

GCSE Chemistry (9 – 1)

Electrolysis – Moderate to Challenging

Name:

Group:

Instructions

- Read each question carefully before you begin to answer it.
- Use black ink or black ball-point pen for your answers.
- Fill in the boxes at the top of this page with your name and group.
- Attempt to answer every question in the booklet.
- Answer the questions in the spaces provided – there may be more space than you need in some answer spaces.
- Calculators may be used for this booklet.
- For any calculations, you **must** show all your working.
- Any and all drawings or graphs should be completed in pencil.



For markers use	
Question	Mark
1	/6
2	/6
3	/6
4	/22
5	/15
Total	/55
%	
Grade	

Information

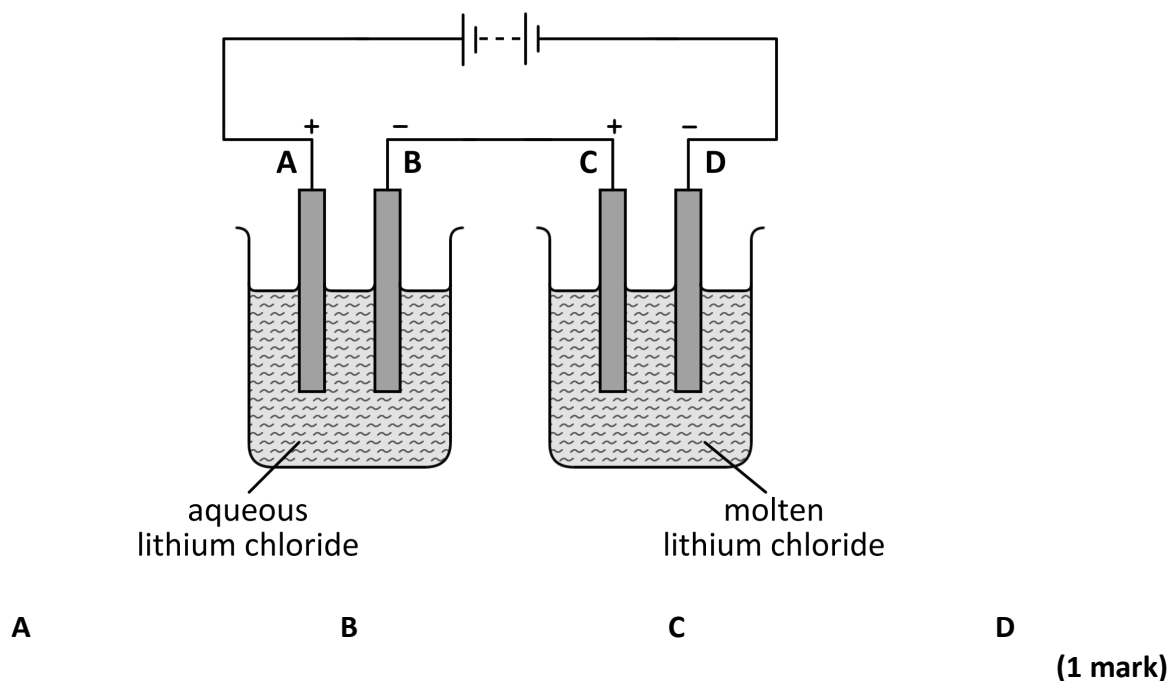
- The maximum mark for this paper is 55 marks.
- The marks for each question are shown in brackets.
- Please be aware that good English and clear presentation are required in your answers.



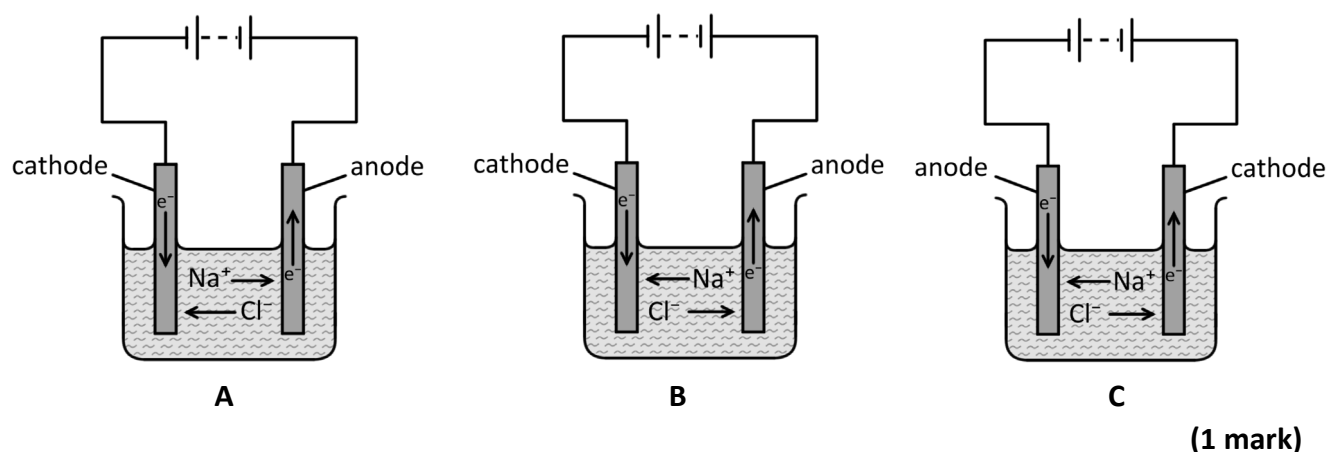
- Electrolysis is the process of using a direct electric current to break down an ionic compound, either molten or in aqueous solution, into its constituent elements.

