AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.4.3.1

The process of electrolysis

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**42**
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.

4.4.3.1 The process of electrolysis

Answer 01 · Mark scheme

January 2008 | CHY1H | Original Q4 | Legacy

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

Answer 02 · Mark scheme

January 2008 | CHY2H | Original Q4 | Legacy

The full source mark scheme begins on page 79. Follow original question 4 in that document.

Answer 03 · Mark scheme

March 2008 | CHY1AP | Original Q5 | Legacy

Five	**1**	**3**	**1**	**1**

Answer 04 · Mark scheme

June 2008 | CHY1AP | Original Q8 | Legacy

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

4.4.3.1 The process of electrolysis

Answer 05 · Mark scheme

June 2008 | CHY2H | Original Q2 | Legacy

question	answers	extra information	mark
2(a)	(propanone) has a low(er) boiling point **or** (propanone) evaporates fast(er) owtte	**or** water has a high(er) boiling point **or** water evaporates slow(er) allow propane / solution / it allow evaporates at lower temperature **or** boils quicker ignore density / reactivity / melting point	1
2(b)(i)	0.29	ignore + **or** – ignore units	1
2(b)(ii)	any **two** sensible suggestions eg: • weighing error • (copper) lost during washing owtte • (copper) lost during electrolysis / reaction owtte • electrodes not completely dry • impurities in the electrode • copper falling off when removing electrode / copper from cell	 accept human error **or** inaccurate measurements allow different washing of electrodes ignore timing errors ignore 'fair test' ignore sludge ignore gases produced	2

Question 2 continued on next page…

4.4.3.1 The process of electrolysis

COMPONENT NUMBER: CHY2H

COMPONENT NAME: Additional Science / Chemistry

STATUS: Final

DATE: June 2008

Question 2 continued…

question	answers	extra information	mark
2(c)	any **four** from: • impure copper is anode / positive (electrode) • pure copper is cathode / negative (electrode) • copper sulfate solution **or** any soluble copper salt in solution		4
	• copper loses electrons **or** copper is oxidised • copper forms positive ions / particles	as alternative to these two points $Cu \rightarrow Cu^{2+} + 2e^{-}$ = **2** marks
	• copper gains electrons **or** copper reduced at <u>negative electrode</u> • copper attracts to / collects at <u>negative electrode</u>	**or** $Cu^{2+} + 2e^{-} \rightarrow Cu$ at <u>negative electrode</u>
	• sludge / impurities collect at the bottom owtte	allow sludge left behind **or** sludge left in solution **or** impurities separated from copper
	• impurities not attracted to electrode	ignore get rid of impurities
Total			**8**

4.4.3.1 The process of electrolysis

Answer 05 · Mark scheme June 2008 | CHY2H | Original Q2 | Legacy

COMPONENT NUMBER: CHY2H

COMPONENT NAME: Additional Science / Chemistry

STATUS: Final

DATE: June 2008

Answer 06 · Mark scheme June 2009 | CHY1AP | Original Q9 | Legacy

Nine	**3**	**3**	**2**	**3**

4.4.3.1 The process of electrolysis

Answer 07 · Mark scheme

June 2009 | CHY1H | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)(i)	many ethene / molecules / monomers join to form a long hydrocarbon / chain / large molecule	accept double bonds open / break accept addition polymerisation ignore references to ethane correct equation gains **2** marks	1 1
6(a)(ii)	(can be deformed but) return to their original shape (when heated or cooled)	ignore 'it remembers its shape'	1
6(a)(iii)	cross links / extra bonds in PEX molecules / chains in PEX are held in position molecules / chains in PEX unable to slide past each other / move	it = PEX throughout accept inter-molecular bonds ignore inter-molecular forces accept rigid structure	1 1 1

Question 6 continues on the next page…

4.4.3.1 The process of electrolysis

CHY1H

Question 6 Continued

question	answers	extra information	mark
6(b)	any **four** from: • less (hydrocarbon) fuels used • less / no electrical energy used • reduce carbon / carbon dioxide emissions • reduce / no pollution by sulfur dioxide / acid rain • continuous process • conserve copper which is running out or only low-grade ores available • reduce the amount of solid waste rock that needs to be disposed • reduce the need to dig large holes (to extract copper ores)	ignore costs / sustainability / non-renewable allow less energy allow no electrolysis allow less global warming allow less / no transportation allow less waste allow less mining	4
Total			**10**

4.4.3.1 The process of electrolysis

Answer 08 · Mark scheme

June 2009 | CHY2H | Original Q5 | Legacy

Question 5

question	answers	extra information	mark
5(a)(i)	any **one** from: • they are positive / cations • they are H^+ • opposite charges attract	ignore atom	1
5(a)(ii)	potassium is more reactive (or reverse)	assume 'it' refers to hydrogen allow potassium reacts <u>with</u> water allow potassium is very reactive **or** most reactive metal / element allow hydrogen gains electrons more easily / is reduced more easily accept potassium is higher up the reactivity series	1
5(b)	6 **and** 2	accept correct multiples and fractions	1
5(c)(i)	the reaction / it is reversible **or** a description of a reversible reaction	allow 'it is an equilibrium' allow reversible symbol drawn correctly allow 'the reverse / back reaction'	1

Question 5 continues on the next page…

CHY2H

Question 5 Continued

question	answers	extra information	mark
5(c)(ii)	**lithium nitride** assume that 'it' or if they do not specify means lithium nitride assume lithium / lithium nitrate refers to lithium nitride • hydrogen is bonded / held / absorbed / has formed a compound / reacted with lithium nitride plus **one** of: • does not explode / cause a fire • is not free / less hydrogen • is not under pressure • does not leak • is only released slowly • compound of hydrogen with lithium nitride / product is (more) stable / less reactive / less chance of a reaction	accept converse for hydrogen as below assume that gas / hydrogen means gas in the cylinder • hydrogen (in cylinder) / gas is not bonded / held / absorbed / in a compound / reacted with lithium nitride plus **one** of: • can explode / cause a fire • is free • is under pressure • can leak • releases quickly	1 1
5(d)(i)	smaller **or** correct indication of size **or** higher surface area	allow very / really small **or** tiny accept few (100) atoms in size allow 1 to 100 nanometres or 10^{-9} metres allow absorption and / or release of hydrogen more quickly allow have different properties allow 'more particles in each volume / area' do not allow reacts more quickly	1

Question 5 continues on the next page…

4.4.3.1 The process of electrolysis

CHY2H

Question 5 Continued

question	answers	extra information	mark
5(d)(ii)	greater surface area		1
5(e)(i)	loss of an electron **or** loses electrons	do not accept any ref. to oxygen	1
5(e)(ii)	full outer shell of 8 electrons on circle	need not be paired can be ×, dot or e do **not** accept if extra electrons added to inner shell	1
Total			**10**

4.4.3.1 The process of electrolysis

Answer 08 · Mark scheme June 2009 | CHY2H | Original Q5 | Legacy

CHY2H

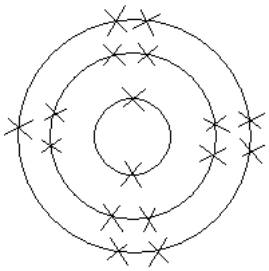
Answer 09 · Mark scheme November 2009 | CHY1AP | Original Q4 | Legacy

Four	**4**	**3**	**2**	**1**

4.4.3.1 The process of electrolysis

Answer 10 · Mark scheme January 2010 | CHY2H | Original Q1 | Legacy

Question 1

question	answers	extra information	mark
1(a)		accept dots / crosses / e must be drawn on diagram electrons do not need to be paired ignore brackets or + or −charges ignore 2,8,7	1
1(b)	(one) electron lost / given away / transferred from sodium / transferred to chlorine owtte	recognition that electrons are involved must be linked to electrons accept loses electron(s) for **2** marks NB loses 2 or more electrons gains **1** mark reference to sharing / covalent max **1** mark ignore charges on ions formed	1 1
1(c)(i)	any **one** from: • ions / atoms / they are / it is negatively charged / anions • opposite (charges) attract	 accept they are negative accept they are attracted or it is oppositely charged ignore opposite forces attract	1
1(c)(ii)	hydrogen	accept H_2 ignore H or H^+	1

Question 1 continues on next page

CHY2H

Question 1 continued

question	answers	extra information	mark
1(d)(i)	poisons released into environment (owtte)	accept any sensible idea of harm / harmful / poisons / poisonous / pollution / damaging do **not** accept answers such as global warming / ozone layer etc. ignore safety unless qualified	1
1(d)(ii)	any **one** sensible idea eg • loss of work / unemployment **or** company goes out of business • any adverse effect on local economy (owtte) • any adverse effect on paper production / cost of paper / cost of water (treatment) • chlorine (compounds) have been used (for many years) without causing harm owtte • only a tiny amount of chlorine is released so it would not cause harm	eg shops / house prices etc. allow less expensive to use chlorine or converse ignore uses of chlorine to treat drinking water unless qualified	1
1(d)(iii)	ideas related to bias	accept more reliable or valid or fair ignore more accurate / fair test	1
Total			**8**

