

4 Electrochemistry

4.1 Electrolysis

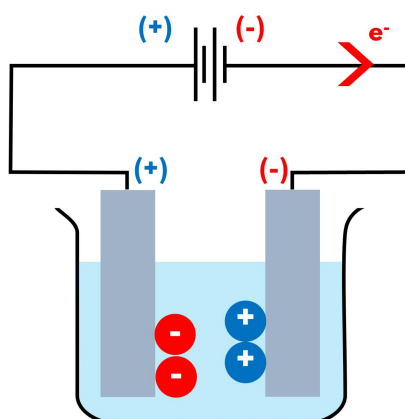
1 Define **electrolysis** as the decomposition of an ionic compound, when molten or in aqueous solution, by the passage of an electric current

2 Identify in simple electrolytic cells:

(a) the anode as the positive electrode

(b) the cathode as the negative electrode

(c) the electrolyte as the molten or aqueous substance that undergoes electrolysis



3 Identify the products formed at the electrodes and describe the observations made during the electrolysis of:

a) molten lead(II) bromide

- At the cathode, a silvery gray deposit of liquid lead is seen
- At anode, red-brown fumes are seen as bromine gas forms.

B) concentrated aqueous sodium chloride

- At the cathode, bubbles of gas hydrogen gas are produced (water provides hydrogen ions). This gas pops when a lighted splint is held close to it.
- At the anode, pale green gas bubbles are seen(chlorine).
- The alkalinity of the solution increases as the concentration of hydroxide ions increases and hydrogen ions decreases. Sodium and hydroxide ions combine to form NaOH(an alkali).

C) dilute sulfuric acid

- At the cathode, bubbles of hydrogen gas are produced(acid provides the hydrogen ions).
- At the anode bubbles of oxygen gas are produced when hydroxide ions are discharged, which relight a glowing splint(hydroxide ion provides the oxygen).
- Water is formed when hydroxide ion is discharged.

using inert electrodes made of platinum or carbon/graphite

NOTE: These two materials are good conductors of electricity.

5 Predict the identity of the products at each electrode for the electrolysis of a binary compound in the molten state[binary compounds have ONLY two different elements] AND 10 Predict the identity of the products at each electrode for the electrolysis of a halide compound in dilute or concentrated aqueous solution

- When molten binary compounds are electrolysed, the non-metal forms at the anode and the metal forms at the cathode.

- When a concentrated halide compound is electrolysed, the less reactive cation is discharged at the cathode and the halide is formed at the anode.
- When a dilute halide compound is electrolysed, the less reactive cation is discharged at the cathode and oxygen gas forms at the anode along with water.
- If no halide ion is present, oxygen forms.

4 State that metals or hydrogen are formed at the cathode and that non-metals (other than hydrogen) are formed at the anode

- The cathode is negatively charged, so it attracts cations which are positively charged.

NOTE: opposite charges attract each other.

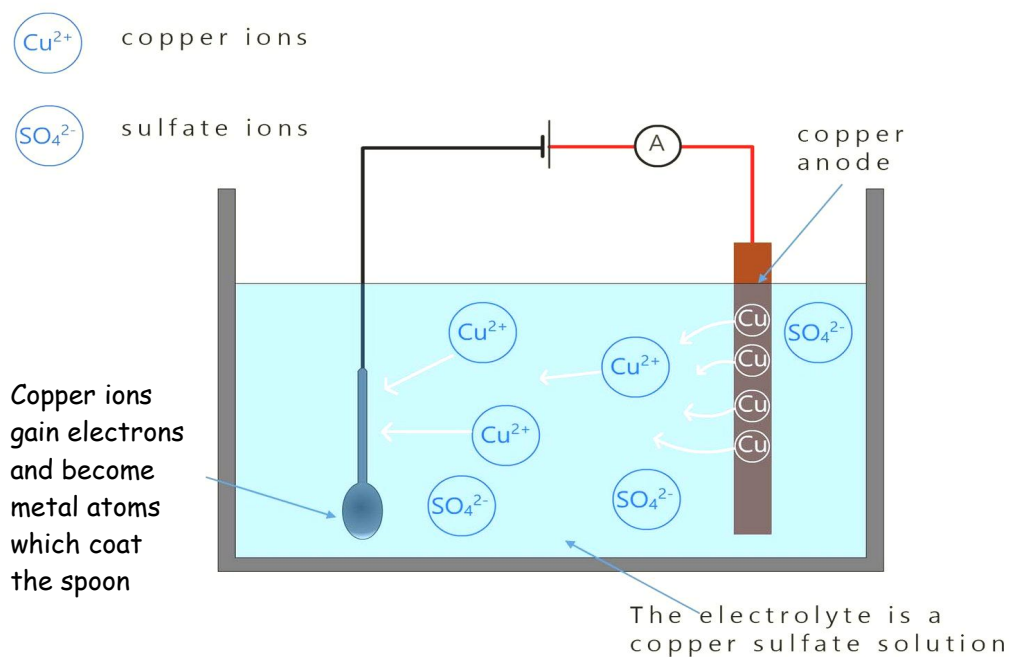
- The anode is positively charged, so it attracts anion which are negatively charged.
- The more reactive a metal is, the more likely it is to stay as ions in a solution.
- Example: In concentrated sodium chloride, there are both hydrogen and sodium ions but sodium is more reactive. This means that hydrogen ions will gain electrons (gets discharged) instead and sodium ions remains ions in solution.
- This is the order of reactivity:

