

EB Education Revision Guide



How to work with Electrolysis

Electrolysis

What is it?

Electrolysis is the **decomposition** of a substance using electricity.

An electric current is passed through in **electrolyte** (a molten or dissolved ionic compound), which causes it to break down.

TOP TIP: Remember OILRIG
Oxidation Is Loss (of electrons)
Reduction Is Gain (of electrons)

TOP TIP: Remember PANIC
Positive Anode
Negative Is Cathode

Oxidation and Reduction

During electrolysis, both oxidation and reduction occur.

Oxidation is the loss of electrons.

Reduction is the gain of electrons.

Positive ions (**cations**) will move towards the **cathode** (negative electrode). Here they will be reduced (gain electrons)

Negative ions (**anions**) move towards the **anode** (positive electrode) and are oxidised (lose electrons)

They then form uncharged substances and are **discharged** from the electrolyte (they come out of the molten/dissolved substance)

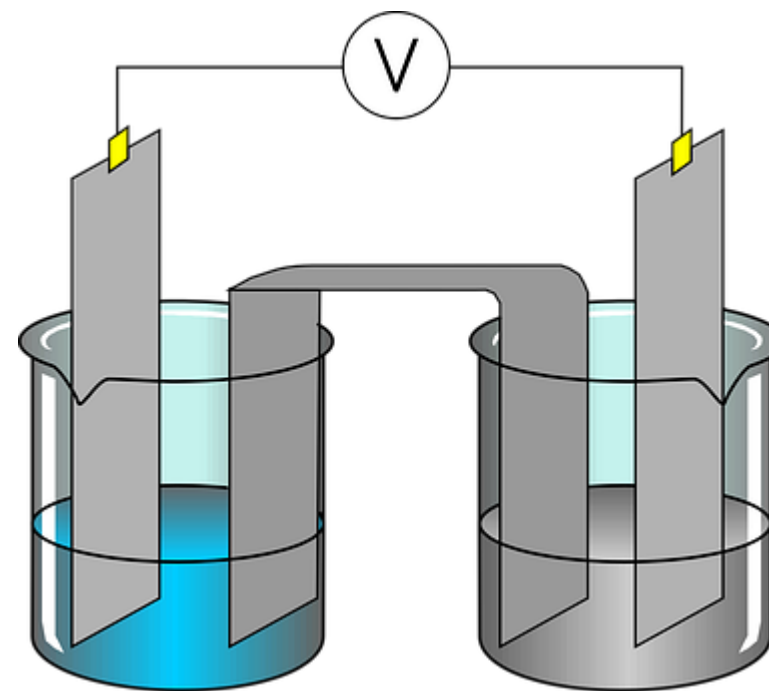
Electrochemical Cells

There are 2 types of Electrochemical cells. One uses chemical reactions to create a voltage, the other uses a voltage to encourage a chemical reaction.

How to set it up

An electrochemical cell is a circuit which includes the anode, cathode, electrolyte, power source or voltmeter (depending on type of Electrochemical cell) and wire to connect the electrodes.

How you set it up depends on which type of cell and if it is to create a chemical reaction, whether the electrolyte is a solution or a molten ionic substance.

