Electrochemical methods for metal recovery

Webinar – 21/03/24

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10 minutes break

We will be back at 15:40

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Programme:

- **Introduction to electrochemistry.**
- **Selective Capacitive Deionization (CDI): An innovative method for metal recovery.**
- **Break**
- **The use of membrane electrolysis for Lithium extraction.**
- **Industrial uses of electrochemistry for metal recovery.**

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Introduction to Electrochemistry

Dr Ir. Luiza Bonin – 21/03/24

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Introduction to Electrochemistry

The relationship between chemical reactions and electricity

- Chemical reactions can create electricity
- Electricity can make certain chemical reactions happen that wouldn't happen otherwise

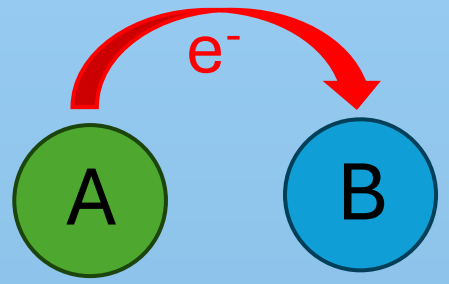
- Chemical reactions can create electricity
- Electricity can make certain chemical reactions happen that wouldn't happen otherwise

Electricity:

$e^- \rightarrow e^- \rightarrow e^- \rightarrow e^- \rightarrow$

movement of electrons

Oxidation-reduction reactions



electrons move between atoms

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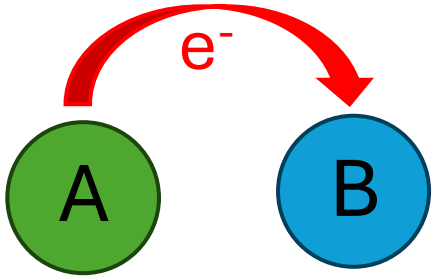
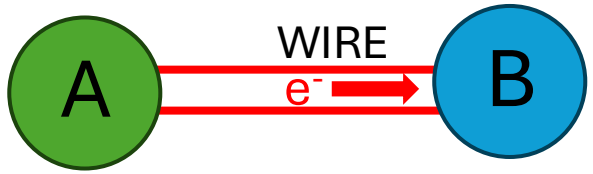
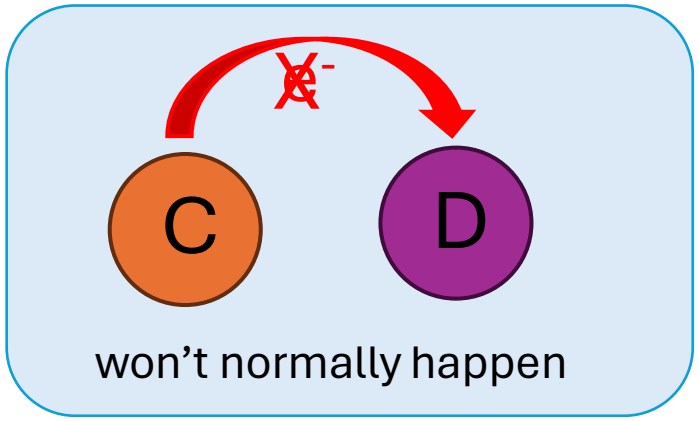
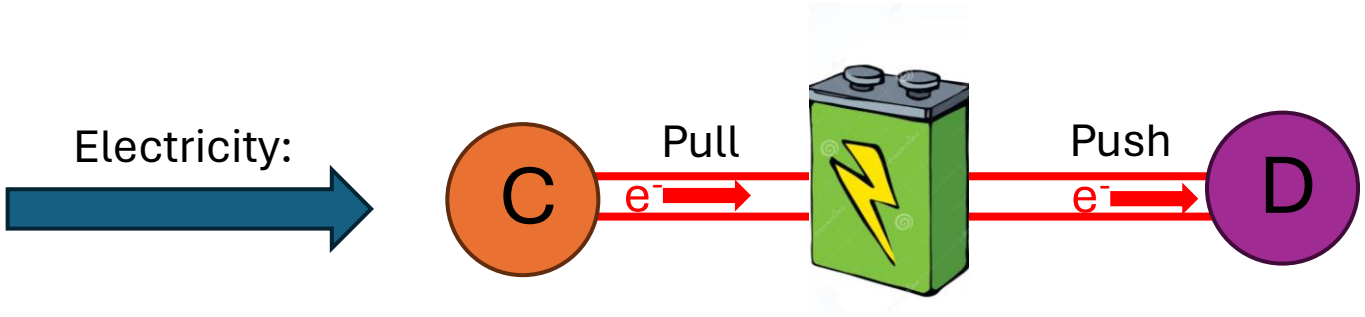
- Chemical reactions can create electricity





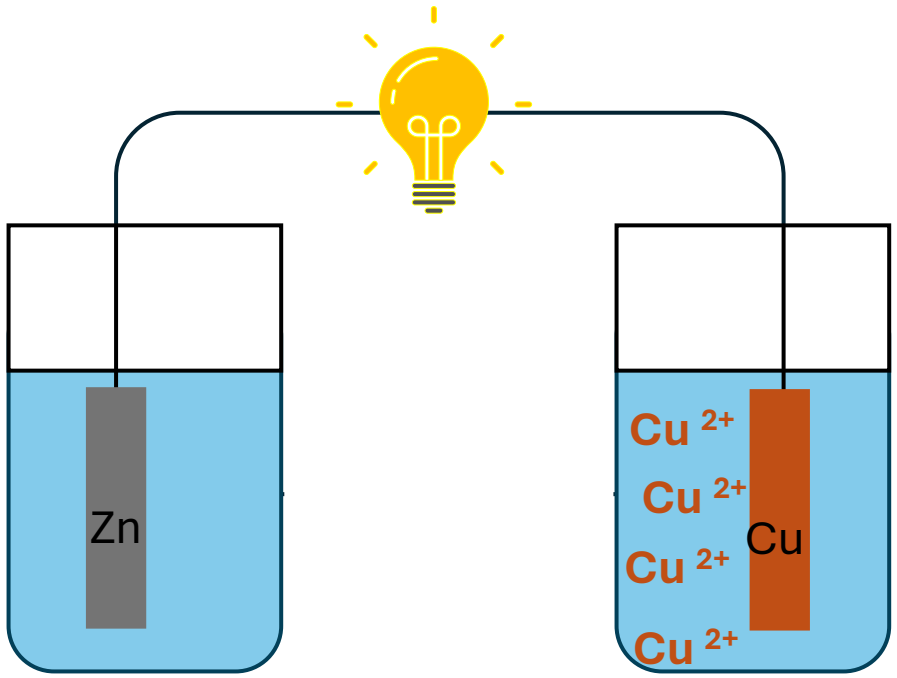
- Electricity can make certain chemical reactions happen that wouldn't happen otherwise





