Questions

Q1.

Figure 4 shows the results obtained from an electrolysis experiment when copper sulfate solution was electrolysed for 10 minutes.

	electrodes	
	anode	cathode
mass of electrode before electrolysis in g	6.43	6.17
mass of electrode after electrolysis in g	5.62	6.95
change in mass in g	– 0.81	+ 0.78

Figure 4

(i) Explain, in terms of ions, the changes in mass of the two electrodes shown in the results in Figure 4.

(3)

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(ii) The electrolysis was repeated using another pair of copper electrodes of the same masses.

Explain a change that could be made to the electrolysis experiment to cause the mass of the cathode to increase by 2.34 g in 10 minutes.

(2)

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(Total for question = 5 marks)

Q2.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

This question is about electrolysis.

A sample of molten potassium bromide is electrolysed.

What are the two products formed?

(1)

- ☐ A hydrogen and oxygen
- ☐ B hydrogen and bromine
- ☐ C potassium and oxygen
- ☐ D potassium and bromine

(Total for question = 1 mark)

Q3.

Molten lead bromide is electrolysed.

The products of this electrolysis are

(1)

- ☐ A hydrogen and bromine
- ☐ B hydrogen and oxygen
- ☐ C lead and bromine
- ☐ D lead and oxygen

(Total for question = 1 mark)

Q4.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Figure 11 shows the apparatus that can be used to electrolyse sodium sulfate solution using inert electrodes.

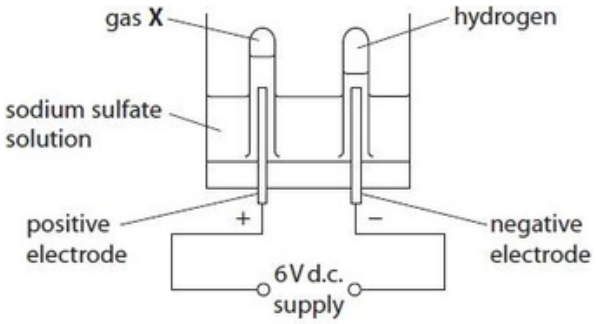


Figure 11

Hydrogen is produced at the negative electrode during electrolysis.

(i) Describe the test to show the gas is hydrogen.

(2)

.....

.....

.....

.....

(ii) What is the name of gas X that forms at the positive electrode?

(1)

- ☒ A ammonia
- ☒ B oxygen
- ☒ C nitrogen
- ☒ D sulfur dioxide

(iii) State what is meant by the term electrolysis.

(2)

.....

.....

.....

.....

(Total for question = 5 marks)

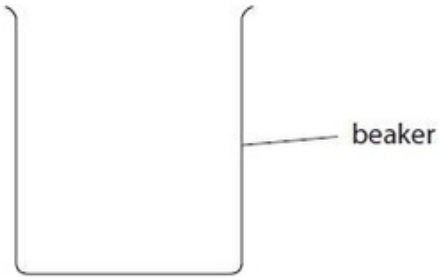
Q5.

A solution of copper sulfate in a beaker is electrolysed using copper electrodes.

(i) Draw a labelled diagram to show how this experiment would be set up.

The beaker has been drawn for you.

(2)



(ii) During the electrolysis, the anode gets smaller, the cathode gets larger and the solution remains the same shade of blue.

Give the reason for each of these observations.

(3)

the anode gets smaller .....

.....

.....

the cathode gets larger .....

.....

.....

the solution remains the same shade of blue .....

.....

.....

(Total for question = 5 marks)

Q6.

When copper sulfate solution is electrolysed using copper electrodes, the mass of each electrode changes.
Draw a labelled diagram to show the apparatus that can be used to electrolyse copper sulfate solution using copper electrodes.

(2)

(Total for question = 2 marks)

Q7.

Figure 10 shows the equipment used to electrolyse a sample of sodium sulfate solution.

