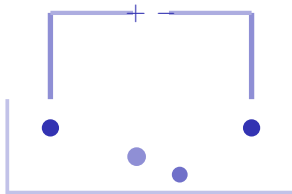


Electrochemistry

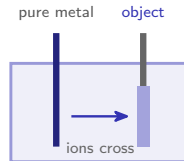
IGCSE Chemistry ■ Topic 4

IGCSE Chemistry



What we will cover

- 1 What electrolysis is
- 2 The electrolytic cell
- 3 Products at each electrode
- 4 Half-equations
- 5 Electroplating
- 6 Hydrogen fuel cells



electroplating

1

Electrolysis

What electrolysis is, and what it needs

Electrolysis 电解 splits an ionic compound by passing a current through it.

- it works only when the substance is **molten or dissolved**, because only then are the **ions** 离子 free to move and carry the charge
- a **solid** ionic compound cannot be electrolysed at all – its ions are locked in place

That single fact answers a whole family of questions: "why does solid lead bromide not conduct?"

The electrolytic cell

Two electrodes dip into an **electrolyte** 电解质:

electrode	charge	ions attracted	what happens
cathode 阴极	negative	cations (+)	gain electrons: reduction
anode 阳极	positive	anions (−)	lose electrons: oxidation

PANCake: **P**ositive **A**node, **N**egative **C**athode.

Products at each electrode

cathode (−) $\longrightarrow$ metal or hydrogen

anode (+) $\longrightarrow$ non-metal

Cathode: metals & **hydrogen** 氢气.

Anode: **non-metals** 非金属.

molten PbBr_2 : lead | bromine

conc. $\text{NaCl}(\text{aq})$: hydrogen |
chlorine 氯气

dilute H_2SO_4 : hydrogen | oxy-
gen

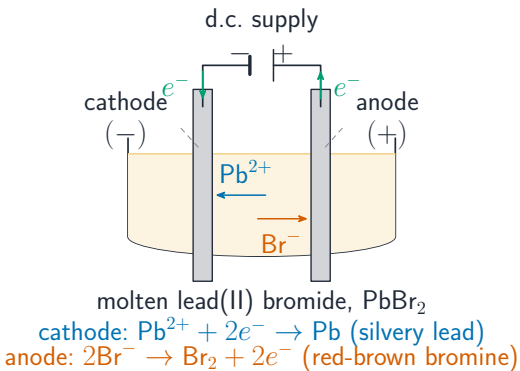
What is formed at each electrode

the simple rule	metals and hydrogen go to the cathode; non-metals go to the anode
molten compounds	only two ions are present, so the products are always the metal and the non-metal
concentrated 浓 NaCl solution	hydrogen at the cathode, chlorine at the anode
dilute 稀 sulfuric acid 硫酸	hydrogen at the cathode, oxygen at the anode
copper 铜 sulfate with copper electrodes	copper deposits at the cathode and dissolves from the anode – purification
why it varies	in solution, water can be decomposed 分解 too, so what wins depends on concentration and on the ions present

The electric current 电流 is carried by ions moving in the electrolyte and by electrons in the wires – never by electrons through the liquid.

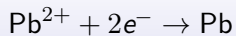
How the charge moves

- **Electrons 电子** move through the wires (the **external circuit 外电路**) from the power supply.
- At the cathode, positive ions gain electrons. Gaining electrons is **reduction 还原**.
- At the anode, negative ions lose electrons. Losing electrons is **oxidation 氧化**.
- Inside the electrolyte, the ions move: positive ions go to the cathode and negative ions go to the anode.

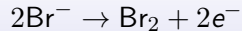


Half-equations

cathode – reduction 还原 (gain e^-)

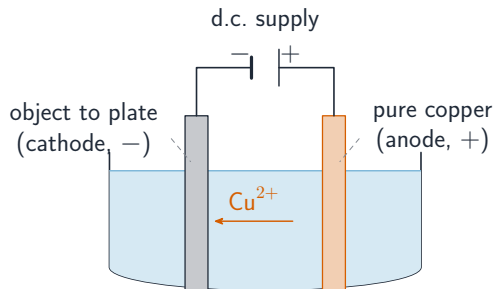


anode – oxidation 氧化 (lose e^-)



Electrons travel the **wires**; ions travel the **electrolyte** – positive to the cathode, negative to the anode.