4.4.3.1 The process of electrolysis

Answer 10 · Mark scheme

January 2010 | CHY2H | Original Q1 | Legacy

CHY2H

4.4.3.1 The process of electrolysis

Answer 11 · Mark scheme

June 2010 | CHY2H | Original Q2 | Legacy

Question 2

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

Question 2 continues on the next page

CHY 2H

Question 2 continued

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

4.4.3.1 The process of electrolysis

Answer 11 · Mark scheme June 2010 | CHY2H | Original Q2 | Legacy

CHY 2H

Answer 12 · Mark scheme November 2010 | CHY1AP | Original Q1 | Legacy

Question	Key		
One	**A**	uses another metal	**3**
	B	does **not** use a chemical reaction	**2**
	C	could be done in a blast furnace	**4**
	D	is called electrolysis	**1**

4.4.3.1 The process of electrolysis

Answer 13 · Mark scheme

January 2011 | CHY1H | Original Q1 | Legacy

Question 1

question	answers	extra information	mark
1(a)(i)	very little / low percentage of metal (in the ore)	accept only 0.5% metal in the ore **or** over 99% waste in the ore **or** nearly 100% waste in the ore ignore reference to percentage of metal in the Earth's crust **or** energy used or pollution	1
1(a)(ii)	any **one** from • iron uses less energy / fuel for extraction • iron has more uses • more demand for iron • iron is stronger • cheaper / costs less • easier to extract	(it = iron) ignore electrolysis / uses electricity / reactivity ignore high abundance in the Earth's crust / high percentage of metal in ore ignore harder	1
1(b)(i)	has melting point lower than 950°C	(it = aluminium) allow has a low melting point ignore boiling point	1
1(b)(ii)	electrode(s) made of carbon oxygen reacts with electrode(s) / carbon	 accept C + O_2 (→ CO_2) NB oxygen reacts with the carbon electrode(s) = **2** marks	1 1

Question 1 continues on the next page

4.4.3.1 The process of electrolysis

CHY1H

Question 1 contd

question	answers	extra information	mark
1(b)(iii)	any **two** from: • saves resources / non renewable • landfill problem • saves energy / fuel / electricity • less carbon dioxide / carbon emissions or reduces carbon footprint • less quarrying / mining	accept aluminium / ore will run out or conserves aluminium accept aluminium does not corrode ignore global warming ignore consequences of quarrying / mining ignore pollution / harms environment / costs / easy to recycle	2
Total			**7**

4.4.3.1 The process of electrolysis

Answer 13 · Mark scheme

January 2011 | CHY1H | Original Q1 | Legacy

CHY1H

4.4.3.1 The process of electrolysis

Answer 14 · Mark scheme

Question 1

question	answers	extra information	mark
1(a)	the ions can <u>move</u> / <u>travel</u> / <u>flow</u> / are <u>free</u> **or** the ions <u>carry</u> the charge / current	accept particles / they for ions allow delocalised ions ignore delocalised / free electrons ignore references to collisions accept converse with reference to solid ignore ions carry electricity	1
1(b)	any **one** from: • because they are negative / anion • opposite charges / attract	allow Cl^- ignore chlorine	1
1(c)	13		1
1(d)(i)	reasonable attempt at straight line which misses the anomalous point	must touch all five crosses do **not** allow multiple lines	1
1(d)(ii)	40	ignore 2.2	1

Question 1 continues on the next page

CHY2H

Question 1 contd

question	answers	extra information	mark
1(d)(iii)	any **two** sensible errors from: • gas escapes • weighing error • error in measuring (volume / amount) of hydrogen • error in measuring (volume / amount) of water • incorrect concentration • timing error • change in voltage / current • change in temperature • recording / plotting error	ignore systematic / human / apparatus / zero /experimental / random / measurement / reading errors unless qualified allow NaCl not measured correctly allow error in measuring volume / scale for **1** mark if neither hydrogen or water mentioned allow NaCl not fully dissolved **or** spilled **or** impure allow faulty power supply	2
1(d)(iv)	any **one** from: • repeat the experiment • results compared with results from /other students / other groups / other laboratories / internet / literature. • results compared with another method	ignore 'do more tests'	1
1(d)(v)	increases owtte	allow directly proportional or positive correlation allow rate / it is faster / quicker	1
Total			**9**

4.4.3.1 The process of electrolysis

Answer 14 · Mark scheme January 2011 | CHY2H | Original Q1 | Legacy

CHY2H

Answer 15 · Mark scheme June 2011 | CHY1AP | Original Q5 | Legacy

Five	**2**	**2**	**1**	**3**

Answer 16 · Mark scheme June 2011 | CHY1AP | Original Q9 | Legacy

Nine	**1**	**2**	**2**	**3**

The AQA UMS Conversion Calculator can be found at the following web address:

http://www.aqa.org.uk/umsconversion

4.4.3.1 The process of electrolysis

Answer 17 · Mark scheme

June 2011 | CHY1H | Original Q2 | Legacy

Question 2

question	answers	extra information	mark
2(a)(i)	heat / high temperature / hot / vaporise	if (fractional) distillation / hydrogenation mentioned as the method = max 1 allow thermal decomposition ignore evaporation do **not** accept 'burns' do **not** accept temperature < 100	1
	catalyst **or** silica / alumina / porous pot **or** steam	ignore other named catalyst allow heat (the vapour) to a very high temperature / >800°C for **2** marks	1
2(a)(ii)	C_2H_3Cl	ignore attempts to balance equation	1
2(a)(iii)	single bonds between C – H, C – Cl **and** C – C	do **not** accept symbols outside the bracket	1
2(b)(i)	so that the amount of plasticiser / (sample of) PVC is the independent / only variable that affects the bending / flexibility of the samples	allow because different sizes would give different results accept because size is a control variable ignore references to reliability / precision etc	1
2(b)(ii)	to improve the reliability (of the investigation)	accept to calculate a mean accept to check for anomalous results **or** to check the range of results ignore accuracy / precision etc	1

Question 2 continues on the next page . . .

4.4.3.1 The process of electrolysis

Answer 17 · Mark scheme

June 2011 | CHY1H | Original Q2 | Legacy

CHY1H

Question 2 continued . . .

question	answers	extra information	mark
2(b)(iii)	23	correct answer with or without working = **2** marks if answer is incorrect allow $\frac{22+23+24}{3}$ **or** 21 for **1** mark	2
2(b)(iv)	(PVC) sample had been stretched / used / tested in first three tests	accept higher temperature allow worn **or** become weaker ignore (human) error ignore more flexible / softer ignore intermolecular forces	1
2(c)	does not bend (easily / much) **or** it is not flexible **or** it is rigid	ignore non-biodegradable / low maintenance ignore sturdy / stronger / harder	1
Total			**10**

4.4.3.1 The process of electrolysis

Answer 17 · Mark scheme

June 2011 | CHY1H | Original Q2 | Legacy

CHY1H

4.4.3.1 The process of electrolysis

Answer 18 · Mark scheme

June 2011 | CHY2H | Original Q5 | Legacy

Question 5

question	answers	extra information	mark
5(a)(i)	electron(s)	allow free / delocalised / negative electrons do **not** accept additional particles	1
5(a)(ii)	ion(s)	allow named ions from table ignore positive or negative do **not** accept additional particles	1
5(b)(i)	copper	accept Cu do **not** accept Cu^{2+}	1
5(b)(ii)	it is / they are positive (ions) and it is the least reactive	accept formula of positive ion	1 1
5(c)(i)	loss of electron(s)	ignore numbers	1
5(c)(ii)	$\mathbf{2H^+} + \mathbf{2e^-} \rightarrow H_2$	accept correct multiples / fractions accept e / e^- allow $\mathbf{2H^+} \rightarrow H_2 - \mathbf{2e^-}$	1
Total			**7**

4.4.3.1 The process of electrolysis

Answer 18 · Mark scheme June 2011 | CHY2H | Original Q5 | Legacy

CHY2H

Answer 19 · Mark scheme November 2011 | CHY1AP | Original Q4 | Legacy

Four	**3**	**2**	**1**	**2**

Answer 20 · Mark scheme November 2011 | CHY1AP | Original Q7 | Legacy

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

4.4.3.1 The process of electrolysis

Answer 21 · Mark scheme

January 2012 | CH1HP | Original Q4 | Legacy

Question 4

question	answers	extra information	mark
4(a)(i)	reduction	accept redox / smelting	1
4(a)(ii)	3 4 3		1
4(b)(i)	55	ignore other units	1
4(b)(ii)	water	accept sodium hydroxide accept correct formulae H_2O or NaOH	1
4(b)(iii)	any **one** from: • save energy / fuel for transporting the ore • (old) quarries nearby for waste/red mud	accept less (cost of) transport allow transported quickly	1

Question 4 continues on the next page …….