Circle the letter of the correct answer for each of the following questions.

- The figure below shows a circuit for the electrolysis of aqueous and molten lithium chloride. At which electrode is hydrogen formed?



- Which figure below shows the direction of movement of ions and electrons during the electrolysis of molten sodium chloride?

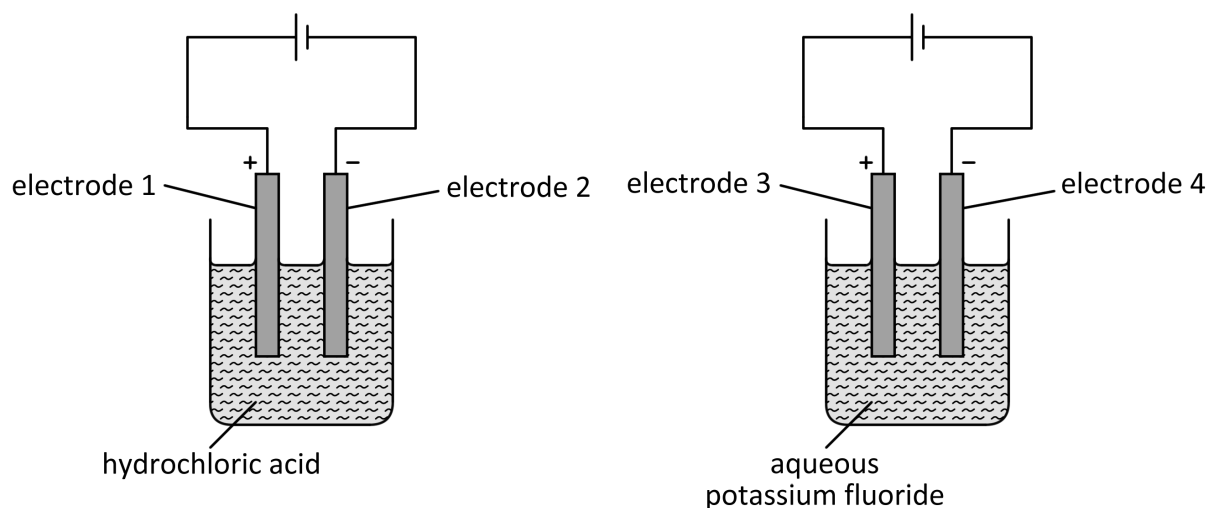


- During the electrolysis of aqueous copper(II) sulfate with copper electrodes, copper(II) ions are reduced at the negative electrode. What is a balanced half-equation to show this reduction.

- A** $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^{-}$
B $\text{Cu}^{2+} + 2\text{e}^{-} \rightarrow \text{Cu}$
C $2\text{H}^{+} + 2\text{e}^{-} \rightarrow \text{H}_2$
D $2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^{-}$

(1 mark)

d. The figure below shows the electrolysis of hydrochloric acid and potassium fluoride.



At which electrodes does hydrogen gas form?

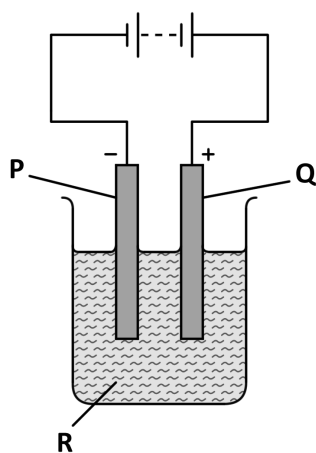
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|------------------|--------------------|------------------|--------------------|
| A | B | C | D |
| Electrode 1 only | Electrodes 1 and 3 | Electrode 2 only | Electrodes 2 and 4 |
- (1 mark)**

e. Molten aluminium oxide is electrolysed to produce aluminium.