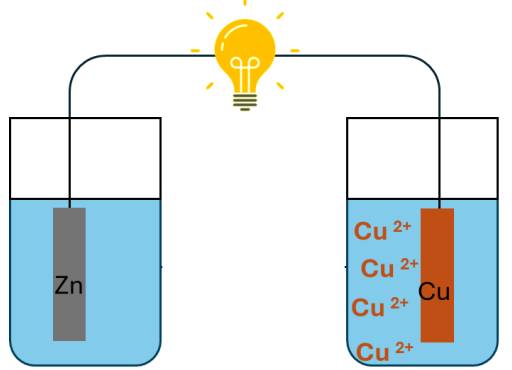
Electricity:
e- → e- → e- → e- →
movement of electrons

- Chemical reactions can create electricity



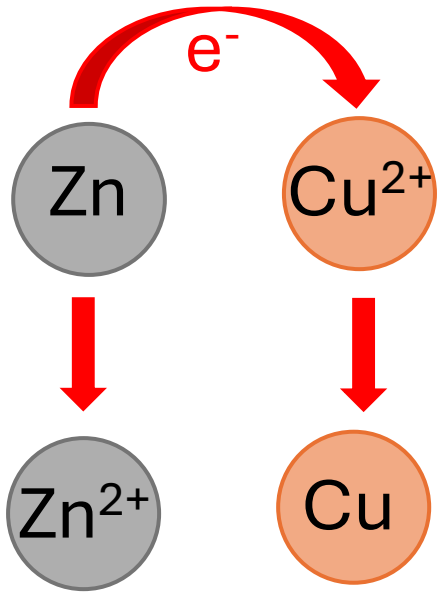
Galvanic Cell or
Voltaic cell
Creates electricity using a chemical reaction.

Chemical reactions can create electricity



Zn has a weaker pull for electrons

Cu has a strong pull for electrons



Zn loses electrons
It is oxidised

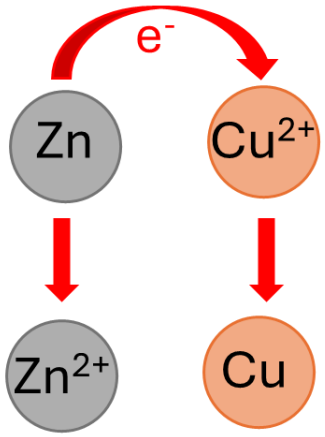
Cu^{2+} gains electrons
It is reduced

This happens on its own, It is spontaneous

Oxidation: Loss of electrons
Reduction: Gain of electrons

Zn has a weaker pull for electrons

Zn loses electrons
It is oxidised



Cu has a strong pull for electrons

Cu^{2+} gains electrons
It is reduced

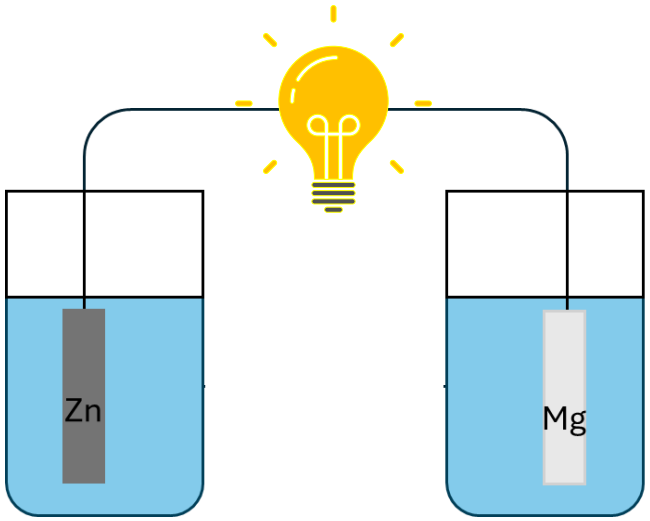
Oxidation: Loss of electrons
Reduction: Gain of electrons

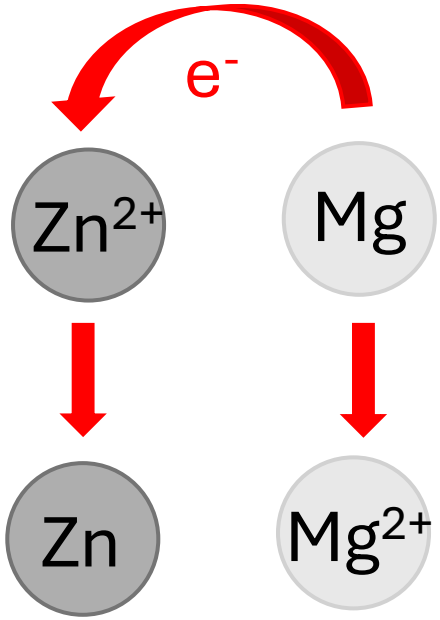
Stronger pull for electrons

increasing strength as an oxidizing agent

Half Reaction					potential
F_2	+	$2e^-$	⇌	$2F^-$	+2.87 V
Pb^{4+}	+	$2e^-$	⇌	Pb^{2+}	+1.67 V
Cl_2	+	$2e^-$	⇌	$2Cl^-$	+1.36 V
Ag^+	+	$1e^-$	⇌	Ag	+0.80 V
Fe^{3+}	+	$1e^-$	⇌	Fe^{2+}	+0.77 V
Cu^{2+}	+	$2e^-$	⇌	Cu	+0.34 V
$2H^+$	+	$2e^-$	⇌	H_2	**0.00 V**
Fe^{3+}	+	$3e^-$	⇌	Fe	−0.04 V
Pb^{2+}	+	$2e^-$	⇌	Pb	−0.13 V
Fe^{2+}	+	$2e^-$	⇌	Fe	−0.44 V
Zn^{2+}	+	$2e^-$	⇌	Zn	−0.76 V
Al^{3+}	+	$3e^-$	⇌	Al	−1.66 V
Mg^{2+}	+	$2e^-$	⇌	Mg	−2.36 V
Li^+	+	$1e^-$	⇌	Li	−3.05 V

increasing strength as an reducing agent





Mg has a weaker pull for electrons
Mg loses electrons
It is oxidised

Zn has a strong pull for electrons
Zn $^{2+}$ gains electrons
It is reduced

Stronger pull for electrons

Half Reaction					potential
F_2	+	$2e^-$	⇌	$2F^-$	+2.87 V
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Cu^{2+}	+	$2e^-$	⇌	Cu	+0.34 V
$2H^+$	**+**	**$2e^-$**	**⇌**	**H_2**	**0.00 V**
Fe^{3+}	+	$3e^-$	⇌	Fe	−0.04 V
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Al^{3+}	+	$3e^-$	⇌	Al	−1.66 V
Mg^{2+}	+	$2e^-$	⇌	Mg	−2.36 V
Li^+	+	$1e^-$	⇌	Li	−3.05 V