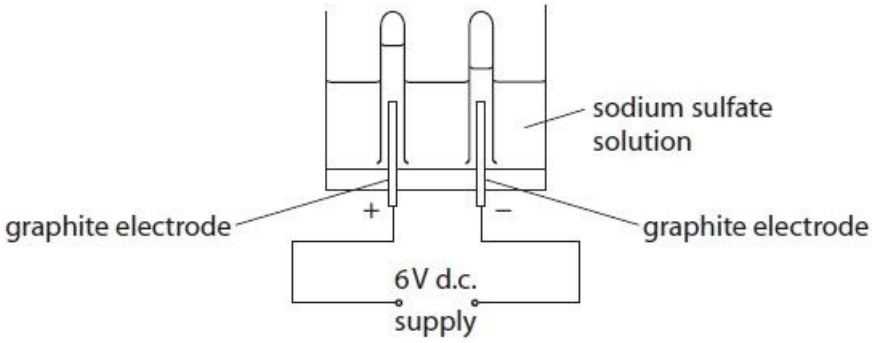


Figure 10

Graphite electrodes are used in the electrolysis of sodium sulfate solution.
Graphite is used because it is inert and conducts electricity.

(i) Figure 11 shows the ions in the sodium sulfate solution.

Draw a circle around each of the ions in Figure 11 that are attracted to the negative graphite electrode during the electrolysis.

(1)

Figure 11

(ii) State why it is important that the electrodes are inert.

(1)

.....

.....

(iii) Explain, in terms of its structure, how graphite conducts electricity.

(2)

.....

.....

.....

(Total for question = 4 marks)

Q8.

Copper sulfate solution was electrolysed using copper electrodes.

(i) Draw a labelled diagram to show the apparatus that is used to carry out this electrolysis in the laboratory.

(2)

(ii) Before the electrolysis, the masses of the electrodes were determined.

After the electrolysis, the electrodes were washed and dried and their masses re-determined.
Figure 6 shows these masses and the resulting changes in masses of the electrodes.

	mass of electrode before electrolysis in g	mass of electrode after electrolysis in g	change in mass of electrode in g
anode	11.27	10.42	−0.85
cathode	11.32	12.17	+0.85

Figure 6

Explain these results.

(4)

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.....

(Total for question = 6 marks)

Q9.

Molten zinc chloride is an electrolyte.

(i) Which row shows the products formed at the anode and at the cathode when molten zinc chloride is electrolysed?

(1)

		product at anode	product at cathode
☒	**A**	oxygen	zinc
☒	**B**	chlorine	hydrogen
☒	**C**	chlorine	zinc
☒	**D**	oxygen	hydrogen

(ii) Which of the following is the reason why molten zinc chloride is an electrolyte?

(1)

☒ A it contains molecules that can move
☒ B it has a giant structure
☒ C it contains delocalised electrons
☒ D it contains ions that can move

(Total for question = 2 marks)

Q10.

Two compounds of barium are barium sulfide and barium chloride.

The sodium chloride solution is electrolysed in the apparatus shown in Figure 8.

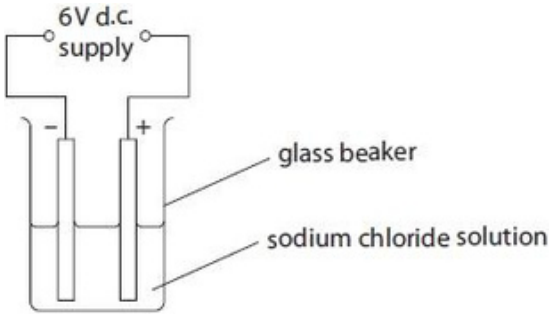

Figure 8

(i) State why sodium chloride solution, rather than solid sodium chloride, must be used in this experiment.

(1)

.....

.....

(ii) The formulae of the ions present in the sodium chloride solution are

Na^+ Cl^- H^+ OH^-

Circle the ions that would be attracted to the anode.

(1)

(iii) Molten lead bromide can be electrolysed to form molten lead and bromine gas.

Explain how a student could modify the apparatus shown in Figure 8 to carry out this electrolysis.

(2)

.....

.....

.....

(Total for question = 4 marks)

Q11.

Calcium nitrate and calcium carbonate are both ionic compounds.