4.4.3.1 The process of electrolysis

CH1HP

Question 4 cont'd…

question	answers	extra information	mark
4(c)	**Environmental** any **one** from: • less mining / quarrying (of bauxite) • less landfill space needed / used • less use of fossil fuels / energy • less carbon dioxide produced **Ethical or social** any **one** from: • saves resources • creates (local) employment • more people aware of the need for recycling	 allow loss of habitat / less qualified noise pollution allow less red mud / waste allow using resources more than once if answers reversed and both correct award **1** mark allow less qualified noise pollution if not given in environmental	1 1
Total			**7**

4.4.3.1 The process of electrolysis

Answer 21 · Mark scheme

January 2012 | CH1HP | Original Q4 | Legacy

CH1HP

4.4.3.1 The process of electrolysis

Answer 22 · Mark scheme

June 2012 | CH1HP | Original Q2 | Legacy

Question 2

question	answers	extra information	mark
2(a)	any **one** from: • there are many stages needed (to extract titanium) • more energy / materials are needed (to extract titanium) • titanium cannot be extracted by using carbon	ignore references to cost / mining / availability allow longer / slower / more complicated process / batch process ignore higher temperature ignore reference to electrolysis do **not** accept titanium extracted by electrolysis	1
2(b)	carbon dioxide	allow CO_2	1
2(c)	magnesium chloride is electrolysed / used / decomposed magnesium and / or chlorine are recycled / reused	 allow the products of electrolysis are recycled word / symbol equation = **1** mark	1 1
2(d)	 because oxygen / nitrogen (in air) would react with the magnesium **or** would produce magnesium oxide / nitride whereas argon is inert / unreactive **or** argon does not react (with magnesium)	accept titanium for magnesium ignore argon is in Group 0 / noble gas	 1 1
2(e)	240		1
2(f)	250	allow range 245 to 250	1
Total			**8**

4.4.3.1 The process of electrolysis

Answer 22 · Mark scheme

June 2012 | CH1HP | Original Q2 | Legacy

CH1HP

4.4.3.1 The process of electrolysis

Question 5

question	answers	extra information	mark
5(a)	52.9(411765) / 53	correct answer with or without working = **2** marks if answer incorrect allow 2 x 27= 54 **or** 27/102 x 100 **or** 26.5 for **1** mark	2
5(b)(i)	because it lowers the melting point (of the aluminium oxide) so less energy is needed (to melt it)	allow lowers the temperature needed do **not** accept lowers boiling point accept so that the cell / equipment does not melt	1 1
5(b)(ii)	**2** O^{2-} on left hand side **4e**$^{-}$ on right hand side	accept correct multiples or fractions accept –**4e**$^{-}$ on left hand side	1 1
5(b)(iii)	because the electrode reacts with oxygen **or** because the electrode burns to form carbon dioxide **or** electrode made from carbon / graphite		1 1
Total			**8**

4.4.3.1 The process of electrolysis

Answer 23 · Mark scheme

June 2012 | CH2HP | Original Q5 | Legacy

CH2HP

4.4.3.1 The process of electrolysis

Answer 24 · Mark scheme

January 2013 | CH2HP | Original Q2 | Legacy

question	answers	extra information	mark
2(a)(i)	because they are positively charged	accept they are positive / H^+ accept oppositely charged **or** opposites attract ignore they are attracted	1
2(a)(ii)	gains one / an electron	accept $H^+ + e^- \rightarrow H$ or multiples allow gains electrons	1
2(b)	3 bonding pairs 1 lone pair	 accept 2 non-bonding electrons on outer shell of nitrogen	1 1
2(c)(i)	hydroxide / OH^-	do **not** accept sodium hydroxide	1
2(c)(ii)	$H^+ + OH^- \rightarrow H_2O$	ignore state symbols ignore word equation	1

4.4.3.1 The process of electrolysis

January 2013

CH2HP

question	answers	extra information	mark
2(d)	Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5.		6

0 marks	Level 1 (1-2 marks)	Level 2 (3-4 marks)	Level 3 (5-6 marks)
No relevant content.	There are basic descriptions of advantages or disadvantages of the electrolysis cells.	There are clear descriptions of environmental or economic advantages or disadvantages of the electrolysis cells. Comparisons may be implied.	There are detailed descriptions of environmental and economic advantages and disadvantages, comparing the electrolysis cells.

examples of chemistry points made in the response:

Accept converse where appropriate.

- mercury cell is more expensive to construct
- mercury is recycled but membranes must be replaced
- mercury is toxic but membrane / polymer is not
- removing traces of mercury from waste is expensive
- mercury cell uses more electricity
- mercury cell produces chlorine that is purer
- mercury cell produces higher concentration / better quality of sodium hydroxide (solution)

Total			12

4.4.3.1 The process of electrolysis

Answer 24 · Mark scheme

January 2013

CH2HP

4.4.3.1 The process of electrolysis

Answer 25 · Mark scheme January 2013 | CH2HP | Original Q5 | Legacy

question	answers	extra information	mark
5(a)	Will kelp last longer than coal as an energy source?		1
5(b)	any **two** from: • cannot be determined by experiment • based on opinion • ethical **or** environmental **or** economic reason	 allow can't predict how long kelp / coal will last allow more testing needed allow could damage ecosystem allow reference to cost	2
5(c)(i)	7		1
5(c)(ii)	 sodium (atom) loses (electron) **and** iodine (atom) gains (an electron) 1 electron (electrostatic) attraction **or** forms ionic bond(s)	reference to incorrect bonding **or** incorrectly named particle = max **2** any or all marks can be obtained from a labelled diagram ignore inner shell electrons if shown	 1 1 1
5(c)(iii)	<u>ions</u> can move (in the solution)		1
5(c)(iv)	**2** I^- → I_2 + **2** e^-		1

Question 5 continues on the next page

4.4.3.1 The process of electrolysis

Answer 25 · Mark scheme

January 2013

CH2HP

Question 5 cont'd

question	answers	extra information	mark
5(c)(v)	hydrogen is formed because sodium is more reactive (than hydrogen)		1 1
Total			**11**

4.4.3.1 The process of electrolysis

Answer 25 · Mark scheme

January 2013

CH2HP

4.4.3.1 The process of electrolysis

Answer 26 · Mark scheme

June 2013 | CH1HP | Original Q2 | Legacy

Question 2

question	answers	extra information	Mark
2(a)	any **two** from: • copper / ores are running out / harder to find • there are no / very small amounts of high-grade copper ores left • copper metal is in demand • copper is expensive • now economical to extract copper from low-grade ores	it = copper allow new methods of extraction e.g. bioleaching and phytomining allow high-grade ores are running out for **2** marks	2
2(b)(i)	large amounts / 98% of rock to dispose of as waste **or** waste rock takes up a lot of space	accept contains toxic (metal) compounds / bioleacher	1
2(b)(ii)	(copper sulfide reacts with oxygen to) produce sulfur dioxide / SO_2 that causes acid rain	allow (sulfur reacts with oxygen to) produce sulfur dioxide / SO_2 allow description of effects of acid rain **or** sulfur dioxide if no other mark awarded allow CO_2 produced which causes global warming **or** CO_2 produced by burning fuel or heating the furnace for **1** mark	1 1
2(b)(iii)	any **one** from: • large amounts of fuels / energy used (for the furnace and electrolysis) • (the extraction has) many steps / stages / processes • large amounts of ore / material have to be mined	allow large amounts of electricity needed ignore high temperature / electrolysis unqualified allow (extraction) is a long process / takes a lot of time allow ores contain a low percentage of copper	1

Question 2 continues on the next page

4.4.3.1 The process of electrolysis

Answer 26 · Mark scheme

June 2013 | CH1HP | Original Q2 | Legacy

Question 2 continued

question	answers	extra information	Mark
2(b)(iv)	(copper ions move towards) the negative electrode / *cathode* because copper ions / Cu^{2+} are positively charged **or** are oppositely charged **or** copper ions need to gain electrons	 allow because metal ions are positive **or** opposites attract	1 1
2(b)(v)	(growing) plants		1
Total			**9**

4.4.3.1 The process of electrolysis

Answer 27 · Mark scheme

June 2013 | CH2HP | Original Q4 | Legacy

Question 4

question	Answers	extra information	Mark
4(a)(i)	current / charge couldn't flow because the ions / particles couldn't move **or** (salt) needs to be molten / dissolved (to conduct electricity) (1) so that the ions / particles can move (1)	allow could not conduct (electricity) do **not** accept electrons/ molecules / atoms do **not** accept electrons / molecules / atoms	1 1
4(a)(ii)	he had status **or** he had evidence / proof	accept he had authority **or** experience accept the experiment could be repeated	1
4(b)	hydrogen / H_2 the ions are positive potassium is more reactive (than hydrogen)	do **not** allow hydrogen ions accept because opposite (charges) attract accept potassium ions are less easily discharged (than hydrogen) **or** potassium ions are less easily reduced (than hydrogen)	1 1 1
4(c)(i)	gain electron(s) one electron	accept fully balanced correct equation for **2** marks if no other marks awarded allow (potassium ions) reduced for **1** mark	1 1
4(c)(ii)	**2**Cl^- → Cl_2 + **2**e^-	must be completely correct, including charge on electron accept correct multiples	1
4(c)(iii)	2, 8, 8	accept any combination of dots, crosses, "e" or any other relevant symbol ignore any charges if given	1
Total			**10**

4.4.3.1 The process of electrolysis

Answer 28 · Mark scheme June 2014 | CH1HP | Original Q4 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
4(a)(i)	phytomining		1	1 / 1.3.1g	G
4(a)(ii)	*(the land contains)* very little copper uneconomical	*allow low grade ore **or** large amounts of waste* *ignore quarrying / benefits of using plants* *accept (smelting) uses a lot of energy / fossil fuels* *allow expensive*	1 1	3 / 1.3.1f/g	E
4(a)(iii)	Cu **2** $CuO + C \rightarrow$ **2** $Cu + CO_2$	*allow* $2\ CuO + C \rightarrow Cu_2 + CO_2$ *for **1** mark*	1 1	2 / 1.3.1f	E
4(b)(i)	iron is more reactive (than copper) iron is cheap(er than copper)	*allow cheaper **or** uses less energy than electrolysis*	1 1	1 + 2 / 1.3.1h	E
4(b)(ii)	*any **two** from:* • copper / ions move **or** are attracted to the negative electrode / *cathode* • where they are reduced **or** gain (two) electrons • *where they form copper (metal / atoms)*		2	1 / 1.3.1h	E
Total			**9**		