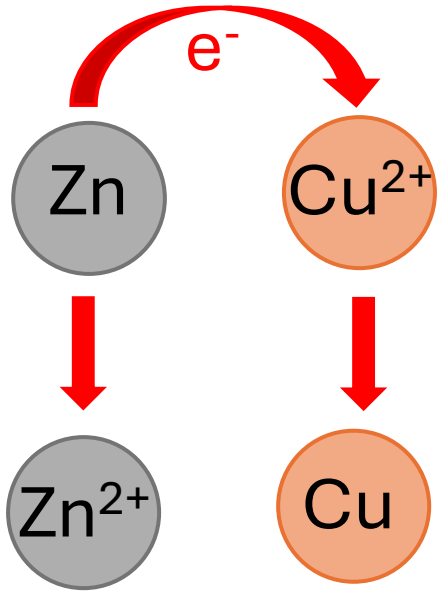
increasing strength as an oxidizing agent

increasing strength as an reducing agent

Chemical reactions can create electricity

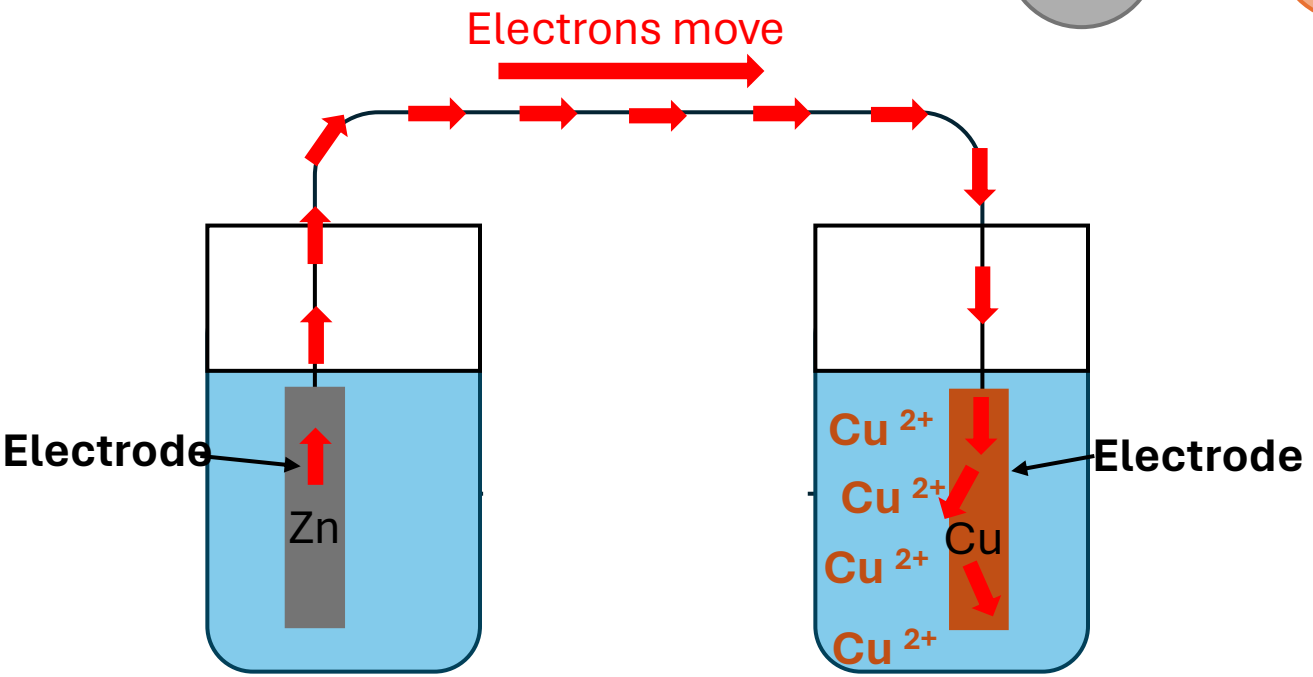
Zn has a weaker pull for electrons

Zn loses electrons
It is oxidised



Cu has a strong pull for electrons

Cu^{2+} gains electrons
It is reduced

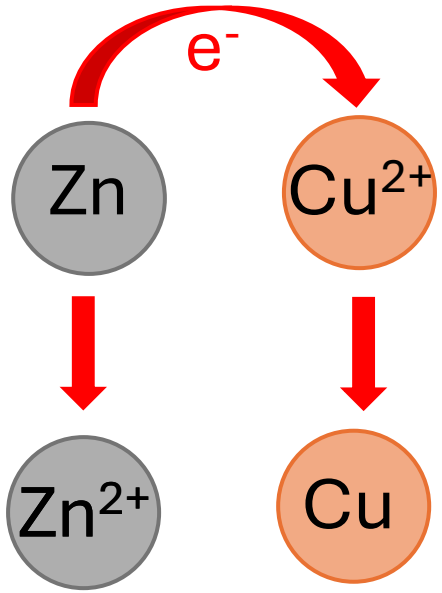


ANODE
Where oxidation happens
CATHODE
Where reduction happens

Chemical reactions can create electricity

Zn has a weaker pull for electrons

Zn loses electrons
It is oxidised



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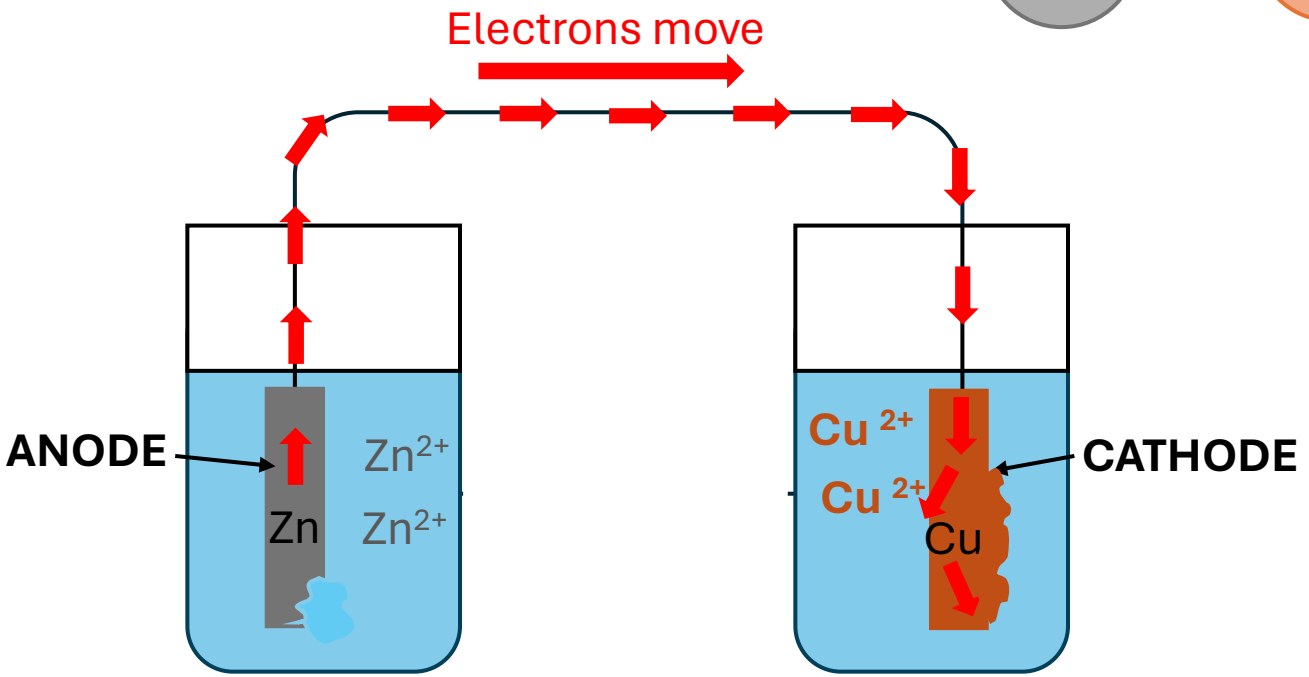


ANODE
Where oxidation happens
CATHODE
Where reduction happens

