scored at least one mark on this item. This was for either identifying the forward reaction as endothermic, or giving the allow statement for marking point 3, that a high temperature increases the rate. The answers for marking point 2 were often quite vague, talking about the reaction moving to the right-hand side, rather than the position of the equilibrium. Many students gave answers in terms of the Haber process, rather than the given reaction, so answers that suggest an increase in the yield of ammonia were incorrect.

09.2 Fewer than half of students scored either or both marks for this high demand item. The most common response was for identifying that the equilibrium position moved to the right, with far fewer giving the link to the number of molecules on either side of the equation. Many incorrect answers were seen in terms of rate of reaction, or because safety is a factor.

09.3 Two thirds of students correctly identified that catalysts have no effect on the position of the equilibrium.

09.4 It is quite rare to ask for an estimate in a calculation question and this was included because the percentage of nitrogen in the air is given as four fifths in the specification. Around 40% of students recognised that nitrogen makes up between

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78 and 80% of the atmosphere, so would require between 62 and 65 dm^3 of air to produce 50 dm^3 of nitrogen. Where students did not score was because they did not know the percentage of nitrogen in the air.

09.5 Around half of students gained at least one mark on this item, usually for the idea that ammonia condenses. Far fewer students knew that this is done by cooling the mixture or that both nitrogen and hydrogen stay as gases and are recycled, many only mentioning recycling, which was given in the diagram.

09.6 Around two-thirds of students gained at least one mark for this high demand interpretation question. The most common answer was for linking carbon dioxide to climate change. Many students did not gain this mark as there was a need to mention that the production of hydrogen causes this, if further detail was given. Mant talked about hydrogen producing carbon dioxide, which is incorrect and did not gain credit. The next most common response was for the idea that nitrogen was abundant in the atmosphere.

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Mark Ranges and Award of Grades

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