4.4.3.1 The process of electrolysis

Answer 28 · Mark scheme

June 2014 | CH1HP | Original Q4 | Legacy



4.4.3.1 The process of electrolysis

Answer 29 · Mark scheme June 2014 | CH2HP | Original Q4 | Legacy

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

4.4.3.1 The process of electrolysis

Answer 29 · Mark scheme June 2014 | CH2HP | Original Q4 | Legacy

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

4.4.3.1 The process of electrolysis

Answer 29 · Mark scheme

June 2014 | CH2HP | Original Q4 | Legacy



4.4.3.1 The process of electrolysis

Answer 30 · Mark scheme

June 2015 | CH2HP | Original Q3 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
3(a)		first 3 marks can be obtained from a suitably labelled diagram incorrect structure or bonding or particle = max 3		AO1 2.1.h,i 2.2.4a
	giant structure / lattice / layers / close packed		1	
	made up of atoms / positive ions		1	
	with delocalized / free electrons		1	
	so electrons can move / flow through the metal	accept so electrons can carry charge through the metal accept so electrons can form a current	1	
3(b)		accept converse for pure metal throughout both marks can be obtained from suitable diagrams		AO1 2,2,4c
	an alloy (is a metal which) has different types / sizes of atoms	allow made of different metals allow mixture of metals / atoms / elements ignore particles ignore properties do **not** accept compound	1	
	alloy has distorted layers	allow layers are unable to slide	1	
3(c)(i)	can return to its original shape	accept shape memory alloy accept smart alloy ignore other properties	1	AO1 2.2.4d

Question 3 continues on the next page

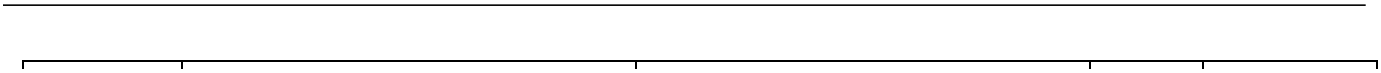
Question 3 continued

3(c)(ii)	(pure copper is too) soft	accept converse accept malleable or bends accept copper is running out ignore references to strength and weakness	1	**AO2** 2.2.4c 2.7.1d
3(c)(iii)	aluminium oxide	accept alumina accept Al_2O_3 ignore bauxite / aluminium ore	1	**AO1** 2.7.1h
3(c)(iv)	any **one** from: • different conditions • different catalyst • different pressure • different temperature	allow different concentration do **not** accept different monomers	1	**AO1** 2.2.5a
3(d)	any **two** from: • accurate • sensitive • rapid • small sample	both needed for 1 mark	1	**AO1** 2.3.2a
Total			**11**	

4.4.3.1 The process of electrolysis

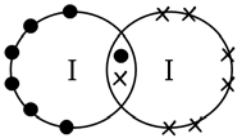
Answer 30 · Mark scheme

June 2015 | CH2HP | Original Q3 | Legacy



4.4.3.1 The process of electrolysis

Answer 31 · Mark scheme June 2015 | CH2HP | Original Q6 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
6(a)	lattice / giant structure	max **3** if incorrect structure or bonding or particles	1	**AO1** 2.1.1adef 2.2.2a
	ionic **or** (contains) ions		1	
	Na^+ **and** Cl^-	accept in words or dot and cross diagram: must include type and magnitude of charge for each ion	1	
	electrostatic attraction	allow attraction between opposite charges	1	
6(b)	hydrogen	allow H_2	1	**AO1** 2.7.1i
	sodium hydroxide	allow NaOH	1	
6(c)	any **one** from, eg: • people should have the right to choose • insufficient evidence of effect on individuals • individuals may need different amounts	allow too much could be harmful ignore religious reasons ignore cost ignore reference to allergies	1	**AO3** 2.1
6(d)(i)	one bonding pair of electrons 6 unbonded electrons on each atom	accept dot, cross or e or – or any combination, eg 	1 1	**AO2** 2.1.1b,g

Question 6 continues on the next page

4.4.3.1 The process of electrolysis

Question 6 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
6(d)(ii)		max **2** if incorrect structure or bonding or particles		**AO1/ AO2** 2.2.1ab
	simple molecules	accept small molecules accept simple / small molecular structure	1	
	with intermolecular forces	accept forces between molecules must be no contradictory particles	1	
	which are weak **or** which require little energy to overcome – must be linked to second marking point	reference to weak covalent bonds negates second and third marking points	1	
6(d)(iii)	iodine has no delocalised / free / mobile electrons or ions		1	**AO1** 2.2.1c
	so cannot carry charge	if no mark awarded iodine molecules have no charge gains **1** mark	1	2.1.1g
Total			**14**	

4.4.3.1 The process of electrolysis

Answer 32 · Mark scheme June 2016 | CH2HP | Original Q5 | Legacy

Question	Answers	Extra information	Mark	AO / SpecRe
5(a)		reference to incorrect particles **or** incorrect bonding **or** incorrect structure = **max 3**		AO1/AO2 2.1.1a,b,c,e,f
	magnesium loses two electrons **and** chlorine gains one electron	accept magnesium loses electrons **and** chlorine gains electrons for 1 mark ignore oxidation and reduction	2	
	one magnesium and two chlorines	accept $MgCl_2$	1	
	noble gas structure **or** eight electrons in the outer shell **or** (electrostatic) attraction between ions **or** forms ionic bonds	accept full outer shell (of electrons) do **not** accept covalent bonds	1	
5(b)(i)		accept converse for solid		AO1 2.2.2b,2.7.1a
	because ions can move	ignore ions attracted do **not** accept molecules/ atoms moving do **not** accept incorrect reference to electrons moving	1	
	(and ions move) to the electrodes **or** (and ions) carry charge		1	

4.4.3.1 The process of electrolysis

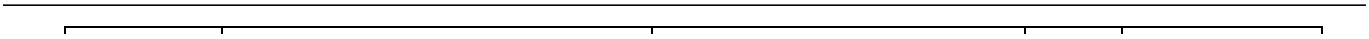
Answer 32 · Mark scheme June 2016 | CH2HP | Original Q5 | Legacy

5(b)(ii)	magnesium (ions) attracted (to the electrode) so magnesium ions gain electrons 2 electrons	 accept magnesium ions are reduced ignore oxidised accept a correct half equation for 2nd **and** 3rd marking points	1 1 1	2AO1 / 1AO2 2.7.1b,c,d,e
5(b)(iii)	hydrogen	allow H_2	1	AO2 2.7.1f
5(b)(iv)	magnesium is more reactive than hydrogen	accept converse allow magnesium is high in the reactivity series **or** magnesium is very/too reactive. do **not** accept magnesium ions are more reactive than hydrogen ions	1	AO2 2.7.1f
5(b)(v)	**2** Cl^- → Cl_2 + **2e**$^-$	must be completely correct	1	AO1 2.7.1g
5(c)	 layers (of particles/atoms/ions) (particles/atoms/ions/layers) can slide	any mention of intermolecular/ weak bonds/forces = **max 1**	 1 1	AO2 2.2.4b
Total			**14**	

4.4.3.1 The process of electrolysis

Answer 32 · Mark scheme

June 2016 | CH2HP | Original Q5 | Legacy



Answer 33 · Mark scheme

June 2017 | CH2HP | Original Q6 | Legacy

The full source mark scheme begins on page 94. Follow original question 6 in that document.

4.4.3.1 The process of electrolysis

Answer 34 · Mark scheme June 2018 | 8462/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	solid (zinc chloride) does not conduct (electricity) **or** zinc chloride needs to be in solution **or** molten	allow liquid / aqueous	1	AO1 4.4.3.1
	(because) ions cannot move in the solid **or** (as) ions can (only) move in liquid / solution	do **not** accept references to movement of electrons in zinc chloride	1	
06.2		allow free electrons for delocalised electrons		AO1 4.2.3.2
	each carbon / atom forms 3 (covalent) bonds		1	
	one electron per carbon / atom is delocalised		1	
	(so) these electrons carry charge through the graphite **or** (so) these electrons move through the structure	ignore carry current / electricity	1	
		if no other mark scored, allow **1** mark for delocalised / free electrons		
06.3	use measuring cylinders (instead of test tubes)	allow use burettes allow use (gas) syringes allow Hoffmann voltameter	1	AO3 4.4.3.4
	(because) test tubes cannot measure volume **or** (because) test tubes have no graduations / scale	allow (so that) volume can be measured	1	

4.4.3.1 The process of electrolysis

Answer 34 · Mark scheme June 2018 | 8462/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	any **three** from: • the volume of hydrogen collected is directly proportional to the time • the rate of collection of hydrogen is 0.45 (cm^3/min) • up to 8 minutes chlorine is collected at an increasing rate • after 8 minutes the rate of collection of chlorine is the same as that of hydrogen **or** after 8 minutes the rate of collection of chlorine is 0.45 (cm^3/min)	allow the (volume of) hydrogen is collected at a constant / steady rate allow any value from 6 to 8 minutes allow initially chlorine is collected at an increasing rate allow any value from 6 to 8 minutes allow after 8 minutes the (volume of) chlorine is collected at a constant / steady rate if neither bullet point 3 nor bullet point 4 is awarded allow **1** mark for chlorine is collected slowly up to 8 minutes and then more quickly allow any value from 6 to 8 minutes	3	AO2 4.4.3.4
06.5	chlorine reacts with water **or** chlorine dissolves (in the solution)		1	AO3 4.3.5 4.4.3.4

