AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.3.2.1

Moles (HT only)

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**12**
Available paper years	**2018–2025**

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.

5.3.2.1 Moles (HT only)

Answer 01 · Mark scheme June 2018 | 8464/C/1H | Original Q6

<table>
<tr><th>Question</th><th>Answers</th><th>Extra information</th><th>Mark</th><th>AO / Spec. Ref.</th></tr>
<tr><td>06.1</td><td>CaO

CO_2</td><td>either order
ignore names</td><td>1

1</td><td>AO1
5.3.1.3</td></tr>
<tr><td>06.2</td><td>

[12 + (3 × 16)]
or 60

(197 − 60 =) 137

barium or Ba</td><td>an answer of 137 scores the 2 calculation marks

barium or Ba without working scores this mark</td><td>

1

1

1</td><td>AO2
5.3.1.2
5.3.1.3
5.1.1.5</td></tr>
<tr><td>06.3</td><td>

(working) Y increase <u>and</u> X increase measured from graph <u>and</u> substitution into $\frac{\Delta Y}{\Delta X}$

(answer) 167

(units) cm^3/g</td><td>an answer of 160–174 scores the 2 calculation marks

<table><tr><td>y-axis</td><td>80–85</td><td>162–170</td><td>248–252</td><td>330–335</td></tr><tr><td>x-axis</td><td>0.5</td><td>1.0</td><td>1.5</td><td>2.0</td></tr><tr><td>=</td><td>160–170</td><td>162–170</td><td>165–168</td><td>165–168</td></tr></table>
allow answer in range 160–174

allow $cm^3\ g^{-1}$

if no other mark awarded allow 1 mark for the inverse ($\frac{\Delta X}{\Delta Y}$)
or 0.006</td><td>

1

1

1</td><td>AO2
5.3.1.2
5.3.1.3</td></tr>
</table>

5.3.2.1 Moles (HT only)

Answer 01 · Mark scheme

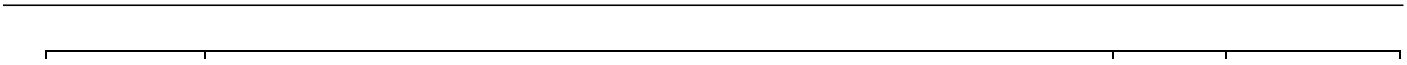
June 2018 | 8464/C/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4		an answer of 140–150 scores **4** marks an answer of 0.14–0.15 scores **3** marks		AO3 5.3.1.2 5.3.1.3
	(from graph) volume to 240 cm^3 mass = 1.45 g	allow answer based on any reading from the graph (eg 250 cm^3 = 1.5 g)	1	
	ratio is $\frac{1}{100}$ (ie $\frac{24\,000}{240}$)	allow ratio from their volume eg $\frac{24\,000}{250}$	1	
	100×1.45	$\left(\frac{24\,000}{250}\right) \times 1.5$	1	
	145	allow range 140–150	1	
	or allow method using answer from question **06.3**			
	$x = \frac{y}{m}$ (1)	(rearrangement of y = mx where m = answer from question **06.3**)		
	24 (dm^3) to 24 000 (cm^3) (1)			
	$\frac{24\,000}{\text{answer from question 06.3}}$ (1)			
	144 (1)	allow range 140–150		
Total			**12**	

5.3.2.1 Moles (HT only)

Answer 01 · Mark scheme

June 2018 | 8464/C/1H | Original Q6



5.3.2.1 Moles (HT only)

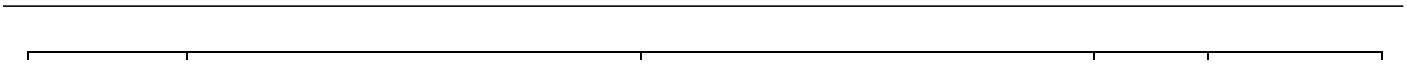
Answer 02 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	a mixture designed as a useful product		1	AO1 5.8.1.2
04.2		an answer of 1.8×10^2 (mol) gains **4** marks		AO2 5.8.1.2 5.3.2.1
	mass = 14 520 g		1	
	(=) $\frac{14\ 520}{80\ (\text{mol})}$	allow correct substitution of incorrectly converted mass must use M_r given (80) to gain marks in steps 2 and 3	1	
	(=) 181.5 (mol)		1	
	(=) 1.8×10^2 (mol)	allow answer correctly given in standard form to correct sig figs from an incorrect calculation	1	
04.3		**max 2** marks for incorrect reference to bonding **or** structure **or** particles		AO1 5.2.2.3
	(giant) lattice	allow giant structure	1	
	ionic		1	
	strong bonds **or** strong electrostatic forces	do **not** accept strong intermolecular forces / bonds	1	
	large amounts of energy needed to overcome	ignore heat	1	
Total			**9**	

5.3.2.1 Moles (HT only)

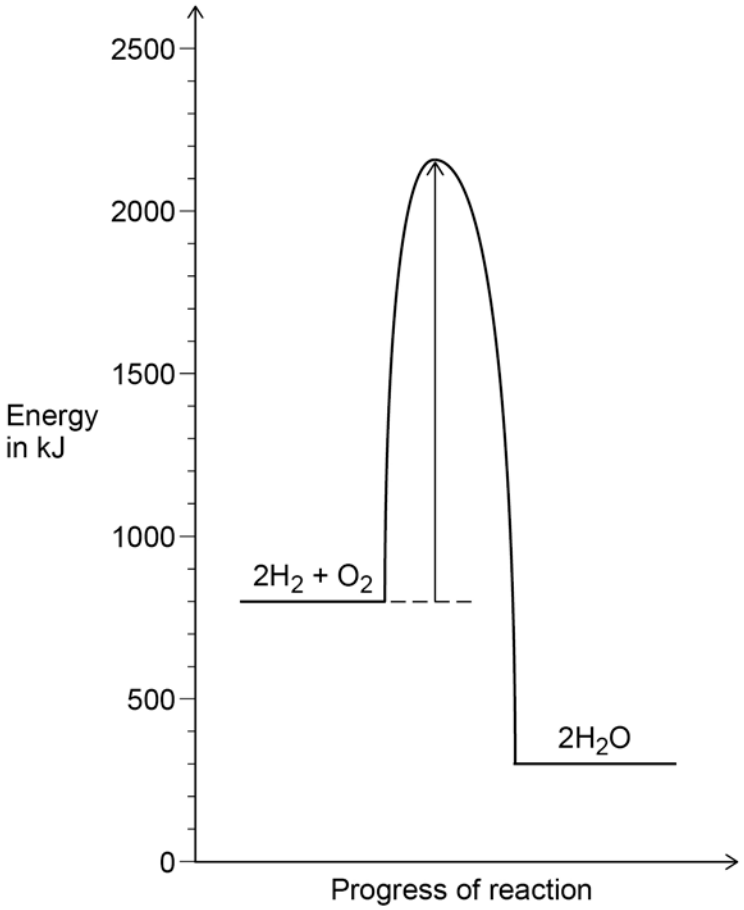
Answer 02 · Mark scheme

June 2018 | 8464/C/2H | Original Q4



5.3.2.1 Moles (HT only)

Answer 03 · Mark scheme June 2019 | 8464/C/1H | Original Q3

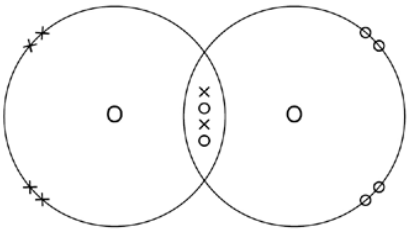
03.1	line from reactants to top of curve (i.e. from 800 to 2160)  ignore arrowheads	1	AO1 5.5.1.2

