1 Concentrated aqueous potassium bromide is an electrolyte.

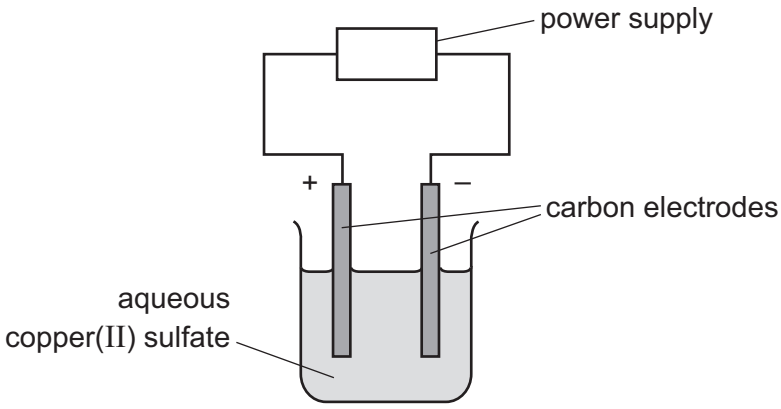
What is meant by the term *electrolyte*?

.....

..... [2]

[Total: 2]

2 A student electrolyses aqueous copper(II) sulfate using the apparatus shown.



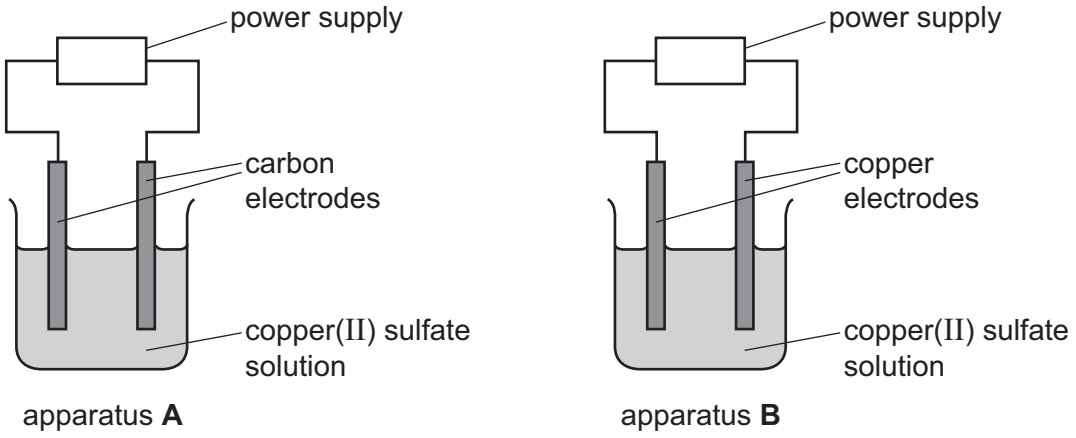
Oxygen gas forms at the positive electrode (anode).

Write an ionic half-equation for the reaction at the negative electrode (cathode).
Include state symbols.

..... [3]

[Total: 3]

3 A student electrolysed copper(II) sulfate solution using the two sets of apparatus shown.



In apparatus **A** the student used carbon electrodes.
In apparatus **B** the student used copper electrodes.

The student made the following observations.

apparatus **A**	apparatus **B**
The mass of the negative electrode increased.	The mass of the negative electrode increased.
The mass of the positive electrode stayed the same.	The mass of the positive electrode decreased.
Bubbles were seen at the positive electrode.	No bubbles were seen at the positive electrode.

(a) Explain why the mass of the negative electrode increased in **both** sets of apparatus.

.....

..... [1]

(b) Name the gas that formed the bubbles seen in apparatus **A**.

..... [1]

(c) Explain why the mass of the positive electrode decreased in apparatus **B**.

.....

..... [1]

[Total: 3]

4 Electrolysis of concentrated aqueous sodium chloride is an important industrial process.

(a) What is meant by the term *electrolysis*?

.....

..... [2]

(b) Name the products of the electrolysis of concentrated aqueous sodium chloride.

1 .....

2 .....

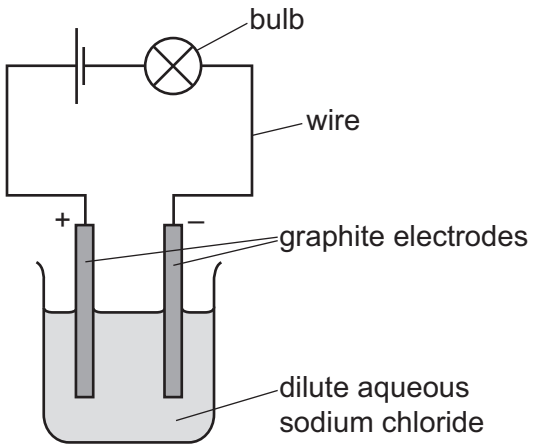
3 ..... [3]

(c) Write an ionic half-equation for the reaction at the cathode.
Include state symbols.