4.4.3.1 The process of electrolysis

Answer 34 · Mark scheme

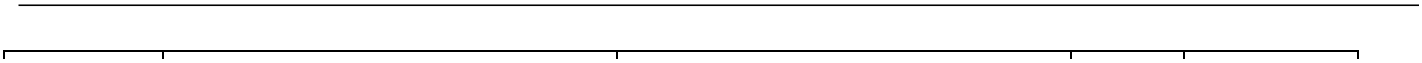
June 2018 | 8462/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.6		an answer of 2.75×10^{-4} (mol) or 2.8×10^{-4} (mol) scores **3** marks an answer of 0.000275 / 0.00028 / 2.75×10^{-1} / 2.8×10^{-1} (mol) / scores **2** marks an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps		AO2 4.3.5
	(volume=) $\frac{6.6}{1000}$ (dm^3) **or** 0.0066 (dm^3)	allow 6.5 (cm^3) for 6.6 (cm^3)	1	
	(moles=) $\frac{0.0066}{24}$	allow use of incorrect volume from step 1	1	
	= 2.75×10^{-4} (mol)	allow 2.8×10^{-4} (mol) allow answer from incorrect calculation given in standard form alternative approach for marking points 1 and 2 24 dm^3 = 24 000 cm^3 (1) (moles =) $\frac{6.6}{24\,000}$ (1)	1	
Total			**14**	

4.4.3.1 The process of electrolysis

Answer 34 · Mark scheme

June 2018 | 8462/1H | Original Q6



4.4.3.1 The process of electrolysis

Answer 35 · Mark scheme

June 2019 | 8462/1H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	mixture has a lower melting point (than aluminium oxide) (so) less energy needed	allow cryolite lowers melting point (of aluminium oxide) ignore boiling point do **not** accept cryolite is a catalyst ignore cost	1 1	AO1 4.4.3.3
07.2	aluminium ions gain electrons		1	AO1 4.4.1.4 4.4.3.3
07.3	$2O^{2-} \rightarrow O_2 + 4e^-$	allow multiples allow **1** mark for an unbalanced equation containing correct species	2	AO2 4.1.1.1 4.4.3.1 4.4.3.3
07.4	the electrode reacts with oxygen the electrode is carbon / graphite (so) carbon dioxide is produced	 allow (so) the electrode / carbon / graphite is used up allow (so) the electrode / carbon / graphite is burned away ignore (so) the electrode / carbon / graphite is worn away ignore (so) the electrode / carbon / graphite is corroded	1 1 1	AO1 4.4.3.3

Question 7 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5		an answer of 941 (kg) scores **4** marks		AO2 4.3.2.2
	(M_r of Al_2O_3 =) 102		1	
	$\left(\frac{2\,000\,000}{102} =\right)$ 19 608 (mol Al_2O_3)	allow correct calculation using incorrectly calculated value of M_r of Al_2O_3	1	
	$\left(19\,608 \times \frac{3}{2} =\right)$ 29 412 (mol O_2)	allow correct calculation using incorrectly calculated value of moles of Al_2O_3	1	
	$\left(\frac{29\,412 \times 32}{1000} =\right)$ 941 (kg)	allow 941.1764706 (kg) correctly rounded to at least 2 significant figures allow correct answer using incorrectly calculated value of moles of O_2	1	
	alternative approach: (2 M_r of Al_2O_3 =) 204 (1) 204 (kg of Al_2O_3) gives 96 (kg of O_2) (1) (2000 kg of Al_2O_3 gives) $\frac{2000}{204}$ × 96 (kg of O_2) **or** $\frac{2000000}{204}$ × 96 (g of O_2) (1) = 941 (kg) (1)			

4.4.3.1 The process of electrolysis

Answer 35 · Mark scheme

June 2019 | 8462/1H | Original Q7

07.6	hydrogen (gas) would be produced (instead of sodium) (because) sodium is more reactive than hydrogen		1 1	AO3 4.4.1.2 4.4.3.3 4.4.3.4
07.7	$\left(\frac{150\,000}{71} =\right)$ 2113 (mol of Cl_2) **or** (volume of 1 g of $Cl_2 = \frac{24}{71} =$) 0.34 (dm^3) ($\frac{150\,000}{71}$ x 24) = 50700 (dm^3)	an answer of 50700 (dm^3) scores **2** marks an answer of 50.7 (dm^3) scores **1** mark allow 50704.22535 (dm^3) correctly rounded to at least 2 significant figures allow correct calculation using their calculated number of moles and/or calculated volume of 1 g	1 1	AO2 4.3.5
Total			**16**	

4.4.3.1 The process of electrolysis

Answer 36 · Mark scheme

November 2020 | 8462/1H | Original Q4

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	CrO_4^{2-} / chromate ions moved to the positive electrode	allow anode for positive electrode allow yellow (coloured) ions moved to the positive electrode	1	AO2
	(because) opposite charges attract	allow (because) negative ions are attracted to the positive electrode	1	AO1 4.4.3.1 RPA 3
04.2	water	ignore copper chromate solution	1	AO1 4.4.3.4 RPA 3
04.3	copper ions gain two electrons	allow Cu^{2+} for copper ions allow **1** mark for copper ions gain electrons **or** allow **1** mark for copper ions are reduced do **not** accept copper ions are oxidised	2	AO2
	(to) form copper (atoms)	allow Cu for copper (atoms) the equation: $Cu^{2+} + 2e^- \rightarrow Cu$ scores **3** marks	1	AO3 4.4.3.1 4.4.3.4 RPA 3
04.4	(negative electrode) hydrogen (positive electrode) iodine	allow H_2 allow I_2	1 1	AO2 4.4.3.4 RPA 3
Total			**8**	

4.4.3.1 The process of electrolysis

Answer 37 · Mark scheme

November 2021 | 8462/1H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1		allow voltage for electricity allow potential difference for electricity allow (electrical) current for electricity		AO1 4.4.3.1 4.5.2.1
	electrolysis uses electricity to produce a chemical reaction	allow electrolysis uses electricity to decompose a compound / electrolyte	1	
	(but) cells use a chemical reaction to produce electricity		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	$2\,Br^- \rightarrow Br_2 + 2\,e^-$	allow multiples allow **1** mark for Br_2 **and** e^-	2	AO2 4.1.1.1 4.4.3.1 4.4.3.2 4.4.3.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3				AO2 4.4.1.2 4.4.3.4 RPA3

Salt solution	Product at positive electrode	Product at negative electrode	Mark
(copper nitrate)	oxygen (1)	(copper)	1
(potassium iodide)	iodine (1)	hydrogen (1)	2

Question 7 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	filter the mixture wash and dry the copper / residue weigh the copper collected add to the increase in mass of the electrode		1 1 1 1	AO3 4.1.1.2 4.4.3.4 RPA3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5	(for given current) straight line through the origin	allow (for given current) when time doubles, mass doubles	1	AO3 4.4.3.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.6	(for given time) when current doubles, mass doubles with supporting data		1	AO3 4.4.3.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.7	copper ions are discharged (from the solution)	allow the solution becomes less concentrated allow copper ions are removed (from the solution) allow copper ions are used up (from the solution)	1	AO3 4.4.3.1

4.4.3.1 The process of electrolysis

Question 7 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.8	(number of moles = $\frac{0.24}{63.5}$ =) 3.78×10^{-3} **or** 0.00378		1	AO2 4.3.2.1
	(number of atoms =) $0.00378 \times 6.02 \times 10^{23}$	allow correct use of an incorrectly calculated number of moles	1	
	$= 2.28 \times 10^{21}$	allow a correct evaluation to 3 significant figures of an incorrect expression which involves only a mass from the graph, the A_r of copper and the Avogadro constant	1	

Total			17

4.4.3.1 The process of electrolysis

Answer 38 · Mark scheme

June 2022 | 8462/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	$Na^+ + e^- \rightarrow Na$		1	AO2 4.4.3.2 4.4.3.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	so the products do not react (to reform sodium chloride)		1	AO3 4.4.3.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	ion		1	AO3 4.4.3.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	hydrogen / H^+ (ions) hydroxide / OH^- (ions)		1 1	AO1 4.4.3.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	sodium hydroxide	allow NaOH	1	AO2 4.4.3.4

4.4.3.1 The process of electrolysis

Answer 38 · Mark scheme

June 2022 | 8462/1H | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.6	sodium ions and hydroxide ions are left (in solution)		1	AO2 4.4.3.4
	(because) hydrogen ions are discharged / reduced (at the negative electrode to form hydrogen)	allow (because) hydrogen ions gain electrons (at the negative electrode to form hydrogen) allow (because at the negative electrode) $2\ H^+ + 2\ e^- \rightarrow H_2$	1	
	(and because) chloride ions are discharged / oxidised (at the positive electrode to form chlorine)	allow (and because) chloride ions lose electrons (at the positive electrode to form chlorine) allow (and because at the positive electrode) $2\ Cl^- \rightarrow Cl_2 + 2\ e^-$	1	