Calcium nitrate mixed with water behaves as an electrolyte.
Calcium carbonate mixed with water does not behave as an electrolyte.
Explain, in terms of solubility and movement of ions, this difference in behaviour.

(2)

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.....

.....

.....

(Total for question = 2 marks)

Q12.

Impure copper can be purified using electrolysis.

In this electrolysis

- the anode is made of impure copper
- the cathode is made from pure copper
- the electrolyte is copper sulfate solution.

The apparatus at the start of the experiment is shown in Figure 10.

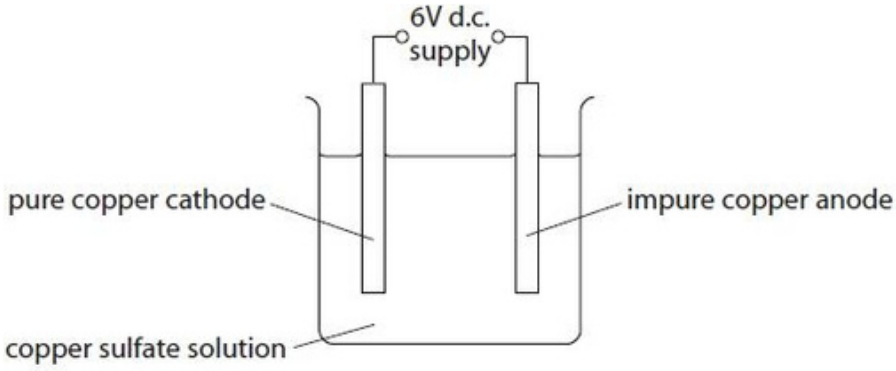

Figure 10

During the electrolysis three observations are made

- the sizes of both the anode and the cathode change
- a solid appears directly beneath the anode
- the colour of the copper sulfate solution does not change.

Explain all three observations.

(Total for question = 6 marks)

Q13.

Before the electrolysis is carried out, the mass of each electrode is determined.

Explain what should be done to the copper electrodes before their masses are determined.

(2)

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(Total for question = 2 marks)

Q14.

When sodium sulfate solution is electrolysed, using inert electrodes, hydrogen is formed at the cathode.
Write the half equation for the formation of hydrogen gas, H_2, from hydrogen ions, H^+.

(2)

.....

(Total for question = 2 marks)

Q15.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Concentrated hydrochloric acid can be broken down using electricity.
The apparatus that can be used is shown in Figure 6.

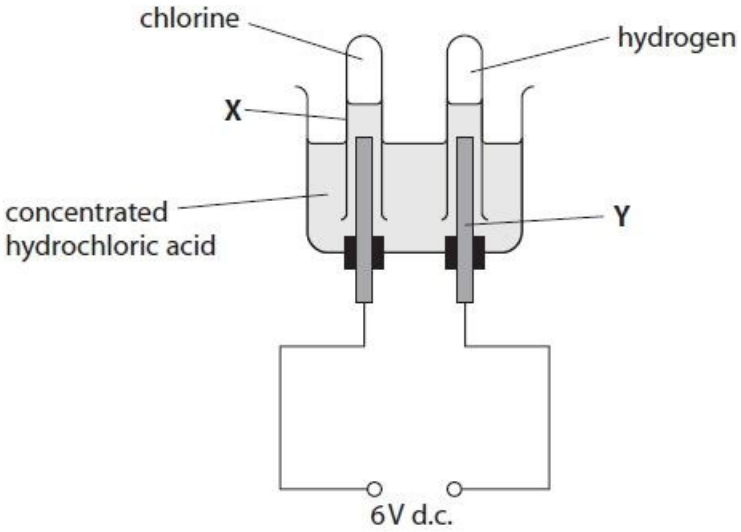

Figure 6

(i) Give the name of the piece of apparatus labelled X.

(1)

.....

(ii) The rod labelled Y in Figure 6 is made of graphite.

What is the name of this piece of apparatus?

(1)

- ☒ A electrode
- ☒ B electrolysis
- ☒ C electrolyte
- ☒ D electron

(iii) Give one reason why graphite is a suitable material to make Y.

(1)

.....