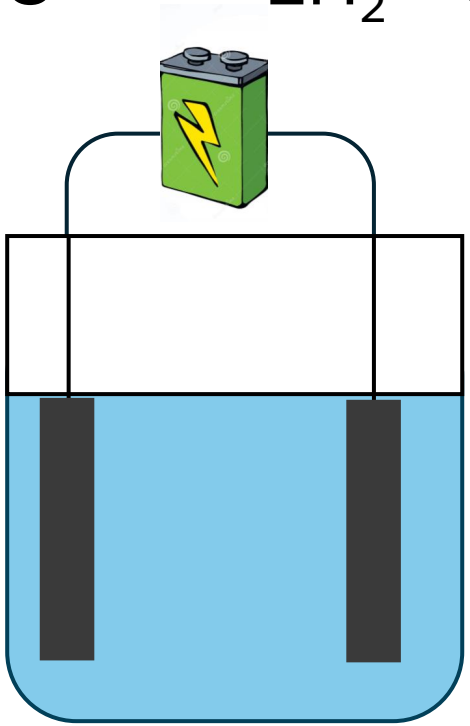
Oxidation: Loss of electrons
Reduction: Gain of electrons

ANODE
Where **oxidation** happens
CATHODE
Where **reduction** happens

- Electricity can make certain chemical reactions happen that wouldn't happen otherwise

Electrolysis

$2H_2O \rightarrow 2H_2 + O_2$

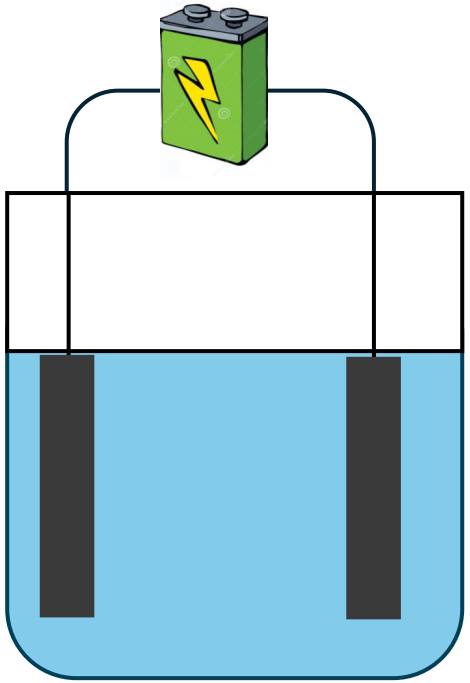


Electrolytic Cell:
A device for doing electrolysis

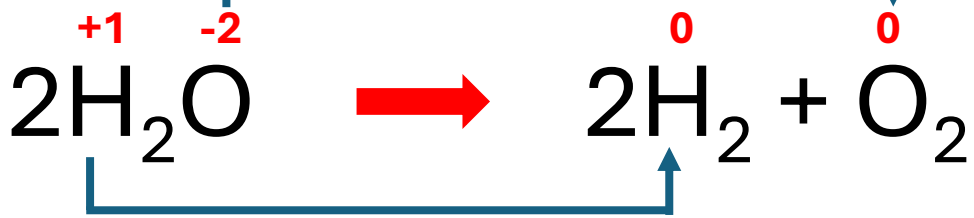
- Electricity can make certain chemical reactions happen that wouldn't happen otherwise

Electrolysis

$2H_2O \rightarrow 2H_2 + O_2$



Oxygen loses electrons
it is oxidised



Hydrogen gains
electrons it is reduced

- Electricity can make certain chemical reactions happen that wouldn't happen otherwise