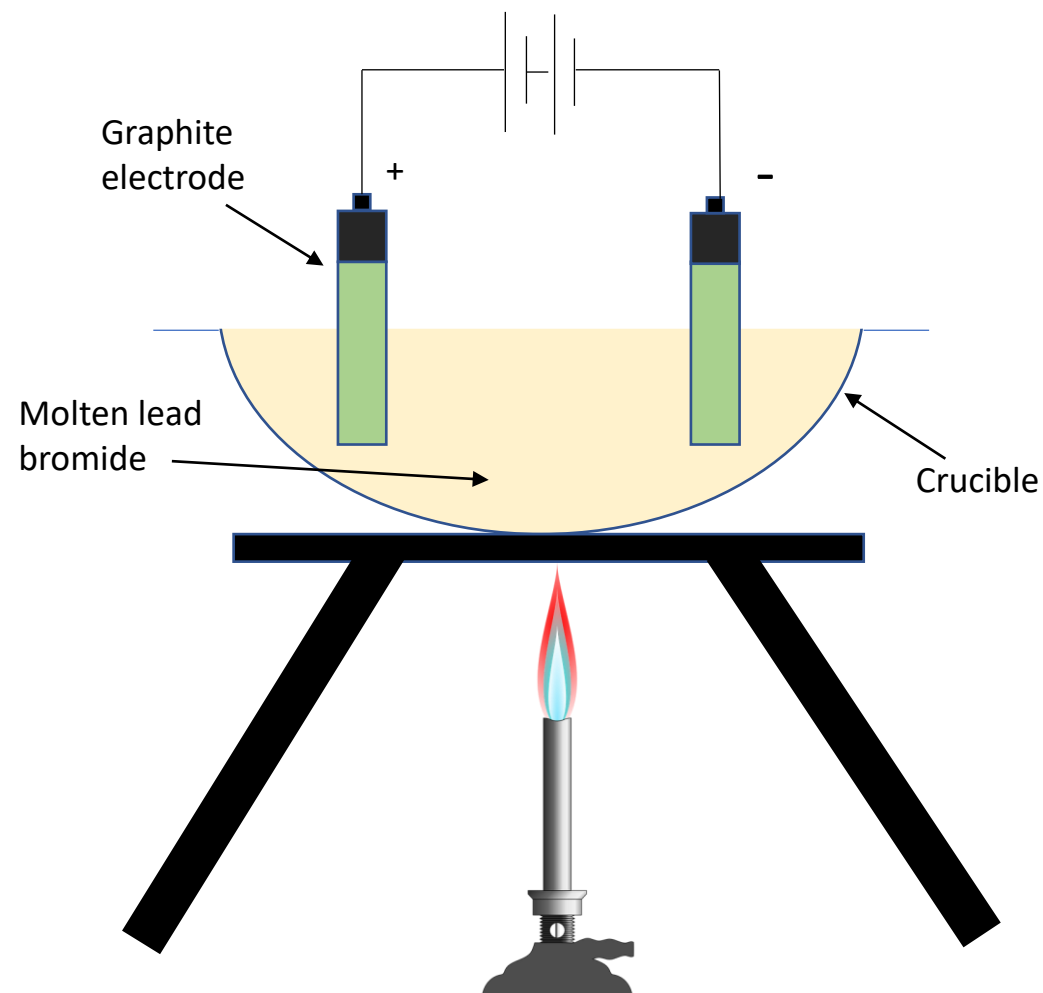


This type electrochemical cell produces a voltage.

Molten

- Place the solid ionic substance in a crucible.
- Heat it with a Bunsen burner until it is molten (in a fume cupboard).
- Once molten, put two inert (unreactive) electrodes into the electrolyte.
- Connect and turn on the power supply.

