OCR GCSE GATEWAY CHEMISTRY A · J248

CHEMISTRY



MARK SCHEME

C3.4 ELECTROLYSIS

SCORE	PERCENTAGE
/88	%

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Question			Answer/Indicative content	Marks	Guidance
1			C	1	
			Total	**1**	
2	a		electrolysis needs to run for longer than 30 seconds (1) otherwise insufficient change at electrodes (1) after electrolysis anode and cathode need to be washed (1) and then dried (1) before measuring the mass	4	
	b		copper is deposited at the cathode (1) copper anode dissolves / copper ions produced at anode (1)	2	**ALLOW** higher level answers in terms of half equations e.g. at cathode $Cu^{2+} + 2e^- \rightarrow Cu$ (1) e.g. at anode $Cu \rightarrow Cu^{2+} + 2e^-$ / $Cu - 2e^- \rightarrow Cu^{2+}$ (1)
			Total	**6**	
3		i	$Al^{3+} + 3e^- \rightarrow Al$ (1)	1	**ALLOW** any correct multiple **ALLOW** = instead of → **DO NOT ALLOW** & or and instead of +
		ii	Ions cannot move (1)	1	**IGNORE** electrons cannot move
			Total	**2**	
4	a		<table><tr><th>Positive ions (cations)</th><th>Negative ions (anions)</th></tr><tr><td>Na^+</td><td>Cl^- (1)</td></tr><tr><td>H^+ (1)</td><td>OH^-</td></tr></table>	2	
	b		Volume = 0.564^3 (1) = 0.179406144 (1) to 3 significant figures = 0.179 (1)	3	**ALLOW** 3 marks for 0.179 without any working out
			Total	**4**	
5	a	i	7.5 (g) (1)	1	**allow** 7.4 to 7.6 (1) **Examiner's Comments** Most candidates correctly interpreted the graph and scored the marks.

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Question			Answer/Indicative content	Marks	Guidance
		ii	75 (g) (1)	1	**allow** ecf from (i) i.e. 10 x answer to (i) **Examiner's Comments** Most candidates correctly interpreted the graph and scored the marks.
	b	i i	potassium (1) bromine (1)	2	**allow** K (1) **allow** Br_2 (1) **do not allow** bromide **Examiner's Comments** The products were usually correctly identified as potassium and bromine. Bromide was a common error.
		ii	ions can move / ions go to electrodes (1)	1	**allow** ions move to anode / ions move to cathode (1) **do not allow** electrons can move **Examiner's Comments** A very common misconception was that molten potassium bromide can be electrolysed because the *electrons* can move.
			Total	**5**	

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Question			Answer/Indicative content	Marks	Guidance
6	a		7.5 (g) (1)	1	**allow** 7.4 to 7.6 **Examiner's Comments** This question focused on the electrolysis of molten potassium chloride. Most candidates were able to interpret the graph and give an answer of 7.5 g.
	b		LOOK FOR ANSWER FIRST OF ALL IF mass = 60 g AWARD 2 MARKS idea that must multiply (7.5) by 4 / idea that must multiply (30) by 2 / idea that must multiply (7.5) by 8 (1)	2	**allow** ecf answer to (a) × 8 e.g. 60.8 if 7.6g and 59.2 if 7.4 **allow** ecf **Examiner's Comments** This question focused on the electrolysis of molten potassium chloride. Candidates were able to use their result to get an answer of 60.0 g. Some candidates used Q=It in their answer and went through complex calculations even remembering 96500 to get the correct answer. Other candidates used the correct method of appreciating that the current was doubled and the time quadrupled so that overall the mass will be 8 times the original mass.
			Total	**3**	
7			ethene + water ? ethanol (1)	1	**allow** = instead of ? **allow** correct symbol equation $C_2H_4 + H_2O$? C_2H_5OH or C_2H_6O **allow** steam for water **Examiner's Comments** Many candidates could write the correct word equation but some wrote ethane rather than ethene.
			Total	**1**	

