1 During the electrolysis of molten potassium chloride, what is made at the cathode?

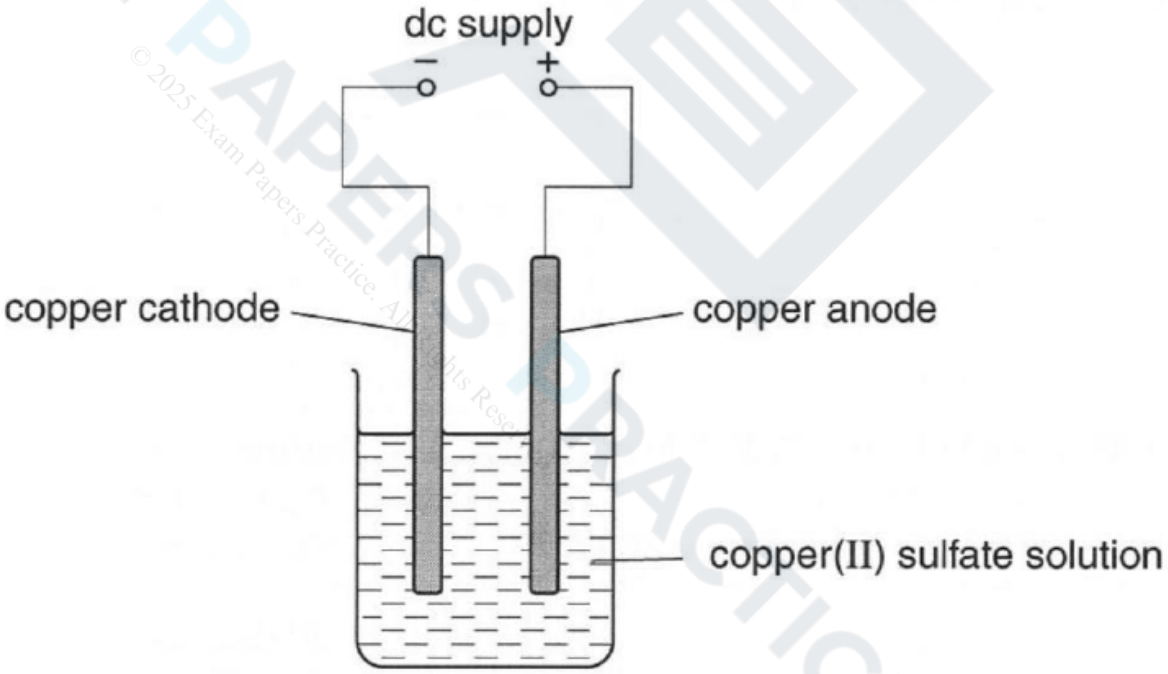
A chlorine
B hydrogen
C potassium
D potassium hydroxide

Your answer ☐

[1]

2(a) Meena electrolyses copper sulfate using copper electrodes.

Look at the diagram. It shows the apparatus she uses.



She investigates the change in mass at each electrode before and after the electrolysis.

Look at Meena's method.

1. Using a balance, measure the mass of the copper cathode and copper anode. 2. Set up the apparatus and run the electrolysis for 30 seconds. 3. Remove the copper cathode and the copper anode and immediately place them on the balance and measure their masses again.

What improvements could you make to Meena's experiment?

Explain your answers.

[4]

(b) Meena finds that

- the cathode gains mass
- the anode loses mass.

Explain these observations in terms of the reactions at each electrode.

[2]

3 Molten aluminium oxide contains Al^{3+} and O^{2-} ions.

The electrolysis of molten aluminium oxide makes aluminium and oxygen.

(i) Write the **balanced symbol** equation for the electrode reaction that happens at the cathode.

Use the symbol e^- to represent an electron.

_____ [1]

(ii) Solid aluminium oxide cannot be electrolysed.

Explain why.

_____

_____ [1]

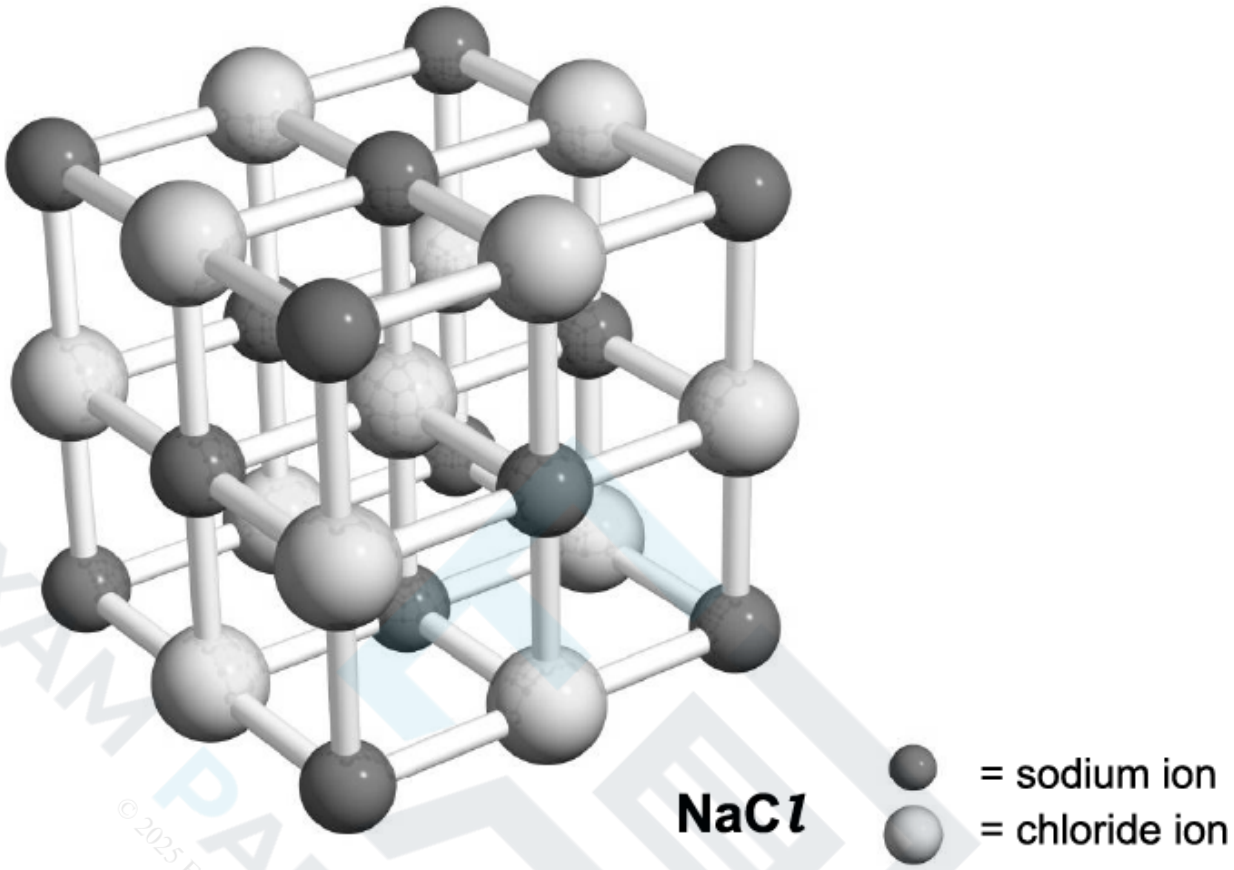
4(a) Javier is electrolysing a solution of sodium chloride, NaCl, in water, H_2O.

