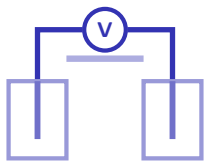
Electrochemistry

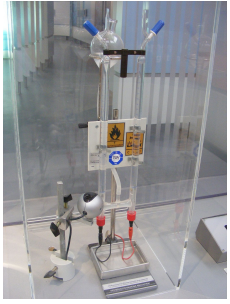
A-Level Chemistry ▪ Topic 24

A-Level Chemistry



What we will cover

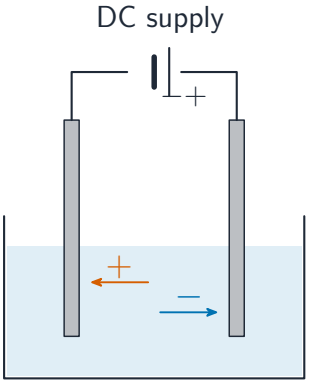
1. Electrolysis
2. Faraday calculations
3. Standard electrode potentials
4. Cell potentials & feasibility
5. The Nernst equation



electrolysis of water

1 Electrolysis

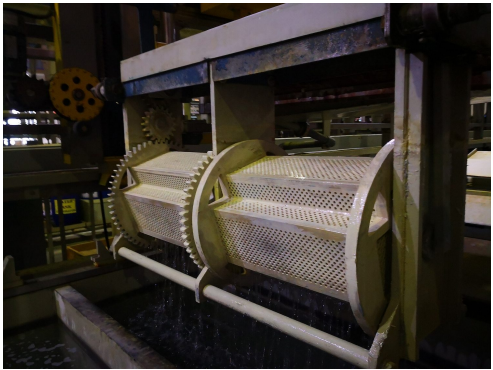
Electrolysis



Electrolysis 电解 breaks down an **electrolyte** 电解质:

- **cathode** 阴极 (−): positive ions gain e^- (reduction)
- **anode** 阳极 (+): negative ions lose e^- (oxidation)

Faraday calculations



Charge $Q = It$; moles of electrons $= Q/F$ (**Faraday constant** 法拉第常量).

2.0 A for 30 min through $CuSO_4$

$Q = 3600\,\mathrm{C}$; $n(\mathrm{e}^-) = 0.0373$; $n(\mathrm{Cu}) = 0.0187 \Rightarrow m \approx 1.2\,\mathrm{g}$

Use the half-equation to find moles of product.

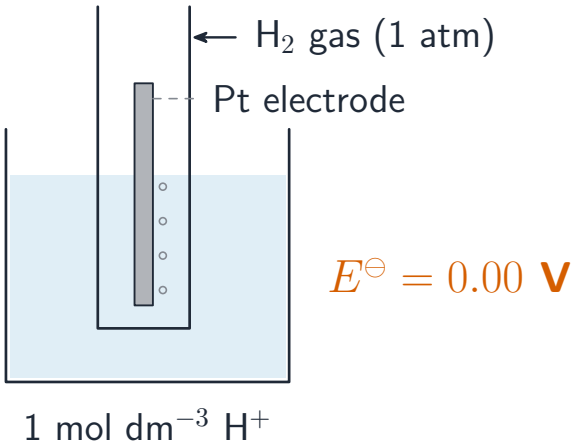
From charge to mass, and back to Avogadro

the charge	$Q = It$ – current in amperes, time in seconds
to moles of electrons	divide by the Faraday constant, $96\,500$ C mol^{-1}
to moles of product	divide by the number of electrons in the **half-equation** 半反应式 – 2 for $Cu^{2+} + 2e^- \rightarrow Cu$
to mass	multiply by the molar mass
a worked figure	2.0 A for 30 minutes is 3600 C, so 0.0373 mol of electrons and 0.0187 mol of copper – about 1.2 g
the Avogadro constant 阿伏加德罗常数	measuring the mass deposited for a known charge lets you work back to a value for it

The half-equation's electron count is the step candidates omit. Write it down before dividing, every time.

2 Electrode potentials

Standard electrode potentials



The **standard electrode potential** 标准电极电势 $E^\ominus$ shows how easily a half-cell is reduced.

