

Electrolysis – Easy

Mark Scheme



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1. Electrolysis is a process that uses an electric current to break down an ionic compound into its simpler elements. Circle the letter of the correct answer for each of the following questions.

a. An electrolysis experiment is done using graphite (carbon) electrodes.

Hydrogen and oxygen are formed at the electrodes.

Which of the following substances **could** act as the electrolyte in this experiment?

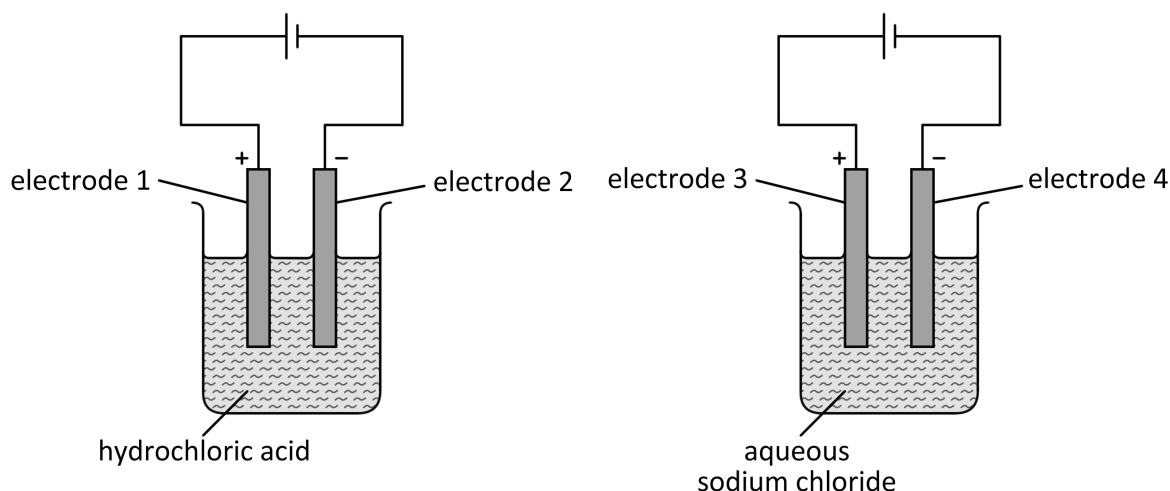
C – is the correct answer.	1 mark
	Total: 1 mark

b. Which substance produces hydrogen and bromine when electrolysed?

C – is the correct answer.	1 mark
	Total: 1 mark

c. A student sets up two experiments to electrolyse two different solutions, as shown in the diagram. In both experiments, a gas is produced at the negative electrode (the cathode).

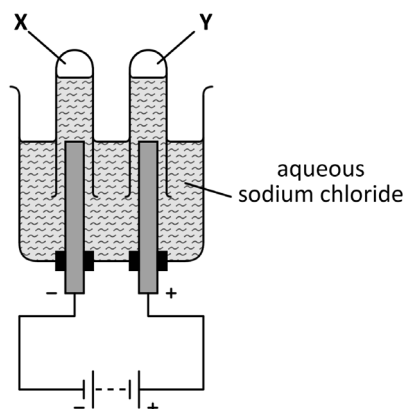
Identify the electrode or electrodes where **hydrogen gas** is produced.



D – is the correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 3 marks)

2. A student investigates what happens when electricity is passed through concentrated aqueous sodium chloride, as shown in the diagram.



- a) The diagram shows that the solution is connected to a power supply.

- i. Name the scientific term for the positive electrode.

Anode.	1 mark
	Total: 1 mark

- ii. Name the scientific term for the negative electrode.

Cathode.	1 mark
	Total: 1 mark

- b) The electrolyte is 'aqueous sodium chloride'. This means sodium chloride is dissolved in water.
List the four types of ion present in the solution.

Sodium (ions) / Na^+ and chloride (ions) / Cl^-	1 mark
Award 1 mark for both ions from sodium chloride.	
Hydrogen (ions) / H^+ and hydroxide (ions) / OH^-	1 mark
Award 1 mark for both ions from water.	
	Total: 2 marks

- c) Two different gases, X and Y, are collected in the test tubes.
Use the diagram and your knowledge of electrolysis to identify them.

i. Name Gas X: Hydrogen	1 mark
	Total: 1 mark

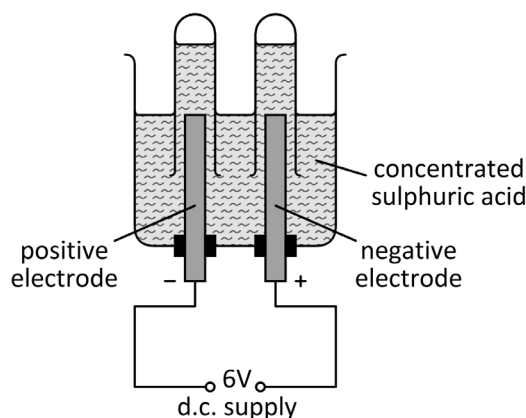
ii. Name Gas Y: Chlorine	1 mark
	Total: 1 mark

- d) Describe the simple chemical test a student could use to prove that Gas Y is chlorine.

