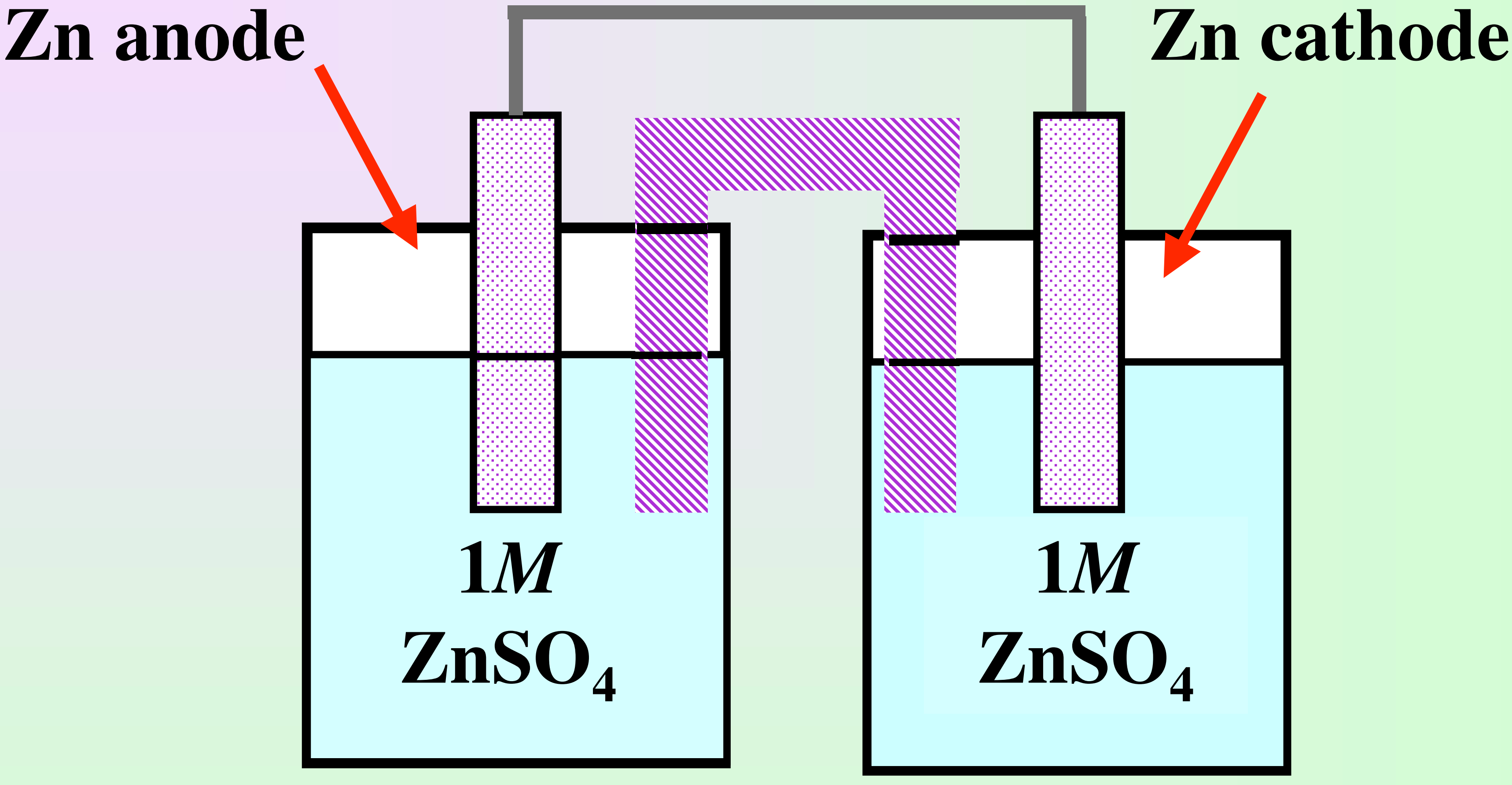