(iv) Complete the balanced equation for the reaction that occurs.

(1)

..... $HCl \rightarrow H_2 + Cl_2$

(Total for question = 4 marks)

Q16.

In the electrolysis of sodium chloride solution, bubbles of a colourless gas form at the cathode.
This gas, when mixed with air, burns with a squeaky pop.

(i) Identify this gas.

(1)

.....

(ii) Explain how this gas is formed at the cathode.

(2)

.....

.....

.....

.....

(Total for question = 3 marks)

Q17.

Objects made from transition metals are sometimes coated with a thin layer of another transition metal to improve their appearance and to protect against corrosion.

Figure 10 shows equipment that can be used to electroplate an iron spoon with silver.

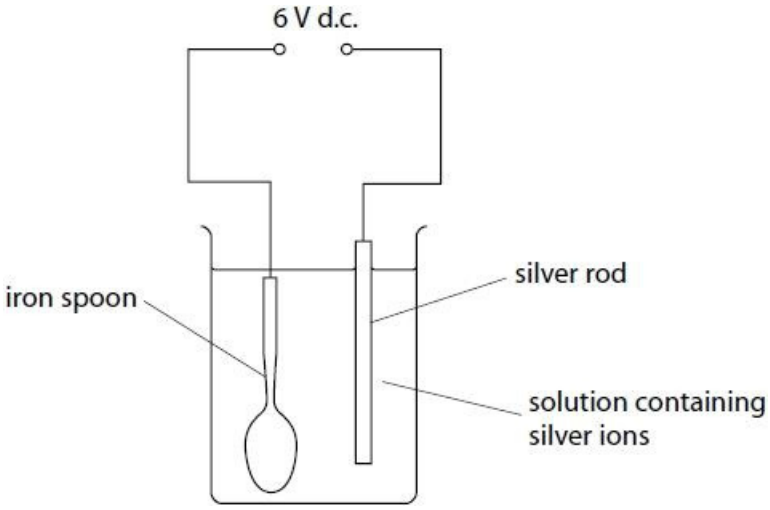

Figure 10

(i) Which row of the table correctly shows the charge on the silver rod electrode and the type of reaction occurring at this electrode?

(1)

	charge	type of reaction
☒ A	negative	oxidation
☒ B	negative	reduction
☒ C	positive	oxidation
☒ D	positive	reduction

(ii) Silver metal is deposited on the spoon.

Which half-equation represents this reaction?

(1)

- ☒ A $Ag + e \rightarrow Ag^+$
- ☒ B $Ag \rightarrow Ag^+ + e^-$
- ☒ C $Ag^+ + e \rightarrow Ag$
- ☒ D $Ag^+ \rightarrow Ag + e^-$

(Total for question = 2 marks)

Q18.

Figure 11 shows the apparatus that can be used to electrolyse sodium sulfate solution using inert electrodes.

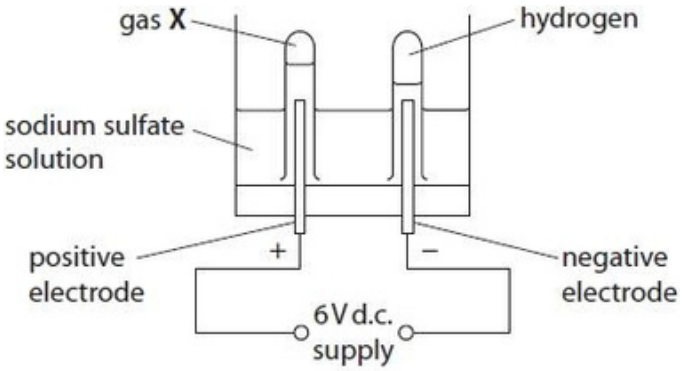

Figure 11

(i) In Figure 11, the gases given off at the electrodes are collected in test-tubes.

However, the actual volume of gases cannot be measured using these test-tubes.
Suggest what apparatus could be used in place of the test-tubes in Figure 11 to measure the volume of gases
given off.

(1)

.....

(ii) State what could be added into the circuit to show a current is flowing during electrolysis.