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Question			Answer/Indicative content	Marks	Guidance
8	a	i	$2Cl^{?} \; ? \; Cl_2 + 2e^{?}$ / $2Cl^{?} \; ? \; 2e^{?} \; ? \; Cl_2$ formulae correct including electrons (1) balancing — dependent on correct formulae (1)	2	**allow** = instead of ? **not** and or & instead of + **allow** any correct multiples including fractions **allow** $e^{?}$ or e for electrons **allow** $2Cl^{?} \; ? \; e^{?} \; ? \; Cl_2 + e^{?}$ for two marks **allow** one mark for correct balanced equation with minor errors of case, subscript and/or superscript eg 2CL? ? Cl2 + $2e^{?}$ **allow** one mark for $Cl^{?} \; ? \; e^{?} \; ? \; Cl$ / $Cl^{?} \; ? \; Cl$ + $e^{?}$ **allow** one mark for $2Cl^{?} \; ? \; Cl_2$ **Examiner's Comments** Candidates found the electrode reaction challenging and often candidates had the electrons on the wrong side of the equation or had the formula of chlorine incorrect. A small proportion of candidates did not attempt this question.
		ii	solid sodium chloride has ions in fixed positions / ions do not move in a solid (1) liquid sodium chloride has ions that move (1)	2	**allow** solid does not have free ions **ignore** electrons cannot move in a solid **allow** liquid sodium chloride has free ions **not** electrons can move in a liquid **allow** if no other marks scored award one mark for particles can move in a liquid but not in a solid / liquid has mobile charge carriers but solid does not **Examiner's Comments** Candidates often appreciated that the charge carrier could not move in a solid but could move in a liquid, however most candidates referred to electrons rather than ions as the charge carrier.
	b			2	**allow** reference to the correct data in the table to identify which experiments they are using

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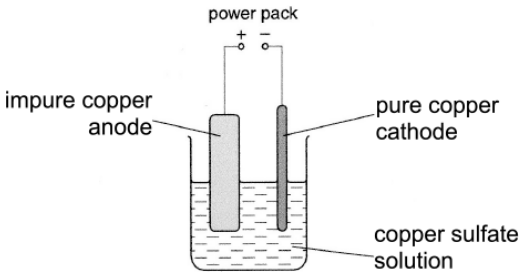
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Question			Answer/Indicative content	Marks	Guidance
			experiments 1 and 3 show that as time doubles mass (of copper made) doubles (1) experiments 3 and 4 show that as the current quadruples, the mass also quadruples (1) OR experiments 1 and 2 show that as current doubles mass (of copper made) doubles (1)		**allow** when the time doubles and the current stays the same the mass doubles **allow** when the current doubles and the time stays the same the mass doubles **allow** if no other marks awarded then as time and current increase the mass (of copper) increases for one mark **Examiner's Comments** In this evaluation question many candidates could use the data to show that as current increases so does the mass and as the time increases so does the mass but were less confident at explaining why this indicated direct proportionality. Only the best answers referred to the experiment numbers in their explanations. Candidates did not always choose sets of experiments where only one variable changed and as a result did not justify the patterns they were describing.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
9	a		$2Br^{?} - 2e^{?} ? Br_2$(1)	1	**allow** any correct multiple, including fractions **not** any additional symbols, other than balancing **Examiner's Comments** Most candidates correctly balanced the equation.
	b		(oxidation because) electrons are lost (from $Br^{?}$) (1)	1	**allow** oxidation number of Br increases (1) **not** bromine (atoms) lose electrons **but allow** ions lose electrons (1) **Examiner's Comments** Most candidates explained that oxidation is loss of electrons. Candidates who did not gain credit either stated that electrons were gained, or suggested that the wrong species was losing electrons, e.g. bromine loses electrons.
			Total	2	
10				2	**all three** labels correct scores 2 marks **one or two** labels correct scores 1 mark **Examiner's Comments** Many candidates scored both marks. Candidates who only scored 1 mark usually correctly identified the electrolyte as copper sulfate solution.
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
11			**advantages any one from:** saves resources (because the ore does not have to be extracted) (1) uses less energy (1) idea of less environmental damage (due to quarrying) (1) **problems any one from:** copper has to be collected (1) copper has to be sorted from other metals (1)	2	must be **one** advantage and **one** problem for 2 marks **allow** copper is in short supply (1) **ignore** saves landfill space **allow** loss of jobs mining or extracting copper ore (1) **Examiner's Comments** Good responses to this question described an advantage and a disadvantage of recycling copper, with candidates usually stating that recycling saves natural resources but that copper is difficult to sort from other metals. Credit was not given for vague references to the environment or reducing pollution.
			Total	2	