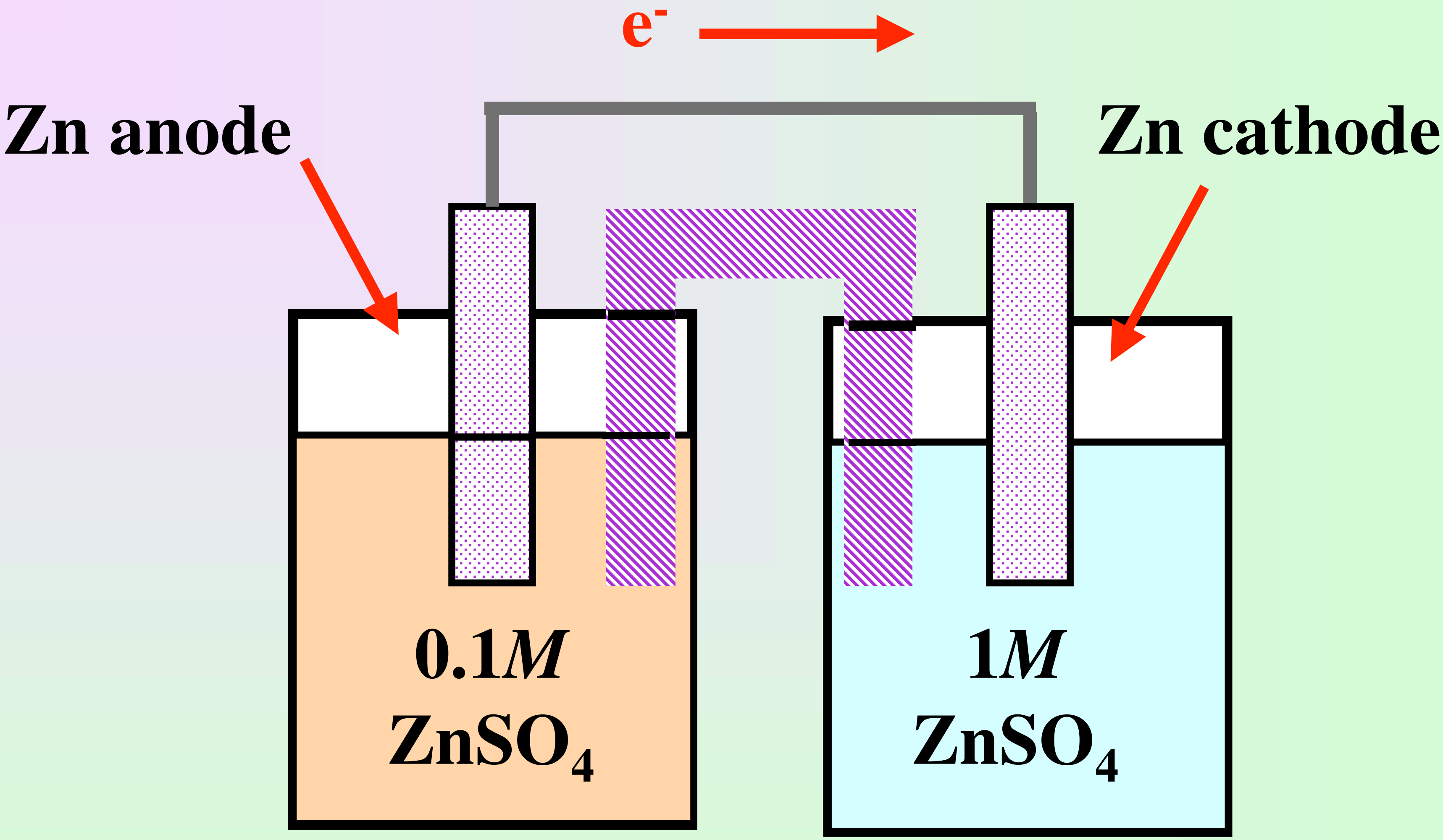
Concentration Cells