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

5.3.2.1 Moles (HT only)

Answer 03 · Mark scheme

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

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

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

Total			**8**

5.3.2.1 Moles (HT only)

Answer 03 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.3.2.1 Moles (HT only)

Answer 04 · Mark scheme June 2019 | 8464/C/1H | Original Q4

04.1	atomic weight	do **not** accept atomic mass or A_r	1	AO1 5.1.2.2
04.2	left gaps / spaces **or** changed the order based on atomic weights	 allow placed them in correct groups according to properties do **not** accept reference to atomic number	1	AO1 5.1.2.2
04.3	weak forces between the molecules **or** weak intermolecular forces (so) little energy required to overcome / break the forces between molecules **or** (so) little energy required to overcome / break the intermolecular forces	allow weak intermolecular bonds do **not** accept incorrect references to covalent bonds allow (so) little energy required to separate the molecules allow (so) little energy required to overcome / break the intermolecular bonds ignore less energy	1 1	AO1 AO3 5.1.2.6 5.2.2.4

04.4	(the) molecules get larger going down the group (so the) forces between the molecules increase **or** (so the) intermolecular forces increase (so the) boiling points increase going down the group **or** (so the) boiling points increase with increasing relative atomic mass	allow converse explanation in terms of boiling point allow (so) more energy is needed to separate the molecules	1 1 1	AO1 AO3 5.1.2.6 5.2.2.4

04.5	2,8 (so) stable arrangement of electrons **or** (so) full outer shell	allow diagram or description	1 1	AO1 5.1.2.4

04.6	$\frac{1}{40} \times 6.02 \times 10^{23}$ **or** $0.025 \times 6.02 \times 10^{23}$ 1.51×10^{22}	an answer of 1.51×10^{22} scores **2** marks allow 1.505×10^{22}	 1 1	AO2 5.3.2.1

Total			**11**

5.3.2.1 Moles (HT only)

Answer 04 · Mark scheme

June 2019 | 8464/C/1H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.3.2.1 Moles (HT only)

Answer 05 · Mark scheme June 2019 | 8464/C/2H | Original Q4

04.1	growing plants (on low-grade ore) plants are burnt (to produce ash) (ash dissolved in acid to produce) solution of a copper compound electrolysis (of solution of a copper compound) **or** displacement (by adding scrap iron to a solution of a copper compound)	allow named plant allow named copper compound allow addition of scrap iron (to a solution of a copper compound)	1 1 1 1	AO1 5.10.1.4

04.2	 M_r $CuSO_4$ = 159.5 $\frac{0.319}{159.5}$ = 0.002 (mol)	an answer of 0.002 **or** 2×10^{-3} (mol) scores **3** marks allow correct use of incorrectly calculated value for M_r allow 2×10^{-3} (mol)	 1 1 1	AO2 5.3.2.1 5.3.2.5

04.3	both reaction profiles start at the same energy level and end at the same energy level.		1	AO3 5.6.1.4

5.3.2.1 Moles (HT only)

Answer 05 · Mark scheme

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

5.3.2.1 Moles (HT only)

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

Total			**12**

5.3.2.1 Moles (HT only)

Answer 05 · Mark scheme

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

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.3.2.1 Moles (HT only)

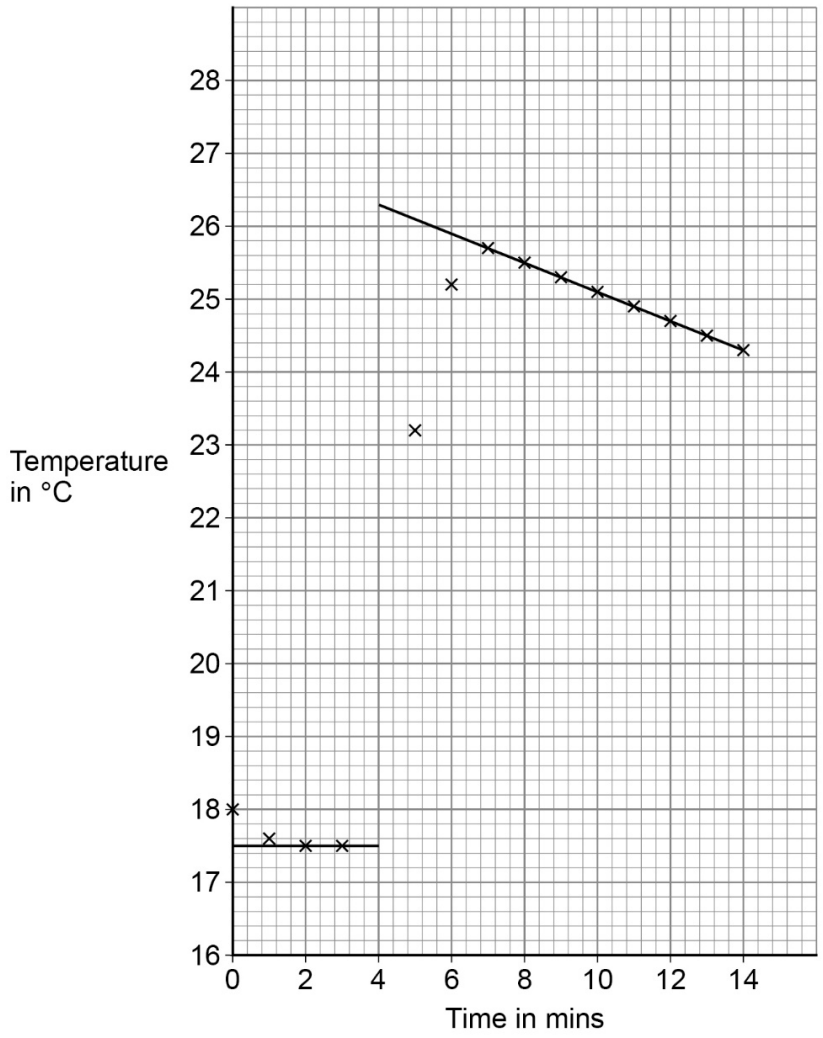
Answer 06 · Mark scheme November 2020 | 8464/C/1H | Original Q5

05.1	temperature (change)		1	AO2 5.4.1.2 5.5.1.1 RPA 10

05.2	to reach a constant temperature	allow to reach room temperature	1	AO3 5.4.1.2 5.5.1.1 RPA 10

5.3.2.1 Moles (HT only)

Answer 06 · Mark scheme

05.3	line of best fit after 7 minutes extends line back to 4 minutes	 ignore extension of line beyond 4 minutes	1 1	AO2 5.4.1.2 5.5.1.1 RPA 10
	the diagram below scores **2** marks  			