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<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>12</td><td></td><td></td><td>
<table>
<tr><th>Ions</th><th>Molecules</th></tr>
<tr><td>(OH^-)</td><td>(H_2)</td></tr>
<tr><td>Cl^-</td><td>Cl_2</td></tr>
<tr><td>H^+</td><td>H_2O</td></tr>
<tr><td>Na^+</td><td></td></tr>
<tr><td></td><td></td></tr>
</table>
all five correct scores (2)
three or four correct scores (1)
two or less correct scores (0)
</td><td>2</td><td>ignore case in formulae

ignore extra entries of OH^- and H_2

Examiner's Comments

Candidates often correctly identified the ions and the molecule from the list.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>2</td><td></td></tr>
<tr><td>13</td><td></td><td></td><td>electrolysis (1)</td><td>1</td><td>allow other ways of indicating correct response eg ringing or ticking the correct answer but answer on answer line takes precedence

Examiner's Comments

Electrolysis was the most common correct answer.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
</table>

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Question			Answer/Indicative content	Marks	Guidance
14	a	i	chlorine (1) potassium (1)	2	**allow** Cl_2 / Cl / CL **not** chloride **allow** K **Examiner's Comments** Generally well known, but a few gave “chloride” as their answer instead of chlorine.
		ii	solid sodium chloride has ions in fixed positions / ions do not move in a solid (1) liquid sodium chloride has ions that move (1)	2	**Ignore** electrons cannot move in a solid **allow** solid has no free ions **allow** liquid sodium chloride has free ions **NOT** electrons can move in a liquid if no other mark scored 1 mark for particles cannot move in a solid but can move in a liquid / liquid has mobile charge carriers but solid does not for one mark **Examiner's Comments** Very few correct answers here. Common errors were to discuss moving electrons or that there is space for the electricity to get through the liquid.

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Question			Answer/Indicative content	Marks	Guidance
	b		experiments **1** and **3** show that as time doubles mass (of copper made) doubles (1) experiments **3** and **4** show that as the current quadruples, the mass also quadruples (1) **OR** experiments **1** and **2** show that as current doubles mass (of copper made) doubles (1)	2	**allow** reference to the correct data in the table to identify which experiments they are using **allow** when the time doubles and the current stays the same the mass doubles **allow** when the current doubles and the time stays the same the mass doubles **allow** if no other marks awarded then as time and current increase the mass (of copper) increases for one mark **Examiner's Comments** Few candidates scored 2 marks here; many candidates were able to score a mark for explaining that as the time and current were increased, the mass of copper deposited increased.
			Total	6	