Test: Place damp or moist blue litmus paper into the gas.	1 mark
Positive result: the litmus paper <u>turns red</u> and is then <u>bleached</u> or <u>turns white</u>.	1 mark
Allow 'turns red then white/bleached'. Do not accept 'turns red' on its own.	
	1 mark
	Total: 2 marks

(Total for Question 2 is 8 marks)

3. The figure below shows the apparatus used for the electrolysis of water acidified with concentrated sulfuric acid.



- a) Give the scientific name for:

- i. the positive electrode.

Anode.	1 mark
	Total: 1 mark

- ii. the negative electrode.

Cathode.	1 mark
	Total: 1 mark

- b) Gases are collected in the two test tubes.

- i. Name the gas produced at the negative electrode.

Hydrogen. Accept: H₂	1 mark
	Total: 1 mark

- ii. Describe the chemical test to identify the gas produced at the negative electrode.

A description to include:	
Test: place a lit splint at the mouth of the test tube.	1 mark
Result: a 'squeaky pop' sound is heard. Accept 'makes a pop'.	1 mark
	Total: 2 marks

- c) Pure water does not conduct electricity. Explain why dilute sulfuric acid is added.

Pure water has no or very few mobile ions. The answer must refer to ions for the mark. Do not accept no free electrons.	1 mark
The sulfuric acid provides ions (H ⁺ and SO ₄ ²⁻) that are free to move (and carry the charge). Accept: acid is an electrolyte or acid contains mobile ions.	1 mark
	Total: 2 marks

- d) After the experiment runs for some time, the volume of gas collected above the negative electrode is different to the volume of gas collected above the positive electrode.

The volume of gas at the negative electrode is twice / double the volume of gas at the positive electrode.	1 mark
Because the ratio of hydrogen (at the negative) to oxygen (at the positive) is 2 : 1.	1 mark
	Total: 2 marks

Copper sulfate solution was electrolysed for 10 minutes using copper electrodes.
The table below shows the mass of the cathode and the appearance of the copper sulfate solution before electrolysis and after electrolysis.

	Mass of cathode (g)	Appearance of copper sulfate solution
Before electrolysis	4.12	pale blue solution
After electrolysis	5.20	pale blue solution

- e) After the experiment, the copper cathode is removed from the solution.

Describe the steps a student should take to prepare the cathode for its final weighing to ensure the result is accurate.

A description to include:	
Rinse / wash the electrode with (distilled) water.	1 mark
Dry the electrode (thoroughly).	1 mark
Accept: pat dry with a paper towel or place in a low-temperature oven or leave to dry.	
	Total: 2 marks

- f) The table shows that the cathode gained mass. Use your knowledge of electrolysis to explain how this happens.

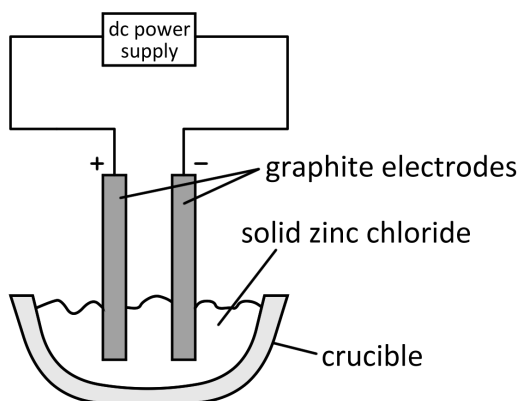
In your answer you should describe:

- which ions in the solution are attracted to the cathode.
- what happens to these ions at the surface of the cathode.

Positive copper(II) ions / Cu^{2+} are attracted to the (negative) cathode.	1 mark
Accept: copper ions.	
The ions gain (two) electrons / are reduced, forming copper atoms / metal.	1 mark
Must state that copper atoms/metal are formed.	
Accept the balanced half-equation: $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$ for this mark.	
	Total: 2 marks

(Total for Question 3 is 13 marks)

4. A student used electrolysis to break down a number of different chemical substances. The figure below shows some of the apparatus that the student used.