A galvanic cell in which both compartments contain the same components but differ in concentrations.



The EMF of the cell is Zero.



What is the EMF of the cell ?

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cathode $Zn^{2+}(aq, 1.0\ M) + 2e^- \longrightarrow Zn(s)$

anode $Zn(s) \longrightarrow Zn^{2+}(aq, 0.1\ M) + 2e^-$

$$Zn^{2+}(aq, 1.0\ M) \longrightarrow Zn^{2+}(aq, 0.1\ M) \qquad E^\circ = 0$$

- -

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$$E = E^\circ - \frac{0.0592}{n} \log Q$$

$$E = 0 - \frac{0.0592}{2} \log \frac{0.1}{1.0}$$

$E = 0.0296\ V$

Electrolysis

Electrolysis

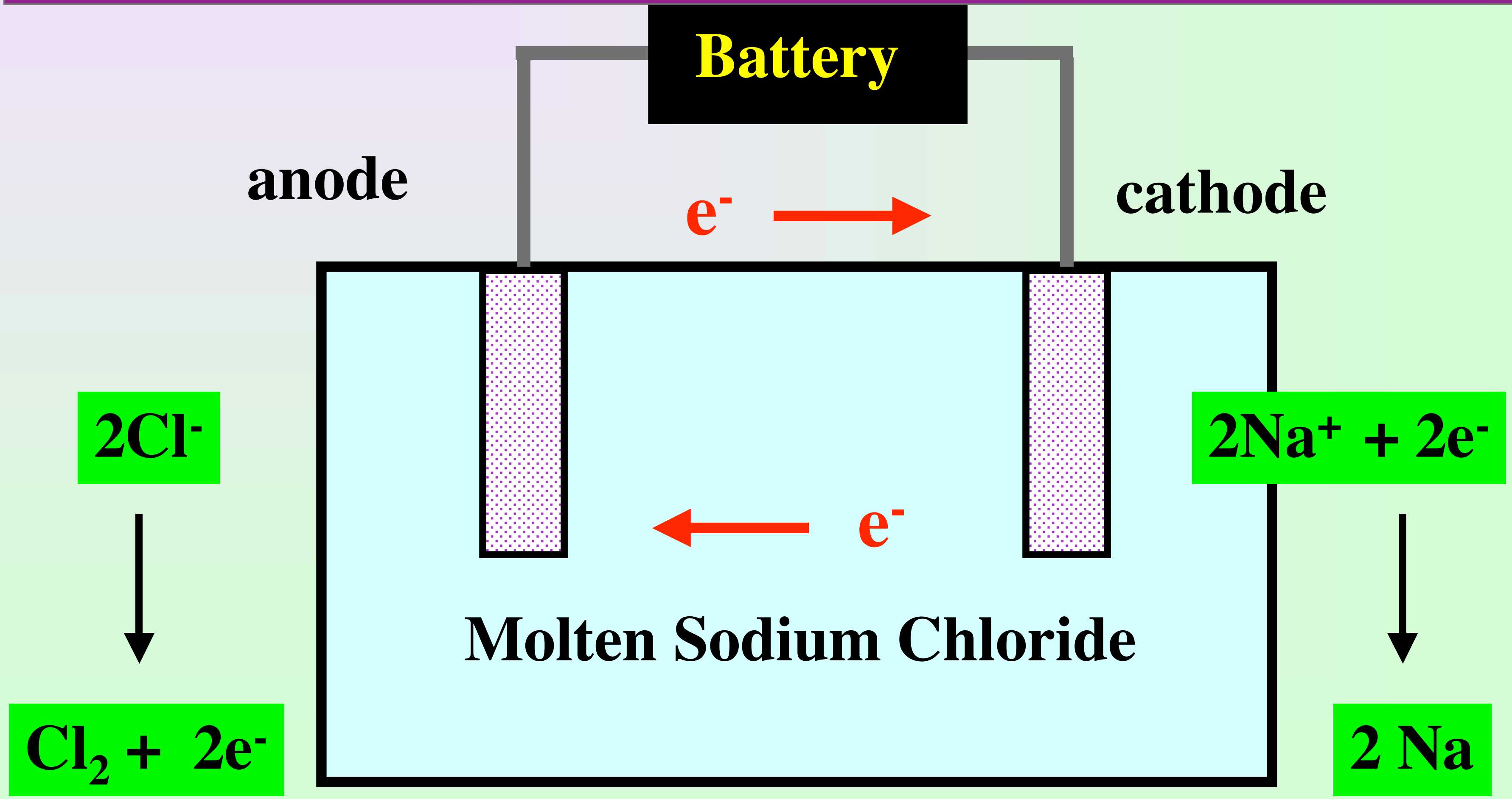
the process in which electrical energy is used to cause a nonspontaneous chemical reaction to occur

has many important applications in industry, mainly in the extraction and purification of metals