Complete the list of ions present in sodium chloride solution.

Positive ions (cations)	Negative ions (anions)
Na^+	_____
_____	OH^-

[2]

(b) Here is a diagram of a sodium chloride crystal.



The Cl-Na-Cl length in a crystal of sodium chloride is 0.564 nm.

What is the volume of this cube in nm^3? Give your answer to 3 significant figures.

volume = _____ nm^3 **[3]**

5(a) Molten (liquid) salts can be electrolysed.

Molten (liquid) potassium chloride can be electrolysed.

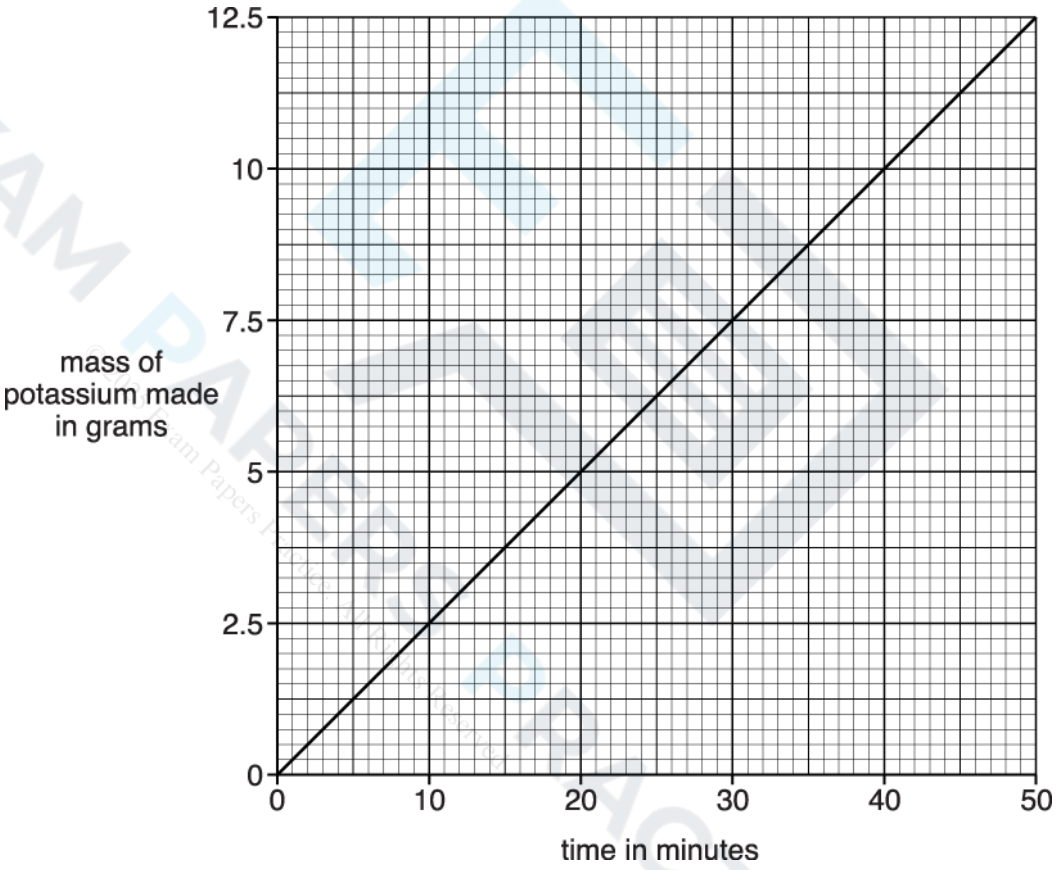
It makes potassium.

Sanjay investigates the mass of potassium made when molten potassium chloride is electrolysed.

He always uses a current of 10.3 amps.

He changes how long, in minutes, he does the electrolysis.

Look at the graph of his results.



(i) What mass of potassium is made after 30 minutes?

_____ g

[1]

(ii) Sanjay electrolyses molten potassium chloride for 300 minutes.

Predict the mass of potassium made.

_____ g

[1]

(b) Sanjay does an electrolysis experiment using potassium bromide.

Solid potassium bromide cannot be electrolysed.