Electrochemical Cells

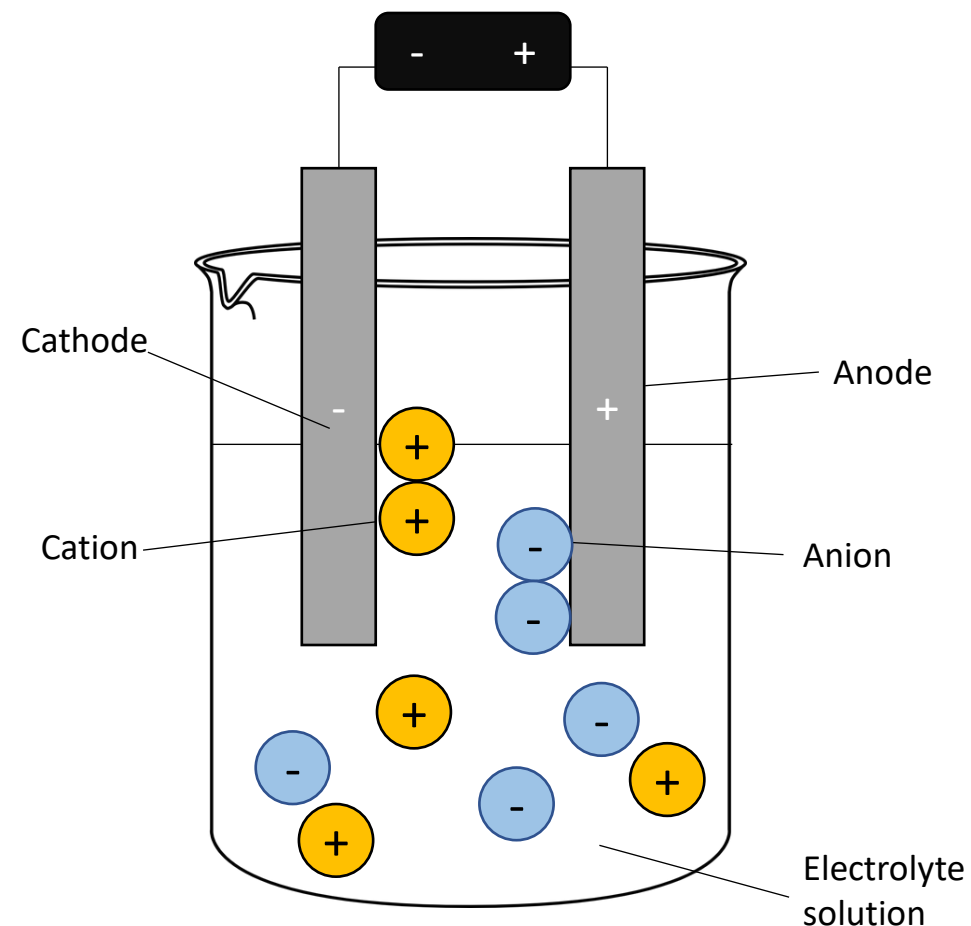


This type electrochemical cell uses a voltage to separate chemicals.

Electrochemical Cells

Solution

- Use two inert electrodes like graphite.
- Clean the surfaces using sandpaper (try not to touch the surfaces so you do not transfer grease back onto them).
- Place the electrodes in a beaker of electrolyte.
- Connect and turn on the power supply.



This type electrochemical cell uses a voltage to separate chemicals.

Electrolysis of Molten Substances

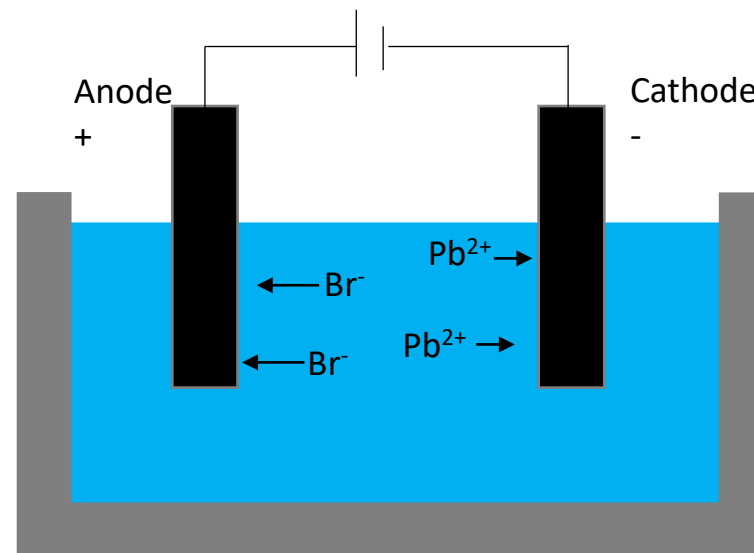
What does it form?

Molten ionic compounds can be electrolysed because the ions can move freely and conduct electricity.

At the cathode, positive metal ions are reduced to metal atoms.

At the anode, negative ions are oxidised to atoms or molecules.

Molten ionic compounds are always broken up into their elements.



Cathode:

You will see silver liquid as molten lead is formed.



This is the half equation – you need to balance the charges and electrons to form atoms

Anode:

You will see brown vapour as bromine gas is formed.