..... [2]

[Total: 7]

5 A student sets up the following electrolysis experiment.



(a) Define the term *electrolysis*.

.....

..... [2]

(b) The student observes bubbles of colourless gas forming at each electrode.

(i) Name the main gas produced at the positive electrode (anode).

..... [1]

(ii) Describe a test for the gas produced in **(b)(i)**.

test .....

result ..... [2]

(iii) Write the ionic half-equation for the reaction taking place at the negative electrode (cathode).

..... [1]

(c) Charge is transferred during electrolysis.

Name the type of particle responsible for the transfer of charge in:

the wires .....

the electrolyte. ..... [2]

(d) The student replaces the dilute aqueous sodium chloride with concentrated aqueous sodium chloride.

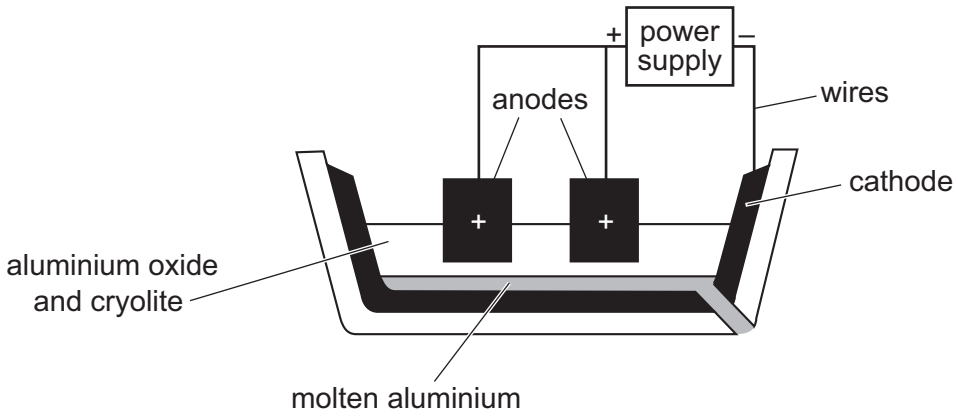
Suggest **two** differences that the student observes.

1 .....

2 ..... [2]

[Total: 10]

6 Aluminium can be extracted by electrolysis using the apparatus shown.



(a) Name the type of particle responsible for the transfer of charge in

the wires, ...

the electrolyte. ..... [2]

(b) Give **two** reasons why cryolite is used.

1 .....

2 ..... [2]

(c) Write the ionic half-equation for the formation of aluminium during the electrolysis.

..... [1]

(d) Explain how carbon dioxide gas is formed at the anodes.

.....

.....

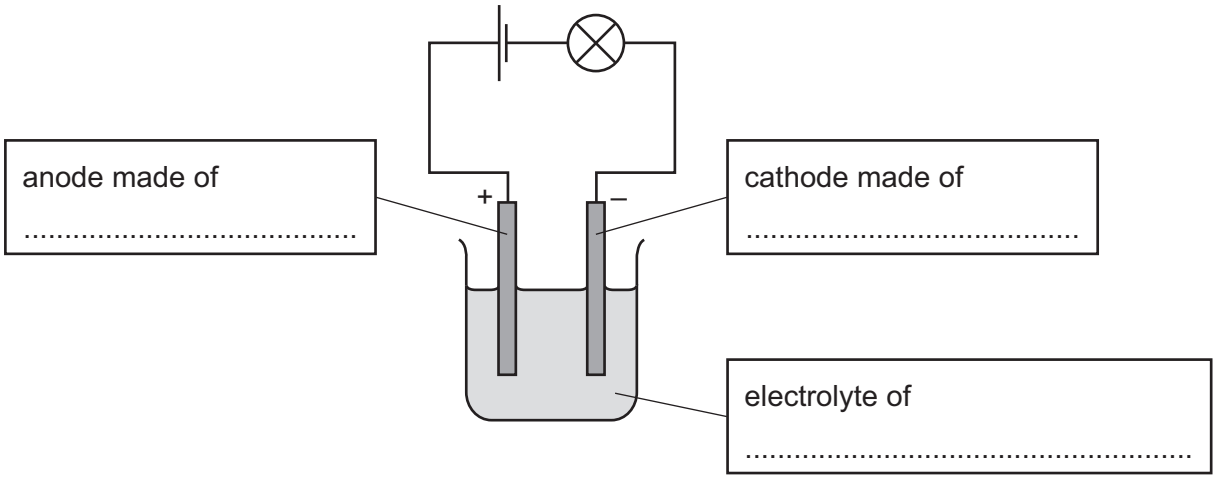
..... [3]

[Total: 8]

7 A student has a small piece of impure copper. The main impurities in the copper are small quantities of silver and zinc.