Molten (liquid) potassium bromide can be electrolysed. It makes two products.

(i) Write down the names of the **two** products made during this electrolysis.

---

[2]

(ii) Explain why molten (liquid) potassium bromide can be electrolysed.

---

[1]

6(a) Molten (liquid) potassium chloride can be electrolysed.

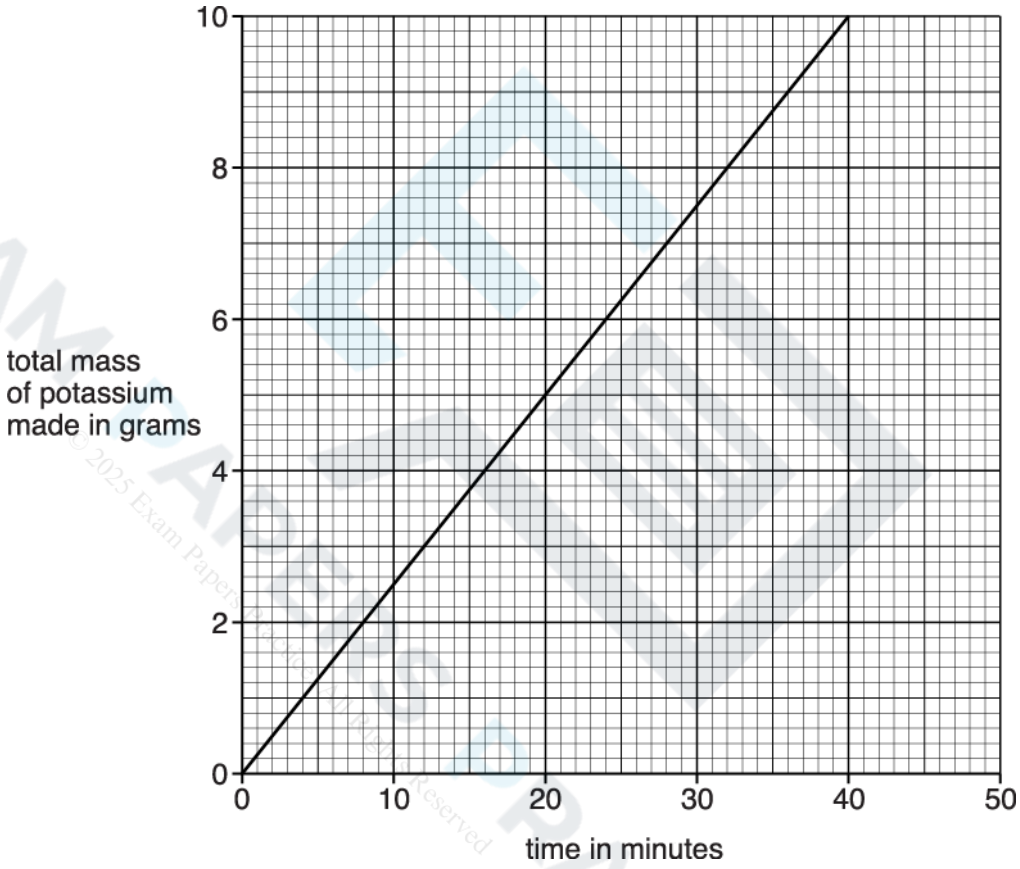
Potassium is made.

Manjit investigates the mass of potassium made when molten potassium chloride is electrolysed.

She always uses a current of 10.3 amps.

She does the electrolysis for different lengths of time.

Look at the graph of her results.



What is the total mass of potassium made in 30 minutes?

_____ g

[1]

(b) Manjit electrolyses molten potassium chloride for 120 minutes.

She uses a current of 20.6 rather than 10.3 amps.

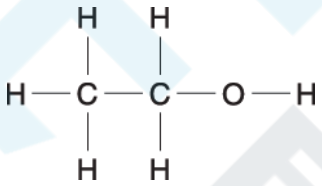
Predict the mass of potassium made.

---

[2]

7 Ethanol, propanol and butanol are alcohols.

Look at the displayed formula of ethanol.



Ethanol is made by the hydration of ethene, C_2H_4.

Write the **word** equation for this reaction.

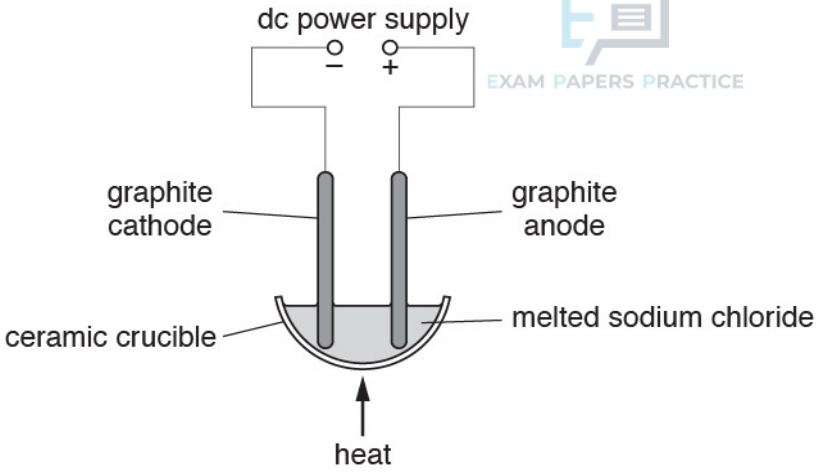
---

[1]

8(a) This question is about electrolysis.

Joel's teacher investigates the electrolysis of melted sodium chloride.

Look at the apparatus he uses.



Sodium chloride contains sodium ions, Na^+, and chloride ions, Cl^-.

(i) Chloride ions, Cl^-, react at the anode.

Chlorine gas, Cl_2, and electrons are the products.

Write a **balanced symbol** equation for the electrode process at the anode.

Use e^- to show an electron.