05.4	(maximum **and** minimum values at 4 minutes) 26.3 (°C) **and** 17.5 (°C) (temperature change at 4 minutes) = 8.8 (°C)	allow ecf from **05.3**	1 1	AO3 5.4.1.2 5.5.1.1 RPA 10
05.5	the reaction finished / stopped (so) energy is lost to surroundings / atmosphere **or** (so the) solution cools (back to room temperature)	allow maximum temperature has been reached allow heat for energy	1 1	AO3 5.4.1.2 5.5.1.1 RPA 10
05.6	aluminium / zinc / iron / beryllium metal **Q** is less reactive (than magnesium) **or** metal **Q** is lower in reactivity series	allow Al / Zn / Fe / Be do **not** accept copper, silver MP2 dependent on a correct answer to MP1 allow converse	1 1	AO3 AO2 5.4.1.2 5.5.1.1 RPA 10

5.3.2.1 Moles (HT only)

Answer 06 · Mark scheme

November 2020 | 8464/C/1H | Original Q5

05.7	(unit conversion) 30.0 cm^3 = 0.030 dm^3 **or** 0.500 dm^3 = 500 cm^3		1	AO2 5.3.2.1 5.4.1.2 5.5.1.1
	(moles = $\frac{30}{500}$ × 0.1 =) 0.006 **or** (moles = $\frac{0.030}{0.50}$ × 0.1 =) 0.006	allow correct use of incorrect / no unit conversion	1	
	mass = 0.006 × 159.5	allow correct use of incorrect value for number of moles	1	
	= 0.957 (g)	allow 0.96 (g)	1	

Total			**14**

5.3.2.1 Moles (HT only)

Answer 06 · Mark scheme

November 2020 | 8464/C/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.

5.3.2.1 Moles (HT only)

Answer 07 · Mark scheme

November 2021 | 8464/C/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	(mass of oxygen = 0.20 – 0.12) = 0.08 (g)		1	AO2 5.1.1.1 5.3.1.1 5.3.1.3 5.3.2.1 5.4.1.1
	(moles of oxygen) = $\frac{0.08}{32}$	allow **1** mark for 0.005 if derived from $\frac{0.08}{16}$	1	
	= 0.0025		1	
06.2	(without a lid the) mass of magnesium oxide was less		1	AO3 5.4.1.1
	(because) products escaped	allow magnesium oxide escaped	1	
06.3	(mass of copper oxide =) $\frac{79.5}{63.5} \times 0.5$		1	AO2 5.1.1.1 5.3.1.1 5.3.1.3 5.3.2.1 5.3.2.2 5.3.2.3 5.4.1.1
	= 0.62598 (g)		1	
	= 0.626 (g)	allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses all the values in the question	1	

5.3.2.1 Moles (HT only)

Answer 07 · Mark scheme

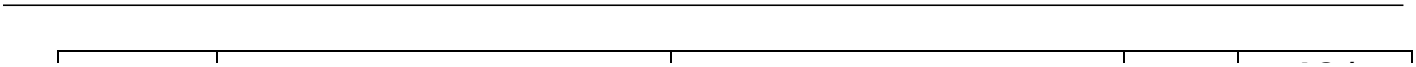
November 2021 | 8464/C/1H | Original Q6

06.4	3:2 ratio Fe : O_2 (molecules) **or** 3:4 ratio Fe : O (atoms)		1	AO2 5.1.1.1 5.3.1.1 5.3.1.3 5.3.2.1
	(formula) Fe_3O_4	allow **1** mark for Fe_3O_2 from 3:2 ratio Fe : O (atoms) (MP2 but not MP1)	1	5.3.2.2 5.3.2.3 5.4.1.1
	$3\,Fe + 2\,O_2 \rightarrow Fe_3O_4$	allow multiples allow correct use of incorrectly determined formula allow **1** mark for Fe, O_2 and Fe_3O_4 **or** allow **1** mark for Fe, O_2 and incorrectly determined formula	2	
Total			**12**	

5.3.2.1 Moles (HT only)

Answer 07 · Mark scheme

November 2021 | 8464/C/1H | Original Q6



5.3.2.1 Moles (HT only)

Answer 08 · Mark scheme

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	completely ionised in aqueous solution	allow completely ionised (when dissolved) in water allow fully dissociated in aqueous solution	1	AO1 5.4.2.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	low concentration of (nitric) acid dissolved in water	allow low concentration of solute / solid / gas dissolved in water	1	AO1 5.4.2.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	decreases by a factor of 100		1	AO2 5.4.2.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	$H^+ + OH^- \rightarrow H_2O$	ignore state symbols	1	AO1 5.4.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	1 : 2		1	AO2 5.3.2.3

5.3.2.1 Moles (HT only)

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	red		1	AO3 5.3.2.4 5.4.2.2 RPA10

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.7	(for each mass of magnesium carbonate) repeat the experiment (discard anomalous results) **and** calculate the mean		1	AO3 5.5.1.1 RPA10
	measure the highest temperature		1	

Total Question 4	**8**

5.3.2.1 Moles (HT only)

Answer 09 · Mark scheme

June 2024 | 8464/C/1H | Original Q8

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	hexagonal (rings of carbon atoms)		1	AO1 5.2.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.2	any **one** from: • nanotechnology • materials	ignore references to electronic use allow suitable use such as: • sporting equipment • body armour allow drug delivery	1	AO1 5.2.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.3	(number of moles =) $\frac{2380}{6.02 \times 10^{23}}$ $= 3.95 \times 10^{-21}$ (mols)	 allow 3.953488×10^{-21} (mols) correctly rounded to at least 2 significant figures	1 1	AO2 5.2.3.3 5.3.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.4	each (carbon) atom forms three covalent bonds (so) one electron from each (carbon) atom is delocalised (so these) delocalised electrons carry (electrical) charge through the structure / nanotube	 ignore throughout for through ignore current / electricity	1 1 1	AO3 5.2.3.3

Total Question 8	7

5.3.2.1 Moles (HT only)

Answer 10 · Mark scheme

June 2024 | 8464/C/2H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	= 198 kJ/mol		1	AO2 5.6.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	equilibrium position shifts to the right		1	AO2 5.6.2.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	equilibrium position shifts to the left		1	AO2 5.6.2.7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	equilibrium position shifts to the left		1	AO2 5.6.2.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	(effect) (equilibrium position) does not change (reason) increases the rate of the forward reaction and reverse reaction equally		1 1	AO3 5.6.1.4 5.6.2.3

5.3.2.1 Moles (HT only)

Answer 10 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.6	210 (s)	allow a value in the range 205 to 210 (s)	1	AO3 5.6.2.3
	lines become level / horizontal		1	
	(because) the rates of the forward reaction and reverse reaction are equal **or** (because) the number of moles (of all three gases) remain constant		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.7	tangent drawn at 60 s		1	AO2 5.6.1.1
	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	

Total Question 5	13

5.3.2.1 Moles (HT only)

Answer 11 · Mark scheme

June 2025 | 8464/C/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	a Bunsen burner reaches a higher temperature	allow a water bath will not reach a high enough temperature	1	AO3 5.3.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	(magnesium) (contents of crucible) increase in mass (from 0.24 to 0.38 g)	allow a value in the range 0.38 to 0.39 for 0.38	1	AO2
	(because magnesium) gains oxygen		1	AO3
	(magnesium carbonate) (contents of crucible) decrease in mass (from 0.84 to 0.44 g)	allow a value in the range 0.44 to 0.45 for 0.44	1	AO2
	(because) carbon dioxide is released	allow (because) carbon dioxide gas is produced	1	AO3 5.3.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	both reactions produce 0.01 mol of magnesium oxide		1	AO3 5.3.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	(if solid escaped) the final mass would be lower for the actual results than for the predicted results	allow (solid cannot have escaped because) same mass of solid product formed allow (solid cannot have escaped because) both form 0.4 g of solid allow (solid cannot have escaped because) the final mass of the contents (of the crucible) are the same	1	AO3 5.3.1.3

