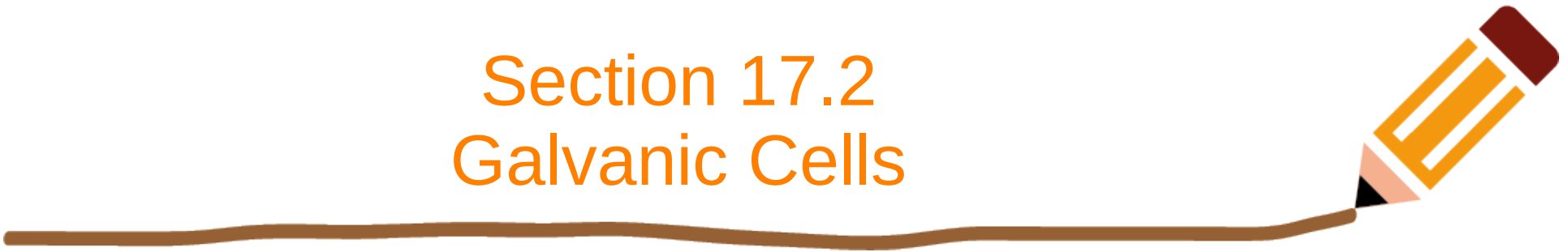
Section 17.2
Galvanic Cells



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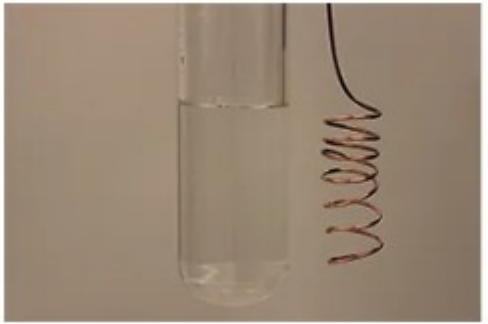
Learning Objectives

- Describe the function of a galvanic cell and its components
- Use cell notation to symbolize the composition and construction of galvanic cells

Redox Reaction Example



overall reaction: $\mathrm{Cu}(s) + 2\mathrm{Ag}^{+}(aq) \longrightarrow \mathrm{Cu}^{2+}(aq) + 2\mathrm{Ag}(s)$

oxidation half-reaction: $\mathrm{Cu}(s) \longrightarrow \mathrm{Cu}^{2+}(aq) + 2\mathrm{e}^{-}$

reduction half-reaction: $2\mathrm{Ag}^{+}(aq) + 2\mathrm{e}^{-} \longrightarrow 2\mathrm{Ag}(s)$

The direct transfer of electrons from the copper wire to the aqueous silver ions is spontaneous

Galvanic Cells

- Electrochemical cells are devices that contains all the reactants and products of a redox system but prevent physical contact between the reactants.
  - Direct transfer of electrons is prevented
  - Transfer takes place indirectly through an external circuit that contacts the separated reactants.
  - Devices based on spontaneous redox reactions are called **galvanic cells** (or **voltaic cells**).

Separating Electron Transfer

- Galvanic cells are comprised of two half-cells
  - Each containing the redox conjugate pair (“couple”) of a single reactant.
- An external circuit is connected to each half-cell at its solid electrode.
  - The **anode** of an electrochemical cell is the electrode at which oxidation occurs
  - The **cathode** is the electrode where reduction occurs.