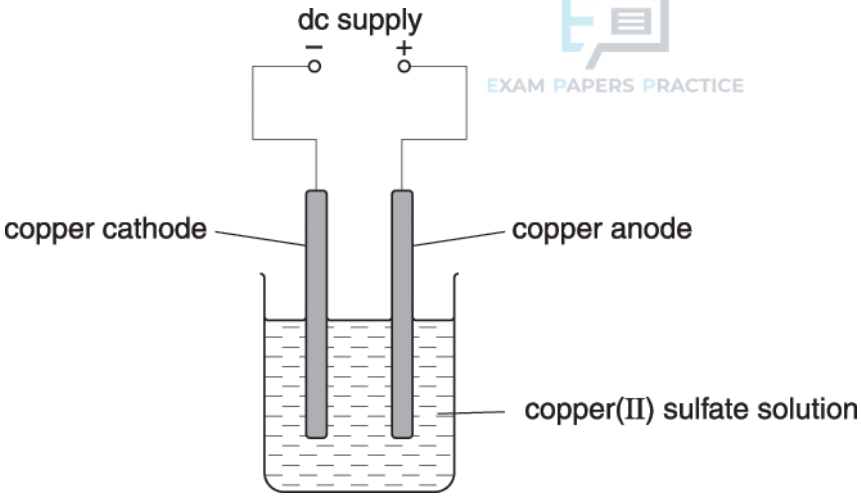
[2]

(ii) **Solid** sodium chloride does **not** conduct electricity, but **melted** sodium chloride **does** conduct electricity.

Explain why.

[2]

(b) Joel passes an electric current through **copper(II) sulfate solution.**



Joel does four experiments.

Joel changes either the **time** or the **current**.

Copper is made at the cathode.

He measures how much copper is made in each experiment.

Experiment	Current in amps	Time in minutes	Mass of copper made in g
1	0.15	5	0.20
2	0.30	5	0.40
3	0.15	10	0.40
4	0.60	10	1.60

Joel concludes that the amount of copper made is **proportional** to both the current and to the time.

Show how the results support this conclusion.

---

[2]

9(a) During the electrolysis of sodium bromide solution, bromide ions make bromine molecules.

Complete the equation for this reaction.

..... Br^- – .....e^- → Br_2

[1]

(b) Explain why this reaction is an example of **oxidation**.

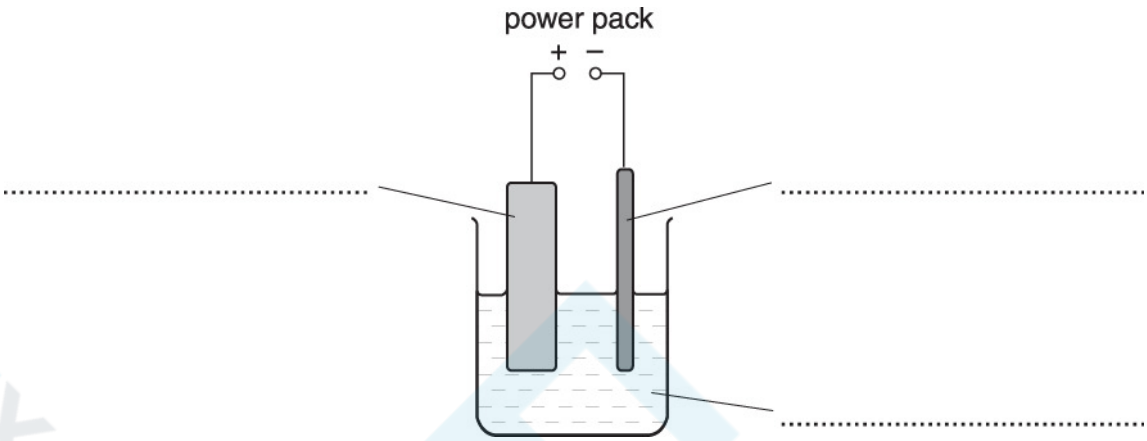
---

[1]

10 Pure copper is used for electrical wiring.

The copper is purified by **electrolysis**.

The diagram shows the apparatus used to purify copper.



Complete the labels on the diagram.

Choose your answers from the list.

copper sulfate solution

dilute sulfuric acid

impure copper anode

impure copper cathode

pure copper anode

pure copper cathode

[2]

11 Explain one **advantage** and one **problem** of recycling copper.

---

[2]

12 Useful products are made from sodium chloride solution by electrolysis.

Electrolysis of sodium chloride solution involves these particles:

Cl^- Cl_2 H^+ H_2

Na^+ H_2O OH^-

Some of the particles are **ions**.

Some of the particles are **molecules**.

Finish the table.

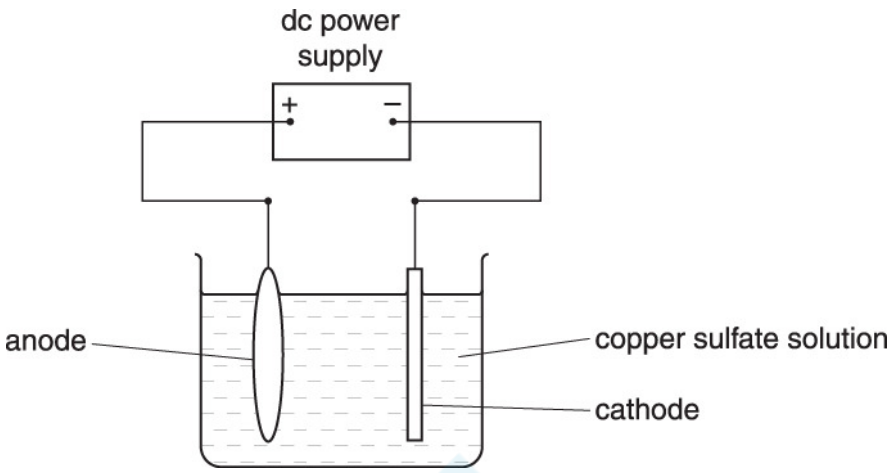
Two particles have been done for you.

