Mark scheme – Electrolysis (H)

Question			Answer/Indicative content	Marks	Guidance
1			A ✓	1(AO1.1)	
			Total	**1**	
2	a		Aqueous solutions contain H^+ and OH^- ions / molten state does not contain H^+ and OH^- ions ✓	1 (AO1.2)	
	b		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
	c	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>
	d	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
	e		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
			Total	**11**	
3		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**	
4			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**	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

			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.*		**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 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 -ve, 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**	
5	a	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
	b		Anode: bubbles / effervescence (1) Cathode: Brown / salmon pink deposit / layer / coating (1)	2	Both correct descriptions but at wrong electrodes

			Total	**4**	
6	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**	
7			C	1	
			Total	**1**	