(1)

.....

(Total for question = 2 marks)

Q19.

When molten zinc chloride is electrolysed, zinc ions, Zn^{2+}, form zinc atoms.

Write the half equation for this reaction.

(2)

.....

(Total for question = 2 marks)

~~Mark Scheme~~

Q1.

Question number	Answer	Additional guidance	Mark
(i)	An explanation linking • at anode copper / atoms {lose electrons / oxidised} / (copper) ions leave anode (– cause mass loss) (1) • (copper) ions (in solution) move to cathode (1) • At cathode (copper) **ions** {gain electrons / reduced} (- cause mass increase) (1)	allow Cu → $Cu^{2+} + 2e^{(-)}$ reject mass loss is due to loss of electrons ignore copper dissolves allow $Cu^{2+} + 2e^{(-)} \rightarrow Cu$ reject mass gain is due to gain of electrons if no other mark scored allow oxidation at anode and reduction at cathode (1)	(3) AO3-2

Question number	Answer	Additional guidance	Mark
(ii)	An explanation linking • mass of copper increased by {3x / calculated 2.34/0.78} (=3) (1) • (so) need (3x) / more {current / voltage} passing through solution (1)	allow need (3 x) {greater surface area of electrode / larger electrode / greater concentration (of copper sulfate solution)} / reduce distance between electrodes allow power in place current or voltage 3x { current / voltage / power }= 2 marks	(2) AO2-2

Q2.

Question number	Answer	Mark
	D potassium and bromine D is the only correct answer. A is incorrect since neither hydrogen nor oxygen are products of this electrolysis. B is incorrect because only bromine is a product and hydrogen is not a product of this electrolysis. C is incorrect since only potassium is a product and oxygen is not a product of this electrolysis.	(1) AO1

Q3.

Question number	Answer	Mark
	C lead and bromine is the only correct answer A is incorrect because lead is produced at the cathode B is incorrect because lead and bromine are produced D is incorrect because bromine is produced at the anode	(1)

Q4.

Question number	Answer	Additional guidance	Mark
(i)	A description including • apply lighted splint (1) • gas burns / (squeaky) pop (1)	 allow flame / ignite gas ignore 'squeaky pop test' / glowing splint second mark is dependent on first	(2)

Question number	Answer	Mark
(ii)	**B** oxygen **The only correct answer is B** **A**, **C** & **D** these gases are not produced in the electrolysis of sodium sulfate solution	(1)

Question number	Answer	Additional guidance	Mark
(iii)	• electrical energy / electricity (1) • {decomposes / breaks down / splits} {electrolytes / (ionic) compounds / substances} (1)	allow electric current allow **separates** ions reject decomposing elements for MP2	(2)

Q5.

Question number	Answer	Additional guidance	Mark
(i)	Diagram to show • electrodes in solution (1) • wires and power supply connected to give a complete circuit (1)	max 1 mark if no labelling Ignore any charges on the diagram	(2) AO1

Question number	Answer	Additional guidance	Mark
(ii)	• anode: smaller because copper atoms form ions (and go into solution) / oxidation of Cu atoms (1) • cathode: larger because copper atoms are formed (from ions in the solution) / reduction of Cu^{2+} (1) • solution: the same number of ions enter and leave solution (1)		(3) AO1

Q6.

Question number	Answer	Additional guidance	Mark
	Diagram showing • two (copper) electrodes in {beaker / suitable container} of {copper sulfate / solution / electrolyte} (1) • connected to {power supply / battery / cell} (1)	diagram needs to be labelled to score full marks electrodes must go into solution for MP1 reject AC / mains supply	(2) AO1-2

Q7.

Question number	Answer	Additional guidance	Mark
(i)	H^+ **and** Na^+ **only** circled		(1) AO1-1

Question number	Answer	Additional guidance	Mark
(ii)	so that they do not react (with the electrolyte/sodium sulfate solution / products formed)	allow graphite is unreactive allow so they do not corrode	(1) AO1-1

Question number	Answer	Additional guidance	Mark
(iii)	An explanation linking: • **electrons** (1) • move (through graphite) / are {delocalised / free / sea of electrons} (1)	 ignore 'charged particles' for MP1 but allow for MP2 reject ions for MP1 and MP2 'electrons in bonds/ electrons in outer shell' scores MP1 only MP2 depends on **electrons** or charged particles being mentioned ignore any other material about structure of graphite, correct or otherwise	(2) AO1-1

Q8.