Ions	Molecules
OH^-	H_2

[2]

13

Look at the diagram. It shows the apparatus used to purify copper.



What is the name of the process used to purify copper?

Choose from the list.

crystallisation

electrolysis

eutrophication

neutralisation

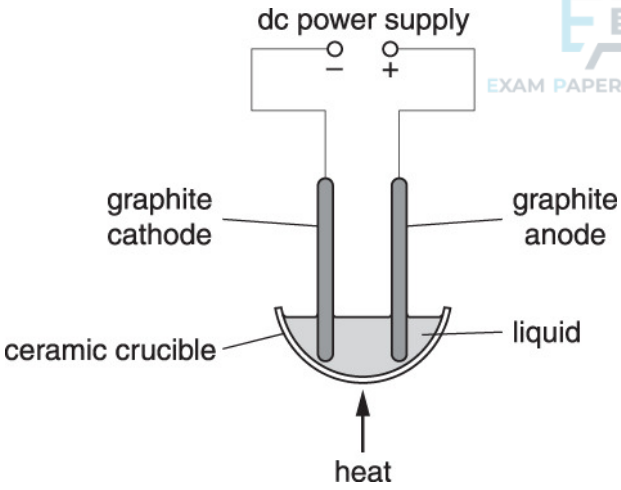
thermal decomposition

answer _____ [1]

14(a) Joel's teacher investigates the electrolysis of four liquids.

The first liquid he uses is melted sodium chloride.

Look at the apparatus he uses.



The table shows the products made.

Liquid	Product at cathode	Product at anode
lead bromide	lead	bromine
lead iodide	lead	iodine
sodium chloride	sodium	_____
potassium iodide	_____	iodine

[2]

(i) Complete the table.

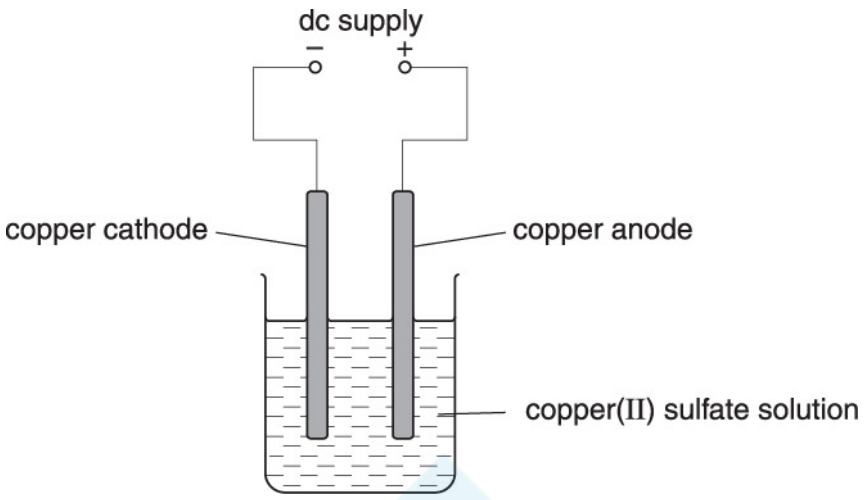
(ii) Sodium chloride contains sodium ions, Na^+, and chloride ions, Cl^-.
Solid sodium chloride does not conduct electricity, but melted sodium chloride does conduct electricity.
Explain why.

_____

_____

_____ [2]

(b) Joel passes an electric current through **copper(II) sulfate solution**.



Joel does four experiments.

Joel changes either the **time** or the **current**.

Copper is made at the cathode.

He measures how much copper is made in each experiment.

Experiment	Current in amps	Time in minutes	Mass of copper made in g
1	0.15	5	0.20
2	0.30	5	0.40
3	0.15	10	0.40
4	0.60	10	1.60

Joel concludes that the amount of copper made is **proportional** to both the current and to the time.

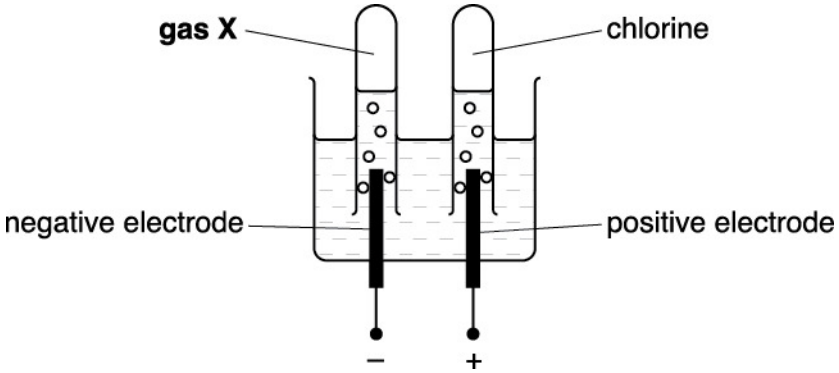
Show how the results support this conclusion.

---

[2]

15(a) Anita investigates the electrolysis of concentrated sodium chloride solution (brine).

Look at the diagram. It shows the apparatus she uses.



What is the name of gas **X**?

Choose your answer from the list.

carbon dioxide

hydrogen

hydrogen chloride

oxygen

answer

---

[1]

(b) It is important to use **inert electrodes** in the electrolysis of sodium chloride solution.

Explain why.

---

[1]

16 During the electrolysis of molten lead bromide, bromine is made at the anode.

Which half equation shows that bromine is made at the anode?