- a) When the student switches on the power supply, no electricity flows and nothing happens. Explain why electrolysis would **not** happen in the apparatus shown in the figure above.

An explanation to include the following:	
Zinc chloride is an ionic compound / contains ions.	1 mark
Accept: it is in an ionic lattice.	
In the solid state, these ions are not free to move (and carry charge).	1 mark
Accept: ions are in fixed positions.	
	Total: 2 marks

- b) The student then heats the crucible until the zinc chloride melts. Electrolysis now takes place.

- i. What is the name given to the substance that is broken down by electrolysis?

Electrolyte.	1 mark
	Total: 1 mark

- ii. Predict the products formed at the positive and negative electrodes.

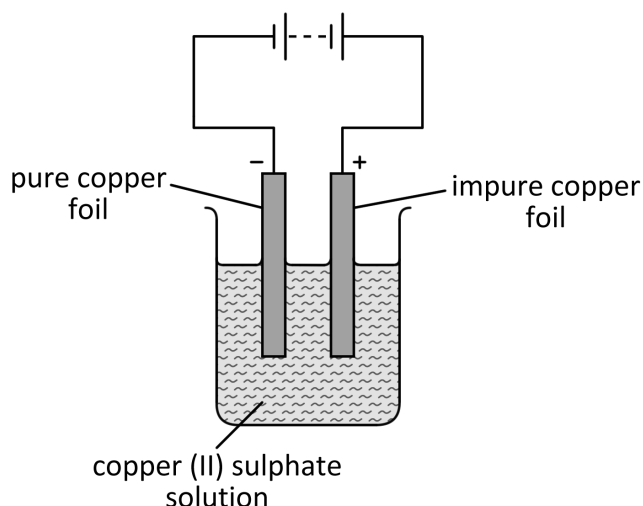
At the positive electrode: Chlorine. Accept: Cl_2	1 mark
At the negative electrode: Zinc. Accept: Zn	1 mark
	Total: 2 marks

- c) Explain why zinc metal is formed at the negative electrode. Refer to ions and electrons in your answer.

Positive zinc ions / Zn^{2+} are attracted to the negative electrode / cathode.	1 mark
At the electrode, the ions gain electron(s) / are reduced to form zinc atoms/metal.	1 mark
Accept: the half-equation $\text{Zn}^{2+} + 2\text{e}^- \rightarrow \text{Zn}$ for this mark.	
	Total: 2 marks

(Total for Question 4 is 7 marks)

5. Copper can be extracted and later purified by the electrolysis of copper sulphate solution. The image below shows the purification of copper from copper sulphate solution.



- a) What is the name for the positive electrode?

Anode.	1 mark
	Total: 1 mark

- b) During the experiment, the masses of the two copper foils change. Describe the change in mass you would expect for:

- i. The pure copper foil.

(Mass) increases / gets bigger.	1 mark
	Total: 1 mark

- ii. The impure copper foil.

(Mass) decreases / gets smaller.	1 mark
	Total: 1 mark

- c) Explain why the mass of the pure copper foil changes. Your answer should be in terms of copper ions and electrons.

An explanation to include:	
(Positive) copper ions / Cu^{2+} are attracted to the pure copper foil / negative electrode.	1 mark
The ions gain (two) electrons / are reduced, forming a layer of copper atoms/metal.	1 mark
	Total: 2 marks

- d) Write the half-equation for the reaction taking place at the pure copper foil (the negative electrode).

$\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$	2 marks
Award 1 mark for correct species on the correct sides of the equation. Award 1 mark for the correct balancing of electrons on the left-hand side	
	Total: 2 marks

6. Sodium chloride can be electrolysed when it is molten or when it is dissolved in water to form an aqueous solution.

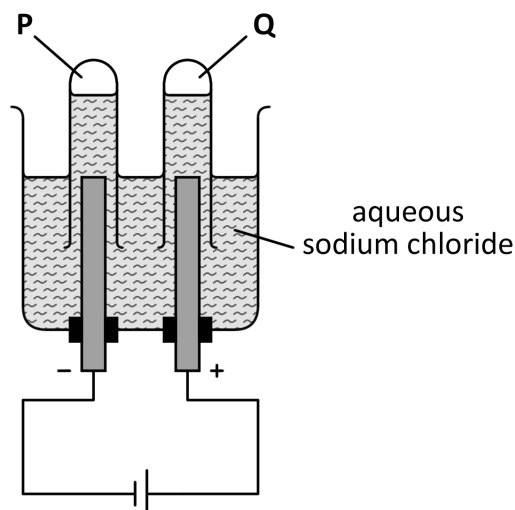
Compare the electrolysis of molten sodium chloride with the electrolysis of aqueous sodium chloride solution.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	A simple statement is made about one or both of the processes. The answer may identify one or two correct products but may confuse the molten and aqueous scenarios.
Level 2	3 - 4	A description of both processes is given with some attempt at comparison. The answer identifies the products formed in both processes, but there may be some errors or omissions. Some explanation for the formation of products is included, but it may be incomplete
Level 3	5 - 6	A detailed and coherent comparison of both processes is given. The answer correctly identifies all ions present in both electrolytes and correctly states the products at both electrodes for both processes. A clear explanation is given for the formation of all products, including the application of rules of selective discharge for the aqueous solution.