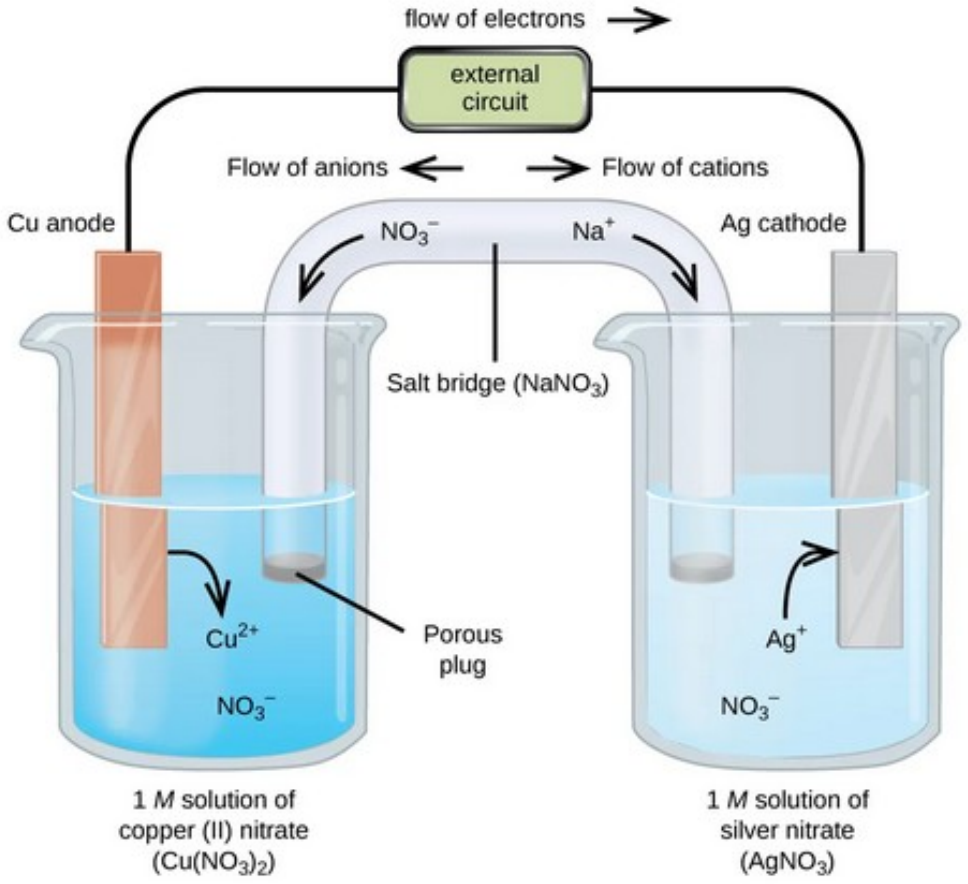
The Salt Bridge

- To keep the reactants separate while maintaining charge-balance, the two half-cell solutions are connected by a tube filled with inert electrolyte solution called a **salt bridge**.
- The spontaneous reaction produces cations in the anode half-cell and consumes anions in the cathode half-cell
- A compensatory flow of inert ions from the salt bridge that maintains charge balance.

Picturing the Cell

$$\mathrm{Cu}(s) \longrightarrow \mathrm{Cu}^{2+}(aq) + 2\mathrm{e}^-$$

$$2\mathrm{Ag}^+(aq) + 2\mathrm{e}^- \longrightarrow 2\mathrm{Ag}(s)$$



Cell Notation

- **Cell notations** or **cell schematics** are an abbreviated symbolism commonly used to represent a galvanic cell by providing essential information on its composition and structure.
- They are written following a few guidelines:
  1) The relevant components of each half-cell are represented by their chemical formulas or element symbols
  2) All interfaces between component phases are represented by vertical parallel lines; if two or more components are present in the same phase, their formulas are separated by commas
  3) By convention, the schematic begins with the anode and proceeds left-to-right identifying phases and interfaces encountered within the cell, ending with the cathode

Cell Notation Example

- A galvanic cell consists of a solid copper anode immersed in an aqueous solution of copper(II) nitrate that is connected via a salt bridge to an aqueous silver(I) nitrate solution, immersed in which is a solid silver cathode.

$$\mathrm{Cu}(s)\,|\,1\ M\ \mathrm{Cu(NO_3)_2}(aq)\,\|\,1\ M\ \mathrm{AgNO_3}(aq)\,|\,\mathrm{Ag}(s)$$

Interpreting Cell Descriptions

- A solid magnesium anode is immersed in an aqueous solution of magnesium chloride that is connected via a salt bridge to an aqueous solution containing a mixture of iron(III) chloride and iron(II) chloride, immersed in which is a platinum cathode.