A $2Br^- \rightarrow Br_2 + 2e^-$

B $Br^- \rightarrow Br + e^-$

C $Br_2 + 2e^- \rightarrow 2Br^-$

D $2Br^- \rightarrow Br_2 - 2e^-$

Your answer [1]

17 During the electrolysis of molten copper chloride, what is made at the **positive** electrode (anode)?

A Chloride

B Chlorine

C Copper

D Hydrogen

Your answer [1]

18 An aqueous solution of concentrated sodium chloride is electrolysed. Bubbles are seen at the **positive** electrode.

What is the name of the substance produced at the positive electrode?

A Chlorine

B Hydrogen

C Sodium

D Oxygen

Your answer [1]

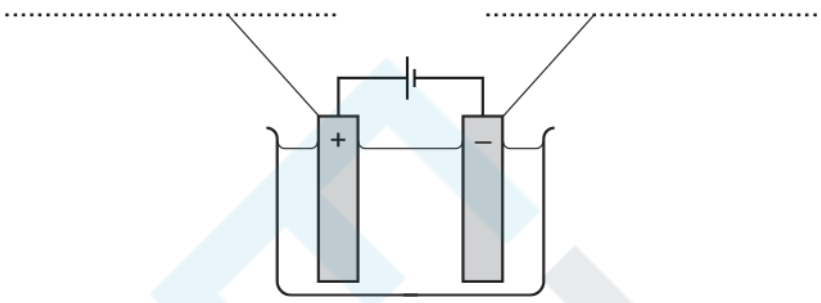
19(a) Electrolysis can be used to separate the elements in some compounds using electricity.

(i) Look at the diagram of an electrolysis experiment.

Complete the diagram using the words in the list.

You may use each word once, more than once or not at all.

cathode **anode** **battery**



[2]

(ii) A teacher demonstrates the electrolysis of molten lead bromide.

Predict the products made at each electrode.

Positive electrode _____

Negative electrode _____

[2]

(iii) Molten lead bromide contains lead ions, Pb^{2+}, and bromide ions, Br^{-}.

What is the formula for lead bromide?

Tick (✓) **one** box.

$PbBr$ ☐

$PbBr_2$ ☐

Pb_2Br ☐

Pb_2Br_2 ☐

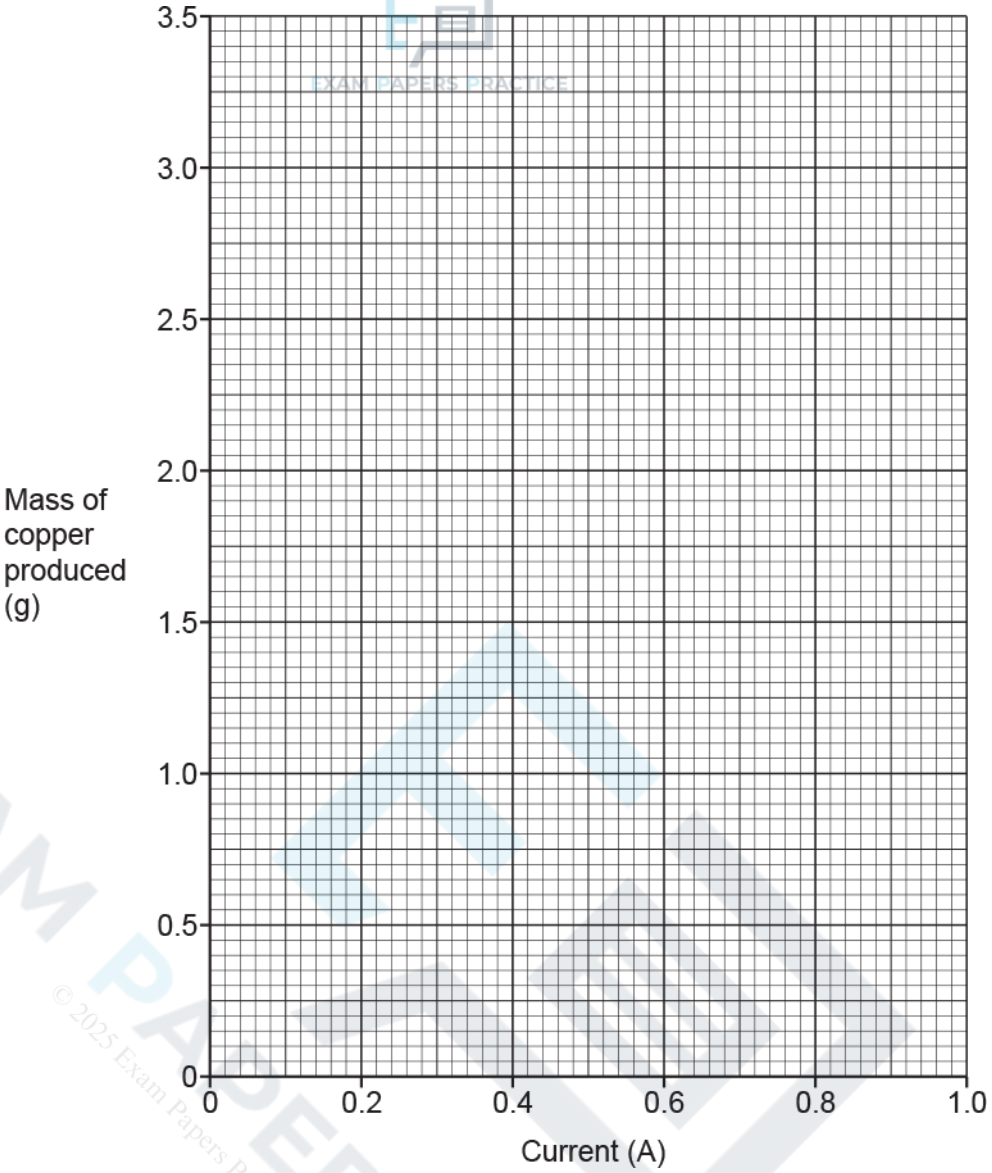
[1]

(b) The student investigates the mass of copper made during the electrolysis of aqueous copper chloride.