How to remember the Reactivity Series?		
Please	Potassium	 Most reactive
Stop	Sodium	
Calling	Calcium	
Me	Magnesium	
A	Aluminium	
Careless	(Carbon)	
Zebra	Zinc	
Instead	Iron	
Try	Tin	
Learning	Lead	
How	(Hydrogen)	
Copper	Copper	
Saves	Silver	
Gold	Gold	
		Least reactive

6 State that metal objects are electroplated to improve their appearance and resistance to corrosion

7 Describe how metals are electroplated

- The object that needed to be electroplated is the cathode and the anode is made up of the metal that will coat the metal.
- The electrolyte will be an aqueous salt of the metal the anode is made up of.
- The anode break down at the metal atoms get oxidized(lose electrons) and become ions. They become part of the electrolyte.
- The metal ions move to the cathode where they are reduced(gain electrons) and become atoms. They get deposited on the object and coat it.



8 Describe the transfer of charge during electrolysis to include:

(a) the movement of electrons in the external circuit

- The positive terminal takes electrons from the anode (forming anions). These electrons move to the negative terminal which pushes it into the cathode (forming cations).

(b) the loss or gain of electrons at the electrodes

- At the anode, oxidation (electron loss) occurs. **[OX.AN]**
- At the cathode, reduction (electron gain) occurs. **[RED.CAT]**

(c) the movement of ions in the electrolyte

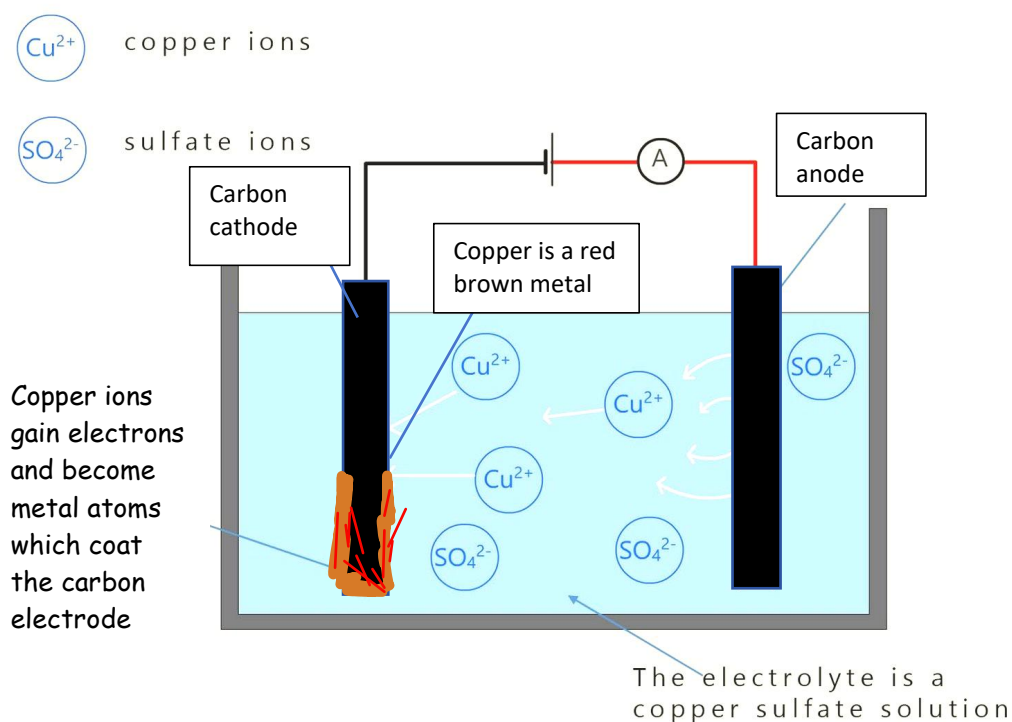
- Cations move to the cathode and anions move to the anode.