The student uses electrolysis to extract pure copper from the small piece of impure copper.

(a) Complete the labels on the diagram of the student's electrolysis experiment.



[3]

(b) Use your knowledge of the reactivity series to suggest what happens to the silver and zinc impurities.
Explain your answers.

silver impurities .....

.....

.....

zinc impurities .....

.....

..... [3]

[Total: 6]

8 Which reactions could take place at the anode during electrolysis?

1 $4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$

2 $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

3 $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

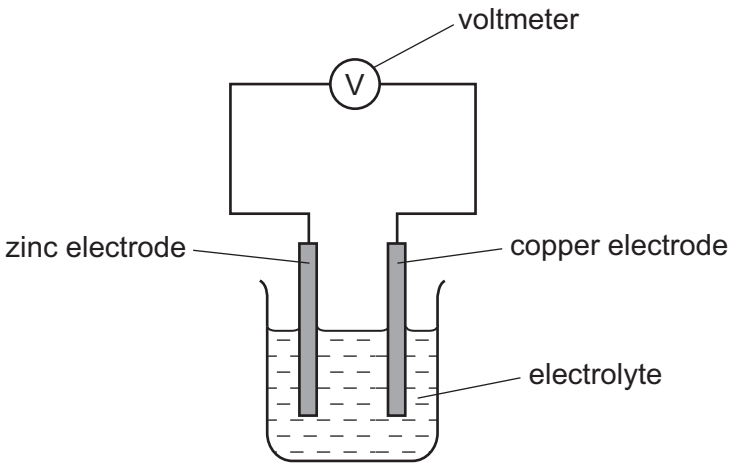
4 $2H^+(aq) + 2e^- \rightarrow H_2(g)$

A 1 and 2 **B** 1 and 4 **C** 2 and 4 **D** 3 and 4

[1]

[Total: 1]

9 The diagram shows a simple cell.



Which statement about the process occurring when the cell is in operation is correct?

A Cu^{2+} ions are formed in solution.

B Electrons travel through the solution.

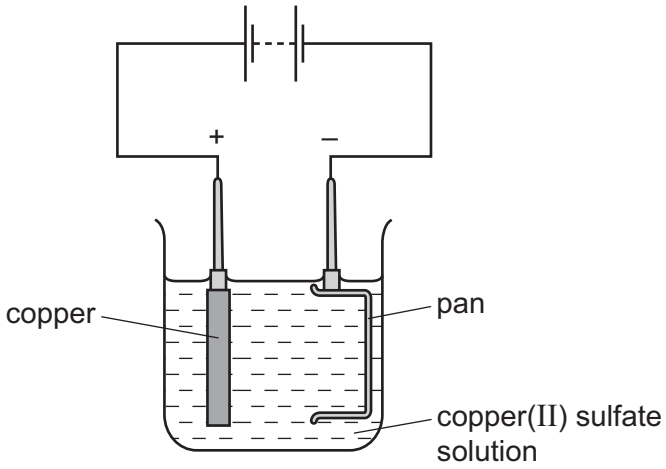
C The reaction $Zn \rightarrow Zn^{2+} + 2e^{-}$ occurs.

D The zinc electrode increases in mass.

[1]

[Total: 1]

10 The diagram shows a method used to copper-plate a pan.



Which equation represents the reaction at the cathode?

A $Cu^{2+} + 2e^- \rightarrow Cu$

B $2H^+ + 2e^- \rightarrow H_2$

C $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

D $2O^{2-} \rightarrow O_2 + 4e^-$

[1]

[Total: 1]

11 Aluminium is obtained by the reduction of aluminium ions to aluminium atoms.

Write an ionic equation for the reduction of an aluminium ion to an aluminium atom.