Question Number	Answer	Additional guidance	Mark
(i)	A diagram of a workable apparatus showing a complete circuit including • electrodes labelled in (copper sulfate) solution (1) • {power supply / power pack / battery} connected (1)	 max 1 if circuit not complete allow labelling as 'electrodes' or 'anode' and 'cathode' or 'copper' ignore 'connected to mains' allow symbol for cell/battery even if wrong way round	(2) AO 1 2

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation linking the following point to a maximum of four • anode lost copper **and** cathode gained copper / reaction at cathode is reverse of reaction at anode / copper ions move into solution at anode AND copper ions move out of solution at cathode (1) and any three from • at anode copper atoms become copper ions (1) and lose **two** electrons (1) OR (at anode) $Cu \rightarrow Cu^{2+} + 2e$ (2) • at cathode copper ions become copper atoms (1) and gain **two** electrons (1) OR (at cathode) $Cu^{2+} + 2e \rightarrow Cu$ (2)	ignore references to zinc, chlorine and zinc chloride allow copper atoms are oxidised (1) marking points independently allow copper ions are reduced (1) marking points independently penalise wrong use of atom / ion once only penalise wrong use of reduced / oxidised once only	**(4)** AO 2 1

Q9.

Question Number	Answer	Mark
(i)	**C** chlorine zinc **The only correct answer is C** ***A*** *is not correct because oxygen cannot be produced by the electrolysis of this molten salt* ***B*** *is not correct because hydrogen cannot be produced by the electrolysis of this molten salt* ***D*** *is not correct because hydrogen and oxygen cannot be produced by the electrolysis of this molten salt*	**(1)** AO 2 1

Question Number	Answer	Mark
(ii)	**D** it contains ions that can move **The only correct answer is D** ***A*** *is not correct because molten zinc chloride does not contain molecules* ***B*** *is not correct because molten zinc chloride does not have a giant structure* ***C*** *is not correct because delocalised electrons are not present*	**(1)** AO 1 1

Q10.

Question Number	Answer	Additional guidance	Mark
(i)	so that the ions can move	allow the solid does not conduct allow conducts when {in solution/liquid} ignore conducts when molten allow so cations / anions can move ignore so particles can move reject electrons move	**(1)** AO 2 2

Question Number	Answer	Mark
(ii)	OH^- and Cl^- only circled	**(1)** AO 1 1

Question Number	Answer	Additional guidance	Mark
(iii)	An explanation linking one of the following pairs of points • use a crucible/metal container (instead of a beaker) (1) • which will not break/melt (when heated strongly) (1) OR • add a Bunsen burner (under the container) (1) • because heat needed to melt the lead bromide / to make the lead bromide a liquid (1)	allow blow torch ignore hot water bath	**(2)** AO 3 3b

Q11.

Question number	Answer	Additional guidance	Mark
	An explanation linking: • (calcium) nitrate {is soluble/ dissolves}/ (calcium) carbonate {is insoluble/ does not dissolve} (1) • so **ions** {free to move in solution / not free in solid} (1)	calcium nitrate dissolves so ions can move (2) or reverse argument for calcium carbonate	(2)

Q12.