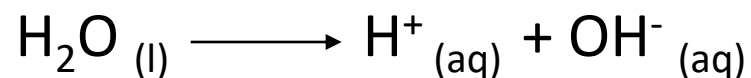


This is the half equation – as bromine is diatomic – you need to balance with 2 bromine ions.

Electrolysis of Aqueous Solutions

What does it form?

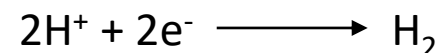
In aqueous solutions, there will be ions from the water, as well as ions from the ionic compound.



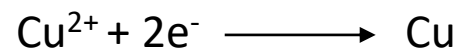
Rules

CATHODE:

Hydrogen gas will be produced if the metal is more reactive than hydrogen (eg sodium)

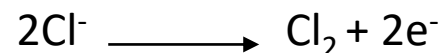


If the metal is less reactive than hydrogen (eg copper), a layer of pure metal will be produced.

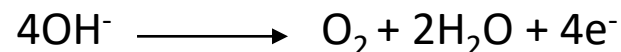


ANODE:

Chlorine, bromine or iodine will always be formed if halide ions (Cl^- , Br^- , I^-) are present.



If no halide ions are present, then oxygen will be formed.

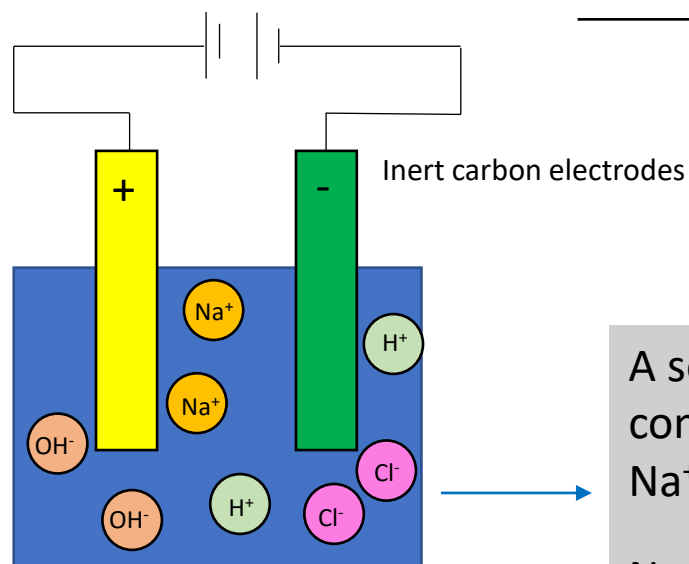
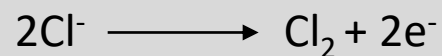


Electrolysis of Aqueous Solutions

Sodium Chloride Solution

Anode:

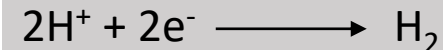
Chlorine gas (bubbles of pale green gas) will be formed here because there are chloride ions present in the solution.



Electrolysis of aqueous HCl

Cathode:

Hydrogen gas will be formed here because sodium is more reactive than hydrogen.



A solution of sodium chloride contains four different ions:
 Na^+ , Cl^- , H^+ , OH^-

NaOH will be left in solution.

