Your notes

GCSE Chemistry: revision notes

Electrolysis

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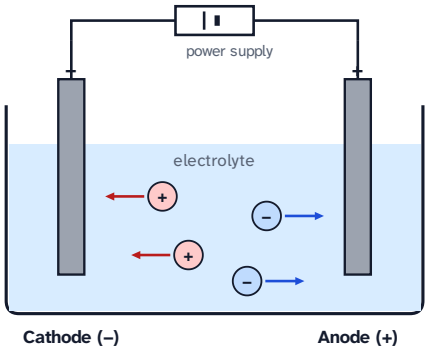
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Start here: splitting compounds with electricity

- **Electrolysis** uses electricity to split an ionic compound into its elements. The compound has to be melted or dissolved, so its ions are free to move.
- Two **electrodes** dip into the liquid. Opposites attract: positive ions move to the negative **electrode** (the **cathode**), and negative ions move to the positive electrode (the anode).
- At the **electrodes**, the ions gain or lose electrons and turn back into atoms or molecules. That is where the products form.

How electrolysis works

- When an ionic compound is melted or dissolved in water, its ions are free to move. The liquid or solution is called an **electrolyte**.
- Passing an electric current through the **electrolyte** makes the ions move to the **electrodes**.
- Positive ions move to the negative **electrode** (**cathode**). Negative ions move to the positive **electrode** (anode).
- At the **electrodes**, ions are **discharged** to form elements.



Molten ionic compounds

- In a molten compound, the metal forms at the **cathode** and the non-metal at the **anode**.
- Example: molten lead bromide gives lead at the **cathode** and bromine at the **anode**.



OIL RIG: Oxidation Is Loss, Reduction Is Gain (of electrons)

Extracting aluminium

- Metals too reactive to be extracted by carbon, such as aluminium, are extracted by **electrolysis** of their molten compounds. This uses large amounts of energy to melt the compound and make the current.
- Aluminium is made by electrolysing a molten mixture of aluminium oxide and **cryolite**. **Cryolite** lowers the melting point, saving energy.
- Aluminium forms at the **cathode**; oxygen forms at the carbon **anode**.
- The oxygen reacts with the carbon **anodes** to form carbon dioxide, so the **anodes** wear away and must be replaced regularly.

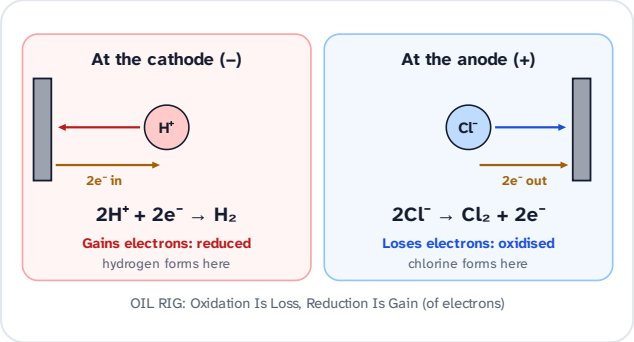


OIL RIG: Oxidation Is Loss, Reduction Is Gain (of electrons)

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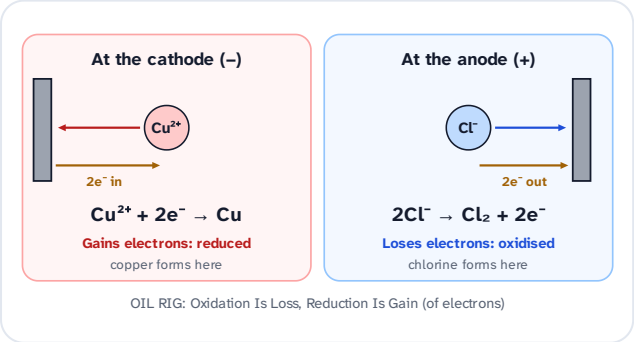
Aqueous solutions

- In aqueous solutions, water also forms some H^+ and OH^- ions, so the products depend on reactivity.
- At the **cathode**: hydrogen is produced if the metal is more reactive than hydrogen; otherwise the metal forms (for example copper).
- At the **anode**: oxygen is produced, unless the solution contains halide ions, when the halogen (such as chlorine) is produced.
- Examples: sodium chloride solution gives hydrogen and chlorine, leaving sodium hydroxide solution. Copper sulfate solution gives copper and oxygen.



