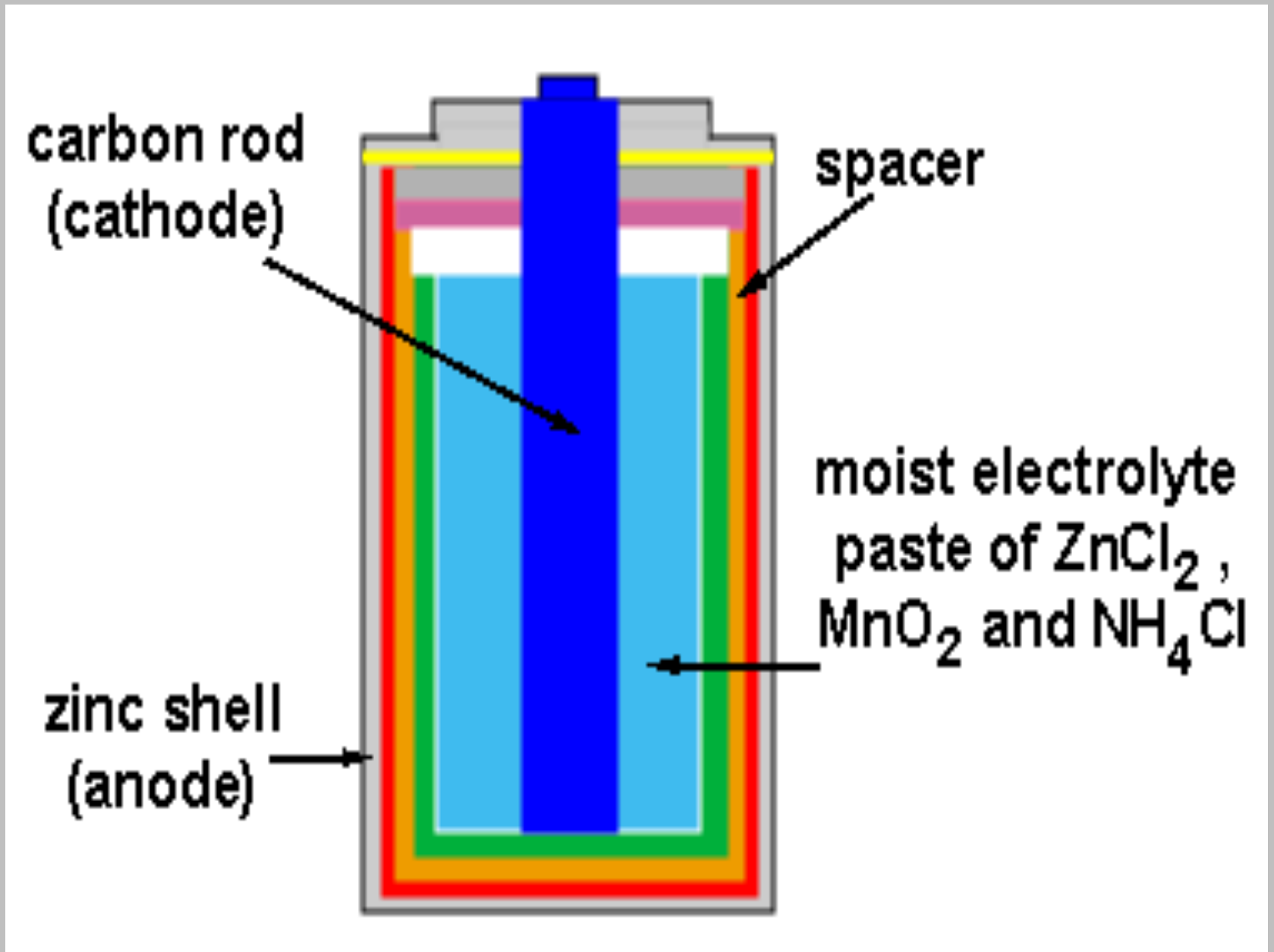
Electrochemistry



Rules for Assigning Oxidation Numbers

- 1. The oxidation number of any uncombined element is 0.
- 2. The oxidation number of a monatomic ion equals the charge on the ion.
- 3. The more-electronegative element in a binary compound is assigned the number equal to the charge it would have if it were an ion.
- 4. The oxidation number of fluorine in a compound is always -1
- 5. Oxygen has an oxidation number of -2 unless it is combined with F, when it is +2, or it is in a peroxide, such as H_2O_2, when it is -1
- 6. The oxidation state of hydrogen in most of its compounds is +1 unless it is combined with a metal, in which case it is -1
- 7. In compounds, the elements of groups 1 and 2 as well as aluminum have oxidation numbers +1, +2 and +3 respectively.
- 8. The sum of the oxidation numbers of all atoms in a neutral compound is 0.
- 9. The sum of the oxidation numbers of all atoms in a polyatomic ion equals charge of the ion.