5.3.2.1 Moles (HT only)

Answer 11 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	(ratio Fe : H_2O) 3:4		1	AO2 5.1.1.1 5.3.1.1
	(formula) Fe_3O_4	allow formula correctly determined from incorrect ratio	1	5.3.2.1 5.3.2.2 5.3.2.3
	3 Fe + 4 H_2O → Fe_3O_4 + 4 H_2	allow multiples allow correct use of an incorrectly determined formula for iron oxide allow **1** mark for Fe, H_2O, Fe_3O_4 and H_2 **or** allow **1** mark for Fe, H_2O, H_2 and an incorrectly determined formula for iron oxide	2	5.4.1.2

Total Question 6	11

Answer 12 · Mark scheme

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	(mass in one phone =) $1.73 \times 10^{-4} \times 197$		1	AO2 5.3.2.1 5.10.1.1
	= 0.034081 (g)		1	
	(total mass =) $0.034081 \times 2.48 \times 10^{6}$	allow (total mass =) $0.034081 \times 2\,480\,000$ allow correct use of an incorrectly determined mass in one phone	1	
	= 84520.88 (g)		1	
	(conversion 84520.88 g =) 84.5 (kg)	allow 84.52088 (kg) correctly rounded to at least 2 significant figures allow conversion at MP2, MP3 allow correct conversion of an incorrectly determined mass using all numbers from the question	1	
	alternative approach			
	(total moles =) $1.73 \times 10^{-4} \times 2.48 \times 10^{6}$ (1)	allow (total moles =) $1.73 \times 10^{-4} \times 2\,480\,000$		
	= 429.04 (1)			
	(total mass =) 429.04 × 197 (1)	allow correct use of an incorrectly determined total moles		
	= 84520.88 (g) (1)			
	(conversion 84520.88 g =) 84.5 (kg) (1)	allow 84.52088 (kg) correctly rounded to at least 2 significant figures allow correct conversion of an incorrectly determined mass using all numbers from the question		

5.3.2.1 Moles (HT only)

Answer 12 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	1.04×10^{20}		1	AO2 5.3.2.1 5.10.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	uses bacteria		1	AO1 5.10.1.4 5.10.2.2
	to produce leachate / solutions containing gold compounds		1	
	from which gold is obtained by displacement / electrolysis		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	any **two** from: • high-grade ores still available • land not available • phytomining takes a long time • very small yields produced • new technology		2	AO3 5.10.1.4

Total Question 6	11

Answer 01 · Examiner comments

June 2018 | 8464/C/1H | Original Q6

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

06.1 The question was not answered well, with large numbers of students missing the key word 'formula' in the question stem. As a result, lots of responses included the names of a wide range of chemicals. Quite a few knew the formula for carbon dioxide.

06.2 Those students who were aware that carbonate had a formula of CO_3 usually came up with the correct answer. Many opted for more well-known Group 2 carbonates such as calcium and magnesium, usually with little justification.

06.3 A good number of students could successfully calculate the gradient. Most students knew the method but could not get the correct figures from the graph. Students seemed to make their life very difficult when selecting values from the graph to calculate the gradient.

The easiest methods would have been to:

- use the increase in mass from 0 g to 1 g, with the equivalent volume increase of 167 cm^3, to give a simple calculation of 167 ÷ 1
- increase in mass from 0 g to 0.5 g, or 0 g to 2 g would have also given relatively easy calculations.

There were very few inverted equations but very few correct units, these were invariably inverted as g/cm^3

When determining a gradient students should be encouraged to draw the sides of their triangle as large as possible, as this reduces the error in reading the *x* and *y* values from the graph.

06.4 This question was answered well by only the highest-attaining students with 4% achieving full marks. Their working followed those methods in the mark scheme or routes based upon these, which also achieved full credit. These students could either see the link from the graph, where 240 cm^3 had a mass of 1.45 g, and the subsequent conversion from 240 cm^3 to 24 dm^3 or they divided the volume (in cm^3) by their gradient.

Some students used a volume on the *y*-axis of 24 cm^3, which gave a mass of approximately 0.15 g on the *x*-axis, which scaled up to (a correct answer of) 150. However, because their scale was so small, some got the mass as 0.16 g. As this is within half a small square and scaled up to 160, these students were also awarded full credit.

Students should be aware that when larger values are taken from the *x* and *y*-axes, errors in subsequent calculations are minimised.

Answer 02 · Examiner comments

Question 4 (standard, standard / high & high demand)

04.1 22% of students knew the definition from the specification or were able to give an equivalent statement. Often students mentioned only that it was 'a mixture or chemicals mixed together' but omitted the idea of 'to form a useful product'. Some students were able to give examples, but not a definition.

As the question stem mentioned fertilisers, a few students answered the question with phrases such as a substance / something to help plants grow or to enhance plant growth.

04.2 5% of students achieved full marks but many students (63%) gained some credit for their calculation. The most common answers that achieved two marks were 0.18 or 0.1815, (not converting 14.52 kg to g and an omission or incorrect conversion of their calculation into standard form to two significant figures).

An answer of 1.8×10^{-1} achieved three marks, the calculation being correct, but the students had not undertaken the initial conversion of kg into g. Several students had multiplied an answer within their calculation by Avogadro's number.

04.3 51% of students achieved some credit on this question. However, there were many references to intermolecular forces (often strong intermolecular forces), covalent bonds and molecules, all of which limited the response to a maximum of two marks.

Many students described in detail how potassium, being in Group 1 of the periodic table would transfer one electron to chlorine which is in Group 7 to obtain full outer shells meaning that the compound would have a high melting point. 'Ionic bonds' was often seen but normally as part of a lengthy explanation of how and why potassium transfers one electron to chlorine.

1% of students achieved full marks, with 7% of students achieving three marks; the description of a 'lattice' or 'giant structure' was seldom seen.

5.3.2.1 Moles (HT only)

Answer 03 · Examiner comments — June 2019 | 8464/C/1H | Original Q3

Question 3

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

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

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

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

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

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

Answer 03 · Examiner comments — June 2019 | 8464/C/1H | Original Q3

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

5.3.2.1 Moles (HT only)

Answer 04 · Examiner comments

June 2019 | 8464/C/1H | Original Q4

Question 4

Most of this question was at standard/high demand.

04.1 Scientists' use of atomic weight to arrange elements in early periodic tables was not well known. Far too many students did not fully appreciate the historical nature of the question and provided concepts that were not known at the time, such as atomic number and electrons.

04.2 Over half the entry gave a correct reason. Large numbers of students appreciated that Mendeleev left gaps or grouped elements with similar properties. Changing the order based upon atomic weights was correct but less common.

04.3 Only the higher-attaining students were able to explain that halogens have low boiling points because of weak intermolecular forces. It is these forces that are overcome when a 'little energy' is applied; less energy did not gain this mark, as less does not necessarily equate to little. Many students answered this question incorrectly in terms of the covalent bonds within the halogens. A lot of students linked the listed values to reactivity within group 7.

