Chapter 6: Electrolysis

Knowledge organiser

Electrolysis

In the process of **electrolysis**, an electric current is passed through an **electrolyte**. An electrolyte is a liquid or solution that contains ions and so can conduct electricity. This causes the ions to move to the electrodes, where they form pure elements.



Electrolysis of molten compounds

Solid ionic compounds do not conduct electricity as the ions cannot move. To undergo electrolysis they must be molten or dissolved, so the ions are free to move.

When an ionic compound is molten:

- The positive metal ions are *attracted* to the **cathode**. where they will gain electrons to form the pure metal
- The negative non-metal ions are *attracted* to the **anode**, where they will lose electrons and become the pure nonmetal.

For example, molten sodium chloride, NaCl, can undergo electrolysis to form sodium at the cathode and chlorine at the anode.

Half equations (HT only)

sodium chloride \rightarrow sodium + chlorine

2NaCl(l) $\rightarrow 2Na(s) + Cl_2(g)$

- at the cathode: $2Na^{+}(l) + 2e^{-} \rightarrow 2Na(s)$
- at the anode: $2Cl^{-}(l) \rightarrow Cl_{2}(g) + 2e^{-}$

Electrolysis of aqueous solutions

Solid ionic compounds can also undergo electrolysis when dissolved in water.

potassium

- It requires less energy to dissolve ionic compounds in water than it does to melt them.
- However, in the electrolysis of solutions, the pure elements are not always produced. This is because the water can also undergo ionisation:

$H_2O(l) \rightarrow H^+(aq) + OH^-(aq)$

most

Products at the anode

In In the electrolysis of a solution, if the non-metal contains oxygen then oxygen gas is formed at the anode:

- The OH⁻(aq) ions formed from the ionisation of water are attracted to the anode.
- The OH⁻(aq) ions lose electrons to the anode and form oxygen gas.
- $4OH^{-}(aq) \rightarrow O_{2}(g) + 2H_{2}O(l) + 4e^{-}$

If the non-metal ion is a halogen, then the halogen gas is formed at the anode.

• $2Cl^{-}(aq) \rightarrow Cl_{2}(g) + 2e^{-}$

reactive sodium calcium magnesium aluminium (carbon) zinc iron tin lead (hydrogen) coppe silver gold least reactive

platinum

Products at the cathode

In the electrolysis of a solution, if the metal is more **reactive** than hydrogen then hydrogen gas is formed at the cathode:

- The H⁺(aq) ions from the ionisation of water are attracted to the cathode and react with it.
- The H⁺(aq) ions gain electrons from the cathode and form hydrogen gas.
- $2H^+(aq) + 2e^- \rightarrow H_2(g)$
- The metal ions remain in solution.

Electrolysis of aluminium oxide

Electrolysis can be used to extract metals from their ionic compounds.

Electrolysis is used if the metal is more reactive than carbon.

Aluminium is extracted from aluminium oxide by electrolysis.

- **1** The aluminium oxide is mixed with a substance called **cryolite**, which lowers the melting point.
- 2 The mixture is then heated until it is molten.
- **3** The resulting molten mixture undergoes electrolysis.

aluminium oxide → aluminium + oxygen

 $2Al_2O_3(l)$ 4Al(l) \rightarrow $+ 3O_{2}(g)$

cathode: pure aluminium is formed $Al^{3+}(l) + 3e^{-} \rightarrow Al(l)$

anode: oxygen is formed $2O^{2-}(l) \rightarrow O_{2}(g) + 4e^{-1}$

In the electrolysis of aluminium, the anode is made of graphite.

The graphite reacts with the oxygen to form carbon dioxide and so slowly wears away. It therefore needs to be replaced frequently.



Electrolysis of zinc chloride

Molten zinc chloride is broken down by electrolysis. This means zinc metal is collected at the cathode and a pale green chlorine gas is collected at the anode. Free ions from the molten zinc chloride are able to move around and carry electric currents, hence why the bulb lights up.

Key terms	Make sure you can	write a definition f
	anode electrolysis	cathode elect



r these key terms.

cryolite crolyte

electrode reactivity

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Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	C6 questions		Answers
1	What is electrolysis?	l :0 Put	process of using electricity to extract elements from a compound
2	What is the name of the positive electrode?	paper h	anode
3	What is the name of the negative electrode?	ere (cathode
4	What is an electrolyte?	Put paper	liquid or solution that contains ions and so can conduct electricity
5	Where are metals formed?	. here	cathode
6	Where are non-metals formed?	Put p	anode
7	How can ionic substances be electrolysed?	baper here	by melting or dissolving them, and then passing a direct current through them
8	Why can solid ionic substances not be electrolysed?	Put pa	they do not conduct electricity, or the ions cannot move
9	In the electrolysis of solutions, when is the metal <i>not</i> produced at the cathode?	aper here	when the metal is more reactive than hydrogen
10	In the electrolysis of a metal halide solution, what is produced at the anode?	Put p	halogen
1	In the electrolysis of a metal sulfate solution, what is produced at the anode?	aper here	oxygen
Ð	What is the half equation for the ionisation of water?] Pu	$H_2O(l) \rightarrow H^+(aq) + OH^-(aq)$
₿	What metals are extracted from ionic compounds by using electrolysis?	t paper he	metals that are more reactive than carbon
14	In the electrolysis of aluminium oxide, why is the aluminium oxide mixed with cryolite?	re 1 Put	to lower the melting point
₽	In the electrolysis of aluminium oxide, what are the anodes made of?	paper here	graphite
16	In the electrolysis of aluminium oxide, why do the anodes need to be replaced?	1	they react with the oxygen being formed
1 4 1 5 1 6	In the electrolysis of aluminium oxide, why is the aluminium oxide mixed with cryolite? In the electrolysis of aluminium oxide, what are the anodes made of? In the electrolysis of aluminium oxide, why do the anodes need to be replaced?	re Put paper here	to lower the melting point graphite they react with the oxygen being formed