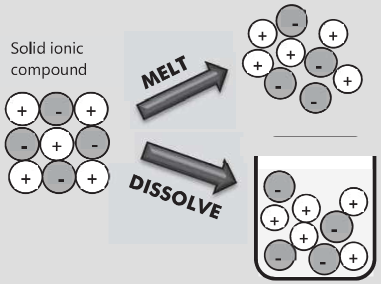
Electrolysis

IONIC CONDUCTIVITY

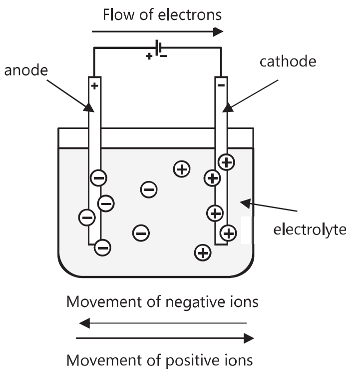


- When solid, ionic compounds **don't** conduct electricity because all the ions are **fixed** in place.
- However, when **molten** or **dissolved** in water the ions are **free to move** and can carry charge through the material and conduct electricity.

The Process of Electrolysis

If you pass an electric current through an **electrolyte** (a liquid that conducts electricity) the ions in it move towards the electrodes. Positive ions (**cations**) go towards the negative electrode (**cathode**), and negative ions (**anions**) go towards the positive electrode (**anode**).

At the electrodes, the ions get **discharged** – they **gain or lose electrons** to become **neutral** atoms/molecules. This process is called **electrolysis**.



HT ONLY

If water is getting electrolysed, these half-equations are occurring:

Electrons are gained so this is a **REDUCTION** → **CATHODE: $2H^+ + 2e^- \rightarrow H_2$**

ANODE: $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$ ← Electrons are lost so this is an **OXIDATION**

Molten Ionic Compounds

EXAMPLE!

Simple ionic compounds contain one type of **metal ion** and one type of **non-metal ion**, e.g. $CuCl_2$. If you electrolyse a molten sample of these compounds, you produce the **elements they are made from**.

$$Cu^{2+}_{(l)} + 2Cl^-_{(l)}$$

Blue-green liquid

$$CuCl_{2(l)} \rightarrow Cu_{(s)} + Cl_{2(g)}$$

Red-brown solid collecting on the cathode

Gas bubbling at the anode

Exam Tip! It's very important to remember to use state symbols!

Ionic Compounds in Solution

When an ionic compound is **dissolved in water**, the products of hydrolysis might be different from when it is a **molten compound**. This is because some of the water molecules **break down** into ions, and these ions can get discharged instead.

$$H_2O_{(l)} \rightarrow H^+_{(aq)} + OH^-_{(aq)}$$

RULES

AT THE POSITIVE ELECTRODE

- If the ionic compound **doesn't** contain halide ions: **oxygen gas** is formed from OH^- ions
- If the ionic compound **does** contain halide ions: the **halogen gas** is formed

AT THE NEGATIVE ELECTRODE

- If the ionic compound contains a metal **more reactive** than hydrogen: **hydrogen gas** is formed from H^+ ions
- If the ionic compound contains a metal **less reactive** than hydrogen: **solid metal** is formed from metal ions

	At the anode	At the cathode
$ZnBr_2(aq)$	$Br_2(g)$	$H_2(g)$
$CuCl_2(aq)$	$Cl_2(g)$	$Cu(s)$
$Na_2O(aq)$	$O_2(g)$	$H_2(g)$

Extraction of Metals

EXAMPLE!

Metals more reactive than carbon can't be extracted from their compounds by reduction with carbon, so must instead be obtained using electrolysis. Extraction of **aluminium** from **aluminium oxide** is a key example of this on an industrial scale.

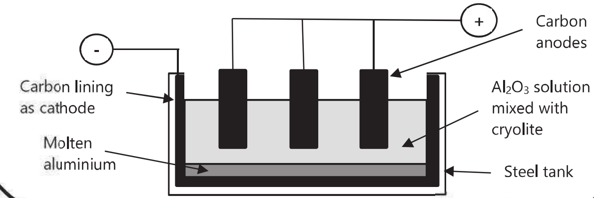
- Aluminium oxide has a melting point of over **2000 °C** – it takes a lot of energy to get temperatures that high and, therefore, costs a lot of money. Bauxite is often mixed with **cryolite**, which reduces the melting point to 950 °C.
- **Inert electrodes** are used – this means they allow electrolysis to occur but don't react themselves. **Graphite** electrodes are commonly used.

$$2Al_2O_{3(l)} \rightarrow 4Al_{(l)} + 3O_{2(g)}$$

Aluminium metal forms at the **cathode**

Oxygen gas forms at the **anode**

- The oxygen produced reacts with the positive carbon electrode slowly to form **carbon dioxide**, so the anode has to be regularly replaced.



HALF-EQUATIONS

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The process of electrolysis can be shown using two half-equations, where one shows loss of electrons and one shows gain.

CATHODE $Cu^{2+}_{(l)} \rightarrow Cu_{(s)}$

ANODE $2Cl^-_{(l)} \rightarrow Cl_{2(g)}$

To make a balanced half-equation, the charges on both sides need to be equal.

$Cu^{2+}_{(l)} + 2e^- \rightarrow Cu_{(s)}$ — **Gain in electrons = REDUCTION**

$2Cl^-_{(l)} \rightarrow 2e^- + Cl_{2(g)}$ — **Loss of electrons = OXIDATION**

Exam Tip! In a pair of half-equations, one should have electrons on the RHS and one should have electrons on the LHS.