Balancing Redox Reactions

- **Assign oxidation states**
  - Determine the element oxidized and the element reduced.

$$3\ Cl_2 + I^- + \rightarrow 6\ Cl^- + IO_3^-$$

0 −1 −1 +5 −2

Balancing Redox Reactions

- **Write oxidation and reduction half-reactions, including electrons.**

Oxidation: $I^- \rightarrow IO_3^-$

Reduction: $Cl_2 \rightarrow 2\ Cl^-$

  - Oxidation electrons on right, and reduction electrons on left of the arrow.

Balancing Redox Reactions

- **Balance half-reactions by mass**.
  - First balance elements other than H and O.
  - Add H_2O where O is needed.
  - Add H^+ where H is needed

Oxidation: $I^- + 3H_2O \rightarrow IO_3^- + 6H^+$

Reduction: $Cl_2 \rightarrow 2\ Cl^-$

Balancing Redox Reactions

- **Balance half-reactions by charge.**
  - Balance charge by adjusting # of electrons.
  - Balance electrons between half-reactions. *Common Multiple*
  - Add half-reactions
  - Check by counting atoms and total charge.

Oxidation: $1x[I^- + 3H_2O \rightarrow IO_3^- + 6\ e^- + 6H^+]$

Reduction: $3x[Cl_2 + 2\ e^- \rightarrow 2\ Cl^-]$

Oxidation: $I^- + 3H_2O \rightarrow IO_3^- + 6\ e^- + 6H^+$

Reduction: $3Cl_2 + 6\ e^- \rightarrow 6\ Cl^-]$

Balancing Redox Reactions

$$\underset{0}{3\,Cl_2} + \underset{-1}{I^-} + \underset{+1\ -2}{3H_2O} \rightarrow \underset{-1}{6\,Cl^-} + \underset{+5\ -2}{IO_3^-} + \underset{+1}{6\,H^+}$$

Oxidation: $1x[I^- + 3H_2O \rightarrow IO_3^- + 6\,e^- + 6H^+]$

Reduction: $3x[Cl_2 + 2\,e^- \rightarrow 2\,Cl^-]$

Oxidation: $I^- + 3H_2O \rightarrow IO_3^- + 6\,e^- + 6H^+$

Reduction: $3Cl_2 + 6\,e^- \rightarrow 6\,Cl^-]$

Half-Reactions

- We generally split the redox reaction into two separate **half-reactions**—a reaction just involving oxidation or reduction.
  - The oxidation half-reaction has electrons as products.
  - The reduction half-reaction has electrons as reactants.

$$\underset{0}{3\,Cl_2} + \underset{-1}{I^-} + \underset{+1\ -2}{3H_2O} \rightarrow \underset{-1}{6\,Cl^-} + \underset{+5\ -2}{IO_3^-} + \underset{+1}{6\,H^+}$$

Oxidation: $I^- \rightarrow IO_3^- + 6\,e^-$

Reduction: $Cl_2 + 2\,e^- \rightarrow 2\,Cl^-$

Oxidation and Reduction

- **Oxidation** is the process that occurs when
  - the oxidation number of an element increases,
  - an element loses electrons,
  - a compound adds oxygen,
  - a compound loses hydrogen, or
  - a half-reaction has electrons as products.
- **Reduction** is the process that occurs when
  - the oxidation number of an element decreases,
  - an element gains electrons,
  - a compound loses oxygen,
  - a compound gains hydrogen, or
  - a half-reaction has electrons as reactants.

Electrochemistry Terminology #2

An old memory device for oxidation and reduction goes like this…

LEO says GER

Lose **E**lectrons = **O**xidation

Gain **E**lectrons = **R**eduction

Electrochemistry Terminology #3

- ***Oxidizing agent***

  The substance that is reduced is the oxidizing agent

- ***Reducing agent***

  The substance that is oxidized is the reducing agent

Electrochemistry Terminology #4

- ***Anode***

  The electrode where oxidation occurs

- ***Cathode***

  The electrode where reduction occurs

Memory device:

Reduction at the **Cat**hode

Current

- **Current** is the number of electrons that flow through the system per second.
  - Unit = ampere
- 1 A of current = 1 coulomb of charge flowing each second
  - 1 A = 6.242×10^{18} electrons per second
- Electrode surface area dictates the number of electrons that can flow.
  - Larger batteries produce larger currents.

Voltage

- The difference in potential energy between the reactants and products is the **potential difference**.
  - Unit = volt
- 1 V = 1 J of energy per coulomb of charge
  - The voltage needed to drive electrons through the external circuit
- The amount of force pushing the electrons through the wire is called the **electromotive force, emf**.