5.3.2.1 Moles (HT only)

Answer 04 · Examiner comments June 2019 | 8464/C/1H | Original Q4

04.4 The concept of intermolecular forces and the fact that the intermolecular forces increase because the molecules got larger was rarely seen in explanations. Many students gained a mark for stating that the boiling points increased down the group; down the table or periodic table did not gain this mark. Students commonly tried to explain a trend in reactivity down the group and attempted to link that to boiling points. Some struggled with negative temperatures.

04.5 Most students were able to state that neon's outer shell was full. Many did not gain the second mark by not giving the electronic structure of neon.

04.6 A third of students calculated the correct answer for 2 marks. Many were confused by standard form, with only a few students making slight calculation errors.
Most wrong answers came from either dividing the Avogadro number by 0.025 (the number of moles) or from multiplying by 40; they did not appreciate that 1g of argon is less than 1 mole of argon so the answer to this question must be less than 6×10^{23}

Answer 05 · Examiner comments June 2019 | 8464/C/2H | Original Q4

Question 4 (standard/high demand)

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

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

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

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

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

5.3.2.1 Moles (HT only)

Answer 07 · Examiner comments

November 2021 | 8464/C/1H | Original Q6

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

06.1 Just over one-tenth of students gained full marks in this calculation. Having correctly calculated the mass of oxygen the most common error was to incorrectly calculate the number of moles by dividing by the relative atomic mass of oxygen (16) rather than the relative formula mass of oxygen molecules (32).

06.2 Few students realised that without a lid the mass of products would decrease as magnesium oxide would escape during the reaction.

06.3 This calculation was answered correctly by approximately one fifth of students. A small number were not able to round their answer correctly to three significant figures.

06.4 Students found this question challenging. Very few students were able to make the link between the moles of reagents that reacted and the formula of the product. Just under one sixth of students were able to correctly write a balanced chemical equation using their iron oxide product from the earlier part of the question.

Answer 08 · Examiner comments

Question 4 (standard & standard/high demand)

04.1 Many students stated that strong acids completely ionise but omitted to include that this happens in water or in aqueous solution. 10% of students gave the correct definition.

04.2 Less than 5% of students gave a correct explanation for 'dilute aqueous solution'. Very few students made reference to being dissolved in water or used the term (low) concentration.

Common incorrect responses made reference to reducing the concentration of the acid or stating that there would be a small volume of acid per unit volume or small volume of acid in aqueous solution. A number of students stated that a high concentration of substance/acid had been dissolved.

04.3 This question proved challenging. To deduce the change in the hydrogen ion concentration students need to know that as the pH decreases by one unit, the hydrogen ion concentration of the solution increases by a factor of 10. A third of students gained the mark with approximately equal numbers choosing the alternative responses.

04.4 Nearly one-fifth of students were able to recall an ionic equation to represent the neutralisation between an acid and an alkali. This question had the highest not attempted rate at 12.5%, which was nearly double that of any other question. A common response was 'acid + alkali → salt' suggesting that students were not familiar with the ions present in acid or alkaline solutions or that this involved neutralisation to produce water.

04.5 Most students were able to deduce the correct ratio of moles from the equation. The most common distractor was 2:1 where the correct ratio was reversed.

04.6 Just over half of students recognised that universal indicator would turn red in the acidic solution produced when magnesium carbonate and excess nitric acid were reacted. Green was the most common distractor which was not correct as excess acid was used in the reaction.

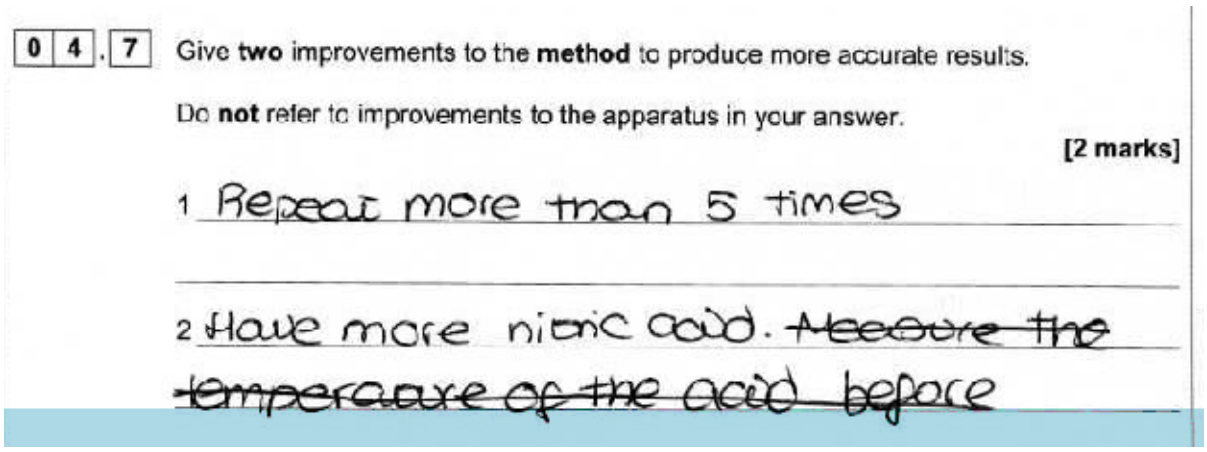
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5.3.2.1 Moles (HT only)

Answer 08 · Examiner comments June 2024 | 8464/C/1H | Original Q4

04.7 This question required improvements to the method, so references to changing the volume or concentration of solution were insufficient. Many students wrote that the experiment should be repeated but to be creditworthy they needed to include that the mean should be calculated. 'Measuring until the temperature stopped increasing' was taken as equivalent to 'measure the highest temperature'. However, 'measuring until the temperature is constant' is insufficient as this may not be the highest temperature or the mixture may have cooled to room temperature.

Just under a quarter of students gained 1 mark and 1% gained 2 marks.


0 4 . 7 Give **two** improvements to the **method** to produce more accurate results.

Do **not** refer to improvements to the apparatus in your answer.

[2 marks]

1 Repeat more than 5 times

2 Have more nitric acid. ~~Measure the temperature of the acid before~~

This student did not gain any credit: repeating the experiment on its own is insufficient as the mean is not calculated (after anomalous results are discarded).

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Answer 09 · Examiner comments