Electroplating



electrolyte: copper(II) sulfate solution
copper coats the object at the
cathode; the copper anode
slowly dissolves to replace it

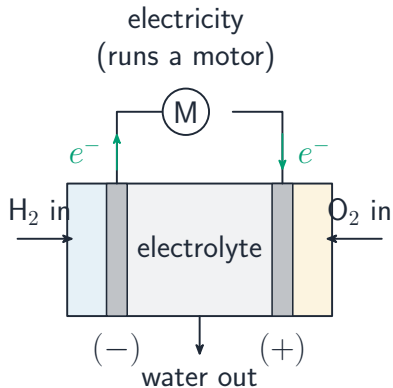
Electroplating 电镀 coats an object to
improve looks & resist **corrosion** 腐蚀.

- object = the **cathode**
- plating metal = the **anode**
- electrolyte = that metal's ions

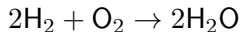
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Fuel cells

Hydrogen–oxygen fuel cells



A **fuel cell** 燃料电池 makes electricity directly; the only product is water.



Clean, but hydrogen is hard to store safely.

Fuel cell against petrol engine

main product	fuel cell: water only . Engine: carbon dioxide and pollutants 污染物
effect on air	fuel cell: clean . Engine: adds to air pollution
efficiency	fuel cell converts chemical energy to electricity efficiently ; the engine loses much of it as heat
fuel storage	hydrogen is hard and dangerous to store – flammable, and needs high pressure. Petrol is easy
the source	hydrogen may be made using fossil fuels ; petrol is made from crude oil

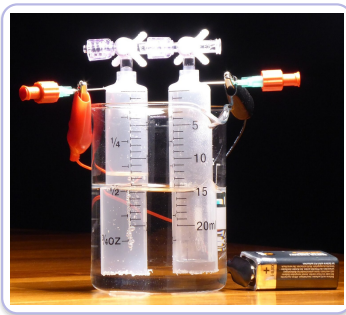
The fuel cell is clean *at the vehicle*. Whether it is clean overall depends entirely on how the hydrogen was made – and that is the evaluation mark.

Electrolysis



The set-up is an **electrolytic cell** 电解池: two **electrodes** 电极 dipping into the **electrolyte** 电解质 – the molten or aqueous substance being broken up. The electrodes are usually **inert** 惰性, **platinum** 铂 or **graphite** 石墨, so they take no part in the reaction.

Electrolysis of water: twice as much hydrogen



Electrolysis of water: gas bubbles off at each electrode and collects in the tubes above, with about twice as much hydrogen as oxygen

Exam tips

- At the **cathode** (negative) you get a metal or hydrogen; at the **anode** (positive) you get a non-metal. Positive ions move to the cathode, negative ions to the anode.
- A **molten** compound just gives its two elements. An **aqueous** solution can give something different (concentrated sodium chloride gives hydrogen and chlorine, not sodium).
- **Reduction** is *gain* of electrons (at the cathode); **oxidation** is *loss* of electrons (at the anode). Remember OIL RIG.
- In a **half-equation** the atoms and the charges must balance, with the electrons on the correct side: $\text{Pb}^{2+} + 2e^{-} \rightarrow \text{Pb}$ (cathode).
- To **electroplate** an object, make it the cathode, make the plating metal the anode, and use a solution containing ions of the plating metal.

3

Recap

Worked example – predicting electrolysis products

Give the products of electrolysis of concentrated aqueous sodium chloride with inert electrodes.

- Ions present: Na^+ , H^+ (cations) and Cl^- , OH^- (anions).
- Cathode (–): the **less reactive** cation is discharged. Na is more reactive than H $\Rightarrow$ **hydrogen**.
- Anode (+): the halide is **concentrated**, so it wins over $\text{OH}^- \Rightarrow$ **chlorine**.
- Na^+ and OH^- stay behind as sodium hydroxide solution.

Cathode = **reduction** (gain electrons), anode = **oxidation**. Dilute halide $\Rightarrow$ oxygen at the anode; concentrated $\Rightarrow$ the halogen.

Topic 4 – key takeaways

1

Electrolysis

splits ionic compounds; needs free ions

2

Electrodes

anode + (oxidation), cathode – (reduction)

3

Products

cathode: metals/H; anode: non-metals

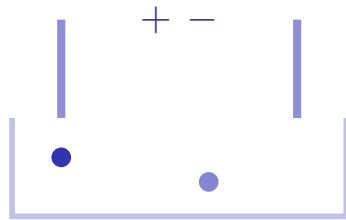
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Fuel cell

$\text{H}_2 + \text{O}_2$; water is the only product

Check yourself

- 1 Why must an electrolyte be molten or aqueous?
- 2 Which electrode is the anode: + or -?
- 3 What forms at the cathode in molten PbBr_2 ?
- 4 What is the only product of a hydrogen fuel cell?



Answers 1. so the ions are free to move 2. the positive (+) 3. lead 4. water