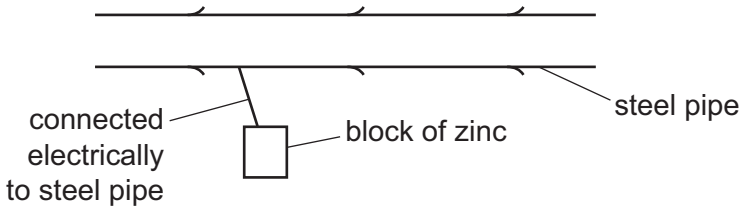
..... [2]

[Total: 2]

12 There are two electrochemical methods of rust prevention.

(a) The first method is sacrificial protection.

Explain why the steel article does not rust.



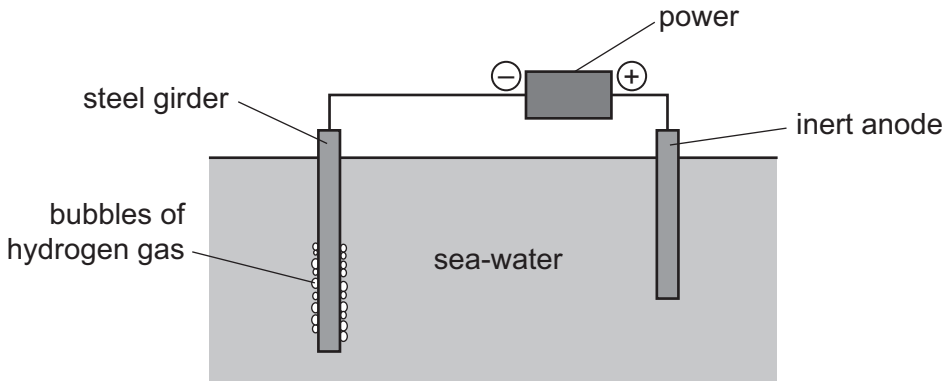
.....

.....

.....

..... [4]

The second method is to make the steel article the cathode in a circuit for electrolysis.



(b) Mark on the diagram the direction of the electron flow.

[1]

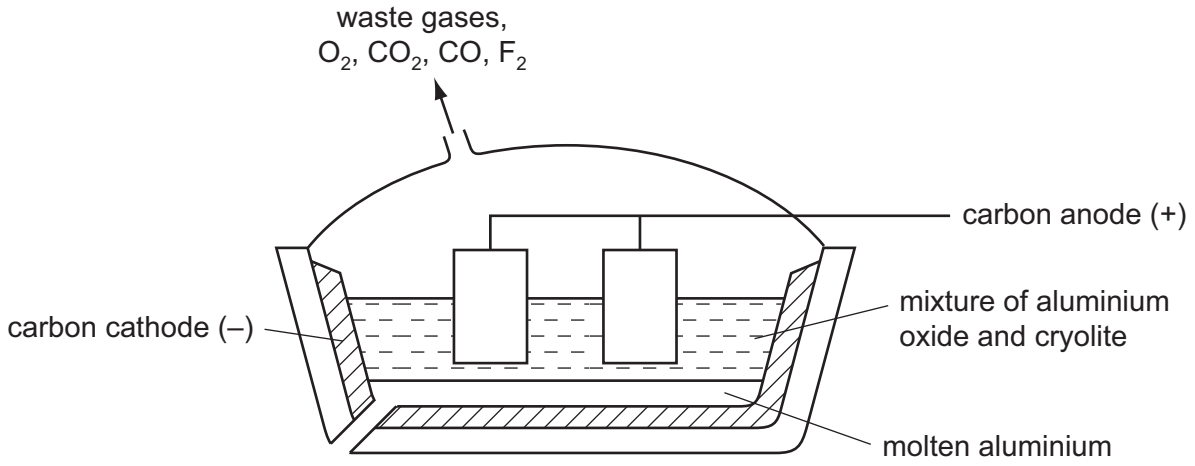
(c) The steel girder does not rust because it is the cathode. Reduction takes place at the cathode. Give the equation for the reduction of hydrogen ions.

..... [2]

[Total: 7]

13 Aluminium is obtained by the reduction of aluminium ions to aluminium atoms.

In the modern method of extraction, aluminium is obtained by the electrolysis of aluminium oxide (alumina) dissolved in molten cryolite, Na_3AlF_6.



(a) The major ore of aluminium is impure aluminium oxide.
What is the name of this ore?

..... [1]

(b) This ore is a mixture of aluminium oxide, which is amphoteric, and iron(III) oxide which is basic.

Explain how these two oxides can be separated by the addition of aqueous sodium hydroxide.

.....

.....

..... [2]

(c) Give **two** reasons why the electrolyte contains cryolite.

.....

.....

..... [2]

[Total: 5]

14 Zinc can be obtained from zinc oxide in a two step process. Aqueous zinc sulfate is made from zinc oxide and then this solution is electrolysed with inert electrodes. The electrolysis is similar to that of copper(II) sulfate with inert electrodes.