The student varies the electric current and passes the current for the same time in each experiment. Here is a table of their results.

Current (A)	Mass of copper produced (g)
0.2	0.6
0.4	1.3
0.6	1.8
0.8	2.5
1.0	3.1

(i) Plot a graph of the student's results and draw a line of best fit.



[3]

(ii) Use your graph to **estimate** the current needed to make 2.25 g of copper.

Current = ... A **[1]**

(iii) Use your graph, and a calculation, to find the mass of copper that would be produced using 15 A.

Give your answer to **2** significant figures.

Mass of copper produced = ... g **[2]**

20 This question is about structure and bonding.

Look at the two structures, **A** and **B**, in **Fig. 22.1**.

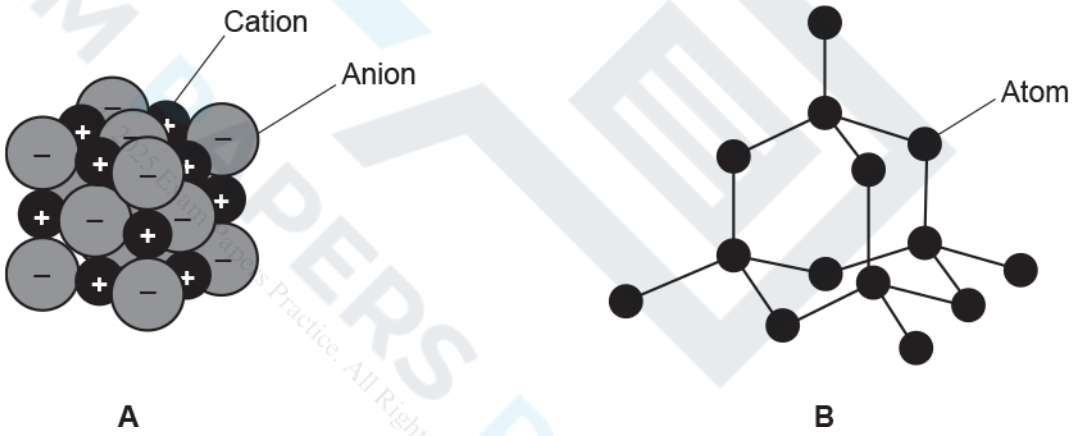


Fig. 22.1

(i) Identify the bonding in structure **A**.

Explain your answer.

Bonding ----------

Explanation ----------

[2]

(ii) Explain why structure **B** has a high melting point.

---

[2]

(iii) Explain why structure **B** does **not** conduct electricity.

---

[1]

21 This question is about structure and bonding.

Look at the two structures, **A** and **B**, in **Fig. 16.1**.

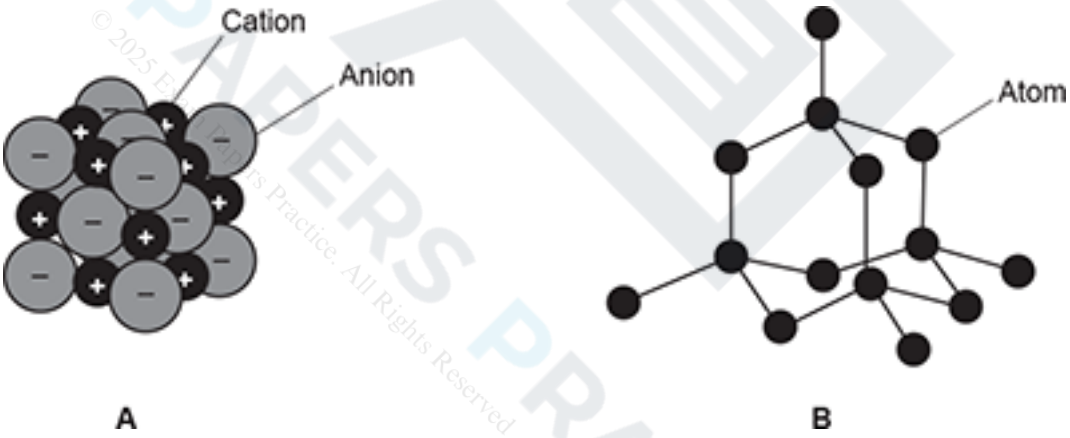


Fig. 16.1

(i) Identify the bonding in structure **A**.

Explain your answer.

Bonding ---

Explanation

[2]

(ii) Explain why structure **B** has a high melting point.

[2]

(iii) Explain why structure **B** does **not** conduct electricity.

[1]

(b) Look at the structure of a metal in **Fig. 16.2**. Metals are malleable, which means they can be hammered or pressed into shape without breaking or cracking.

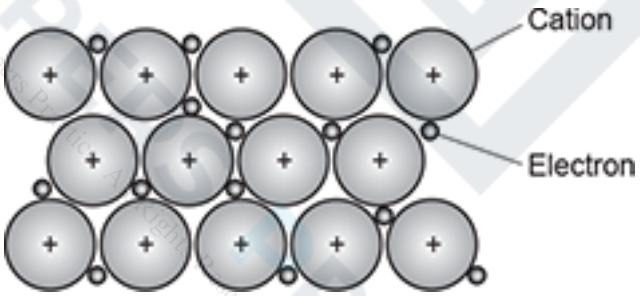


Fig. 16.2

Explain why metals are **malleable**.

[2]

22(a) The electrolysis products of ionic compounds can be different in the molten or aqueous states.

Suggest why.

---

[1]

(b) A student investigates the electrolysis of aqueous solutions of ionic compounds.

Aqueous solution	Product at cathode	Product at anode
Copper sulfate	Copper	Oxygen
Zinc bromide	Hydrogen	Bromine
Copper chloride	Copper	Chlorine
Sulfuric acid	Hydrogen	Oxygen

Write the formulae of the **ions** that are present in aqueous copper sulfate solution.