Indicative content	
Ions Present: - In molten sodium chloride, the ions present are sodium (Na^+) and chloride (Cl^-). - In aqueous sodium chloride, the ions present are sodium (Na^+), chloride (Cl^-), hydrogen (H^+) and hydroxide (OH^-). Electrolysis of Molten Sodium Chloride: - At the negative electrode (cathode): Positive sodium ions (Na^+) are attracted. They gain electrons to form sodium metal. - At the positive electrode (anode): Negative chloride ions (Cl^-) are attracted. They lose electrons to form chlorine gas. Electrolysis of Aqueous Sodium Chloride: - At the negative electrode (cathode): Both Na^+ and H^+ ions are attracted. Hydrogen is produced because hydrogen is less reactive than sodium. Hydrogen ions gain electrons to form hydrogen gas. - At the positive electrode (anode): Both Cl^- and OH^- ions are attracted. Chlorine is produced because the solution is concentrated, so the halide ion is discharged. Chloride ions lose electrons to form chlorine gas. Key Comparisons: - The product at the positive electrode (chlorine) is the same for both. - The product at the negative electrode is different: sodium for molten, hydrogen for aqueous. - This difference is because in the aqueous solution water is present, providing H^+ ions which are discharged in preference to the more reactive Na^+ ions.	
	Total: 6 marks

(Total for Question 6 is 6 marks)

7. A student uses the apparatus shown below to investigate the electrolysis of concentrated aqueous sodium chloride. Gases are collected in test tubes P and Q.



- a) The electrolyte contains four different ions. Name all four ions present in the solution.

Sodium (ions) / Na^+ and Chloride (ions) / Cl^-	1 mark
Award 1 mark for both ions from sodium chloride.	
Hydrogen (ions) / H^+ and Hydroxide (ions) / OH^-	1 mark
Award 1 mark for both ions from water.	
	Total: 2 marks

- b) Explain why hydrogen gas is produced at the negative electrode (in test tube P) and not sodium metal.

An explanation to include:	1 mark
Hydrogen is less reactive than sodium.	1 mark
Therefore, hydrogen ions gain electrons / are discharged in preference to sodium ions.	1 mark
	Total: 2 marks

- c) Describe the chemical test a student would use to identify the gas collected in test tube Q.

State the positive result.

Test: place damp / moist litmus paper into the gas.	1 mark
Positive result: the litmus paper turns red and is then bleached or turns white.	1 mark
Allow 'turns red then white/bleached'. Do not accept 'turns red' on its own.	
	Total: 2 marks

- d) After the experiment has run for some time, the remaining solution is tested with universal indicator. The indicator turns blue/purple.

- i. What does this pH change indicate about the solution?

The solution is alkaline / a base.	1 mark
	Total: 1 mark

- ii. Name the chemical substance formed during the electrolysis that causes this pH change.

Sodium hydroxide. Accept: NaOH	1 mark
	Total: 1 mark

- e) Write the **balanced** half-equation for the reaction occurring at the **positive electrode**.

$2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$	2 marks
Award 1 mark for the correct species.	
Award 1 mark for the correct balancing.	
	Total: 2 marks

- f) Write the **balanced** half-equation for the formation of the gas in test tube P.

$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$	2 marks
Award 1 mark for the correct species.	
Award 1 mark for the correct balancing.	
	Total: 2 marks

- g) The student repeats the experiment but uses dilute aqueous sodium chloride instead of a concentrated solution.

- i. Name the gas that would now be produced at the positive electrode (in test tube Q).

Oxygen. Accept: O₂	1 mark
	Total: 1 mark

- ii. Explain why this gas is produced instead of the gas that was formed in the first experiment.

An explanation to include:	
In a dilute solution, hydroxide ions / OH ⁻ are discharged.	1 mark
Accept: chloride ions are not discharged unless the solution is concentrated.	
Because there are not enough / a low concentration of chloride ions.	1 mark
Accept: there is a higher concentration of hydroxide ions than chloride ions.	
	Total: 2 marks

(Total for Question 7 is 15 marks)