9 Identify the products formed at the electrodes and describe the observations made during the electrolysis of

aqueous copper(II) sulfate using inert carbon/graphite electrodes and when using copper electrodes

● **Using carbon electrodes:**

- At the anode oxygen bubbles are produced.
- At the carbon cathode, the copper ions are reduced to atoms. The copper atoms get deposited and coat the carbon electrode.
- The blue colour of the solution fades and as the concentration of copper ions in the solution decreases.

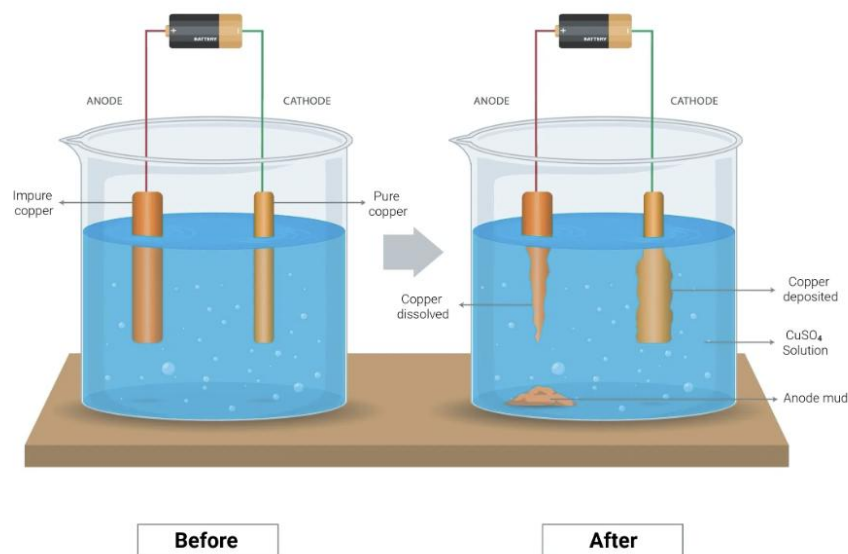


● **Using copper electrodes:**

- the anode breaks down into copper ions which end up in the electrolyte, increasing copper ion concentration. The size of electrode decreases.
- At the carbon cathode, the copper ions are reduced to atoms. The copper atoms get deposited and coat

the carbon electrode (red brown metal). the size of electrode increases.

- The blue colour of the solution remains as the rate of formation of copper ions at the anode is equal to rate of removal of copper ions at the cathode. Concentrations remains unchanged.



11 Construct ionic half-equations for reactions at the anode (to show oxidation) and at the cathode (to show reduction)

- For the reactions in 3:

a) At cathode: $\text{Pb}^{2+}_{(\text{aq})} + 2\text{e}^{-} \rightarrow \text{Pb}_{(\text{l})}$ AND at anode:
 $2\text{Br}^{-} \rightarrow \text{Br}_{2(\text{g})} + 2\text{e}^{-}$

b) At the cathode: $2\text{H}_2\text{O}_{(\text{l})} + 2\text{e}^{-} \rightarrow \text{H}_{2(\text{g})} + 2\text{OH}^{-}_{(\text{aq})}$ AND at anode: $2\text{Cl}^{-}_{(\text{aq})} \rightarrow \text{Cl}_{2(\text{g})} + 2\text{e}^{-}$