Oxygen loses electrons
it is oxidised

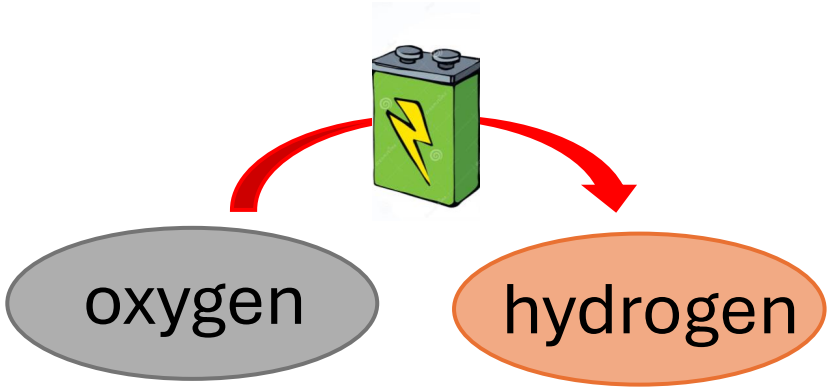
+1 -2 0 0

$2H_2O \rightarrow 2H_2 + O_2$

Hydrogen gains
electrons it is reduced

Oxygen has a stronger pull for electrons

hydrogen has a weaker pull for electrons



Standard reduction potential

$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$	+1.23
$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$	-0.83

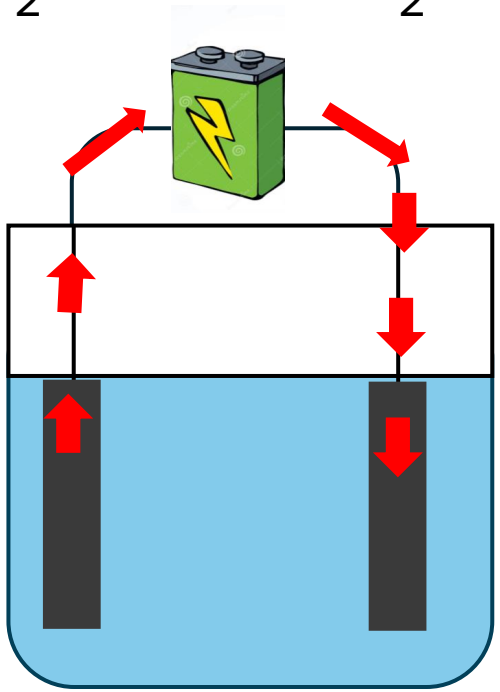
Reaction doesn't happen on its own
It is not spontaneous

A battery can pull the electrons from oxygen and push them to hydrogen.

- Electricity can make certain chemical reactions happen that wouldn't happen otherwise

Electrolysis

$2H_2O \longrightarrow 2H_2 + O_2$



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Electricity can make certain chemical reactions happen that wouldn't happen otherwise

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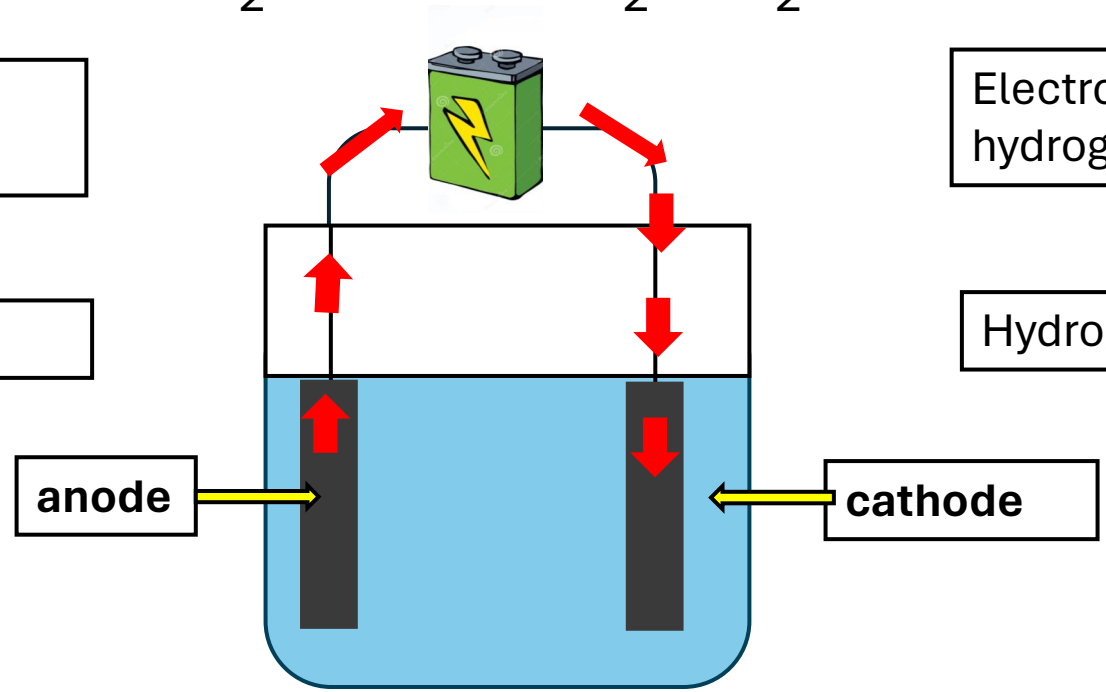
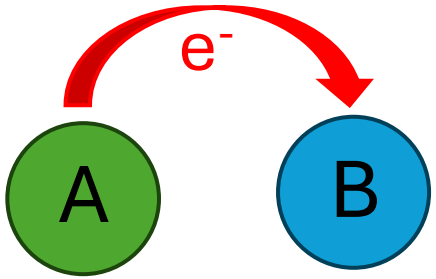
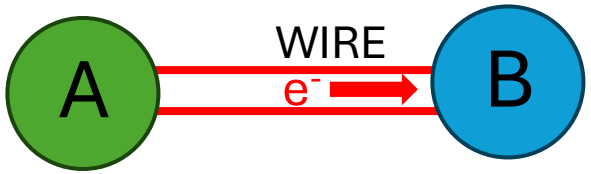
Electrolysis