Total Question 6		9

4.4.3.1 The process of electrolysis

Answer 39 · Mark scheme

June 2023 | 8462/1H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	$Al^{3+} + 3e^- \rightarrow Al$	allow multiples	1	AO2 4.1.1.1 4.4.3.3 4.4.3.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	sodium is more reactive than aluminium		1	AO3 4.4.3.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3		allow hydroxide ions for OH^- throughout		AO1 4.4.3.4
	water (molecules) break down		1	
	(to) produce (H^+ and) OH^- (ions)		1	
	(OH^- (ions) are attracted / move to the positive electrode		1	
	(OH^- (ions) are discharged / oxidised to give oxygen (molecules)	allow (OH^- (ions) lose electrons to give oxygen (molecules)	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4		allow (inverted) burettes for measuring cylinders allow gas syringes for measuring cylinders		AO3 4.4.3.4
	(change) use measuring cylinders (instead of test tubes)		1	
	(reason) because there is a scale (on the measuring cylinders)	allow measuring cylinder(s) measure volume	1	

4.4.3.1 The process of electrolysis

Answer 39 · Mark scheme June 2023 | 8462/1H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5	10 cm^3		1	AO2 4.3.5

Total Question 7	**9**

4.4.3.1 The process of electrolysis

Answer 40 · Mark scheme

June 2024 | 8462/1H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	each calcium atom loses two electrons	allow **1** mark for calcium atoms lose electrons **and** chlorine atoms gain electrons	1	AO2 4.2.1.2
	(and) each chlorine atom gains one electron		1	
	(so) one calcium atom reacts with two chlorine atoms		1	
	(to form) Ca^{2+} ions **and** Cl^- ions **or** (to form) calcium ion(s) **and** chloride ion(s)	allow (to form) ions with full outer shells allow energy level for shell	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	the ions cannot move	allow the ions are in fixed positions	1	AO1 4.2.2.3 4.4.3.1 4.4.3.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	hydrogen	allow H_2	1	AO2 4.4.3.4 RPA3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	$2Cl^- \rightarrow Cl_2 + 2e^-$		1	AO2 4.1.1.1 4.4.3.4 4.4.3.5 RPA3

4.4.3.1 The process of electrolysis

Answer 40 · Mark scheme June 2024 | 8462/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5		allow cathode for negative electrode allow anode for positive electrode allow attraction for movement		AO3 4.4.3.1
	Cu^{2+} / copper ions are blue **and** CrO_4^{2-} / chromate ions are yellow		1	
	(because) Cu^{2+} / copper ions move to the negative electrode		1	
	(and also) CrO_4^{2-} / chromate ions move to the positive electrode		1	

Total Question 5	10

4.4.3.1 The process of electrolysis

Answer 41 · Mark scheme

June 2024 | 8462/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	(most reactive) Mg Zn Ni Cu Ag (least reactive) (justification) the higher the (positive) voltage the more reactive the metal	allow name of metal for symbol allow **1** mark for (most reactive) Mg Zn Ni **or** Ni Cu Ag (least reactive) allow the most reactive (metal) has the highest (positive) voltage allow the least reactive (metal) has the most negative voltage allow the greater the difference in reactivity the greater the (magnitude of the) voltage	2 1	AO3 4.4.1.2 4.5.2.1

4.4.3.1 The process of electrolysis

Answer 41 · Mark scheme

June 2024 | 8462/1H | Original Q6

Question	Answers	Mark	AO / Spec. Ref.
06.2	**Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6	AO3 4.3.4 4.5.2.1
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content • **set up cell with sodium chloride solution as the electrolyte** • **use two different metals as electrodes** • **measure voltage** • **repeat at different concentrations of electrolyte solution** • **by diluting the sodium chloride solution with water** • using measured volumes of sodium chloride solution and water • measure volumes with a measuring cylinder (allow pipette / burette) • use the same two metals each time • use the same volume of electrolyte solution		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3		ignore references to electrodes		AO1 4.5.2.2
	hydrogen is oxidised (electrochemically)	allow hydrogen loses electrons	1	
	to produce water		1	

Total Question 6	11

4.4.3.1 The process of electrolysis

Answer 42 · Mark scheme

June 2025 | 8462/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	strong electrostatic forces	allow strong forces of attraction ignore strong ionic bonds	1	AO1 4.2.1.3 4.2.2.3
	between oppositely charged ions	allow between (positive) aluminium ions and (negative) oxide ions allow between Al^{3+} (ions) and O^{2-} (ions)	1	
	(which) act in all directions (in the giant structure)		1	
	(so) need a lot of energy to break (the many strong bonds)		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	cryolite	allow Na_3AlF_6	1	AO1 4.4.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	the mixture has a lower melting point than aluminium oxide	allow to lower the melting point (of the mixture) allow to lower the energy demand (of the process)	1	AO1 4.4.3.3

4.4.3.1 The process of electrolysis

Answer 42 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	$2\,O^{2-} \rightarrow O_2 + 4\,e^-$	allow multiples allow **1** mark for $O^{2-} \rightarrow O_2 + e^-$ with no / incorrect balancing numbers	2	AO2 4.1.1.1 4.4.3.2 4.4.3.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	the (positive) electrode is made of carbon / graphite		1	AO1 4.4.3.3
	(so) the carbon / graphite reacts with oxygen (produced in the electrolysis)		1	
	(which) produces carbon dioxide		1	

Total Question 6	**11**

Version 1.0: 0108

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Secondary Education

Additional Science 4463 / Chemistry 4421

CHY2H Unit 2 Chemistry

Mark Scheme

2008 examination – January series

4.4.3.1 The process of electrolysis

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

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

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4.4.3.1 The process of electrolysis

MARK SCHEME

Information to Examiners

1. General

The mark scheme for each question shows:

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

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

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

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

2. Emboldening

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

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

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

3. Marking points

3.1 Marking of lists

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

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

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

4.4.3.1 The process of electrolysis

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

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

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

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

3.2 Use of chemical symbols / formulae

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

3.3 Marking procedure for calculations

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

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

3.4 Interpretation of 'it'

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

3.5 Errors carried forward

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

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

3.6 Phonetic spelling

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

3.7 Brackets

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

3.8 Unexpected Correct Answers not in the Mark Scheme

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

4.4.3.1 The process of electrolysis

CHY2H

Question 1

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

4.4.3.1 The process of electrolysis

CHY2H

Question 2

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

4.4.3.1 The process of electrolysis

CHY2H

Question 3

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

4.4.3.1 The process of electrolysis

CHY2H

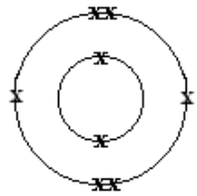
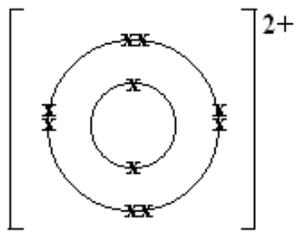
Question 4

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

4.4.3.1 The process of electrolysis

CHY2H

Question 5

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

continued…

4.4.3.1 The process of electrolysis

CHY2H

Question 5 continued…

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

4.4.3.1 The process of electrolysis

CHY2H

Question 6

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

4.4.3.1 The process of electrolysis

CHY2H

Question 7

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

continued…

4.4.3.1 The process of electrolysis

CHY2H

Question 7 continued…

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

continued…

4.4.3.1 The process of electrolysis

CHY2H

Question 7 continued…

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

continued…

4.4.3.1 The process of electrolysis

CHY2H

Question 7(d) continued…

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

4.4.3.1 The process of electrolysis

GCSE

Additional Science / Chemistry

CH2HP
Final Mark scheme

4408 / 4402
June 2017

Version/Stage: v1.0

4.4.3.1 The process of electrolysis

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4.4.3.1 The process of electrolysis

Information to Examiners

1. General

The mark scheme for each question shows:

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

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

2. Emboldening and underlining

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

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

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

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

3. Marking points

3.1 Marking of lists

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

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

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

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

[1 mark]

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

4.4.3.1 The process of electrolysis

Example 2: Name two planets in the solar system.

[2 marks]

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

3.2 Use of chemical symbols/formulae

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

3.3 Marking procedure for calculations

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

3.4 Interpretation of 'it'

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

3.5 Errors carried forward

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

3.6 Phonetic spelling

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

3.7 Brackets

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

3.8 Accept/allow

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

3.9 Ignore/Insufficient/Do not allow

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

4 Quality of Written Communication and levels marking

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

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

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

Level 1: Basic

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

Level 2: Clear

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

Level 3: Detailed

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

4.4.3.1 The process of electrolysis

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

4.4.3.1 The process of electrolysis

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

4.4.3.1 The process of electrolysis

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

Metal:

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

4.4.3.1 The process of electrolysis

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

Total			**6**

4.4.3.1 The process of electrolysis

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

4.4.3.1 The process of electrolysis

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

4.4.3.1 The process of electrolysis

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

4.4.3.1 The process of electrolysis

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

4.4.3.1 The process of electrolysis

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

4.4.3.1 The process of electrolysis

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

4.4.3.1 The process of electrolysis

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

Answer 34 · Examiner comments

June 2018 | 8462/1H | Original Q6

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

06.1 Students found it difficult to score both marks on this question, although 77% of students scored one or more marks. Lower-attaining students simply stated that the electrolyte was a solid, without further explanation. Others incorrectly referred to the movement of delocalised electrons, rather than ions. Some refereed to zinc instead of zinc chloride.