June 2024 | 8464/C/1H | Original Q8

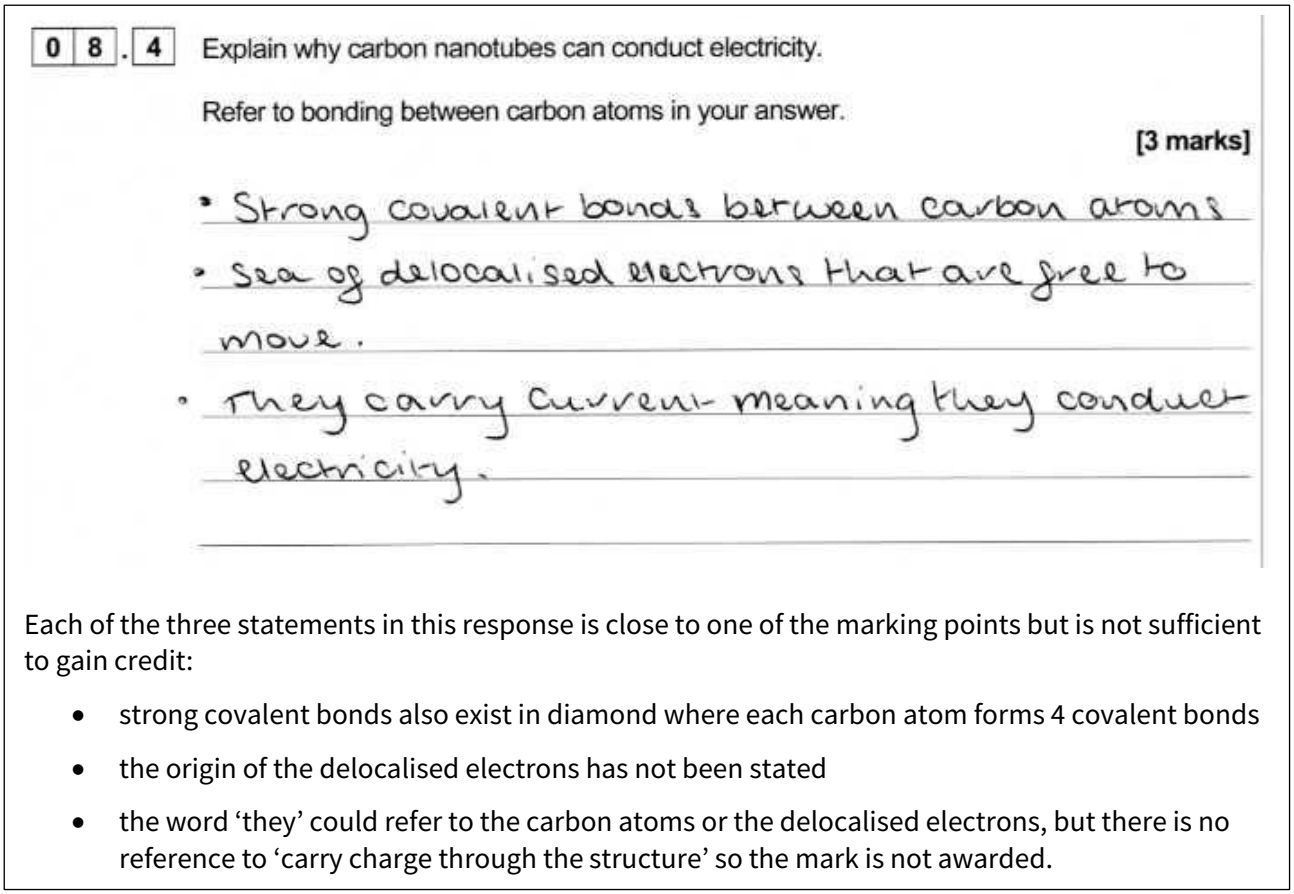
Question 8 (standard & high demand)

08.1 A third of students scored one mark. A diagram was included to help students describe the structure of fullerenes as based on hexagonal rings of carbon atoms.

08.2 A third of students gave an appropriate use of nanotubes.

08.3 In this question students were asked to calculate the number of moles of carbon in a nanotube that contains 2380 carbon atoms. Students needed to divide the number of carbon atoms by the Avogadro constant. Just under 20% of students gained 1 mark with about half of these being able to continue and evaluate the expression correctly.

08.4 Students found it challenging to explain why carbon nanotubes can conduct electricity. Responses were frequently too vague to access a marking point. Those who looked at the diagram of the nanotube would have seen that each atom forms three covalent bonds. Students might have linked the hexagonal structure as also being present in the more familiar structures of graphene and graphite where one electron from each atom is delocalised and that these delocalised electrons carry electrical charge through the structure.



0 8 . 4 Explain why carbon nanotubes can conduct electricity.

Refer to bonding between carbon atoms in your answer.

[3 marks]

- Strong covalent bonds between carbon atoms
- Sea of delocalised electrons that are free to move.
- They carry current- meaning they conduct electricity.

Each of the three statements in this response is close to one of the marking points but is not sufficient to gain credit:

- strong covalent bonds also exist in diamond where each carbon atom forms 4 covalent bonds
- the origin of the delocalised electrons has not been stated
- the word ‘they’ could refer to the carbon atoms or the delocalised electrons, but there is no reference to ‘carry charge through the structure’ so the mark is not awarded.

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5.3.2.1 Moles (HT only)

Contact us

Our friendly team will be happy to support you between 8am and 5pm, Monday to Friday.

Tel: 01483 477756
Email: gcsescience@aqa.org.uk

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Answer 10 · Examiner comments

Question 5 (standard/high & high demand)

05.1 Three-quarters of students correctly responded that the energy change in the backwards reaction was equal to the energy change in the forward reaction.

05.2 Half of students identified the correct equilibrium shift.

05.3 The multiple-choice questions at the beginning of question 5 become progressively harder, testing the students' understanding of Le Châtelier's principle. Fewer than half of all students correctly answered this question on the effect of pressure on the equilibrium.

05.4 Making the link from the stem that energy is released to the reaction being exothermic, and consequently the effect that a temperature change would have made on the position of this equilibrium, made this the most difficult of these multiple-choice questions. Fewer than 40% of students selected the correct answer.

05.5 Fewer than a third of students correctly gave the effect of a catalyst on equilibrium position for 1 mark. This was a high demand question and the small number of students who gained the second mark reflected this.

Many students had the same misconception that a catalyst only speeds up the forwards reaction. There were two common answers following this misconception: either that this meant the equilibrium would shift right as the forwards reaction had been sped up or that the equilibrium would therefore shift to the left to oppose this.

05.6 Most students were able to gain 1 mark, for the correct time. Common incorrect responses were 200 and 82.5 (seconds). If students put 82.5 then they had the misconception that the equilibrium was reached when the lines crossed and so were prevented from getting any further marks. Students often referred to equilibrium being where the moles were equal at 82.5 seconds.

The mark scheme identified where equilibrium was reached, how the graph showed this and what the graph meant in terms of moles of the three gases.

For the second marking point, a clear description of the line flattening out, not just straightening, was required as 'straightening' could be vertical.

The third marking point is for the number of *moles* not changing. Some students stated that the reaction had stopped, meaning that they could not be awarded the third marking point. Equally, if a student stated that the number of moles was equal, the mark could not be given.

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5.3.2.1 Moles (HT only)

Answer 10 · Examiner comments June 2024 | 8464/C/2H | Original Q5

0 5 . 6 Determine the time taken for the reaction to reach equilibrium.

Explain your answer.

Use **Figure 5**.

[3 marks]

Time 210 s

Explanation All the lines go straight to show that the ~~mole~~ number of moles is not changing, ~~and the reaction is ready~~ meaning the reaction has reached equilibrium.

0 5 . 6 Determine the time taken for the reaction to reach equilibrium.

Explain your answer.

Use **Figure 5**.

[3 marks]

Time 210 s

Explanation This is where the line flattens out on the graph. The reaction has taken place and reached equilibrium because the number of moles of each gas is not changing, so therefore the reaction is no longer occuring.

In the first response the student gains the mark for the time, but the 'lines go straight' is insufficient for marking point 2. Marking point 3 is given for the number of moles not changing.

The second response gains marking point 1 for a correct time. Marking point 2 is also given for the '… line flattens out …'. The student would have been given the third marking point for '… the number of moles of each gas is not changing …'; however, this mark cannot be awarded as the student goes on to state that the '… reaction is no longer occurring'.