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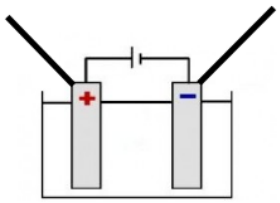
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Question			Answer/Indicative content	Marks	Guidance
15	a		hydrogen (1)	1	**allow** correct answer ticked, circled or underlined in list if answer line is blank Examiner's Comments ??Most candidates correctly identified gas X as hydrogen. Hydrogen chloride was the most common misconception.
	b		chlorine is reactive (and may react with the electrode) / so that the products don't react with the electrode (1)	1	**allow** electrode product reacts with electrode / hydrogen reacts with electrode (1) **ignore** so electrodes do not react with sodium chloride (solution) / so electrodes do not react with solution or electrolyte Examiner's Comments Good responses to this question appreciated that the chlorine gas produced in the electrolysis of sodium chloride may react with the electrode. When candidates did not gain credit it was usually because they suggested that the electrodes would react with the sodium chloride solution. A common misconception was also that inert electrodes would 'make the current flow better'.
			Total	2	
16			A ✓	1(AO1.1)	
			Total	1	
17			B	1 (AO2.2)	Examiner's Comments Candidates found this difficult and all responses were seen; D being the most common.
			Total	1	
18			A	1 (AO2.2)	
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
19	a	i	anode  cathode	2 (AO2 × 1.2)	All correct = 2 marks 1 or 2 correct = 1 mark
		ii	Positive electrode: bromine ✓ Negative electrode: lead ✓	2 (AO2 × 2.2)	**DO NOT ALLOW** bromide **ALLOW** reversed 1 mark
		iii	$PbBr_2$ ✓	1 (AO2.1)	
	b	i	All points plotted correctly scores 2 mark ✓✓ Straight line of best fit through the points ✓	3 (AO2 × 2.2 1.2)	**ALLOW** ± ½ square 3 or 4 points plotted correctly scores 1 mark **ALLOW** correctly drawn line of best fit through incorrectly drawn points; this may be a curve
		ii	0.72 (A) ✓	1 (AO3.1a)	**ALLOW** answer in the range 0.70 A – 0.74 A / ecf
		iii	**FIRST CHECK ANSWER ON ANSWER LINE** **If answer = 47(g) award 2 marks** 5A = 15.5(g) = 15.5 × 3 = 46.5(g) ✓ = 47(g) (2 sig. figs) ✓	2 (AO2.1 1.2)	**ALLOW** 1.0 A = 3.1 (g) (from graph or table) 10(A) = 31(g) and 5 (A) = 1.55 (g) ✓ 15(A) = 31 + 1.55 = (46.5) 47 (g) ✓
			Total	**11**	

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Question			Answer/Indicative content	Marks	Guidance
20		i	ionic✓ oppositely charged ions✓	2 (AO1.1)	**ALLOW** oppositely charged particles / has + and – particles **IGNORE** contains anions and cations (in diagram) **IGNORE** oppositely charged atoms / molecules **DO NOT ALLOW** positive nucleus and negative electrons **Mark independently**
		ii	**Any two from:** Idea of many strong ✓ covalent bonds ✓ (which) require a lot of energy to break ✓	2 (AO1.1)	**Reference to intermolecular forces / bonds / molecular forces scores 0 for question** **ALLOW** many covalent bonds break at high temperatures for 2 marks **ALLOW** idea that each atom has 4 strong covalent bonds for 2 marks **ALLOW** giant covalent structure for 1 mark
		iii	No delocalised electrons / no sea of electron / no mobile charge carriers / ions / electrons structure contains atoms ✓	1 (AO1.1)	**IGNORE** just free electrons
			Total	**5**	

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Question			Answer/Indicative content	Marks	Guidance
21		i	Ionic ✓ oppositely charged ions ✓	2 (AO1.1)	**ALLOW** oppositely charged particles / has + and - particles **IGNORE** contains anions and cations (in diagram) **IGNORE** oppositely charged atoms / molecules **DO NOT ALLOW** positive nucleus and negative electrons **Mark independently**
		ii	**Any two from:** Idea of many strong ✓ covalent bonds ✓ (which) require a lot of energy to break ✓	2 (AO1.1)	**Reference to intermolecular forces / bonds / molecular forces scores 0 for question** **ALLOW** many covalent bonds break at high temperatures for 2 marks **ALLOW** idea that each atom has 4 strong covalent bonds for 2 marks **ALLOW** giant covalent structure for 1 mark
		iii	No delocalised electrons / no sea of electrons / no mobile charge carriers / ions / electrons / structure contains atoms ✓	1 (AO1.1)	**IGNORE** just free electrons
			Total	**5**	