(a) Name the reagent which will react with zinc oxide to form zinc sulfate.

..... [1]

(b) Complete the following for the electrolysis of aqueous zinc sulfate.

Write the equation for the reaction at the negative electrode.

.....

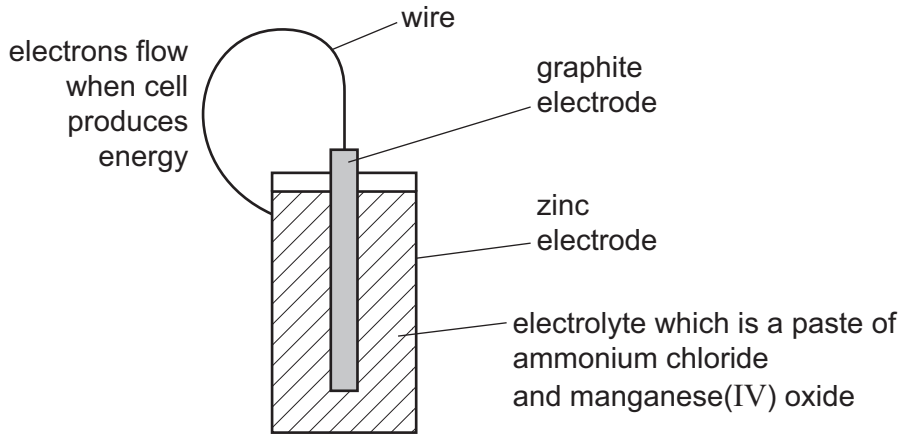
Name the product at the positive electrode.

.....

The electrolyte changes from zinc sulfate to ..... [3]

[Total: 4]

15 A dry cell (battery) has a central rod, usually made of graphite. This is the positive electrode which is surrounded by the electrolyte, typically a paste of ammonium chloride and manganese(IV) oxide, all of which are in a zinc container which is the negative electrode.



(a) Draw an arrow on the diagram to indicate the direction of electron flow.

[1]

(b) Suggest why the electrolyte is a paste.

..... [1]

(c) The following changes occur in a dry cell.
For each change, decide if it is oxidation or reduction and give a reason for your choice.

Zn to Zn^{2+}

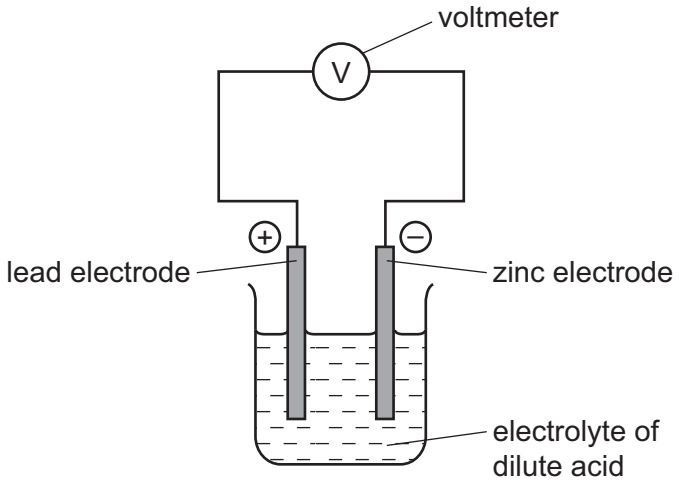
.....

manganese(IV) oxide to manganese(III) oxide

..... [2]

[Total: 4]

16 Another way of determining the order of reactivity of metals is by measuring the voltage and polarity of simple cells. The polarity of a cell is shown by which metal is the positive electrode and which metal is the negative electrode. An example of a simple cell is shown below.



(a) Mark on the above diagram the direction of the electron flow.

[1]

(b) Explain, in terms of electron transfer, why the more reactive metal is always the negative electrode.

.....

.....

..... [2]

[Total: 3]

17 A way of determining the order of reactivity of metals is by measuring the voltage and polarity of simple cells. The polarity of a cell is shown by which metal is the positive electrode and which metal is the negative electrode.

The following table gives the polarity of cells using the metals zinc, lead, copper and manganese.

cell	electrode	polarity	electrode 2	polarity
A	zinc	–	lead	+
B	manganese	–	lead	+
C	copper	+	lead	–

(a) What information about the order of reactivity of these four metals can be deduced from the table?

.....

.....

..... [2]

(b) What additional information is needed to establish the order of reactivity of these four metals using cells?

..... [1]

[Total: 3]