Electrolysis of Aqueous Solutions

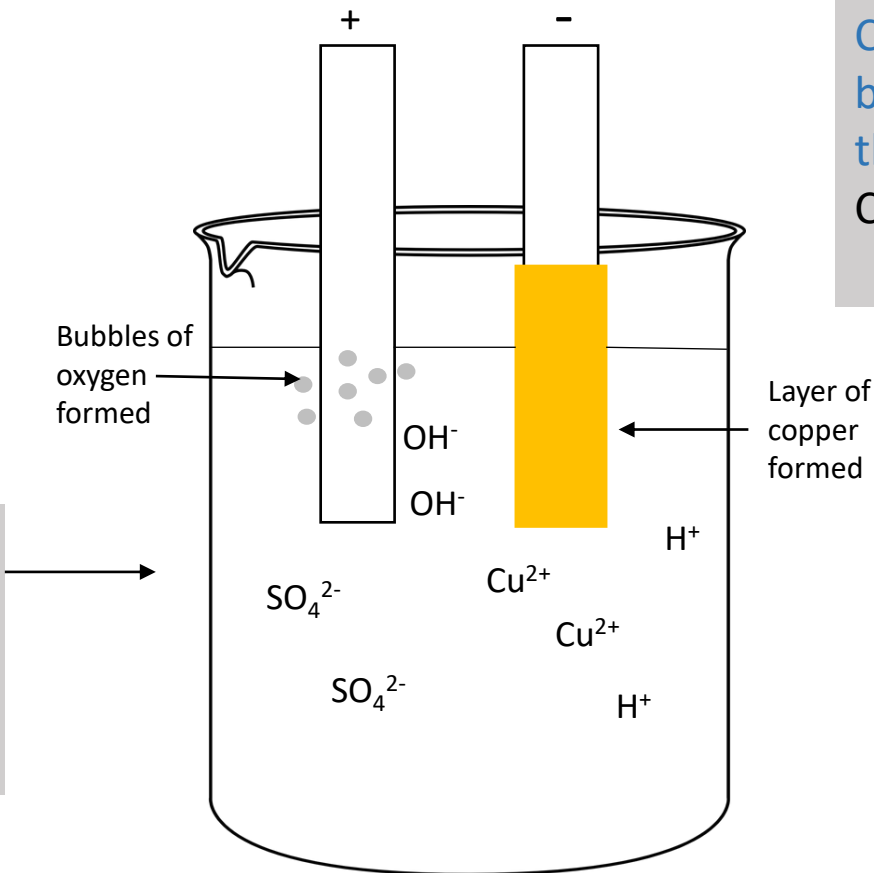
Copper Sulphate Solution

Anode:

Oxygen gas will be formed here because there are no halide ions present in the solution.

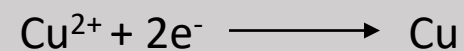


A solution of copper sulphate contains four different ions:
 Cu^{2+} , SO_4^{2-} , H^+ , OH^-



Cathode:

Copper metal will be formed here because copper is less reactive than hydrogen.



Your turn:

1 Chlorine and hydrogen are produced from the electrolysis of hydrochloric acid

a) Explain what is meant by electrolysis.

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b) Describe the test to show that chlorine gas is produced.

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.....

2. The ions present in sodium chloride solution are

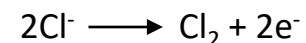
- sodium ions, Na⁺
- chloride ions, Cl⁻
- hydrogen ions, H⁺
- hydroxide ions, OH⁻

A direct electric current is used to electrolyse sodium chloride solution.

a) Which ions will be attracted to the cathode during the electrolysis of sodium chloride solution?

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b) One of the products of the electrolysis is chlorine.
The half equation for the production of chlorine is



Explain how the half equation shows that the chloride ions are oxidised.

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c) Suggest why the solution remaining at the end of electrolysis is alkaline.

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Your turn:

d) Metallic sodium is not produced by the electrolysis of sodium chloride.

What change would you need to make to the electrolyte to obtain metallic sodium.

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e) Oxygen is formed at the positively charged anode when copper sulphate is electrolysed using inert electrodes.

Explain how oxygen is formed from ions in the solution.

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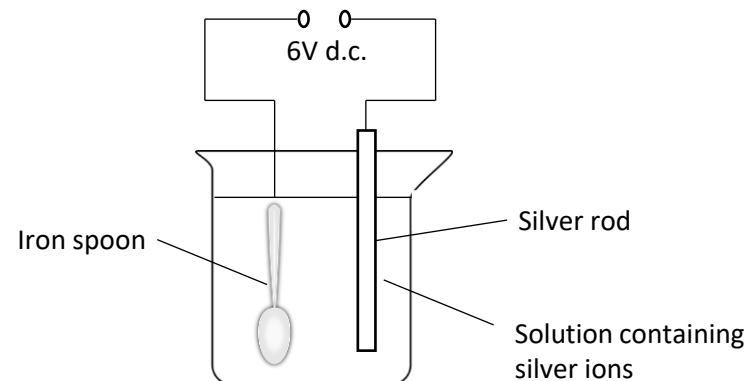
f) Copper is also produced.