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (6 marks)** • copper atoms form copper ions at anode • (copper atoms are oxidised / lose electrons) • $Cu \rightarrow Cu^{2+} + 2e$ • copper ions pass into solution • copper ions move to / are attracted by the cathode • cathode increases in size / gains mass • pink/ brown colour on the surface of the cathode • solid copper deposited on the cathode • (copper ions are reduced/gain electrons) • copper ions form copper atoms • $Cu^{2+} + 2e \rightarrow Cu$ • copper sulfate solution is blue colour • colour remains same since for every copper ion entering the solution at the anode, one is removed from the solution at the cathode • concentration of copper sulfate (solution) remains the same • solid is the insoluble impurities falling from the anode	(6)

Level	Mark	Descriptor
	0	• No awardable content
Level 1	1-2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1) • Presents a description which is not logically ordered and with significant gaps. (AO1)
Level 2	3-4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1) • Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing.(AO1)
Level 3	5-6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1) • Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	**Mark**	**Additional Guidance**	**General additional guidance – the decision within levels** Eg - At each level, as well as content, the scientific coherency of what is stated backed up by further detail will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance A simple statement about one of the three observations	Possible candidate responses • the cathode increases in size and anode decreases in size • solid beneath the anode is the impurities • the amount of copper in solution stays the same / same blue colour throughout
Level 2	3–4	Additional guidance Explains at least one of the observations OR gives two or more partial explanations	Possible candidate responses • solid copper deposits on the cathode, so size increases • solid beneath the anode is the insoluble impurities • copper ions moving and direction from anode to cathode
Level 3	5–6	Additional guidance Explains at least two observations OR at least one in detail	Possible candidate responses • the ions move to the correct electrodes linked with the correct change in size of both electrodes • colour does not change since copper ions enter solution at anode copper ions removed from solution at cathode • copper atoms form copper ions at the anode and pass into the solution, so size of anode decreases; copper ions in the solution are attracted to the cathode

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Q13.

Question number	Answer	Additional guidance	Mark
	An explanation linking • (electrodes) cleaned (using emery paper) (or similar) (1) • to remove {surface oxide / grease / impurities} (1)	 allow scrubbed allow dip / wash into named organic solvent allow dirt / other substances reject rust	**(2)** AO1-2

Q14.

Question Number	Answer	Additional guidance	Mark
	$2H^+ + 2e^{(-)} \rightarrow H_2$ / $2H^+ \rightarrow H_2 - 2e^{(-)}$ (2) species in correct place as shown above (1) balancing of correct species in correct place (1)	allow use of = or ⇌ in place of → allow multiples reject h2 / h_2 / H2 / H^2	**(2)** AO 1 1

Q15.

Question number	Answer	Mark
(i)	test tube/ boiling tube	**(1)** **AO1**

Question number	Answer	Mark
(ii)	**A** electrode is the only correct answer. **B**, **C** and **D** are incorrect because they are not electrodes.	**(1)** **AO2**

Question number	Answer	Additional guidance	Mark
(iii)	it conducts (electricity)/ is inert	ignore high melting point	**(1)** **AO1**

Question number	Answer	Mark
(iv)	**2** $HCl \rightarrow H_2 + Cl_2$	**(1)** **AO2**

Q16.

Question number	Answer	Mark
(i)	hydrogen / H_2	(1) AO3

Question number	Answer	Additional guidance	Mark
(ii)	An explanation linking • hydrogen ions attracted to cathode/negatively charged electrode (1) • (two) hydrogen ions {gain (two) electrons /are reduced / form hydrogen molecules} / correct half equation ($2H^+ + 2e^{(-)} \rightarrow H_2$) (1)	allow positively charged ions attracted to cathode ignore references to sodium ions	(2) AO1

Q17.

Question number	Answer	Mark
(i)	C	(1)

Question number	Answer	Mark
(ii)	C	(1)

Q18.

Question number	Answer	Additional guidance	Mark
(i)	measuring cylinder(s)	allow alternative apparatus eg graduated test-tube, burette, Hofmann voltameter, gas syringe	(1)

Question number	Answer	Additional guidance	Mark
(ii)	light bulb / lamp / ammeter	allow alternative equipment eg buzzer ignore voltmeter / data-logger alone	(1)

Q19.

Question number	Answer	Additional guidance	Mark
	$Zn^{2+} + 2e^{(-)} \rightarrow Zn$ (2)	if not fully correct, allow 1 for Zn^{2+} + (any number) $e^{(-)} \rightarrow$ (anything) allow ZN, zn allow multiples reverse reaction scores (0) ignore state symbols $Zn^{2+} \rightarrow Zn - 2e^{(-)}$ (0)	(2)