oxidation half-reaction: $\mathrm{Mg}(s) \longrightarrow \mathrm{Mg}^{2+}(aq) + 2\mathrm{e}^-$

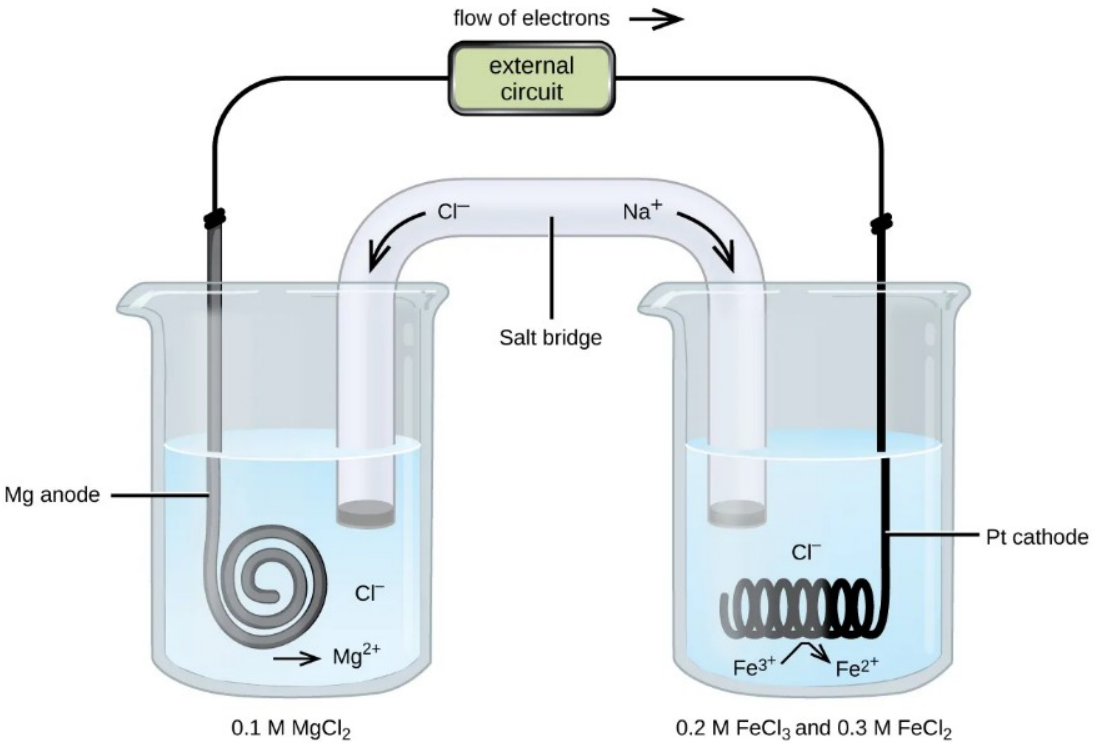
reduction half-reaction: $2\mathrm{Fe}^{3+}(aq) + 2\mathrm{e}^- \longrightarrow 2\mathrm{Fe}^{2+}(aq)$

net cell reaction: $\mathrm{Mg}(s) + 2\mathrm{Fe}^{3+}(aq) \longrightarrow \mathrm{Mg}^{2+}(aq) + 2\mathrm{Fe}^{2+}(aq)$

Interpreting Cell Descriptions

$$\mathrm{Mg}(s)\,|\,0.1\ M\ \mathrm{MgCl_2}(aq)\,\|\,0.2\ M\ \mathrm{FeCl_3}(aq), 0.3\ M\ \mathrm{FeCl_2}(aq)\,|\,\mathrm{Pt}(s)$$

- Notice the cathode in this half-cell is neither a reactant nor a product.
- Its electrode is comprised of a substance (Pt)



Inert Electrodes

- **Inert Electrodes** are required when neither member of the half-cell's redox couple can reasonably function as an electrode.
  - Electrically conductive and in a phase separate from the half-cell solution.