1.29g of copper were produced in an experiment.

Calculate the number of moles of copper produced.

.....

3. Thin layers of transition metals can be used to form a coating on objects made of a different transition metal. This can be done to protect them against corrosion and improve their appearance.



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

Charge	Type of reaction
positive	reduction
negative	oxidation
positive	oxidation
negative	reduction

Your turn:

b) Silver metal is deposited on the spoon. A silver ion has a charge of +1. Write the half equation for this reaction.

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c) The voltage of a cell is 1.5V. Why does the voltage of the cell decrease when the cell is left connected in a circuit?

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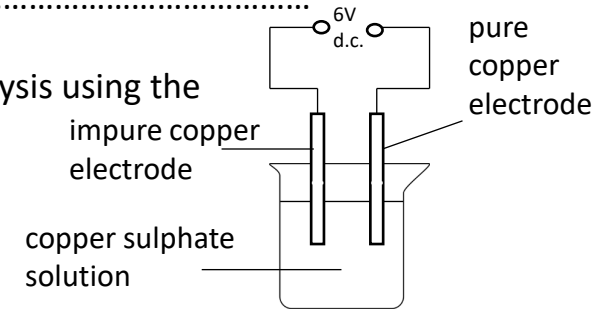
d) Duralumin is an alloy of copper and aluminium. The table below shows the radii of aluminium and copper atoms.

Metal	Radius of atom/m
aluminium	1.43×10^{-12}
copper	1.27×10^{-12}

Explain why copper added to the aluminium to form the alloy will make the alloy stronger than pure aluminium.

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4. Impure copper can be purified by electrolysis using the apparatus shown .



a) Give the name of the electrode which is made from pure copper.

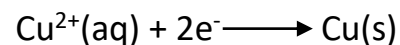
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b) Describe how each electrode will have changed at the end of the electrolysis process.

.....

Your turn:

c) What process does this half equation represent?



- A: Oxidation
- B: Displacement
- C: Reduction
- D: Redox

d) Copper sulphate solution is the electrolyte used in this process of electrolysis.

Explain how copper sulphate solution conducts electricity.

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5. A solution of sodium sulphate is electrolysed.

The solution contains Na^{+} ions, SO_4^{2-} ions, H^{+} ions and OH^{-} ions.

Hydrogen is produced at one electrode, and oxygen is produced at the other electrode.

Explain how these products are formed from the ions during electrolysis, and how you would identify the products.

You may include ionic equations in your answer.

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Answers:

1 Chlorine and hydrogen are produced from the electrolysis of hydrochloric acid

a) Explain what is meant by electrolysis.

Decomposition (splitting) of a compound using electricity

b) Describe the test to show that chlorine gas is produced.

Damp blue litmus paper bleaches (goes white)

2. The ions present in sodium chloride solution are

sodium ions, Na⁺
chloride ions, Cl⁻
hydrogen ions, H⁺
hydroxide ions, OH⁻

A direct electric current is used to electrolyse sodium chloride solution.

a) Which ions will be attracted to the cathode during the electrolysis of sodium chloride solution?

H⁺ and Na⁺ ions

b) One of the products of the electrolysis is chlorine. The half equation for the production of chlorine is



Explain how the half equation shows that the chloride ions are oxidised.

Chlorine ions have lost electrons

c) Suggest why the solution remaining at the end of electrolysis is alkaline.

It forms sodium hydroxide, which is alkaline

Answers:

d) Metallic sodium is not produced by the electrolysis of sodium chloride.

What change would you need to make to the electrolyte to obtain metallic sodium.

Use molten sodium

e) Oxygen is formed at the positively charged anode when copper sulphate is electrolysed using inert electrodes.

Explain how oxygen is formed from ions in the solution.

