

Electrolysis

Q1. (2018)

A)

24	(a)			2	2 x 1.2									
		<table><tr><th>Experiment</th><th>What happens at cathode (-)</th><th>What happens at anode (+)</th></tr><tr><td>1</td><td>copper deposited / formed ✓</td><td>oxygen made</td></tr><tr><td>2</td><td>copper deposited</td><td>(copper) anode dissolves ✓</td></tr></table>	Experiment	What happens at cathode (-)	What happens at anode (+)	1	copper deposited / formed ✓	oxygen made	2	copper deposited	(copper) anode dissolves ✓			<p>ALLOW copper atoms form (at cathode) IGNORE copper purified (at cathode)</p> <p>ALLOW (anode) loses mass / copper loses electrons / copper ions made / copper is lost (at anode) DO NOT ALLOW copper ions lose electrons</p>
Experiment	What happens at cathode (-)	What happens at anode (+)												
1	copper deposited / formed ✓	oxygen made												
2	copper deposited	(copper) anode dissolves ✓												

B)

	(b)	Non-inert electrodes are changed during electrolysis ✓	1	1.2	ALLOW idea that non-inert electrodes can react (with the solution or the electrode products)
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C)

	(c)	$\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$ formulae ✓ balancing ✓	2	2 x 2.2	<p>balancing mark is conditional on correct formulae ALLOW = or = instead of arrow DO NOT ALLOW and or & instead of + ALLOW $\text{Cu}^{2+} \rightarrow \text{Cu} - 2\text{e}^-$ ALLOW any correct multiples including fractions e.g. $2\text{Cu}^{2+} + 4\text{e}^- \rightarrow 2\text{Cu}$ ALLOW one mark for correct equation with minor errors in case, subscript or superscript e.g. $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{CU}$ IGNORE state symbols</p>
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D)

	(d)	Idea that hydrogen is less reactive than sodium / ORA ✓ So is discharged before sodium / ORA ✓	2	2 x 1.2	<p>ALLOW idea that hydrogen gains electrons more easily (than sodium) / idea that hydrogen is reduced more easily (than sodium) IGNORE hydrogen is made</p>
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Q2. (2019)

14	A ✓	1	1.1	
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Q3. (2019) – 21b

	(b)*	<p>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</p> <p>Level 3 (5–6 marks) Analyses ideas and applies knowledge to explain the formation of the products during the electrolysis of potassium bromide solution, including balanced half equations. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) Analyses ideas and applies knowledge to explain the formation of the products during the electrolysis of potassium bromide solution OR applies knowledge to write balanced half equations. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Applies knowledge to identify the products formed at the electrodes OR applies knowledge to identify the ions present in the solution OR applies knowledge to identify which ions move to each electrode. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks <i>No response or no response worthy of credit.</i></p>	6	<p>2 x 1.1 2 x 2.1 2 x 3.2b</p>	<p>AO1.1 Knowledge of electrolysis</p> <ul style="list-style-type: none"> Negative electrode is cathode Positive electrode is anode Ions move to oppositely charged electrodes <p>AO2.1 Apply knowledge and understanding of the electrolysis of salt solutions</p> <ul style="list-style-type: none"> Hydrogen ions are discharged more readily than potassium ions, so hydrogen is formed at the cathode Bromide ions are discharged more readily than hydroxide ions, so bromine is formed at the anode Cathode: $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ / $2\text{H}^+ \rightarrow \text{H}_2 - 2\text{e}^-$ Anode: $2\text{Br}^- \rightarrow \text{Br}_2 + 2\text{e}^-$ / $2\text{Br}^- - 2\text{e}^- \rightarrow \text{Br}_2$ <p>AO3.2b Analyse ideas about electrolysis to draw conclusions about the electrolysis of potassium bromide solution</p> <ul style="list-style-type: none"> Solution contains K^+ and Br^- ions from potassium bromide and H^+ and OH^- ions from water Positive ions / K^+ and H^+ ions move to negative electrode Negative ions / Br^- and OH^- ions move to positive electrode <p>DO NOT ALLOW reference to bromine ions</p>
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Q4. (2020)