Half equations, step by step (Higher)

- A **half equation** shows what happens to the ions at one **electrode**. An electron is written as e^-.
- At the **cathode**, positive ions gain electrons. Gaining electrons is reduction. A 2+ ion gains 2 electrons: $Cu^{2+} + 2e^- \rightarrow Cu$.
- At the **anode**, negative ions lose electrons. Losing electrons is oxidation. Two Cl^- ions each lose an electron to make one Cl_2 molecule: $2Cl^- \rightarrow Cl_2 + 2e^-$.
- Remember OIL RIG: Oxidation Is Loss, Reduction Is Gain (of electrons).
- To write one: write the ion and what it becomes, balance the atoms, then add electrons to the side that needs them, so the charges balance.
- Hydrogen ions at the **cathode** make hydrogen: $2H^+ + 2e^- \rightarrow H_2$. Hydroxide ions at the **anode** make oxygen: $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$.



Your notes

Exam tip

- Say where the ions go: positive ions go to the negative **electrode** (**cathode**) and gain electrons; negative ions go to the positive **electrode** (anode) and lose electrons.
- For solutions, hydrogen forms at the **cathode** unless the metal is less reactive than hydrogen. Oxygen forms at the **anode**, unless there's a halide.

Common mistakes

- Sending positive ions to the positive **electrode**.
- Using the molten rules for a solution.
- (Higher) **Half equations** whose charges don't balance.

Worked examples

(Higher) Write the half equation for chlorine forming at the anode.

Write the ion and what it becomes: chloride ions, Cl^-, make chlorine gas, which is in pairs of atoms, Cl_2. **$Cl^- \rightarrow Cl_2$**

Balance the atoms: two chloride ions make one Cl_2. **$2Cl^- \rightarrow Cl_2$**

Balance the charges: the left is 2–, the right is 0, so 2 electrons are lost. They go on the right. **$2Cl^- \rightarrow Cl_2 + 2e^-$**

Check: the charge is 2– on both sides. Electrons are lost, so it is oxidation. **2– = 2–**

Answer: $2Cl^- \rightarrow Cl_2 + 2e^-$

(Higher) Write the half equation for aluminium forming at the cathode.

Aluminium ions are Al^{3+}, and they become aluminium atoms. **$Al^{3+} \rightarrow Al$**

The atoms balance already. The left is 3+ and the right is 0, so 3 electrons are gained. They go on the left. **$Al^{3+} + 3e^- \rightarrow Al$**

Electrons are gained, so this is reduction.

Answer: $Al^{3+} + 3e^- \rightarrow Al$

What forms at each electrode when copper chloride solution is electrolysed?

At the cathode: copper is less reactive than hydrogen, so the metal forms. **copper**

At the anode: the solution has chloride ions (a halide), so the halogen forms. **chlorine**

Answer: Copper at the cathode, chlorine at the anode

Key terms

Electrolysis	Breaking down an ionic compound using electricity.

Your notes

Electrolyte	A molten or dissolved ionic compound that conducts electricity.
Electrode	A conductor through which current enters or leaves the electrolyte.
Cathode	The negative electrode, where positive ions gain electrons.
Anode	The positive electrode, where negative ions lose electrons.
Discharged	When an ion gains or loses electrons at an electrode to form an element.
Cryolite	A compound added to aluminium oxide to lower its melting point.
Inert electrode	An electrode, such as graphite or platinum, that does not react.
Half equation	An equation showing the electrons gained or lost at one electrode.

Your notes

Quick questions

Cover the answers and test yourself: remembering is what makes it stick.

1. Why must ionic compounds be molten or dissolved for electrolysis?
2. Which ions move to the cathode?
3. What forms at the cathode when molten lead bromide is electrolysed?
4. Why is cryolite used in the extraction of aluminium?
5. Why must the carbon anodes be replaced?
6. What forms at the cathode when sodium chloride solution is electrolysed?
7. What forms at the anode when copper sulfate solution is electrolysed with inert electrodes?
8. What forms at the anode when sodium chloride solution is electrolysed?

Answers

1. So the ions are free to move
2. Positive ions
3. Lead
4. To lower the melting point and save energy
5. Oxygen reacts with the carbon to form carbon dioxide
6. Hydrogen
7. Oxygen
8. Chlorine

What to do next

Practise 11 questions on this topic

Try 7 exam questions, with mark schemes

Read the lesson, one step at a time

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