What is the half-equation for the reaction that occurs at the anode?

- | | | | |
|--|--|---|---|
| A | B | C | D |
| $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$ | $\text{Al} \rightarrow \text{Al}^{3+} + 3\text{e}^-$ | $2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^-$ | $\text{O}_2 + 4\text{e}^- \rightarrow 2\text{O}^{2-}$ |
- (1 mark)**

f. The figure below shows the electrolysis of sodium fluoride. Fluorine is produced at P and sodium at Q.



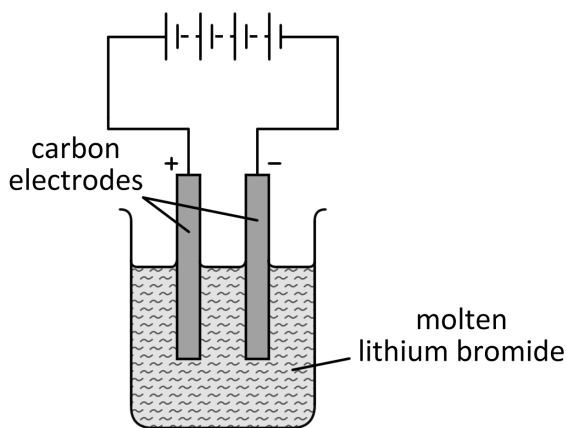
Which labels are correctly identified?

	P	Q	R
A	Cathode	Anode	NaF
B	Anode	Cathode	NaF
C	Anode	Cathode	NaF ₂
D	Cathode	Anode	NaF ₂

(1 mark)

(Total for Question 1 is 6 marks)

2. The diagram shows the apparatus used for the electrolysis of molten lithium bromide (LiBr).



- a. Explain why the lithium bromide must be **molten** for this electrolysis to occur.

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(2 marks)

- b. Name the product formed at the anode.

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(1 mark)

- c. Write the balanced half-equation for the reaction taking place at the cathode.

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(2 marks)

- d. The carbon electrodes are described as **inert**.
What is meant by the term 'inert' in this context?

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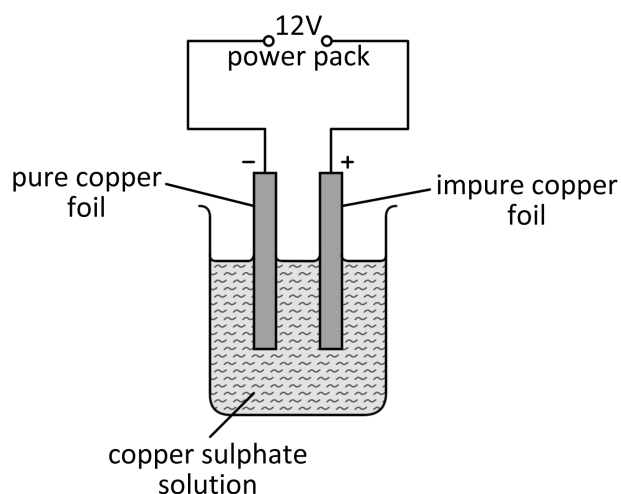
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(1 mark)

(Total for Question 2 is 6 marks)

3. An impure copper foil can be purified by electrolysis.

The setup involves an impure copper anode, a pure copper cathode, and copper sulfate solution as the electrolyte. The figure below shows the set up used by a student.



During the process, a student makes three key observations:

- The mass of the impure copper anode decreases.
- The mass of the pure copper cathode increases.
- A solid sludge containing silver and platinum collects at the bottom of the beaker.

Explain all three observations. In your answer, you should refer to the processes occurring at each electrode and the relative reactivity of the metals.

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[illegible]

(6 marks)

(Total for Question 3 is 6 marks)

4. A student was conducting an electrolysis of aqueous zinc chloride (ZnCl_2).
- a) Draw a **labelled diagram** of the apparatus that the student could use to carry out the electrolysis of aqueous zinc chloride (ZnCl_2) using graphite electrodes.

On your diagram, you must include and clearly label:

- The anode and the cathode.
- The DC power supply, with the correct polarity (+ and –).
- The electrolyte.
- The named gaseous product formed at each electrode.

(6 marks)

- b) A different electrolysis of **molten** zinc chloride was conducted by another student.
Explain why it must be molten to be electrolysed.

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(2 marks)

c) At the anode, a pale green gas is produced.

i. Name the pale green gas produced.

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(1 mark)

ii. Write the half-equation for the formation of this gas.

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(2 marks)

iii. State the name of the process that occurs at the anode and define it in terms of electrons.