A)

23	(a)	(i)	Cu^{2+} , SO_4^{2-} , H^+ , OH^-	2	2.2	All 4 ions correct for 2 marks 2 or 3 ions correct for 1 mark
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B)

	(b)		Idea that inert electrodes do not react with the electrolyte / inert electrodes are unreactive ✓	1	1.2	ALLOW so that electrodes do not take part in the reaction
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C)

	(c)	(i)	Copper sulfate ✓	1	3.2a	
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D)

		(ii)	<p>Copper chloride produces chlorine which is a toxic gas / copper sulfate does not produce chlorine which is a toxic gas ✓</p> <p>Zinc bromide / sulfuric acid do not have copper <u>ions</u> OR copper sulfate / copper chloride contain copper <u>ions</u> ✓</p>	2	2 x 3.2b	<p>IGNORE idea that chlorine gas is dangerous / hazardous</p> <p>ALLOW idea that the solution contains copper <u>ions</u></p>
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E)

	(d)	(i)	Oxygen / O_2 ✓	1	3.2a	IGNORE O
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F)

		(ii)	Hydrogen is less reactive than sodium / ORA ✓	1	3.2b	Assume unqualified answer refers to hydrogen (gas)
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G)

		(iii)	$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ Formula ✓ Balancing ✓	2	2.1 1.2	ALLOW any correct multiple, including fractions ALLOW = OR $\Rightarrow$ instead of $\rightarrow$ DO NOT ALLOW and / & instead of '+' ALLOW e for e^- Balancing mark is dependent on the correct formulae but ALLOW 1 mark for a balanced equation with a minor error in subscripts / formulae e.g. $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$
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H)

	(e)		Aqueous solutions contain H^+ and OH^- ions / molten state does not contain H^+ and OH^- ions ✓	1	1.2	
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Q5. (2021)

A)

20	(a)		Any one from: Copper anode is decreased in mass / the graphite anode does not decrease in mass ✓ Oxygen is formed at the graphite anode / oxygen is not formed at the copper anode ✓ Copper anode takes part in the reaction / graphite anode doesn't take part in the reaction ✓ Copper anode forms copper ions ✓	1	2.2	ALLOW positive electrode for anode and negative electrode for cathode throughout
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B)

	(b)	(i)	$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ Formulae ✓ Balancing ✓	2	2 x 2.2	ALLOW any correct multiple, including fractions DO NOT ALLOW and / & instead of '+' Balancing mark is dependent on the correct formulae but ALLOW 1 mark for a balanced equation with a minor error in subscripts / formulae e.g. $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$
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C)

		(ii)	Chlorine / Cl_2 ✓	1	2.2	DO NOT ALLOW Cl DO NOT ALLOW Chloride / Cl^-
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D)

		(iii)	Any two from: <u>Ions</u> are free to move in aqueous solution ✓ <u>Ions</u> cannot move in solid ✓ <u>Ions</u> carry a charge / current ✓	2	2 x 2.1	DO NOT ALLOW electrons moving
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E)

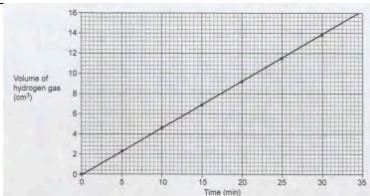
	(c)		B ✓ An (inert) electrode has to conduct electricity ✓ An (inert) electrode has to remain solid / not dissolve ✓	3	3 x 3.2a	If C or D is chosen, score 0 for the question If A is chosen, allow 1 mark for an (inert) electrode has to conduct electricity
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Q6. (2022)

8		C ✓		1	1.2	
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Q7. (2022)

A)

