Electrolysis

Mark Scheme 3

Level	IGCSE(9-1)
Subject	Chemistry
Exam Board	Edexcel IGCSE
Module	Single Award (Paper 2C)
Topic	Principles of Chemistry
Sub-Topic	Electrolysis
Booklet	Mark Scheme 3

Time Allowed: **70 minutes**

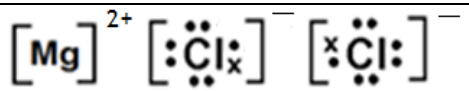
Score: **/58**

Percentage: **/100**

Grade Boundaries:

9	8	7	6	5	4	3	2	1
>90%	80%	70%	60%	50%	40%	30%	20%	10%

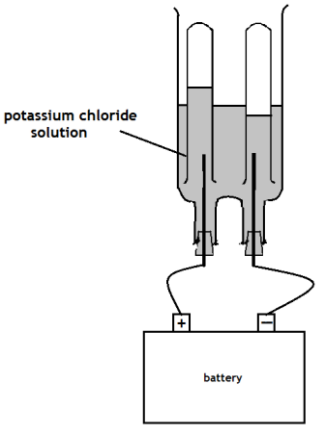
Question number	Answer	Notes	Marks
1 (a)		Ignore name and formula of compound	1
(i)	Na / sodium / Mg / magnesium	Accept aluminium	
(ii)	Si / silicon / P / phosphorus / S / sulfur / Cl / chlorine	If both name and formula given both must be correct If both name and formula given both must be correct	1

(b) (i)	 **M1** correct electronic configuration for magnesium ion and correct charge on ion **M2** correct electronic configuration for both chloride ions **M3** correct charges on both chloride ions	Allow electrons on brackets Allow any combination of dots and crosses Allow 0 or 8 electrons in outer shell M3 indep	3
(ii)	**M1** electrostatic attraction/forces between ions **M2** of opposite charge	accept positive	2

(iii)	**M1** attraction (between ions) is strong **M2** lots of ions (in structure) / giant structure / lattice / lots of/many bonds **M3** (therefore) lot of (thermal/heat) <u>energy</u> required to overcome attraction / to break down the lattice	and negative ions accept cations and anions M2 dep on M1 Accept attraction/forces between oppositely charged ions for 1 mark only Reject references to atoms/molecules/IMF for M1 and M2 Accept strong (ionic) bonding/strong (ionic) bonds	3

		Accept lot of (thermal/heat) energy required to break (ionic) bonds If any reference to attraction between atoms/molecules/electrons scores 0/3 If any reference to covalent bonding/covalent structure/IMF scores 0/3	
(c)		Correct answer with or without working scores 2 marks	2

	M1 mol Al = 20/3 (= 6.67) **M2** mass Al = (answer to M1 x 27) = 180 (g) **OR** **M1** 3 faradays give 1 mol **OR** 27 g / 30 faradays give 10 mol OR 270 g **M2** 20 faradays gives 180 (g)	M2 CQ on M1 eg 540 scores 1 mark 6.67 gives 180(.09) scores 2 marks 6.7 gives 180.9 = 181 scores 2 marks 6.66 gives 179.82 scores M2 only Accept any number of sig fig except 1	

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>2 a</td><td> 
</td><td>M1 both bungs inserted AND electrodes connected to battery

M2 both tubes inverted over electrodes

M3 solution placed in the voltameter and labelled as potassium chloride / KCl(aq)

For M3, ignore all three liquid levels, except that the level in the voltameter must be above the bottoms of both tubes if present</td><td>3</td></tr>
<tr><td>b</td><td><table><tr><th>Polarity</th><th>Equation</th></tr><tr><td>−(ve)</td><td>($2H_2O + 2e^- \rightarrow H_2 + 2OH^-$)</td></tr><tr><td>+(ve)</td><td>$2Cl^- \rightarrow Cl_2 + 2e^{(-)}$</td></tr></table></td><td>M1 for $2Cl^- \rightarrow Cl_2 + 2e^{(-)}$
ACCEPT $2Cl^- - 2e^{(-)} \rightarrow Cl_2$

M2 for −(ve) in top row AND +(ve) in bottom row
ACCEPT negative and positive
IGNORE cathode and anode</td><td>2</td></tr>
<tr><td>c</td><td>burns with a pop / squeak

OR

use burning/lit spill / use flame to see if pop/squeak</td><td>Must be reference to test and result
Reference to spill/match with no indication of flame is not enough
ACCEPT splint for spill
REJECT reference to glowing spill/splint
Ignore flame extinguished
'Squeaky pop test' alone is not sufficient</td><td>1</td></tr>
</table>

Question number			Answer	Notes	Marks
3	a		too reactive / very reactive **OR** high in the reactivity series	Accept words with equivalent meaning eg highly	1
	b	i	B (stage 2)		1
		ii	calcium chloride / $CaCl_2$	If both name and formula given, mark name only	1
		iii	(they / the ions) are mobile	Accept free to move Accept move to electrodes (allow even if incorrect electrodes) Accept ions break free from lattice/crystal Not just free Allow they/ions are delocalised Ignore references to conduction	1
		iv	$2Cl^- \rightarrow Cl_2 + 2e^{(-)}$	Accept $2Cl^- - 2e^{(-)} \rightarrow Cl_2$	1

Question number				Answer	Notes	Marks
3	c	i	**M1** **M2**	Correct calculation of M_r ($MgCl_2$) M1 x 2	Sample calculation: M1 = 95 M2 = 190 (kg) Accept 190 000 g **M2** CQ on **M1** when **M1** is a genuine attempt to calculate M_r ($MgCl_2$) Correct answer with no working scores 2	2
	c		Award 2 marks for 4 000 Award 1 mark if one error		2 000 (wrong ratio for Mg and electrons) 4 (working in grams instead of kilograms)	2