[2]

(c) Why is it important that the investigation is done with **inert** electrodes?

---

[1]

(d) Electroplating is used to cover a metal with another metal.

(i) Which aqueous solution would you use to electroplate a metal spoon with copper using a safe method?

Tick (✓) **one** box.

Copper sulfate ☐

Zinc bromide ☐

Copper chloride ☐

Sulfuric acid ☐

[1]

(ii) Give **two** reasons for your answer to **(i)**.

1 ----------

---

2 ----------

---

[2]

(e)

(i) Predict the product made at the anode when sodium sulfate solution is electrolysed.

[1]

(ii) Hydrogen gas is made at the cathode instead of sodium metal.

Explain why.

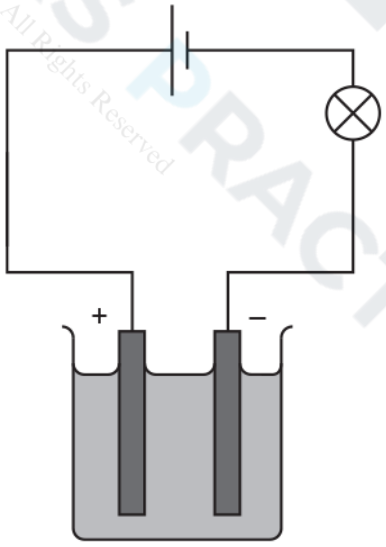
[1]

(iii) Write the **balanced half equation** for the formation of hydrogen gas.

Use e^- to represent an electron.

[2]

23 * A student investigates the electrolysis of potassium bromide solution.



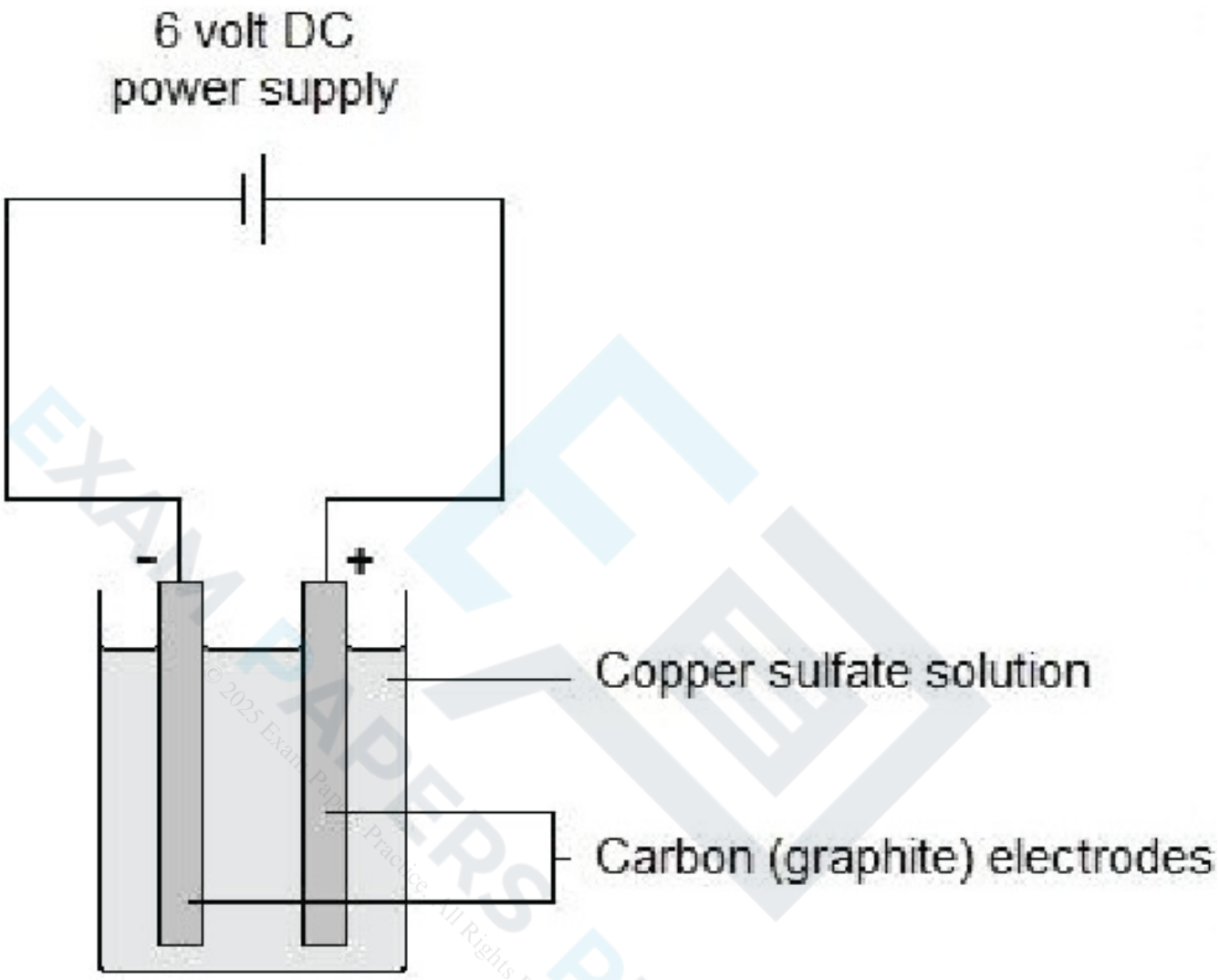
He notices that different products are formed at each electrode.

Explain the formation of the products during the electrolysis of potassium bromide solution.

[6]

24 Copper is made by the electrolysis of copper sulfate solution.

Look at the diagram of the apparatus used in this electrolysis.



Describe what you would **see** at each of the electrodes.

At the anode: _____

At the cathode: _____

[2]

END OF QUESTION PAPER