06.2 Students struggled to put sufficient detail into their answers, although no more was required than what is directly stated in the specification. 9% of students achieved all three marks.

A lot of weakly expressed ideas were seen. Instead of stating that each atom forms three covalent bonds, many students stated that graphite has three covalent bonds, or that three out of four carbon atoms are bonded, both of which are untrue.

Very few said that each carbon atom has one delocalised electron: a statement directly from the specification. Those who did score the marks for the structure often didn't say that delocalised electrons move or carry charge **through** the structure. They often implied the delocalised electrons just moved around at random. Many students misunderstood the process of electrical conductivity completely, thinking that it is something to do with layers sliding over each other.

Some students referred to other properties such as softness, instead of confining their answer to the question posed.

06.3 58% of students did not achieve a mark for this question. The investigation was stated to be about the relationship between volume and time, but the diagram showed no means of measuring volume. The expected answer was to use inverted measuring cylinders so that volume (not 'amount') could be measured.

Although it would pose practical difficulties, the idea of using gas syringes was also accepted (on the grounds that it could be made to work if they were attached to funnels placed over the electrodes). Many suggested changing the electrodes as graphite is not inert, suggesting a lack of understanding of the required practical. Some students suggested that the apparatus is upside down.

4.4.3.1 The process of electrolysis

Answer 34 · Examiner comments

June 2018 | 8462/1H | Original Q6

06.4 Although 75% of students achieved one mark, usually for the trend in the hydrogen graph, just 7% achieved three marks.

In order to score the mark for proportionality of the hydrogen graph, both variables had to be stated, not just 'it is proportional'. Alternatively, a steady rate of collection would gain the mark. It had not been anticipated that students would calculate the rate of collection, but those who did were awarded credit. Some referred to proportionality correctly, but did not state which gas they were referring to.

The chlorine line posed more difficulty. Many described the chlorine line after 8 minutes as proportional. It is not as it shows a linear relationship, where the volume of chlorine increases at a steady rate.

Students are very unsure of how to describe trends in curved graphs; the idea of the chlorine being collected at an increasing rate (which could be expressed as faster and faster) being very rarely seen.

As in other questions, the language used by students created a barrier to attaining marks. 'It remains constant' could mean the gas volume no longer changes, rather than the rate of collection.

06.5 2% of students were able to answer this question. Many students either had not read or understood the statement that the number of moles of each gas produced is the same.

There were attempts to justify the difference in terms of reactivity, formula mass, size of molecules, pressure difference or the concentration of H^+ and Cl^- in solution. Some students referred to the length of time taken for the chlorine to react, rather than to be formed. Others suggested the molar volume was different for different gases, ignoring what they know from the part of the specification on gas volumes.

The formation of chlorine and hydrogen is part of the electrolysis required practical, so students should not be completely unfamiliar with the bubbles of chlorine taking longer to form. They should also be familiar with 'chlorine water' from their work on Group 7.

06.6 Students found this calculation on a new area of the specification quite difficult, with 26% of students providing a fully correct answer.

It was necessary to read off the correct volume from the graph and change the units from cm^3 to dm^3, or to change those of the gas molar volume to cm^3/mol, but many students didn't do this. Many students also struggled to express their answer in standard form.

4.4.3.1 The process of electrolysis

Answer 35 · Examiner comments

June 2019 | 8462/1H | Original Q7

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

07.1 The explanation for the use of cryolite in the extraction of aluminium does not appear to be well known. Almost two-thirds of students scored 0 marks.

A common misconception was that cryolite acts as a catalyst.

Common responses seen that were not credited included:

- to melt the aluminium oxide so that it conducts electricity
- so that the ions can move freely
- to reduce costs.

07.2 Almost 60% of students correctly identified that aluminium ions gain electrons as the process occurring at the negative electrode.

07.3 Students found the completion of the half-equation difficult. Almost 70% scored 0 marks.

Common errors included:

- including Al / Al_2O_3
- representing the oxide ion as O^- or O_2^-
- 2 electrons rather than 4 electrons being produced.

07.4 However, only approximately a quarter of students were able to state why the positive electrode needs to be replaced and hence score all 3 marks.

4.4.3.1 The process of electrolysis

Answer 35 · Examiner comments June 2019 | 8462/1H | Original Q7

07.5 Most students scored at least 1 mark. Approximately 40% scored all 4 marks.

The most frequently scored mark was for M_r (Al_2O_3) = 102 (or '204' from the alternative approach in the mark scheme).

A common error was M_r (Al_2O_3) = 156 but students were still able to score marks for using this incorrect value in subsequent steps.

A valid variation on the reacting mass method was to calculate the percentage by mass of oxygen in Al_2O_3 and then use this to calculate the mass of oxygen in 2000 kg of Al_2O_3

It was not always clear which approach was being used. A common incorrect final answer was 1412 (kg) where students had applied the 2 : 3 mole ratio (from the main approach) as well as the 96 / 204 mass ratio (from the alternative approach).

07.6 Students found this question difficult. Almost two-thirds of students scored 0 marks.

Even when students realised that reactivity was the key idea, they sometimes compared the reactivity of the wrong species, for example, sodium and chlorine or Na^+ ions and H^+ ions

A common misconception was that sodium chloride solution does not conduct electricity.

07.7 Approximately two-thirds of students scored at least 1 mark for this calculation.

However, the most common final answer was 50.7 dm^3. The error here was the omission of the unit conversion, kg to g.

Answer 36 · Examiner comments November 2020 | 8462/1H | Original Q4

Question 4 (standard and standard / high demand)

04.1 Students needed to give the idea of movement of the relevant ions to the positive electrode and to give a reason for that movement in terms of the attraction of opposite charges. Students often managed to convey one, but not both, of those ideas.

04.2 Only a third of students recognised that water provided the hydroxide ions. Vague references to the electrolyte were not sufficient.

04.3 Whilst many students realised that the solid was copper, some expressed this poorly, saying that copper ions were deposited on the electrode. Some students were able to explain the process in terms of the copper ions being reduced, or gaining electrons, but few scored all three marks by saying that the ions gained two electrons to form atoms.

04.4 Many students deduced that iodine would be the product at the positive electrode. Potassium was seen as the response to the product at the negative electrode far more often than hydrogen.

4.4.3.1 The process of electrolysis

Answer 37 · Examiner comments

November 2021 | 8462/1H | Original Q7

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

07.1 Very few students picked up on the link between chemical reactions and electricity given in the question. The idea that electrolysis uses electricity to produce a chemical reaction was poorly understood. Many students believe electrolysis is a method of 'separating' compounds, rather than decomposing a compound. Very few realised that a chemical cell uses a reaction to produce electricity, with many making statements about a cell using electricity.

07.2 Many students were unable to write the formula of bromine. Those who could, often scored at least one mark, although the half-equation was not always balanced.

07.3 Students found difficulty in naming all 3 products. Many students did score the mark for iodine, though iodide was a common response. Very few could work out that in the absence of a halide ion, oxygen must be produced at the positive electrode, with many suggesting nitrogen as the product.

4.4.3.1 The process of electrolysis

Answer 37 · Examiner comments November 2021 | 8462/1H | Original Q7

07.4 Of the students who recognised that the copper needed to be filtered from the solution, very few then washed and dried the copper, despite that step having been provided in the method for dealing with the electrode itself. Some said the filtered copper would be measured, rather than specifically that the mass would be measured. Some then said incorrectly that the mass would be added to the mass of the electrode, rather than the mass gain of the electrode. Many wasted time describing steps that had already been done, particularly weighing the electrode before and after the experiment.

07.5 The concept of proportionality is poorly understood. Even those who referred to the lines being straight rarely referred to their passing through the origin. Most simply described how the results showed a positive correlation, or a linear relationship.

07.6 The idea of one variable doubling (or trebling) as did the other variable was known by very few students.

07.7 Very few recognised that the blue colour was due to copper ions, which were being removed from the solution. Copper does not dissolve, and is not blue, so the phrase ‘copper is removed from the solution’ has no merit. Many think that the ions are being separated, rather than discharged.

07.8 Many students could make no progress as they had not calculated the number of moles of copper. Some tried to include the current, the time or both in their calculation, instead of using those values to establish the mass of copper formed from the graph.

Answer 38 · Examiner comments June 2022 | 8462/1H | Original Q6

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

06.1 Two thirds of students selected the correct half equation. A significant number chose a distractor in which Na was present at the start rather than formed in the reaction.

06.2 Most students realised the need to prevent the products from reacting together and reforming sodium chloride. However, a significant minority failed to appreciate that the reverse reaction would occur and instead focused on preventing the products from mixing or ensuring product purity.

4.4.3.1 The process of electrolysis

Answer 38 · Examiner comments June 2022 | 8462/1H | Original Q6

06.3 Only 60% of students recognised that ions must pass through the mesh. Nearly all other responses were 'electrons'. Many students seem to think that an electric current can only be conducted by electrons moving, even through a solution in which there are no free electrons.

06.4 Most students recognised that hydrogen ions would be present in aqueous sodium chloride. However, only just over a half of students also recognised that hydroxide ions were present. Some stated that the fourth ion would be oxygen, showing a lack of understanding of the ionisation of water.