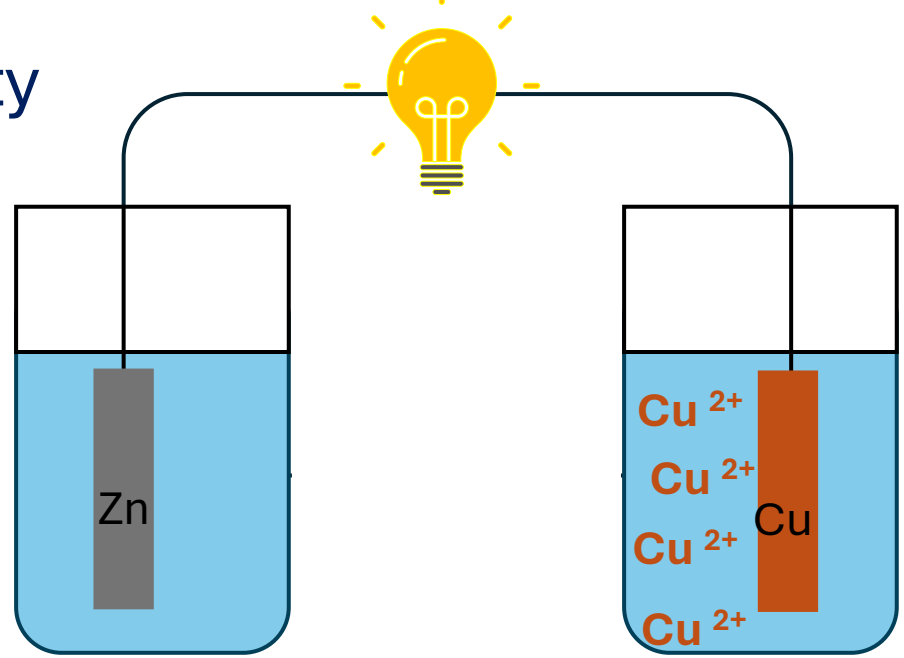
$$2H_2O \longrightarrow 2H_2 + O_2$$



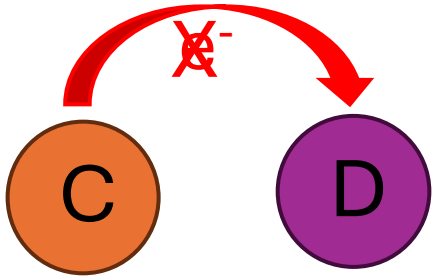
- Chemical reactions can create electricity



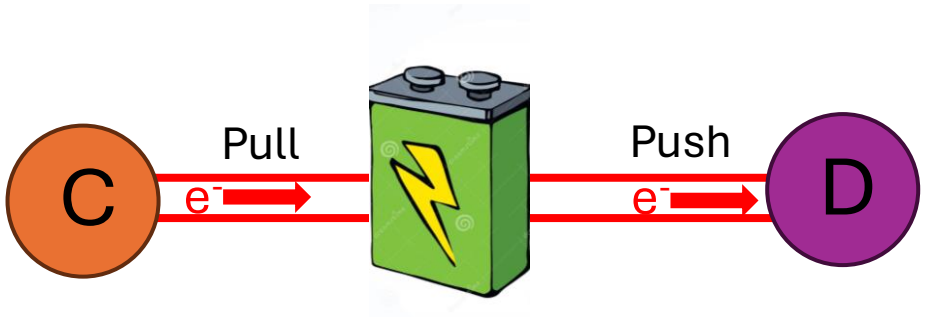




- Electricity can make certain chemical reactions happen that wouldn't happen otherwise