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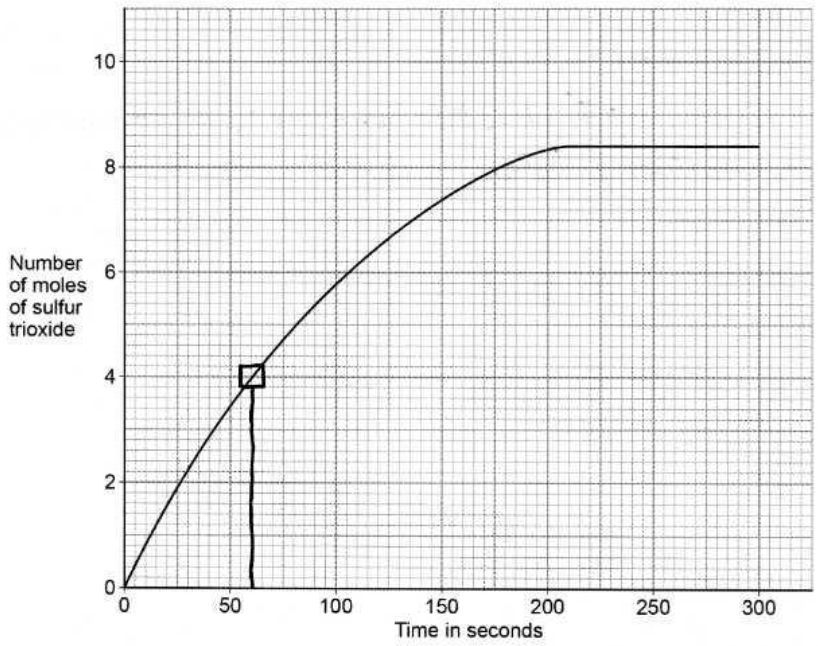
5.3.2.1 Moles (HT only)

Answer 10 · Examiner comments June 2024 | 8464/C/2H | Original Q5

05.7 It is evident that students are becoming more familiar with drawing gradients to calculate rates, with a third of students gaining full marks on this high-demand calculation. It should be noted that students who do not draw a tangent cannot gain any marks since the fundamental chemical idea is not known and understood.

0 5 . 7 **Figure 6** shows the results for sulfur trioxide.

Figure 6



Determine the rate of reaction at 60 seconds.

[4 marks]

2÷50 = 0.04 mol/s

Rate = 0.04 mol/s

The student needs to first draw a tangent at 60 s in order to be able to calculate the rate. Here, no tangent has been drawn, so no marks are awarded.

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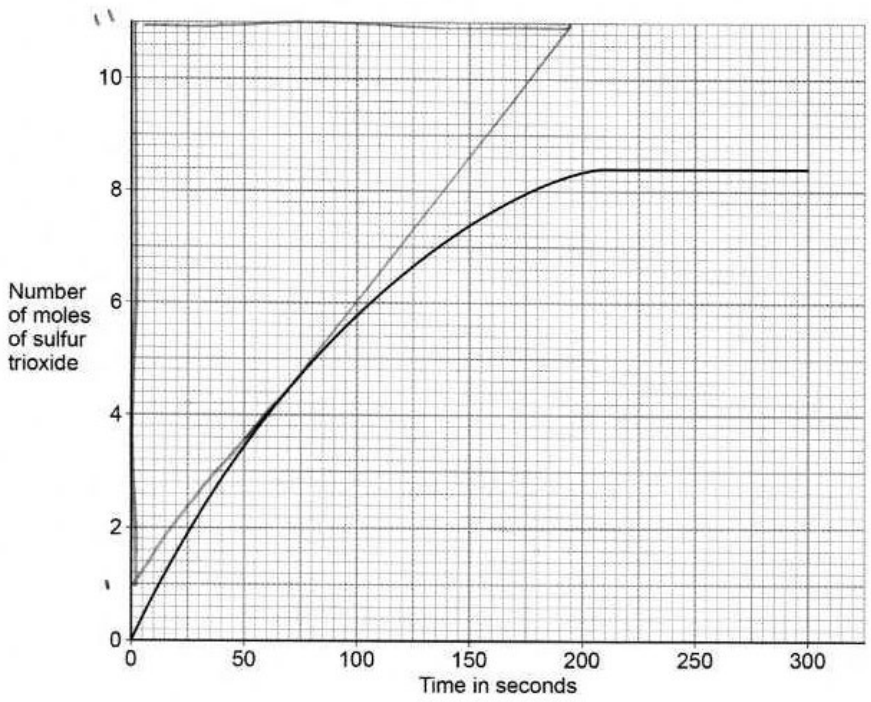
5.3.2.1 Moles (HT only)

Answer 10 · Examiner comments June 2024 | 8464/C/2H | Original Q5

The most common errors were misreading the *x*-step and/or the *y*-step. Progress could still be made in the calculation if it was clear that the values had come from a tangent and had been used correctly. Substitution into the equation upside down meant that neither marking point 3 nor marking point 4 could be given.

0 5 . 7 **Figure 6** shows the results for sulfur trioxide.

Figure 6



Determine the rate of reaction at 60 seconds.

[4 marks]

11 − 1 = 10 $\frac{10}{195}$ = 0.051282

195 − 0 = 195

Rate = 0.051282 mol/s

This student has made a good attempt at drawing the tangent at 60 s, so marking point 1 can be awarded. They have drawn a triangle on the graph and substituted correct values for the *y*-step and the *x*-step into the expression (10 ÷ 195), which they have then correctly evaluated. The recurring dots can be ignored as there was no significant figures mark for this question. All 4 marks are awarded.

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Answer 11 · Examiner comments

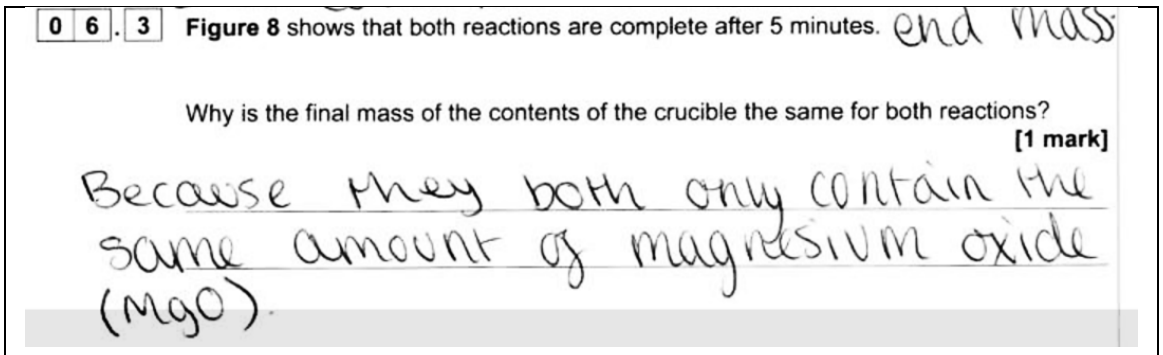
June 2025 | 8464/C/1H | Original Q6

Question 6 (Standard, Standard/High and High demand)

06.1 The reason why the student used a Bunsen burner instead of a water bath is that the Bunsen burner reaches a higher temperature. Common responses which were not creditworthy made no reference to a temperature comparison or stated that a Bunsen burner gives more heat.