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(2 marks)

d) A silvery substance is formed at the cathode.

i. Write the half-equation for the formation of the product at the cathode.

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(2 marks)

ii. The melting point of zinc is 420 °C and the melting point of zinc chloride is 290 °C.

The experiment was carried out at 350 °C.

Use this information to predict and explain the physical state of the zinc produced.

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(2 marks)

e) In one experiment, 13.0 g of zinc was produced at the cathode.

Calculate the volume of gas, in dm^3 , produced at the anode.

(Assume the reaction goes to completion and is measured at room temperature and pressure, where 1 mole of any gas occupies 24 dm^3).

(Relative atomic masses: $\text{Zn} = 65$, $\text{Cl} = 35.5$)

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(4 marks)

f) This experiment should be carried out in a fume cupboard.

Suggest why.

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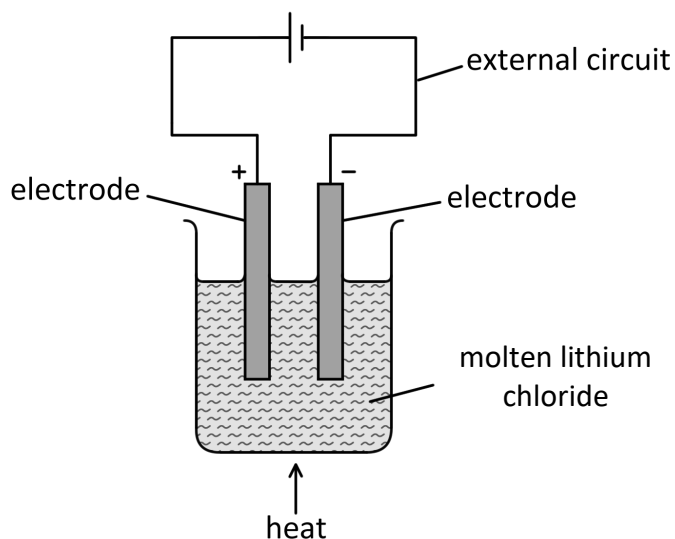
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(1 mark)

(Total for Question 4 is 22 marks)

5. The diagram shows the apparatus used for the electrolysis of molten lithium chloride (LiCl). When the current is switched on, a pale green gas is observed at the positive electrode and a silvery liquid is observed at the negative electrode.



a) Name the product formed at:

- i. The anode.

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(1 mark)

- ii. The cathode.

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(1 mark)

b) Write a balanced half-equation for the reaction occurring at the positive electrode (anode).

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(2 marks)

c) Explain why the substance formed at the negative electrode is a good conductor of electricity. Refer to its structure and bonding in your answer.

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(3 marks)

d) The gas produced at the positive electrode is hazardous.

i. State **one** safety precaution that should be taken.

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(1 mark)

ii. Describe the positive test to identify this gas.

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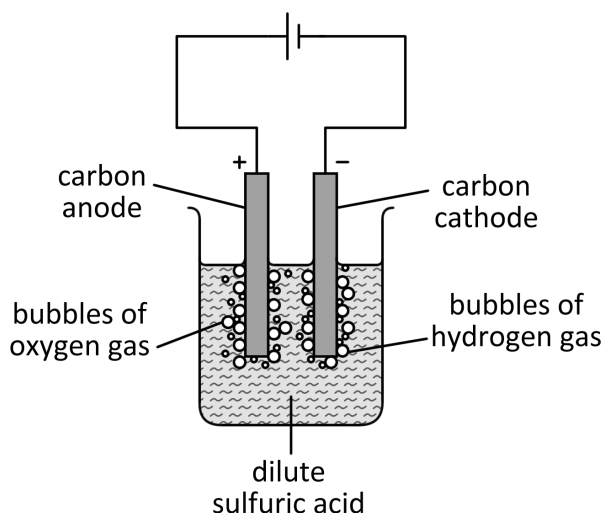
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(2 marks)

The diagram below shows the electrolysis of dilute sulfuric acid.

Hydrogen is formed at the cathode, oxygen at the anode and the concentration of sulfuric acid increases as the electrolysis is occurring.



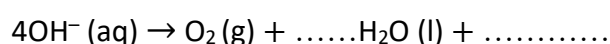
e) The ions present in the dilute acid are $\text{H}^+(\text{aq})$, $\text{OH}^-(\text{aq})$ and $\text{SO}_4^{2-}(\text{aq})$.

i. Write an equation for the reaction at the cathode.

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(2 marks)

ii. (Complete the equation for the reaction at the positive electrode (anode).



(2 marks)

iii. Explain why the concentration of the sulfuric acid increases as the electrolysis occurs.

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(1 mark)

(Total for Question 5 is 15 marks)