Question number				Answer	Notes	Marks
3	d		**M1**	Mix magnesium oxide and sulfuric acid (and heat)		5
			M2	Use excess MgO		
			M3	Filter (before heating to remove some water)		
			M4	Heat (the solution) to remove some water / for a short period of time	If heated to dryness, no M4 or M5	
			M5	Leave to crystallise	Allow place in a warm oven (to evaporate the excess water) to form crystals	

Question number	Answer	Notes	Marks
4 a i	correct statement about connection between number of electrons and moles/molecules/amounts (of both gases) OR reference to number of moles/molecules being equal (in both equations)	eg same number of electrons give same numbers of moles eg equal moles of gases have equal volumes / volumes are proportional to numbers of moles	1
ii	(some/chlorine/it) is soluble / dissolves (in water / in the solution) OR (some/chlorine/it) reacts with water	Accept (some) oxygen also collected Reject chlorine reacts with graphite Ignore chlorine gas escapes Reject reacts with sodium chloride / reacts with sodium hydroxide	1
iii	M1 (solution) alkaline / pH greater than 7 M2 (because) hydroxide ions / OH^- (formed)	Mark M1 and M2 independently Ignore basic Accept any value above 7 up to 14 Accept sodium hydroxide formed	2
b	M1 (result of litmus test) bleaches / goes white M2 (result of KI test) brown (solution) / black precipitate or equivalent	 Ignore red as intermediate colour Accept decolourises / colourless Accept yellow and orange in place of brown Accept grey in place of black Ignore shades such as pale / dark Reject red / red-brown / purple / blue-black	2

Question number	Answer	Notes	Marks
4 c i	to sterilise / disinfect (the water) OR to make it safe to drink	Accept kill bacteria / microbes / pathogens / microorganisms / (harmful) organisms / germs / viruses Ignore references to cleaning / purifying / bleaching / changing pH	1
ii	$H_2 + Cl_2 \rightarrow 2HCl$	Ignore state symbols	1
iii	dissolve in / add to water	Accept mixing with water / bubbling through water / react with water / make aqueous Ignore adding to liquid	1
			Total 9 marks

Question number			Answer	Notes	Marks
5	a		decomposition / breakdown / breakup / splitting / chemical change by electricity / (electric) current / (flow of) electrons	Ignore specific examples that do not include key words (eg obtaining aluminium from its ore) Ignore separation / movement of ions Mark independently	2
	b		A = chlorine / Cl_2 B = hydrogen / H_2 C = sodium hydroxide / NaOH	Ignore Cl Ignore H Ignore references to sodium chloride If both name and formula given, both must be correct, but ignore Cl and H Award 1 mark for chlorine and hydrogen the wrong way round	3

Question number			Answer	Notes	Marks
5	c	i	so that ions are mobile/can flow/free to move (in liquid) OR ions not mobile / cannot flow/ not free to move in solid	Accept Na^+ / Cl^- in place of ions Ignore references to charged species and particles Reject references to moving electrons Reject no ions in solid Reference to solid can be implied (eg if not molten…)	1
		ii	$2Cl^- \rightarrow Cl_2 + 2e^{(-)}$	M1 for Cl^- on left and Cl_2 on right M2 for balancing, DEP on M1 correct Accept $-2e^{(-)}$ on LHS If neither M1 nor M2 awarded, then award 1 mark for $Cl^- \rightarrow Cl + e^{(-)}$ or $2Cl^- \rightarrow 2Cl + 2e^{(-)}$	2

(Total for Question 5 = 8 marks)

<table>
<tr><th>Question number</th><th>Answer</th><th>Accept</th><th>Reject</th><th>Marks</th></tr>
<tr><td>6 (a)</td><td>
<table>
<tr><th>Solution</th><th>Negative electrode</th><th>Positive electrode</th><th>Substance left</th></tr>
<tr><td>silver sulfate</td><td>silver</td><td></td><td></td></tr>
<tr><td>potassium nitrate</td><td></td><td>oxygen</td><td>potassium nitrate</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>
</td><td>correct formulae throughout</td><td>O for oxygen</td><td>1
2</td></tr>
<tr><td>(b) (i)</td><td>platinum</td><td>carbon / graphite
copper/ silver / gold / titanium</td><td></td><td>1</td></tr>
<tr><td>(ii)</td><td>to increase its (electrical) conductivity / to make it a (better) (electrical) conductor / to lower its (electrical) resistance
IGNORE references to carrying current / charge / adds hydrogen ions</td><td>to increase the concentration/number of ions</td><td></td><td>1</td></tr>
<tr><td>(c) (i)</td><td><u>Moles/amount</u> of hydrogen (produced) = 2 x <u>moles/amount</u> of oxygen (produced)

IGNORE explanations based on forming water</td><td>number of <u>molecules</u> of hydrogen (produced) is twice that of oxygen</td><td>explanations based on atoms</td><td>1</td></tr>
<tr><td>(ii)</td><td>(some of the) oxygen dissolves in water/acid</td><td>(some of the) oxygen reacts with the (carbon) electrode/to form CO_2 (which then dissolves)</td><td>oxygen reacts with water/(sulfuric) acid</td><td>1</td></tr>
<tr><td>(d)</td><td>M1 - number of faradays = $\frac{482\,500}{96\,500}$ or 5

M2 - $n(H_2)$ = ½ x M1 or 2.5

Final answer on its own without working scores 2</td><td></td><td>Incorrect units</td><td>1
1</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>9</td></tr>
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