06.2 The question asked students to explain the trends in the graph for the first 3 minutes. The trends of magnesium increasing in mass or magnesium carbonate decreasing in mass were described well. Many students who attempted to support their trends with data misread the graph scale so did not gain MP1 and/or MP2; 0.82 g and 0.22 g were common incorrect starting masses, similar errors were made at 3 minutes and others referred to the common mass of 0.4 g at 4 minutes. Reasons for these changes namely magnesium gaining oxygen and carbon dioxide being released from magnesium carbonate were frequently omitted.

06.3 Making the link with the equations and graphs made this a demanding question. When students wrote about moles they usually referred to the moles of the reactants being the same rather than the moles of the product.



0 6 . 3 **Figure 8** shows that both reactions are complete after 5 minutes. end mass

Why is the final mass of the contents of the crucible the same for both reactions?

[1 mark]

Because they both only contain the same amount of magnesium oxide (MgO).

This response did not score but was a near miss. The student is referring to the product from both reactions but the same amount (of MgO) is not equivalent to the same moles.

06.4 This high-demand AO3 question proved challenging. Students could have either described what happened if the conclusion was correct which would result in a final mass lower than predicted or use the graph to conclude that both lines have the same final mass (0.4 g) so solid cannot have escaped. Responses often failed to include mass.

06.5 Many students were able to calculate the ratio of iron to water but only those who gave the simplest ratio were credited with MP1. Most were unable to make the link between the moles of reagents that reacted and the formula of the product so MP2 was rarely awarded. When writing symbols lowercase letters must be discernibly smaller than upper case letters. Many students gave a balanced equation using their formula for iron oxide; FeO and FeO_2 were common incorrect responses which were then used correctly to access MP3 and MP4. Those students who gave the formula of hydrogen as H were unable to access the final 2 marks.

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5.3.2.1 Moles (HT only)

Answer 11 · Examiner comments June 2025 | 8464/C/1H | Original Q6

0 6 . 5 Iron reacts with steam (H_2O) to produce an oxide of iron and hydrogen gas.

0.120 moles of iron reacts with 0.160 moles of steam.

Determine the balanced equation for the reaction.

You should determine:

- the simplest whole number mole ratio of Fe : H_2O
- the formula of the iron oxide produced.

[4 marks]

0.12 mol : 0.16 mol

12 : 16 mol

Simplest mole ratio of Fe : H_2O = 12 : 16

Formula of the iron oxide = FeO_2

Balanced equation for the reaction:

$Fe + 2H_2O \rightarrow FeO_2 + 2H_2$

This response was awarded 2 marks. The student has not evaluated the simplest ratio and the formula is incorrect. However, they gave a balanced equation using their formula for iron oxide (FeO_2) so gain MP3 and MP4.

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5.3.2.1 Moles (HT only)

Answer 12 · Examiner comments

June 2025 | 8464/C/2H | Original Q6

Question 6 (Standard/High and High demand)

06.1 Students found the format the numbers were presented in difficult, and often incorrectly used figures such as 1.73 and 2.48, rather than 1.73×10^{-4} and 2 480 000
Many students were unable to carry out the full calculation, but most gained some credit for successfully multiplying by 2.48 million.
Of the students who successfully carried out the calculation many did not complete the correct conversion from grams to kilograms correctly, often using a factor of 100, rather than 1000.

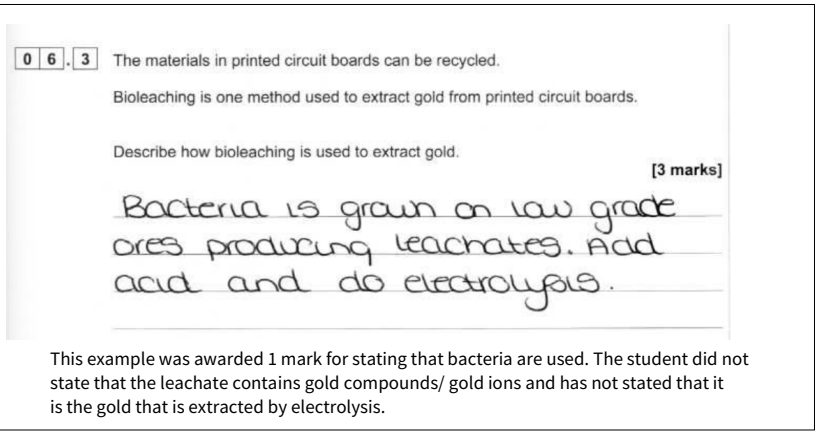
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5.3.2.1 Moles (HT only)

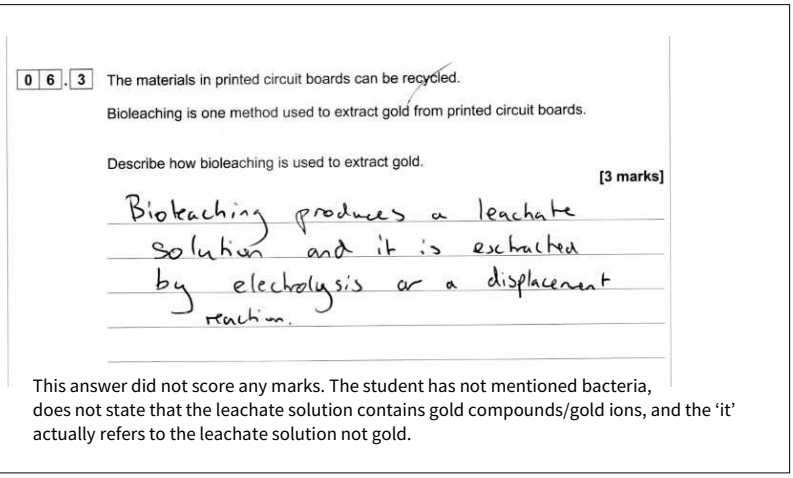
Answer 12 · Examiner comments June 2025 | 8464/C/2H | Original Q6

06.2 By selecting 1.04 x 10^{20}, the majority of students answered correctly.

06.3 The process of bioleaching was not well known.
Of the students that gained credit in this question many did so as they were able to identify that bacteria were involved.
Although some students were able to make a link to the idea of a leachate or solution, very few were able to explain that the leachate or solution contained gold compounds or gold ions.
When methods of extraction were included in a response they were often correctly identified.



This example was awarded 1 mark for stating that bacteria are used. The student did not state that the leachate contains gold compounds/ gold ions and has not stated that it is the gold that is extracted by electrolysis.



This answer did not score any marks. The student has not mentioned bacteria, does not state that the leachate solution contains gold compounds/gold ions, and the 'it' actually refers to the leachate solution not gold.

06.4 Many students understood that phytomining is a time-consuming process and when marks were credited this was by far the most common correct response.

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5.3.2.1 Moles (HT only)

Answer 12 · Examiner comments June 2025 | 8464/C/2H | Original Q6

Some students were aware that only small yields were produced and that a lot of land is needed but these ideas were not always clearly expressed using the correct terminology. Amount is not equivalent to yield, and lots of space is not equivalent to lots of land, for example.
Many students gave the answer of being expensive or damaging to the environment which are not specific to the process of phytomining.

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5.3.2.1 Moles (HT only)

Answer 12 · Examiner comments

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Our friendly team will be happy to support you between 8am and 5pm, Monday to Friday.

Tel: 01483 477756
Email: gcsescience@aqa.org.uk

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