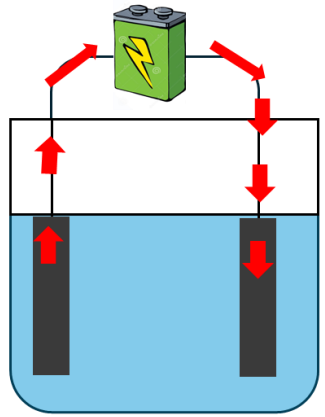


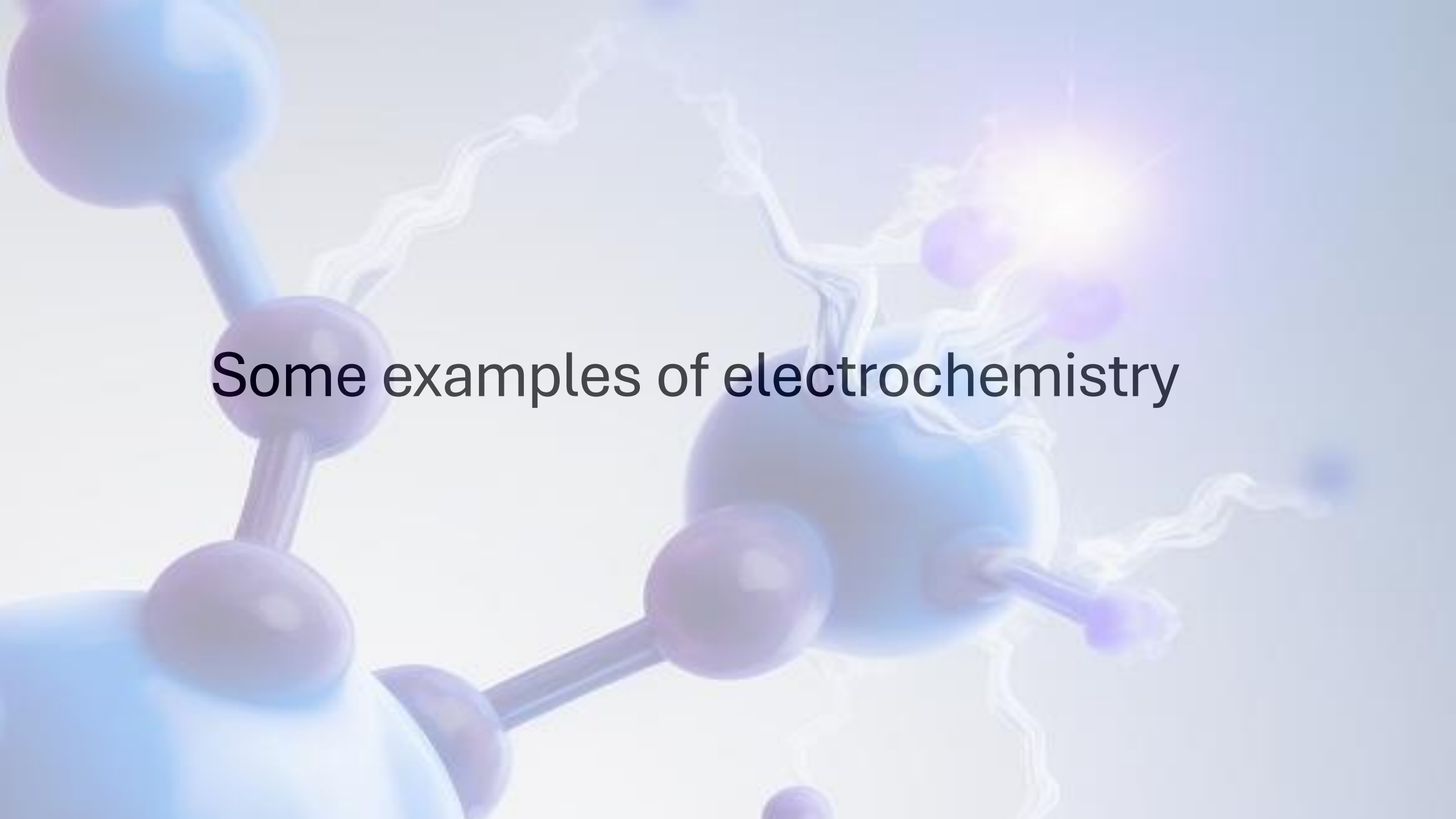
won’t normally happen



Electrolysis

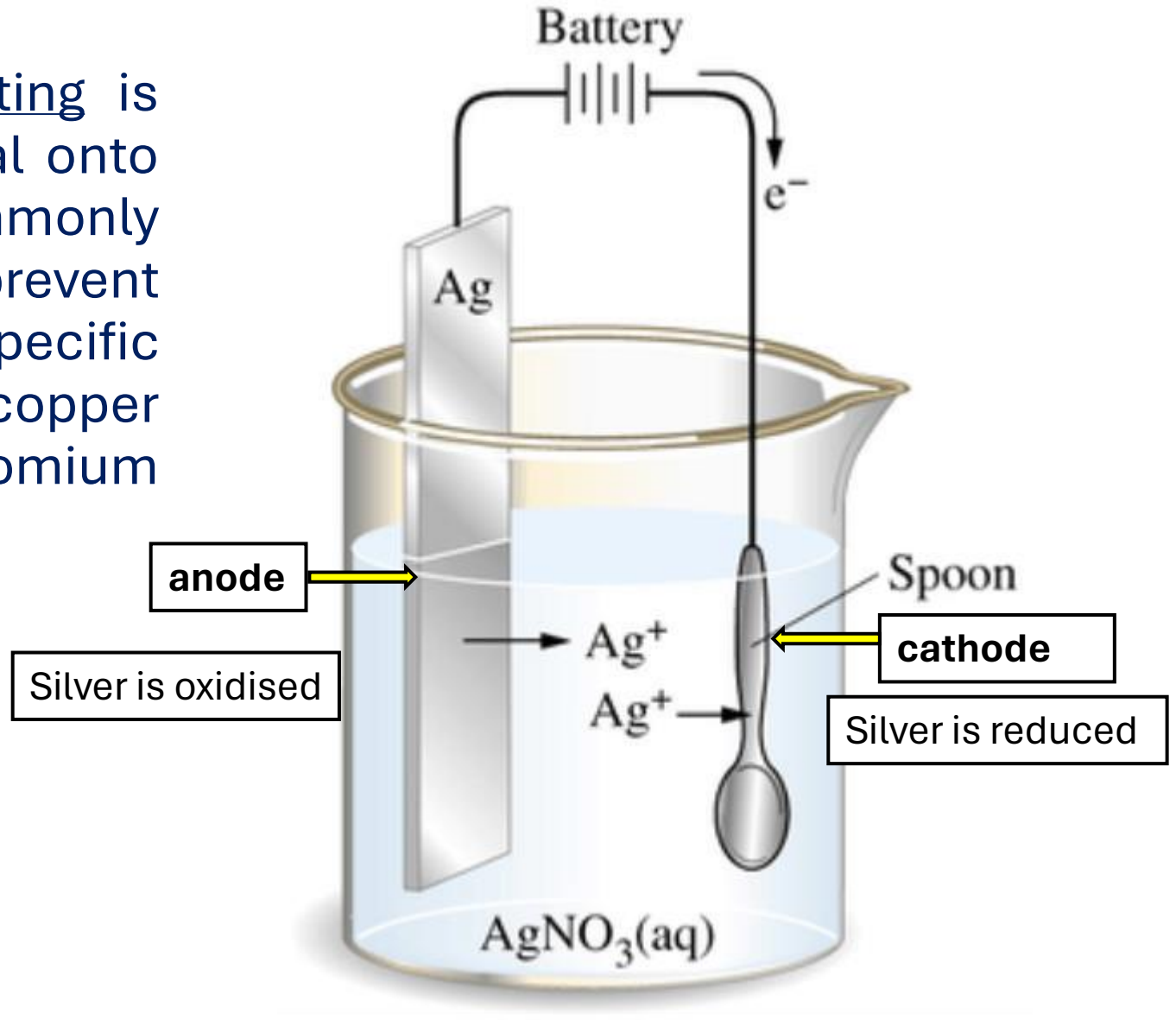
$2H_2O \rightarrow 2H_2 + O_2$



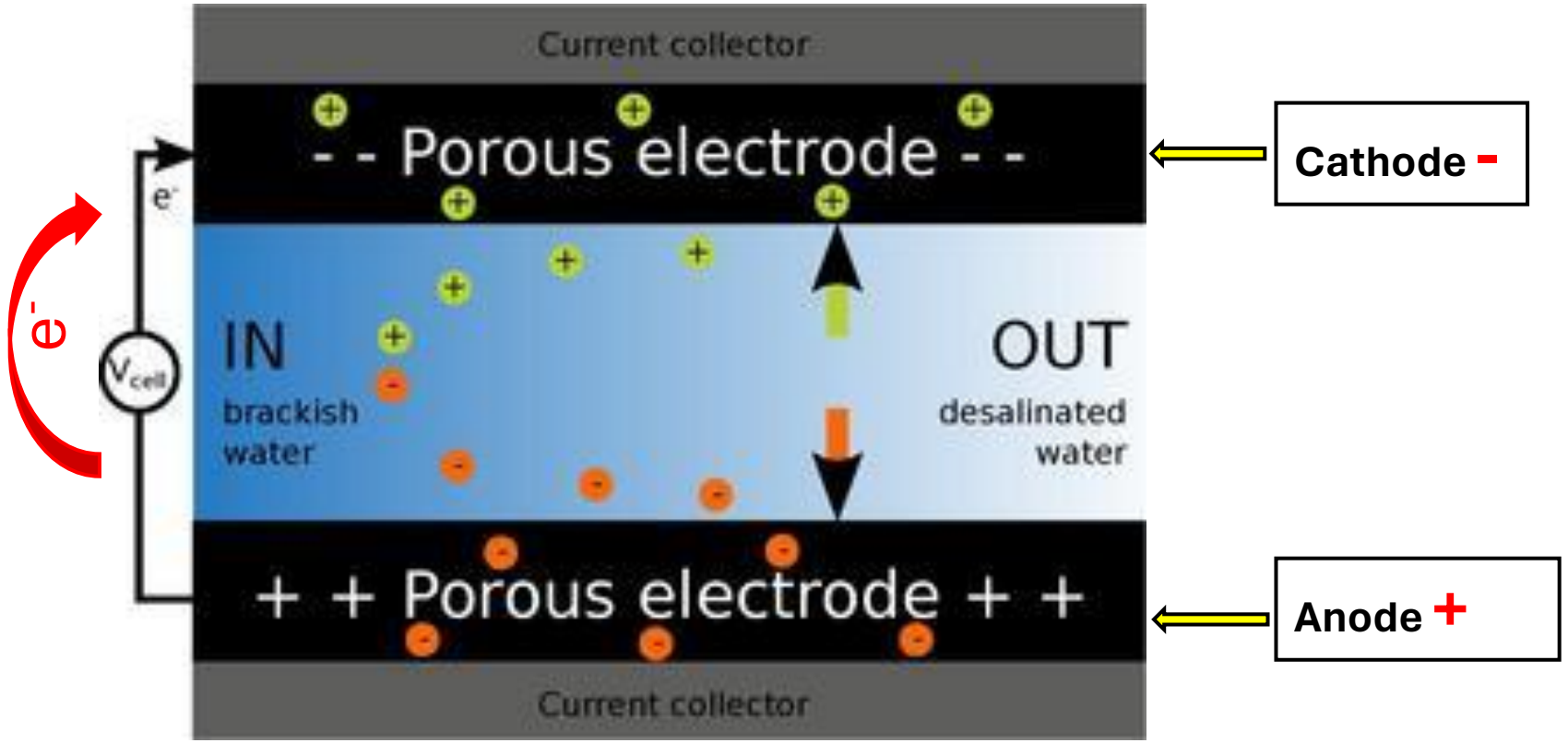


Some examples of electrochemistry

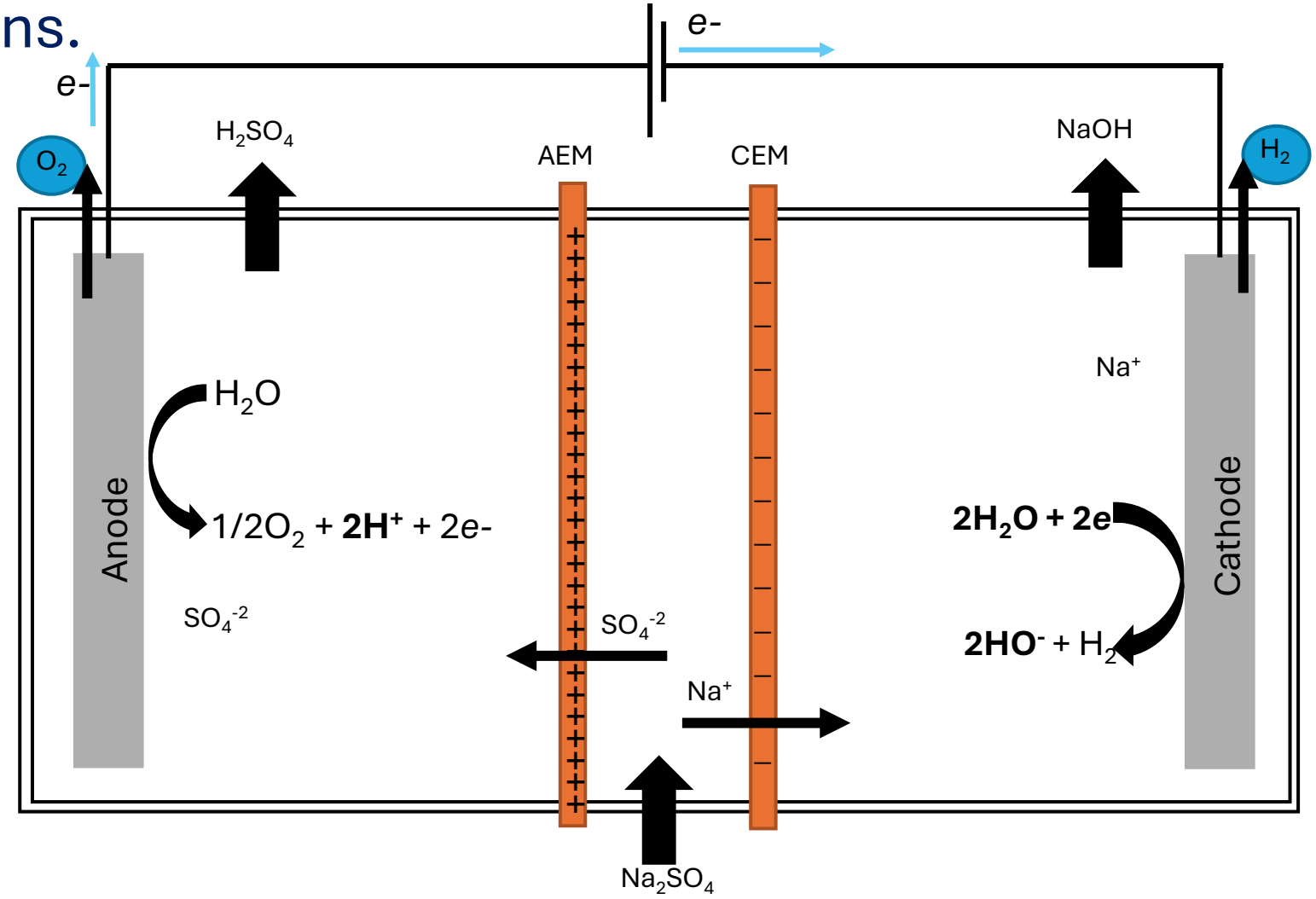
- Electrodeposition or Electroplating is the process of plating one metal onto another by hydrolysis, most commonly for decorative purposes or to prevent metal corrosion. There are also specific types of electroplating such as copper plating, silver plating, and chromium plating.



- Capacitive deionization (CDI) is an emerging and promising technology for removing ionic and polarizable species from water. It is an alternative to membrane-based technologies, with low operational cost, enhanced energy efficiency, and less water rejection.



- Membrane electrolysis (ME) is an electrochemical technique in which both electrode reactions, the cathodic reduction and the anodic oxidation, are linked to the transport and transfer of charged ions.



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