AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.6.2.3

Equilibrium

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**15**
Available paper years	**2008–2025**

Using this booklet

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

Name: _____ **Date:** _____

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

4.6.2.3 Equilibrium

Answer 01 · Mark scheme

question	answers	extra information	mark
8(a)	25.4(%)	correct answer with **or** without working accept 25(%) accept 25.433……..(%) allow 26(%) for **1** mark if incorrect answer **1** mark for identification of 44 as M_r of useful product **or** 173 as total M_r of reactants / products	2
8(b)	any **two** sensible ideas from eg: • no / less waste • less materials / reactants needed / used • fewer / no environmental problems **or** less / no pollution • better for sustainable development / resources running out • more useful use of atoms • less purification / separation of products owtte	ignore references to energy / cheaper / profit / cost / efficient	2

Question 8 continued on next page…

COMPONENT NUMBER: CHY2H

COMPONENT NAME: Additional Science / Chemistry

STATUS: Final

DATE: June 2008

Question 8 continued...

question	answers	extra information	mark
8(c)	increase yield more (gaseous) reactant molecule than (gaseous) product molecule owtte	owtte accept more molecules on left hand side **or** converse accept Le Chatelier based answers for second mark ignore rate of reaction	1 1
8(d)	reduce yield **or** less product owtte	allow no yield ignore waste / less efficient	1
Total			**7**

4.6.2.3 Equilibrium

Answer 02 · 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…

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**

4.6.2.3 Equilibrium

Answer 02 · Mark scheme

June 2009 | CHY2H | Original Q3 | Legacy

CHY2H

4.6.2.3 Equilibrium

Answer 03 · Mark scheme

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**

4.6.2.3 Equilibrium

Answer 04 · 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

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**

4.6.2.3 Equilibrium

Answer 05 · Mark scheme

January 2011 | CHY2H | Original Q6 | Legacy

Question 6

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

Question 6 continued on the next page

Question 6 contd

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

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**

4.6.2.3 Equilibrium

Answer 06 · Mark scheme

June 2014 | CH3HP | Original Q5 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
5(a)	$2NH_3$	allow NH_3 with incorrect or missing balancing for **1** mark *allow multiples*	2	2 / 3.5.1b	E
5(b)(i)	200		1	3 / 3.5	G
5(b)(ii)	rate of reaction (too) slow	*allow converse* ignore references to yield / *cost*	1	2 / 3.5.1f/h	E
5(b)(iii)	400		1	2 / 3.5	A
5(b)(iv)	lower yield	*allow converse* accept shifts equilibrium to left allow favours the backward reaction allow favours side with *more* (gaseous) molecules allow lower rate	1	2 / 3.5.1g/h	E
5(c)	(gases) cooled *ammonia* liquefied	*it = ammonia* accept *ammonia* condensed accept ammonia cooled below boiling point for **2** marks	 1 1	1 / 3.5.1b	E
Total			**8**		

4.6.2.3 Equilibrium

Answer 06 · Mark scheme

June 2014 | CH3HP | Original Q5 | Legacy



4.6.2.3 Equilibrium

Answer 07 · Mark scheme

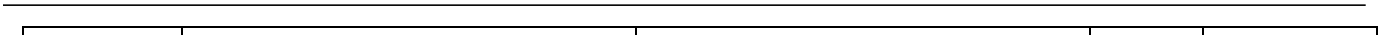
June 2015 | CH3HP | Original Q6 | Legacy

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**	

4.6.2.3 Equilibrium

Answer 07 · Mark scheme

June 2015 | CH3HP | Original Q6 | Legacy



4.6.2.3 Equilibrium

Answer 08 · 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

4.6.2.3 Equilibrium

Answer 08 · Mark scheme

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	allow provides a different mechanism / route	1	AO1 4.6.1.4
	(which has a) lower activation energy	 ignore references to collisions	1	

4.6.2.3 Equilibrium

Answer 08 · Mark scheme

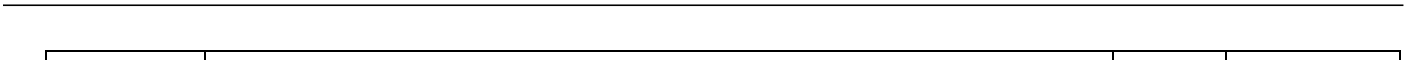
June 2018 | 8462/2H | Original Q9

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	

4.6.2.3 Equilibrium

Answer 08 · Mark scheme

June 2018 | 8462/2H | Original Q9



4.6.2.3 Equilibrium

Answer 09 · Mark scheme

June 2019 | 8462/2H | Original Q10

Question 10

Question	Answers	Extra information	Mark	AO / Spec. Ref.
10.1	$\frac{6}{34} \times 100$ = 17.6 (%)	an answer of 17.6470588 (%) correctly rounded to at least 2 significant figures scores **2** marks allow 17.6470588 (%) correctly rounded to at least 2 significant figures	1 1	AO2 4.3.3.2
10.2	higher yield (of hydrogen or carbon monoxide or product) (because) fewer moles / molecules / particles on left hand side **or** (because) more moles / molecules / particles on right hand side	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 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 1	AO2 4.6.2.4 4.6.2.7
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