19	(a)	(i)		1	1.2	LOBF must go through the origin
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B)

		(ii)	10.5 (cm ³) ✓	1	2.2	ALLOW Answer ± ½ square of their own graph
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C)

		(iii)	Cathode / negative electrode ✓	1	1.2	
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D)

		(iv)	Chlorine / Cl ₂ ✓	1	1.2	DO NOT ALLOW Cl DO NOT ALLOW Chloride / Cl ⁻
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E)

	(b)	<p>Idea that hydrogen is produced (at the cathode) if ions from a more reactive metal (than hydrogen) are present / idea that only 1 ion is discharged at each electrode / discharge is based on the reactivity series / less reactive ions are discharged in preference ✓</p> <p>Hydrogen is less reactive than sodium / ORA ✓</p> <p>Copper is less reactive than hydrogen / ORA ✓</p>	3	3 x 1.2	
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F)

	(c)	<p>Weigh the <u>negative</u> electrode / <u>cathode</u> before the experiment ✓</p> <p>Weigh the <u>negative</u> electrode / <u>cathode</u> with the copper formed ✓</p> <p>Calculate the change in mass / mass increase ✓</p>	3	3 x 3.3b	<p>ALLOW idea of weighing <u>both</u> electrodes in MP1 and MP2</p> <p>MP3 is independent of MP1 and MP2, i.e. MP3 can still be awarded if anode referred to</p> <p>ALLOW for MP3 weigh the mass of copper formed on the cathode / weigh the residue on the cathode</p> <p>ALLOW weigh the electrode before the experiment and weigh the electrode after the experiment for 1 mark if no other mark awarded</p>
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Q8. (2023)

A)

19	(a)*	<p>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</p> <p>Level 3 (5–6 marks) Accurately applies knowledge and a detailed understanding to explain the product made at the electrode in each experiment</p> <p>AND</p> <p>Determines that the scientist should use experiment 2</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) Clearly, but with some limitations, applies knowledge and understanding to explain the product made at the electrode in each experiment</p> <p>AND</p> <p>Determines that the scientist should use experiment 2</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Attempts to apply knowledge and understanding to explain the product made at the electrode in one of the experiments</p>	6	4 x 2.2 2 x 3.2b	<p>AO3.2b Applies knowledge and understanding of electrolysis</p> <ul style="list-style-type: none"> In experiment 1, molten copper chloride contains only Cu^{2+} ions and Cl^- ions In experiment 2, copper sulfate solution contains Cu^{2+}, SO_4^{2-}, H^+ and OH^- ions Positive metal / hydrogen ions are attracted to the negative cathode Negative non-metal ions and are attracted to the positive anode Cu^{2+} ions are less reactive than H^+ ions Cu^{2+} ions are discharged in preference to H^+ ions <p>AO3.2b Analyses information and ideas to draw conclusions</p> <ul style="list-style-type: none"> Experiment 1 forms chlorine at the anode Experiment 1 forms copper at the cathode Experiment 2 forms copper at the cathode Experiment 2 forms oxygen at the anode Experiment 2 should be used
		<p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks No response or no response worthy of credit.</p>			

B)

	(b)	<p>Electrodes should be in the lead bromide / electrolyte ✓</p> <p>Lead bromide should be molten / the lead bromide should be heated (until it is molten) ✓</p>	2	2 x 3.3b	<p>IGNORE use inert electrodes</p> <p>IGNORE connect the wire together</p> <p>IGNORE lead bromide should be in aqueous solution</p>
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C)

	(c)	<p>$2\text{Br}^- - 2\text{e}^- \rightarrow \text{Br}_2$</p> <p>Correct species ✓</p> <p>Balancing ✓</p>	2	2 x 1.2	<p>Second MP is dependent on the first</p>
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Q9. (2024)

6	B	1	1.2	
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Q10. (2024)

7	A	1	1.2	
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Q11. (2024)

11	C	1	2.2	
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