06.5 A majority of students recognised that the alkaline solution must be sodium hydroxide solution.

06.6 This was a high demand question which students found very challenging. The most common mark scored was for the sodium ions and hydroxide ions remaining in solution after the electrode processes. However, many students did not refer to ions. Others thought that hydroxide ions or sodium ions would be made, rather than being in the solution throughout the process. Whilst students often correctly stated the product at each electrode, few described the actual processes occurring at the electrodes as required by the question. Some otherwise creditworthy responses were let down by referring to chlorine ions instead of chloride ions, or by confusing the polarities of anode and cathode, or by confusing oxidation and reduction.

Answer 39 · Examiner comments June 2023 | 8462/1H | Original Q7

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

07.1 Nearly all students could balance the ionic equation correctly.

07.2 About a fifth of students answered this high demand question correctly. Some students compared the reactivity of sodium with hydrogen instead of with aluminium. Imprecise language was sometimes a problem; it is elemental sodium which is more reactive, not sodium ions. Aluminium is released at the electrode, not discharged (it is the ion which is discharged, ie loses its charge). There is no displacement occurring.

07.3 The question discriminated well, but very few fully correct answers were seen, with just over a third of students scoring at least one mark. Students were asked to explain how oxygen is produced from water, not why oxygen is produced. Few students described the initial step outlined in the specification; that water molecules break down to form H^+ ions and OH^- ions. Many seem to think that oxide or 'oxygen' ions are responsible, rather than hydroxide ions. The attraction of the hydroxide ions to the positive electrode was reasonably well known, but few students then correctly described the oxidation or discharge of the hydroxide ions to form oxygen. As in the previous question, the term 'discharged' is widely misunderstood – the word means 'loses its charge', so to say that oxygen is discharged is not correct.

4.4.3.1 The process of electrolysis

Answer 39 · Examiner comments June 2023 | 8462/1H | Original Q7

07.4 Nearly two thirds of students scored at least one mark, but just over half of these also scored the second mark. The easiest change to the apparatus is to change the test tubes to measuring cylinders or inverted burettes. Many students suggested gas syringes; this was allowed, although it would be difficult to set up the apparatus in such a way that this would work. However, a 'gas cylinder' is not a measuring device. One popular misconception is that gas would escape from the apparatus so a lid should be used.

Most students realised that the reason was so that the gas volume could be measured rather than estimated, or that test tubes have no scale; any equivalent way of expressing this idea was allowed. Some students used imprecise language such as 'so the gas could be measured' without referring to volume or a scale.

07.5 The great majority of students gave the correct response, with 20 cm^3 being the most common incorrect choice.

4.4.3.1 The process of electrolysis

Answer 40 · Examiner comments June 2024 | 8462/1H | Original Q5

Question 5 (standard, standard/high and high demand)

05.1 This question required the use of precise scientific language in responses, which was a major difficulty for many students. Only one in eight students scored all four marks, with more than a third not scoring at all. Although the question asked students to describe what happens to atoms of calcium and chlorine, many failed to include the word 'atoms' when referring to calcium and chlorine. 'Calcium' and 'chlorine' refer to the elements in bulk, not to individual atoms. Similarly, the ions formed were often not referred to as ions either by name (chloride, not 'chlorine' ions) or by formula. It is the resulting ions which have complete outer shells, not atoms. Some students did not read the question properly and described the electrolysis of calcium chloride rather than its formation. Some students described the transfer of electrons from calcium atoms to chlorine atoms correctly, but then referred to the atoms 'sharing' electrons.

05.2 Only two fifths of students could give a correct answer in terms of the lack of mobility of the ions. Many students referred to the inability of electrons to move rather than ions. Some said that substances have to be molten or in aqueous solution to be electrolysed but did not say why that was the case.

05.3 Fewer than half of the students knew that hydrogen was the product. Calcium was the most popular incorrect response, with chlorine and hydrogen ions also being named as the product.

05.4 Two thirds of students identified the correct half equation, with the most popular distractor being the reverse half equation, with chlorine as a reactant rather than the product.

05.5 Over half of students recognised that the Cu^{2+} ions were moving towards the negative electrode, and that the CrO_4^{2-} ions were moving towards the positive electrode. However, less than a third deduced that Cu^{2+} ions are blue and CrO_4^{2-} ions are yellow, with many referring to the 'formation' of those colours rather than their separation. Some tried to refer to electrode processes, even though the diagram shows that the ions in question have not yet reached the electrodes. Many failed to refer to ions at all, referring instead to 'copper' and 'chromium oxide;' these gained no credit. Some students seem to believe that copper is blue (rather than copper ions).

4.4.3.1 The process of electrolysis

Answer 41 · Examiner comments — June 2024 | 8462/1H | Original Q6

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

06.1 Over three fifths of students scored all three marks. Most students could list the metals in order of decreasing reactivity, although some ignored the sign and ordered the metals in order of absolute magnitude of voltage. A few tried to remember the reactivity series, even though nickel and silver are not listed in the specification. The best answers justified the order not only in terms of the most reactive metal producing the most positive voltage, but also that the negative voltages were produced by elements less reactive than nickel.

06.2 This extended response plan of a non-required practical discriminated very well. About a third of responses reached Level 3, with more than two thirds reaching level 2.

There were some excellent descriptions of a plan which would work, including details of how the different concentrations to be tested would be made. Some students thought the pure water was to be used as a control rather than for diluting the sodium chloride solution. The top mark in Level 3 was only available if there was detail about how the voltage could be linked quantitatively to the concentration of sodium chloride. This was often poorly expressed using terms such as

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Answer 41 · Examiner comments — June 2024 | 8462/1H | Original Q6

'amount' rather than 'volume,' and did not always mention both the sodium chloride solution provided and the water. The control variable 'use the same two metals each time' was essential to access a Level 3 mark, since the method must lead to a valid outcome. This was often implied in responses where a student named different metals, or stated they must be different, and then said, 'repeat using different concentrations of sodium chloride.' Many students, however, specified that all of the different metals should be used, which was completely unnecessary and possibly rendered the outcome invalid.

A common error was to use two electrodes of the same metal, or to refer simply to 'the electrodes' without specifying what type of electrodes to use. This restricted the answer to Level 2.

It was not uncommon to see reference to a power supply, which restricted the answer to Level 1; there is some confusion between an electrolytic cell and an electrochemical cell.

06.3 Only 1 in 25 students scored both marks by repeating the statement in the specification that hydrogen is oxidised electrochemically to produce water, and only a quarter of students scored one mark. There were a few excellent answers showing the half equations at both electrodes; as long as these showed hydrogen losing electrons, and water being a product, they gained full credit. Those who referred to hydrogen losing electrons in the fuel cell gained credit; however, students often thought that hydrogen ions were reacting, rather than hydrogen molecules. Other types of oxidation, such as combustion, were not accepted. Some students appear to believe that the water is produced as steam, which then drives a turbine generating electricity.

4.4.3.1 The process of electrolysis

Answer 42 · Examiner comments

June 2025 | 8462/1H | Original Q6

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

06.1 This was a high demand question which required the use of correct terminology. The question discriminated well, with three fifths of students gaining one mark but very few scoring all four. Many students referred correctly to strong electrostatic forces of attraction and to the large amount of energy needed to break these. Fewer referred correctly to the particles that those forces acted between, i.e. the oppositely charged ions; some referred incorrectly to the forces being between bonds. Some referred to

4.4.3.1 The process of electrolysis

Answer 42 · Examiner comments

'oxygen ions' rather than oxide ions. There were very few who stated that the electrostatic forces act in all directions in the giant structure, despite the statement in the specification; this was the mark that most students did not score. Some students ruined their answer by the use of the word 'intermolecular', which is not appropriate as there are no molecules. Most students did recognise that a lot of energy was needed to break bonds but had contradicted this marking point earlier in their response by referring to the bonds as intermolecular forces. Some referred to 'more' energy being needed to break the bonds; this did not gain credit because the question did not require a comparison to anything else, and 'more' does not necessarily imply 'a lot'.

06.2 Only a half of students knew that cryolite was the correct substance. The most common incorrect answer was water.

06.3 Only one in five students scored the mark. Many students missed the point and referred to allowing ions to flow. The idea that the mixture has a lower melting point than pure aluminium oxide so that less energy is required was not well known. It is not correct to say that the melting point of aluminium oxide is lowered, as aluminium oxide has a fixed melting point. Some appear to think incorrectly that cryolite is a catalyst.

06.4 Students had difficulty with this high demand question, but it did discriminate well between the higher achieving students. One in five students scored both marks. Many could not write the formula of the oxide ion, and of those who could, some had the oxygen on the left and the oxide ion on the right. Those who could write the correct formulae could often balance the equation correctly, with the correct number of electrons on the right. An electron must be written with its charge in an ionic equation, as e^-, so that the charge balances as well as the atoms.

06.5 This question discriminated well, with half of students scoring at least one mark and more than a third scoring all three. Those who knew that the positive electrode is made of carbon often went on to score all three marks, although some merely referred to oxidation of the electrode rather than a specific reaction with the oxygen produced. There appeared to be much guesswork, with unspecified corrosion of an electrode made of an unspecified material being fairly common. Some thought that the deterioration of the electrode was due to its gaining electrons, and some thought that the electrode was made of iron and would rust.