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**	

Answer 10 · 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		1	AO2 4.6.2.7
	(because) no gases are present	allow (because) only aqueous solutions are present	1	
10.5	Co^{2+}		1	AO2 4.1.3.2 4.6.2.5
Total			**10**	

4.6.2.3 Equilibrium

Answer 11 · 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

4.6.2.3 Equilibrium

Answer 11 · 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	

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**

Answer 12 · Mark scheme

June 2023 | 8462/2H | Original Q9

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	

4.6.2.3 Equilibrium

Answer 12 · Mark scheme

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

4.6.2.3 Equilibrium

Answer 12 · 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

4.6.2.3 Equilibrium

Answer 13 · Mark scheme

June 2024 | 8462/2H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	combustion reversible		1 1	AO2 4.6.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	water molecules break down and reform at the same rate		1	AO2 4.6.2.3

4.6.2.3 Equilibrium

Answer 13 · Mark scheme

June 2024 | 8462/2H | Original Q3

Question	Answers	Mark	AO / Spec. Ref.
03.3	**Level 3:** Relevant points (reasons / causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO1 4.10.1.2 4.10.1.3
	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 **Potable water production** • pass water through filter beds • to remove solids • use chlorine / ozone / UV light • to sterilise water • to destroy microbes **Waste water treatment** • screening • using a metal grid • to remove solids • to remove grit • sedimentation • to produce sewage sludge and effluent • anaerobic digestion of sewage sludge • aerobic biological treatment of effluent access to **Level 3** requires reference to **both** potable water production **and** waste water treatment.		

Total Question 3	**9**

4.6.2.3 Equilibrium

Answer 14 · 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	

4.6.2.3 Equilibrium

Answer 14 · 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**

4.6.2.3 Equilibrium

Answer 15 · Mark scheme

June 2025 | 8462/2H | Original Q9

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	

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**

Answer 08 · 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.

4.6.2.3 Equilibrium

Answer 10 · Examiner comments

November 2020 | 8462/2H | Original Q10

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.

4.6.2.3 Equilibrium

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.

4.6.2.3 Equilibrium

Mark Ranges and Award of Grades

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

4.6.2.3 Equilibrium

Answer 11 · 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.

4.6.2.3 Equilibrium

Answer 11 · 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.

4.6.2.3 Equilibrium

Answer 12 · 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.

4.6.2.3 Equilibrium

Answer 13 · Examiner comments June 2024 | 8462/2H | Original Q3

Question 3 (standard demand)

03.1 This multiple-choice question proved challenging, with around a quarter of students gaining two marks. However, the vast majority were able to score one mark.

03.2 This multiple-choice question was extremely well answered, with more than 90% of students gaining credit.

03.3 This standard demand item was generally answered quite well. A majority of students had a good overall understanding of the sequence of steps involved in potable water production and wastewater treatment and so scored highly on this item. Weaker responses tended to focus on wastewater treatment, for which the diagram in the stem provided more scaffolding.

Most students recognised that ground water needed to be filtered initially. A few responses referred to screening before the use of filter beds, although only referring to screening in potable water production was considered insufficient. Sometimes the descriptions of things removed by filter beds did not make it clear that they were solid. The process of sterilisation was generally well described, although removal of microbes rather than their destruction was not creditworthy.

Removal of solids using a metal grid was included by most students. Fewer students referred to this step as screening and again things removed by screening were not always clearly identified as solid. Organic matter in sewage is not removed by screening as this is treated subsequently. The final steps were less well addressed overall. Most students referred to sludge and effluent (again these featured in the diagram), but many failed to recognise that these were separated by sedimentation. Some responses confused the separation of sludge and effluent with their biological treatment afterwards. Some students recognised that sludge is treated anaerobically and effluent aerobically but did not refer to digestion or biological treatment or an equivalent description of microbial action.

References to flocculation, desalination, fluoridation or pH adjustment were considered irrelevant and ignored in the marking of this item.

Around a third of students gained a Level 3 mark, with roughly another third achieving Level 2.

Answer 14 · Examiner comments June 2024 | 8462/2H | Original Q7

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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4.6.2.3 Equilibrium

Answer 14 · Examiner comments June 2024 | 8462/2H | Original Q7

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.

4.6.2.3 Equilibrium

Answer 15 · Examiner comments

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

4.6.2.3 Equilibrium

Answer 15 · Examiner comments June 2025 | 8462/2H | Original Q9

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.

4.6.2.3 Equilibrium

Answer 15 · Examiner comments

June 2025 | 8462/2H | Original Q9

Mark Ranges and Award of Grades

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