OH⁻ ions are formed from water

The ions are oxidised (lose electrons)

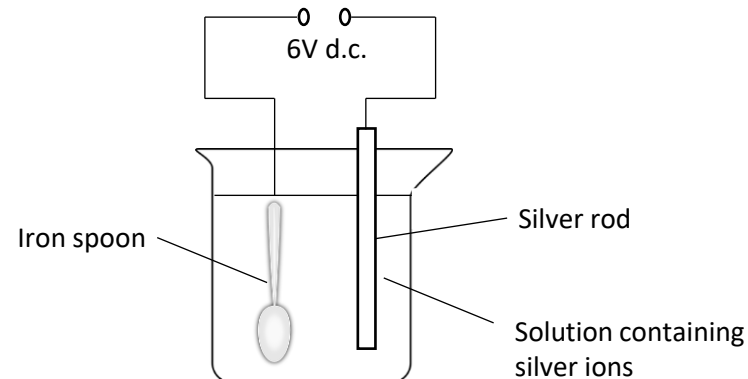
f) Copper is also produced.

1.29g of copper were produced in an experiment.

Calculate the number of moles of copper produced.

$1.29 \div 63.5 = 0.02 \text{ mol}$

3. Thin layers of transition metals can be used to form a coating on objects made of a different transition metal. This can be done to protect them against corrosion and improve their appearance.



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

Charge	Type of reaction
positive	reduction
negative	oxidation
positive	oxidation X
negative	reduction

b) Silver metal is deposited on the spoon. A silver ion has a charge of +1. Write the half equation for this reaction.



c) The voltage of a cell is 1.5V. Why does the voltage of the cell decrease when the cell is left connected in a circuit?

Reactants are being used up

d) Duralumin is an alloy of copper and aluminium. The table below shows the radii of aluminium and copper atoms.

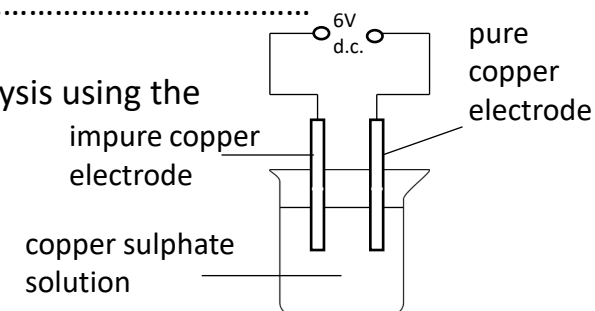
Metal	Radius of atom/m
aluminium	1.43×10^{-12}
copper	1.27×10^{-12}

Answers:

Explain why copper added to the aluminium to form the alloy will make the alloy stronger than pure aluminium.

Aluminium and copper atoms are a different size, and this prevents the layers sliding over each other

4. Impure copper can be purified by electrolysis using the apparatus shown .



a) Give the name of the electrode which is made from pure copper.

Cathode

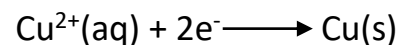
b) Describe how each electrode will have changed at the end of the electrolysis process.

Anode (impure copper) becomes smaller as copper atoms are oxidised to form ions in the solution.

Cathode (pure copper) becomes bigger as copper ions are reduced and added to the electrode

Answers:

c) What process does this half equation represent?



- A: Oxidation
- B: Displacement
- C: Reduction **X**
- D: Redox

d) Copper sulphate solution is the electrolyte used in this process of electrolysis.

Explain how copper sulphate solution conducts electricity.

.....
 Ions (copper ions and sulphate ions) are free to
 move in solution, resulting in a flow of charge

5. A solution of sodium sulphate is electrolysed.

The solution contains Na^{+} ions, SO_4^{2-} ions, H^{+} ions and OH^{-} ions.

Hydrogen is produced at one electrode, and oxygen is produced at the other electrode.

Explain how these products are formed from the ions during electrolysis, and how you would identify the products.

You may include ionic equations in your answer.

In solution ions will move when current is passed through.

Overall water decomposition from



Anode:.....

Sulphate ions will move to anode.....

Hydroxide ions move to anode and are oxidised (lose electrons) to form oxygen.



Oxygen test – glowing splint relights.....

Cathode:.....

Sodium ions move to cathode.....

Hydrogen ions move to cathode and are reduced (gain electrons) to form hydrogen gas.



Hydrogen test – lit splint in gas causes squeaky pop

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