

Cell Potential

Cell Potential (E_{cell})

- Cell potential (electromotive force, **emf**) is the driving force in a galvanic cell that pulls electrons from the oxidation in one compartment to the reduction in the other.
- The **volt (V)** is the unit of electrical potential.
- Electrical charge is measured in **coulombs (C)**.
- A volt is 1 joule of work per coulomb of charge transferred: $1 \text{ V} = 1 \text{ J/C}$.
- A **voltmeter** is a device which measures cell potential.

Standard Reduction Potentials

- The measured potential of a voltaic cell is affected by changed in concentration of the reactants as the reaction proceeds and by energy losses due to heating of the cell and external circuit.
- In order to compare the output of different cells, the standard cell potential (E°_{cell}) is obtained at 298 K, 1 atm for gases, 1 M for solutions, and the pure solid for electrodes.

- The Standard Hydrogen Electrode is considered the reference half-cell electrode, with a potential equal to **0.00 V**.
- It is obtained when platinum is immersed in 1 M $\text{H}^+(\text{aq})$, through which $\text{H}_2(\text{g})$ is bubbled.

The Standard Electrode (Half-Cell) Potential ($E_{\text{half-cell}}$)

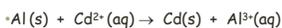
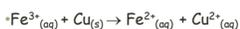
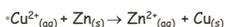
- A standard electrode potential always refers to the half-reaction written as a **reduction**.
- Oxidized form + $n e^- \rightarrow$ reduced form $E^{\circ}_{\text{half-cell}}$
- If you need the oxidation, you will have to reverse the reaction
- Reversing a reaction **changes the sign of the potential**.
- $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{reduction}} + E^{\circ}_{\text{oxidation}}$

Thermodynamically favored reactions

- As the potential increases in value (more positive), the reaction is more likely to occur (Thermodynamically favored, spontaneously occurs).
- E°_{cell} must be positive for the cell to produce electricity.
- A substance will have a thermodynamically favored or *spontaneous* reaction with another substance of a lower E°_{cell} .
- Although some half-reactions must be manipulated with coefficients, **NEVER MULTIPLY THE E°_{cell} BY THE COEFFICIENT!!!**

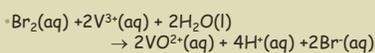
Galvanic Cell Problems

Consider a galvanic cell based on the following reactions. For each give the balanced half cell reactions and calculate E°_{cell} .



Calculating an Unknown $E^{\circ}_{\text{half-cell}}$ from E°_{cell} .

A voltaic cell based on the reaction between aqueous Br_2 and vanadium (III) ions has $E^{\circ}_{\text{cell}} = 1.39 \text{ V}$:



What is the standard electrode potential for the reduction of VO^{2+} to V^{3+} ?

Line Notations.

- The components of the anode compartment are written to the left of the cathode compartment.
- Double vertical lines separate the half-cells and represents the wire and salt bridge.
- Within each half-cell, a single vertical line represents a phase boundary. A comma separates half-cell components in the same phase.
- Half-cell components appear in the same order as in the half-reaction, while electrodes appear at the extreme left and right of the notation.
- $\text{Mg}(\text{s}) | \text{Mg}^{2+}(\text{aq}) || \text{Al}^{3+}(\text{aq}) | \text{Al}(\text{s})$
- $\text{Fe}(\text{s}) | \text{Fe}^{2+}(\text{aq}) || \text{H}^+, \text{MnO}_4^-(\text{aq}), \text{Mn}^{2+}(\text{aq}) | \text{Pt}(\text{s})$

Describing a Galvanic Cell.

- A cell will always be thermodynamically favored, or spontaneous, in the direction that produces a positive cell potential.
- A complete description of a galvanic cell always includes four items:
 1. The cell potential (always positive for a galvanic cell) and the balanced cell reaction.
 2. The direction of electron flow, obtained by inspecting the half-reactions and using the direction that gives a positive E°_{cell} .

3. Designation of the anode and cathode.
4. The nature of each electrode and the ions present in each compartment. A chemically inert conductor is required if none of the substances participating in the half-reaction is a conducting solid.

Diagramming Voltaic Cells

- In one compartment of a voltaic cell is an acidic solution of $\text{Cr}(\text{NO}_3)_3$, and a chromium electrode; in the other, a tin bar dips into a $\text{Sn}(\text{NO}_3)_2$ solution. A KNO_3 salt bridge joins the half-cells.
- Diagram the cell, show balanced equations, and write the cell notation.

Description of a Galvanic Cell.

- Describe completely the galvanic cell based on the following half-reactions under standard conditions:



- In addition, draw the cell and write the line notation.