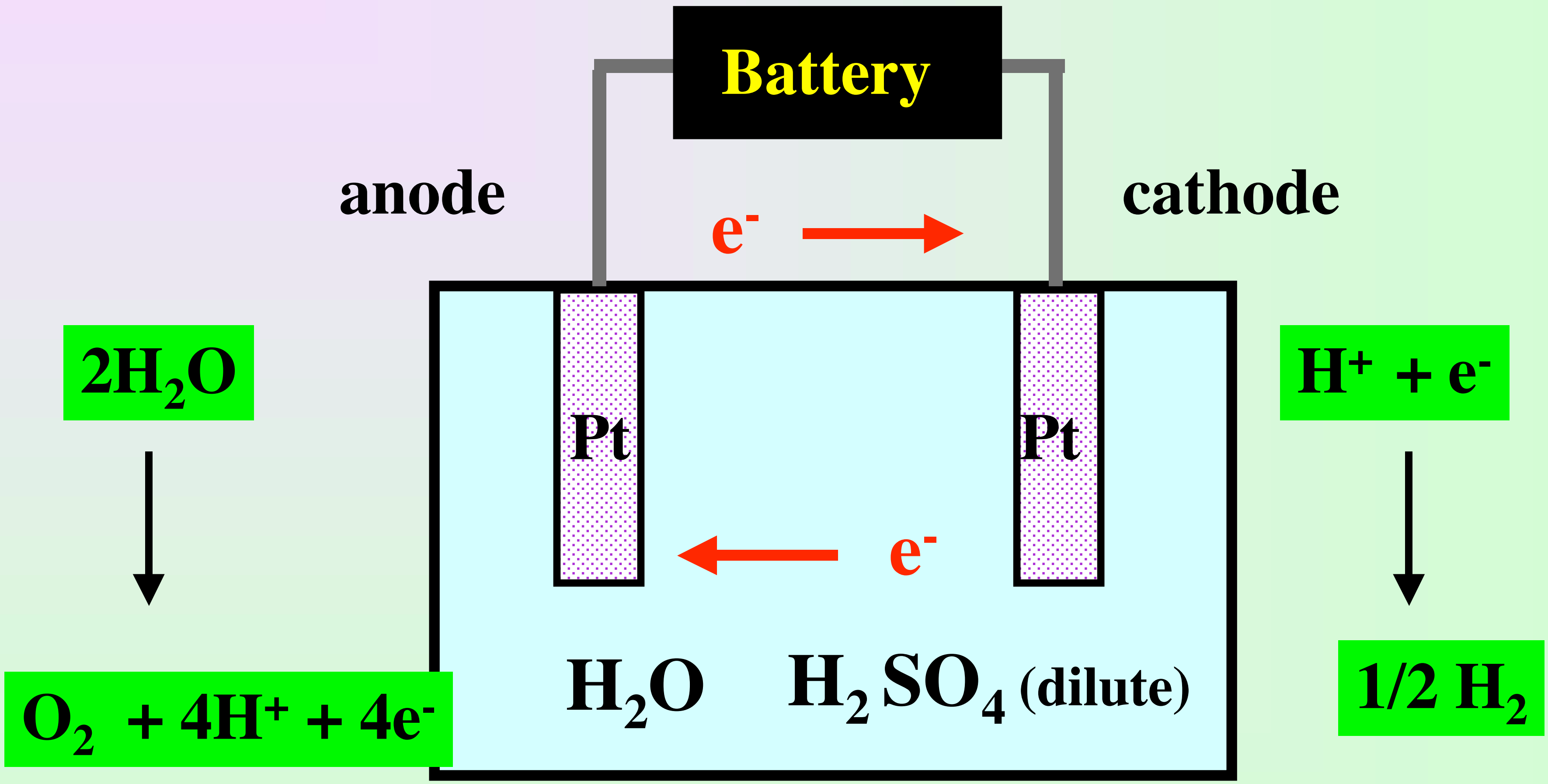
two examples

the battery serves as an electron pump

- driving electrons to the cathode
- withdrawing electrons from the anode



water $2H_2O \rightarrow 2H_2 + O_2 \quad \Delta G^\circ = 474.4$ kJ



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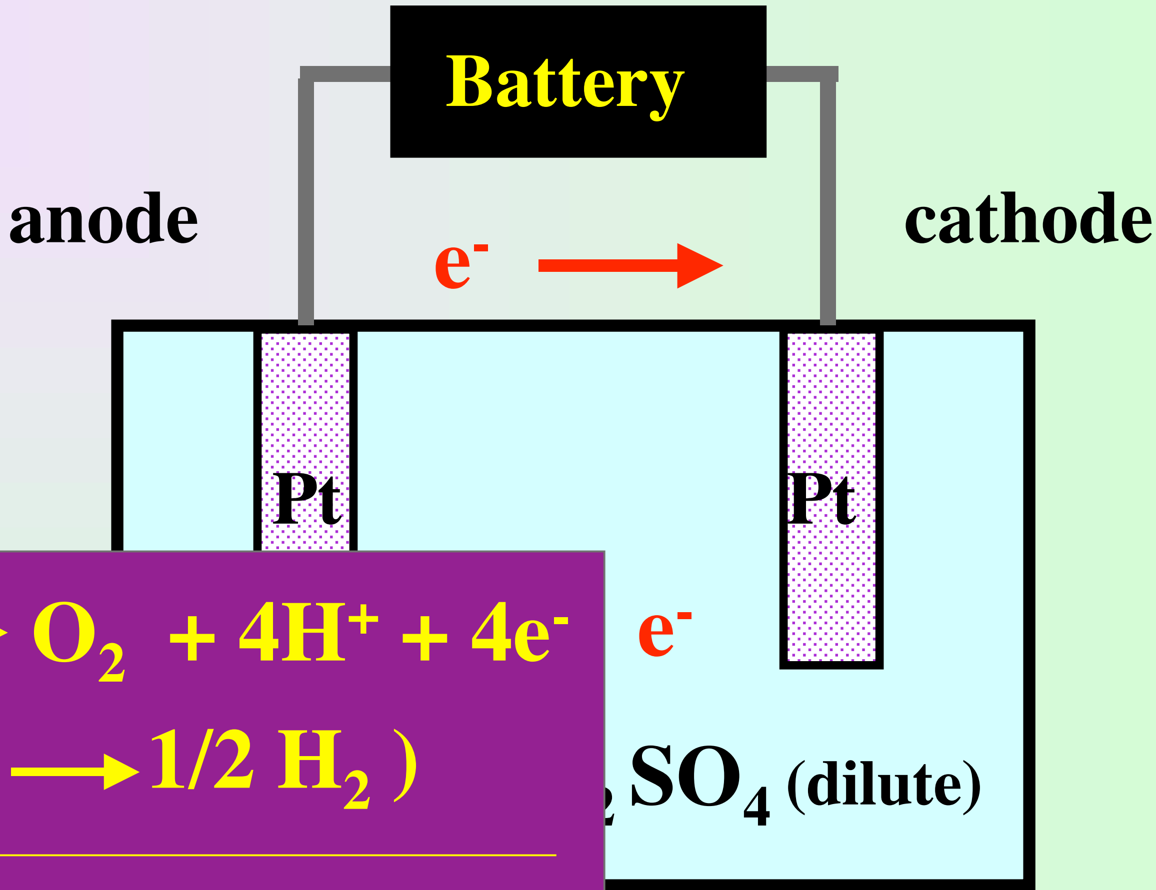

$$2H_2O \longrightarrow O_2 + 4H^+ + 4e^-$$

$$4(\ H^+ + e^- \longrightarrow 1/2\ H_2\ )$$

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

Quantitative Aspects of Electrolysis

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Faraday observed that the mass of product formed (or reactant consumed) at an electrode is proportional to both the amount of electricity transferred and the molar mass of the substance in question

We generally measure the amount of electricity transferred (current) in amperes,A

$$\text{amperes} = \frac{\text{coulomb}}{\text{second}}$$

The steps involved in calculating amounts of substances reduced or oxidized in electrolysis