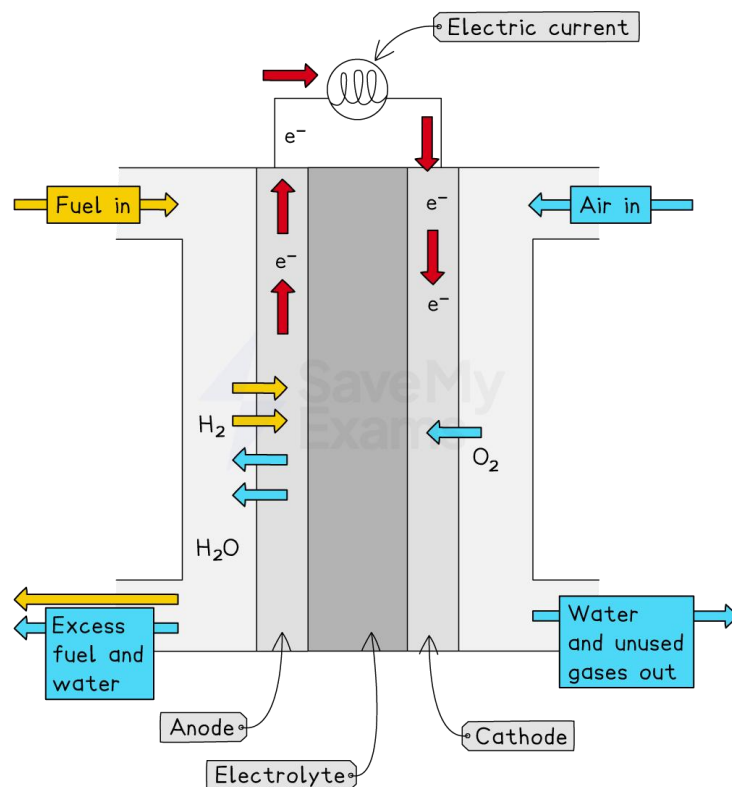
c) At the cathode: $2\text{H}^{+}_{(\text{aq})} + 2\text{e}^{-} \rightarrow \text{H}_{2(\text{g})}$ AND at the anode:
 $4\text{OH}^{-}_{(\text{aq})} \rightarrow \text{O}_{2(\text{g})} + 2\text{H}_2\text{O}_{(\text{l})} + 4\text{e}^{-}$

- How to write half equations for a):

- Step 1: equation, $\text{PbBr}_{2(l)} \rightarrow \text{Pb}_{(l)} + \text{Br}_{2(g)}$
- Step 2: ionic equations, $\text{Pb}^{2+} + 2\text{Br}^- \rightarrow \text{Pb}_{(l)} + \text{Br}_{2(g)}$
- Step 3: split the ionic equation, $\text{Pb}^{2+} \rightarrow \text{Pb}_{(l)}$ AND $2\text{Br}^- \rightarrow \text{Br}_{2(g)}$
- Step 4: balance out the charges of the ions by adding electrons, to balance out Pb^{2+} add two electrons like this $\text{Pb}^{2+} + 2\text{e}^- \rightarrow \text{Pb}_{(l)}$. For Bromide ion remove two electrons like this $2\text{Br}^- - 2\text{e}^- \rightarrow \text{Br}_{2(g)}$ but you MUST write it like this $2\text{Br}^- \rightarrow \text{Br}_{2(g)} + 2\text{e}^-$ by moving the electrons to the other side.

4.2 Hydrogen-oxygen fuel cells

1 State that a hydrogen-oxygen fuel cell uses hydrogen and oxygen to produce electricity with water as the only chemical product



2 Describe the advantages and disadvantages of using hydrogen-oxygen fuel cells in comparison with gasoline/petrol engines in vehicles

Aspect	Hydrogen-Oxygen Fuel Cells	Gasoline/Petrol Engines
Efficiency	Higher efficiency (adv.)	Lower efficiency (dis.)
Emissions	Only water vapor (clean, no CO ₂)(adv.)	Produces CO ₂ , NO _x , and other pollutants(dis.)
Fuel Source	Hydrogen (can be renewable if produced via electrolysis)(adv.)	Fossil fuels (non-renewable, finite)(dis.)
Environmental Impact	Environmentally friendly (adv.)	Significant greenhouse gas emissions(dis.)
Refueling/Infrastructure	Hydrogen refueling stations are limited and costly(dis.)	Extensive global petrol station network(adv.)
Energy Density	Hydrogen has high energy per mass but low per volume (needs compression/liquefaction) (dis.)	Petrol is energy-dense and easy to store(adv.)
Safety	Hydrogen is flammable and requires careful storage(dis.)	Petrol is also flammable but easy to avoid burning(adv.)
Cost	Fuel cells and hydrogen storage are expensive(dis.)	Petrol engines are cheaper and widely available(adv.)
Maintenance	Fewer moving parts, potentially lower maintenance(adv.)	More moving parts, higher maintenance needs(dis.)

END OF CHAPTER