AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.4.3.5

Representation of reactions at electrodes as half equations (HT only)

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**13**
Available paper years	**2011–2025**

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.

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 01 · 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**

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 01 · Mark scheme

June 2011 | CHY2H | Original Q5 | Legacy

CHY2H

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 02 · 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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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**

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 02 · Mark scheme

January 2013 | CH2HP | Original Q5 | Legacy

January 2013

CH2HP

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 03 · 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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 03 · Mark scheme

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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 03 · Mark scheme

June 2014 | CH2HP | Original Q4 | Legacy



4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 04 · 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	

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

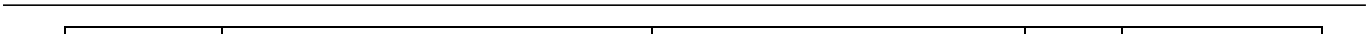
Answer 04 · Mark scheme June 2016 | CH2HP | Original Q5 | Legacy

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 + **2**e^-	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**	

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 04 · Mark scheme

June 2016 | CH2HP | Original Q5 | Legacy



Answer 05 · Mark scheme

June 2017 | CH2HP | Original Q6 | Legacy

The full source mark scheme begins on page 35. Follow original question 6 in that document.

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 06 · Mark scheme June 2018 | 8462/1H | Original Q8

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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 06 · Mark scheme

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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 06 · Mark scheme

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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 06 · Mark scheme

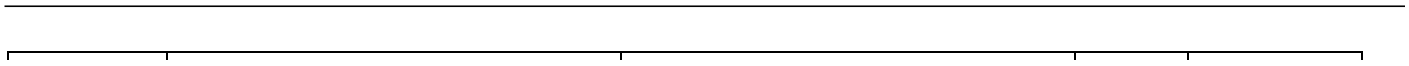
June 2018 | 8462/1H | Original Q8

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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 06 · Mark scheme

June 2018 | 8462/1H | Original Q8



4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 07 · 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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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)			

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 07 · 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**	

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 08 · Mark scheme

November 2020 | 8462/1H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	the activation energy should be from the reactants (line to the peak) the products (line) should be below the reactants (line) **or** the products should have less energy than the reactants	ignore description of where the activation energy is on the diagram allow the product (line) is above the reactants (line) allow the products have more energy than the reactants allow the profile shows an endothermic reaction ignore the arrow for the overall energy change should point downwards	1 1	AO3 4.5.1.2
07.2	any **two** from: (hydrogen fuel cells) • no toxic chemicals to dispose of at the end of the cell's life • take less time to refuel (than to recharge rechargeable cells) • travel further before refuelling (than before recharging rechargeable cells) • no loss of efficiency (over time)	allow converse arguments for a rechargeable cell allow has a greater range allow does not lose capacity / range in cold weather	2	AO1 4.5.2.2

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 08 · Mark scheme

November 2020 | 8462/1H | Original Q7

Question 7 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	any **one** from: • $H_2 \rightarrow 2H^+ + 2e^-$ • $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ • $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$ • $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$	allow multiples allow $H_2 - 2e^- \rightarrow 2H^+$ allow $H_2 + 2OH^- - 2e^- \rightarrow 2H_2O$	1	AO1 4.5.2.2
07.4	any **two** from: • hydrogen is not shown as H_2 / molecules • particles are shown as spheres • particles are shown as solid • does not show the (weak) forces (between particles) • does not show the movement / speed (of particles) • is only two-dimensional		2	AO1 4.2.2.1
07.5	any **one** from: • under (higher) pressure • cool • absorb / adsorb in a solid	allow increase concentration allow condense allow store as a liquid / solid allow develop more efficient engines	1	AO3 4.2.2.1 4.5.2.2

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Question 7 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.6	(58 MJ =) 58 000 kJ **or** (290 kJ =) 0.290 MJ	allow (58 MJ =) 58 000 000 J **and** (290 kJ =) 290 000 J	1	AO2 4.3.2.1 4.3.5 4.5.2.2
	(moles = $\frac{58000}{290}$ **or** $\frac{58}{0.290}$ =) 200	allow correct use of an incorrectly converted or unconverted value of energy	1	
	(volume =) 200 × 24	allow correct use of an incorrectly calculated number of moles of hydrogen	1	
	= 4800 (dm^3)		1	
	alternative approach: (58 MJ =) 58 000 kJ (1) (energy released per dm^3 = $\frac{290}{24}$ =) 12.08333 (kJ/dm^3) (1) (volume =) $\frac{58000}{12.08333}$ (1) = 4800 (dm^3) (1)	allow correct use of an incorrectly converted or unconverted value of energy allow correct use of an incorrectly calculated energy released per dm^3		

Total			12

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 09 · 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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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**

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 10 · 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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 10 · 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**

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 11 · 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	

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 11 · 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**

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 12 · 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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 12 · 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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 13 · 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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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**

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

GCSE

Additional Science / Chemistry

CH2HP
Final Mark scheme

4408 / 4402
June 2017

Version/Stage: v1.0

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' 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.

Further copies of this mark scheme are available from aqa.org.uk

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4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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.

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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.

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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**	

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

<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>

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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**

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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**	

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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	

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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**	

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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**	

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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 06 · Examiner comments

Question 8 (standard / high and high demand)

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

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

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

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

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

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

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

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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 06 · Examiner comments

June 2018 | 8462/1H | Original Q8

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

Common errors were:

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

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

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

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 07 · 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.

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 07 · 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 08 · Examiner comments November 2020 | 8462/1H | Original Q7

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

07.1 Many students spotted that the curve was for an endothermic reaction rather than exothermic. Many also realised the activation energy was incorrect but could not always express correctly that activation energy should start at the energy of the reactants rather than the products.

07.2 Most students did not score well on this question. There were many vague references to 'better for the environment' without any justification for that statement. Many students referenced the fact that water is the only product, failing to realise that rechargeable cells produce no waste products at all. Others failed to realise that the infrastructure for recharging cells is actually better than that for refuelling with hydrogen. Some students

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 08 · Examiner comments November 2020 | 8462/1H | Original Q7

were effectively giving advantages of hydrogen fuel cells over petrol engines, instead of answering the question. Others failed to express themselves clearly; saying that hydrogen fuels cells take less time to charge which did not gain credit, as the cells are refuelled, not recharged.

07.3 Many students did not realise that either hydrogen or oxygen had to be a reactant. Many impossible species such as e^{2-} or O_2^+ were seen.

07.4 Many students were able to score at least one mark but only one in six scored both. Many noted that the movement of the particles was not shown; many also noted that the particles are not shown as diatomic, or that the forces between them are not shown.

07.5 This was quite well answered, with most students favouring compressing the gas rather than cooling to condense the gas. A number of students incorrectly stated that hydrogen can be taken in from the atmosphere.

07.6 A third of students were able to score full marks. It was not possible to give partial credit for working when the students did not explain what they were doing; too often there was a jumble of numbers with various operators between them, with no words or units. No credit was given for multiplying a value by 24 unless that value was identified as a number of moles.

Answer 09 · 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.

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 09 · 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 10 · 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.

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

Answer 10 · 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 11 · 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.

4.4.3.5 Representation of reactions at electrodes as half equations (HT only)

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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.

Answer 12 · 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).

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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

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'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.