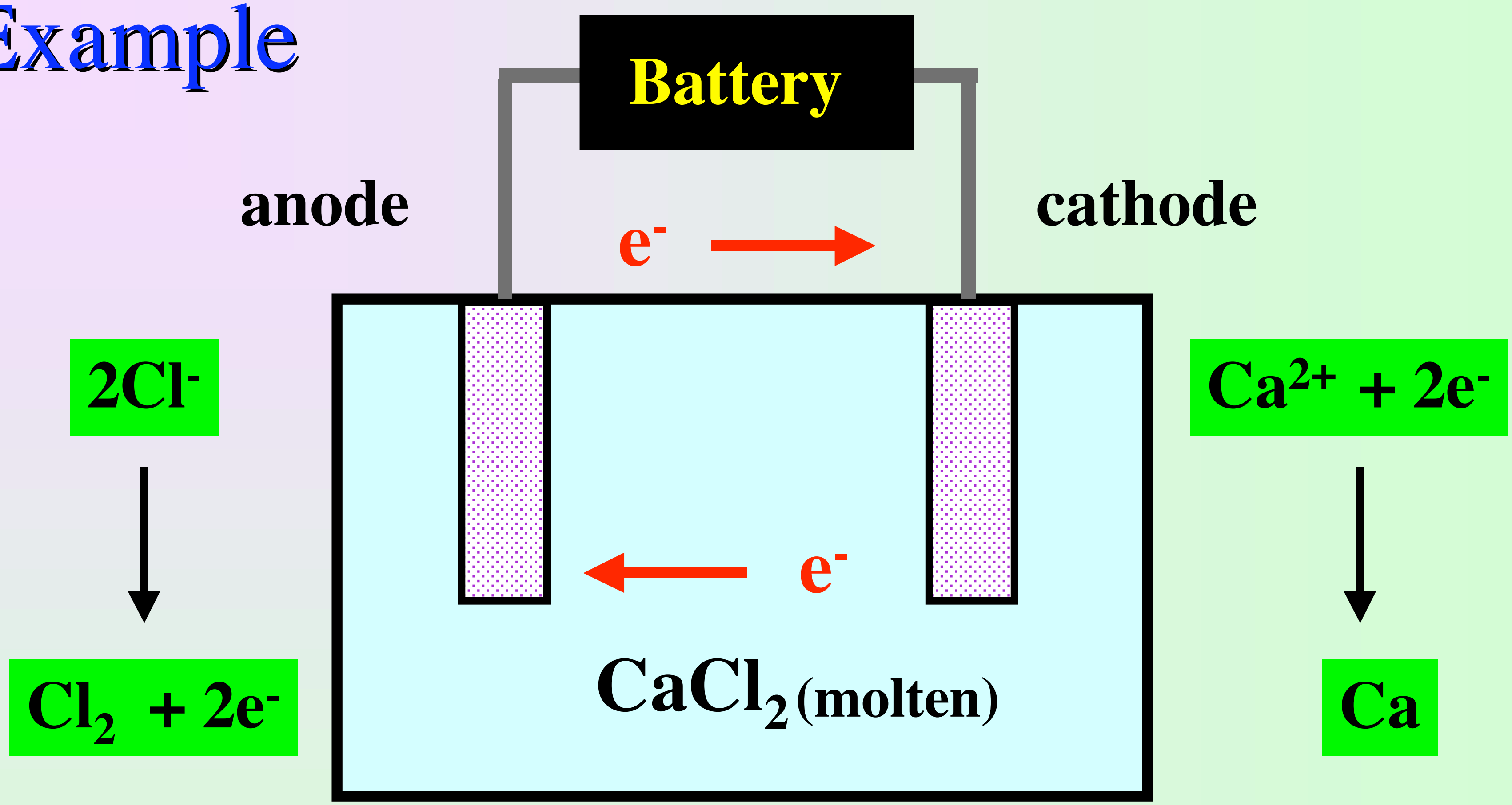
current (amperes) and time → charge in coulombs → number of Faradays →

moles of substance reduced or oxidized → grams of substance reduced or oxidized

Example

A current of 0.452 A is passed through an electrolytic cell containing molten $CaCl_2$ for 1.50 hours. Write the electrode reactions and calculate the quantity of products formed at the electrodes.

Example



$$Ca^{2+} + 2Cl^{-} \longrightarrow Ca\,(l) + Cl_2\,(g)$$

$$1.50\ \text{h} \times \frac{0.452\ \text{C}}{\text{s}} \times \frac{3600\text{s}}{1\ \text{h}} \times \frac{1\ \text{mol}\ e^-}{96485\ \text{C}}$$

$$\times \frac{1\ \text{mol}\ Ca^{2+}}{2\ \text{mol}\ e^-} \times \frac{40\ \text{g}}{1\ \text{mol}\ Ca^{2+}} = 0.506\text{g Ca}$$

$$1.50\ \text{h} \times \frac{0.452\ \text{C}}{\text{s}} \times \frac{3600\text{s}}{1\ \text{h}} \times \frac{1\ \text{mol}\ e^-}{96485\ \text{C}}$$

$$\times \frac{1\ \text{mol}\ Cl_2}{2\ \text{mol}\ e^-} \times \frac{70\ \text{g}}{1\ \text{mol}\ Cl_2} = 0.896\text{g}\ Cl_2$$