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Question			Answer/Indicative content	Marks	Guidance
22	a		Aqueous solutions contain H^+ and OH^- ions / molten state does not contain H^+ and OH^- ions ✓	1 (AO1.2)	
	b		Cu^{2+}, SO_4^{2-}, H^+, OH^-	2 (AO2.2)	All 4 ions correct for 2 marks 2 or 3 ions correct for 1 mark
	c		Idea that inert electrodes do not react with the electrolyte / inert electrodes are unreactive ✓	1 (AO1.2)	**ALLOW** so that electrodes do not take part in the reaction
	d	i	Copper sulfate ✓	1 (AO3.2a)	
		ii	Copper chloride produces chlorine which is a toxic gas / copper sulfate does not produce chlorine which is a toxic gas ✓ Zinc bromide / sulfuric acid do not have copper <u>ions</u> **OR** copper sulfate / copper chloride contain copper <u>ions</u> ✓	2 (AO2 × 3.2b)	**IGNORE** idea that chlorine gas is dangerous / hazardous **ALLOW** idea that the solution contains copper <u>ions</u>
	e	i	Oxygen / O2 ✓	1 (AO3.2a)	**IGNORE** O
		ii	Hydrogen is less reactive than sodium / ORA ✓	1 (AO3.2b)	**Assume unqualified answer refers to hydrogen (gas)**
		iii	$2H^+ + 2e^- \rightarrow H_2$ Formula ✓ Balancing ✓	2 (AO2.1 1.2)	**ALLOW** any correct multiple, including fractions **ALLOW** = **OR** ⇌ instead of → **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. 2H+ + 2e → H2
			Total	**11**	

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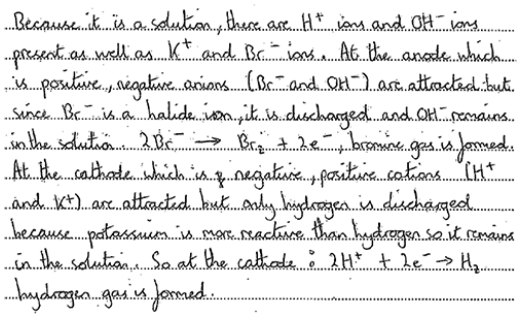
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Question			Answer/Indicative content	Marks	Guidance
23			Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** **Analyses ideas and applies knowledge to explain the formation of the products during the electrolysis of potassium bromide solution, including balanced half equations.** *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **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.** *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **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.** *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	6(AO2 × 1.1 2 × 2.1 2 × 3.2b)	**AO1.1 Knowledge of electrolysis** • Negative electrode is cathode • Positive electrode is anode • Ions move to oppositely charged electrodes **AO2.1 Apply knowledge and understanding of the electrolysis of salt solutions** • 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: $2H^+ + 2e^- \rightarrow H_2$ / $2H^+ \rightarrow H_2 - 2e^-$ • Anode: $2Br^- \rightarrow Br_2 + 2e^-$ / $2Br^- - 2e^- \rightarrow Br_2$ **AO3.2b Analyse ideas about electrolysis to draw conclusions about the electrolysis of potassium bromide solution** • 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 **DO NOT ALLOW** reference to bromine ions **Examiner's Comments** This 6-mark, Level of Response, question assessed AO1, AO2 and AO3. At Level 3 (5 - 6 marks) candidates needed to analyse ideas about electrolysis to draw conclusions about the ions contained in potassium bromide solution and describe which ions move to each electrode. They also needed to explain the formation of the products (hydrogen at the cathode and bromine at the anode), including balanced

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Question			Answer/Indicative content	Marks	Guidance
					half equations. Some of the responses were excellent, with clear explanations of the products formed at each electrode. The answers of lower ability candidates described the formation of the products in the electrolysis of molten, rather than aqueous, potassium bromide. Where candidates scored Level 2, rather than Level 3, it was usually because they omitted to include balanced half equations in their answer. Exemplar 3  Because it is a solution, there are H^+ ions and OH^- ions present as well as K^+ and Br^- ions. At the anode which is positive, negative anions (Br^- and OH^-) are attracted but since Br^- is a halide ion, it is discharged and OH^- remains in the solution. $2Br^- \rightarrow Br_2 + 2e^-$, bromine gas is formed. At the cathode which is -, positive cations (H^+ and K^+) are attracted but only hydrogen is discharged because potassium is more reactive than hydrogen so it remains in the solution. So at the cathode : $2H^+ + 2e^- \rightarrow H_2$, hydrogen gas is formed. This is a Level 3 (6 mark) response, which has correctly identified the ions contained in potassium bromide solution and described which ions move to each electrode. The candidate has explained the formation of the products (hydrogen at the cathode and bromine at the anode), including balanced half equations.
			Total	6	
24			Anode: bubbles / effervescence (1) Cathode: Brown / salmon pink deposit / layer / coating (1)	2	Both correct descriptions but at wrong electrodes
			Total	2	

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