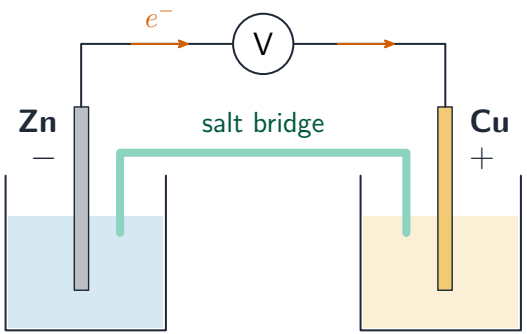
It is measured against the **standard hydrogen electrode** 标准氢电极, defined as exactly $0.00\,\mathrm{V}$.

Combining half-cells

The **standard cell potential** **标准电池电势** is the difference between the two standard electrode potentials:

- find the **polarity**: the more negative electrode is the negative terminal, and electrons flow from it through the external circuit to the positive electrode.
- judge **reactivity**: a more positive $E^{\ominus}$ means a better **oxidising agent** **氧化剂** (easily reduced).

Cell potentials and feasibility



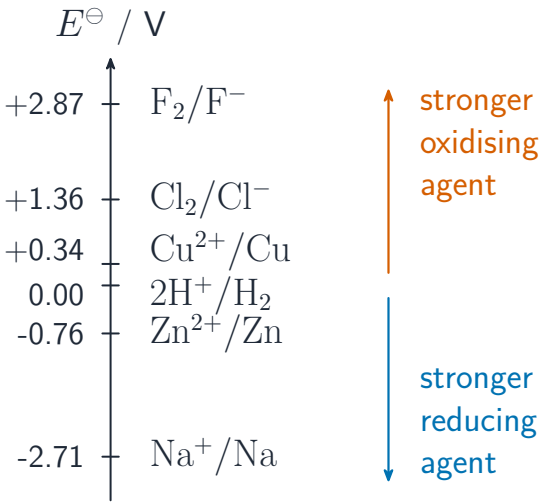
$E^\ominus_{\text{cell}} = E^\ominus(\text{more}+) - E^\ominus(\text{less}+)$.

Zn (-0.76) & Cu ($+0.34$)

$$E^\ominus_{\text{cell}} = 0.34 - (-0.76) = 1.10\,\text{V}$$

A reaction is **feasible** 可行 when $E^\ominus_{\text{cell}} > 0$. ($\Delta G^\ominus = -nE^\ominus F$.)

The electrochemical series



- a more positive $E^{\ominus}$ → a stronger **oxidising agent** 氧化剂 (easily reduced)
- a more negative $E^{\ominus}$ → a stronger **reducing agent** 还原剂

The Nernst equation

$$E = E^{\ominus} + \frac{0.059}{z} \log \frac{[\text{oxidised}]}{[\text{reduced}]}$$

Away from standard conditions, raising the **oxidised** 氧化态 species' concentration makes E more positive (z = electrons in the half-equation).

Predicting the products

molten
metal at cathode
non-metal at anode

aqueous
also contains water,
so H_2 or O_2 may form

A molten electrolyte gives the metal and non-metal; aqueous also has water

Exam tips

- $E^{\ominus}_{\text{cell}} = E^{\ominus}(\text{more positive}) - E^{\ominus}(\text{less positive})$; a **positive** $E^{\ominus}_{\text{cell}}$ means the reaction is feasible.
- Standard conditions for $E^{\ominus}$: **298 K,** 1 **mol dm**$^{-3}$**, 100 kPa**, platinum electrode – state them if asked.
- A **more negative** electrode potential means a **stronger reducing agent**; use the series to predict the direction.
- For electrolysis quantities use $Q = It$ and moles of electrons $= Q/F$.

3 Recap

Topic 24 – key takeaways

1 Electrolysis

cathode reduces; anode oxidises

2 Faraday

$Q = It$; moles of $e^- = Q/F$

3 $E^{\ominus}$

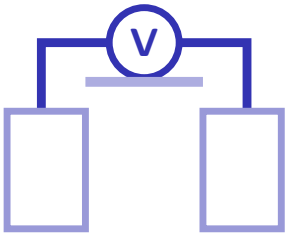
measured vs the hydrogen electrode (0 V)

4 Cells

$E^{\ominus}_{\text{cell}} > 0$ means feasible

Check yourself

1. What happens at the cathode?
2. What is the charge Q equal to?
3. What is the SHE defined as?
4. A cell is feasible when $E^{\ominus}_{\text{cell}}$ is what?



Answers **1.** reduction (positive ions gain e^-) **2.** It **3.** 0.00 V **4.** positive