ELECTROCHEMISTRY

General Information

- charge = gain electrons
+ charge = lose electrons
- In a compound, the positive charge usually comes first
- metals tend to have a + charge

The Nature of Energy Once More

-thermodynamics has shown us how energy moves between samples of matter, that it can always move between hot and cold objects, that energy is conserved (free energy decreases)
-however, if the reactants that comprise an exothermic reaction are allowed to come into contact indirectly, a chemical reaction takes place with little or no $\triangle T$.
-Volta with other scientists (Galvani) recognized that reactions of this type involve a new type of energy transfer. Michael Faraday later perfected this theory.
-These reacting cells consist of several basic elements:

1. The reactants cannot be placed in direct physical contact with each other, or any reaction will take place exothermically. The reactants are placed in half cells.
2. The reaction must take place in a completed circuit called a cell, and the electrical current flows in on direction (from one half cell to another) spontaneously.
3. Two electrodes are required of different substances, usually metals, one of which always "grows" (increases in mass, cathode), while the other "shrinks" (decrease in mass, anode).
4. A porous barrier (known as a salt bridge) connects the two half cells.
5. Each half cell contains a solution of the metal being used as the electrode.

- by convention, the electrical current produced by the cell flows from anode to cathode.
-A reaction will take place if there is (usually): 1. Movement of electrons, 2. Formation of water, 3i. formation of solid 3ii. Formation of gas
- Electrons flow from products to reactants. (Electrons on right side = anode, oxidation)
- If electricity flows through a cell spontaneously (no activation energy), the reaction has a negative free energy change ($-\triangle G$) and is called a voltaic (or Galvanic) cell.
- Nernst equation: $\triangle G = -nFE_{cell}$

n = number of electrons (always +)
F = Faraday constant (+)
E_{cell}= cell voltage (if not positive, then $\triangle G$ is positive, which is impossible)

- $E_{cell} = -\triangle G /(nF)$
- $-\triangle G$ is always positive voltage

OILRIG/REDCAT

OILRIG = Oxidation is lost, reduction is gained.
REDCAT = reduction the cathode
- oxidation = loses electrons, decreases in size, anode, black lead, most reactive metal
- reduction = gains electrons, increases in size, cathode, red lead

VOLT/COULOMB/AMP

- Volt (V) = JC^{-1} (a Joule per Coulomb)
- Coulomb = a unit of charge (how much zap!)
- Amp = Cs^{-1}(a coulomb per second)
- F (faraday constant) = 96485 C/mol
- e^- = 1.602×10^{-19} C

	Waterfall thing	Real
Voltage	height	Energy that each electron has

Amperage	how much water per second	# of moving electrons (more reactants, more amps
Faraday	wetness of each mole of water	Charge of each electron

ELECTRICAL POLES (607 - 610)

-A battery has two opposite poles that have two opposite electrical charges: anode(+), cathode (-)
-Electrical charge passes from the anode to the cathode, making the anode pole shrink, and the most reactive metal, while the cathode, least reactive, grows
-Oxan = oxidation at the anode
- redcat = reduction at the cathode
-Electrical current will always flow from the most reactive metal to the least reactive, from the anode to the cathode

VOLTAIC VS. ELECTROLYTIC (610 - 613)

- A feasible chemical reaction can be used to generate direct electrical power in a voltaic/galvanic cell
- a new fuel cell technology uses this technique to generate electricity where H and O cannot come into contact

$$2H_2 + O_2 \rightarrow 2H_2O$$

-this equation liberates large quantities of clean energy, water is produced, and is stable
-the cell is voltaic because the reaction is spontaneous and constant, only disconnecting the circuit or running out of reactant stops the reaction
-However, it's possible to reverse the reaction. The discovery of electrochemistry and the nature of matter allows us to seemingly defy the laws of thermodynamics
- by "pushing" electrons in the opposite direction (from cathode to anode) the reaction reverses with all the appropriate reversal of quantities.
- a high voltage is necessary to do this
- this type of cell is called an electrolytic cell. They require an external power source (thermodynamics) which must overcome the natural tendency of the electron flow by using appropriate quantities of energy
- However, the products of this electrolytic cell are more unstable than the reactants. This is not always the case, but should be thought of when considering the nature of the cell
-Electroplating cells are a primary use of electrolytic cells. By using an anode of a selected metal and a solution of that metal, an object can be "plated" by pushing the electrons in a desired direction

E.M.F. (613 - 616)

- voltaic cells spontaneously produce electricity. However, the amount of electricity is based upon the nature of the reactants themselves
-What is a volt? An energy term used for charge carriers. On J/C. Charge is how much ZAP is available during the process. Volts is how much energy is in the ZAP. Amp is amount of charge every second. C/s
-The reason different ½ cell combinations have different voltages is that each set of reactants has a different amount of energy to provide to the number of electrons transferred during the process.
- To increase AMPS, connect - to - and + to +. To increase volt, connect + to -. (Cd player)
- the substance at the anode is typically the most reactive metal, and as a result has its needs met first. This is analogous to thinking that this substance has the greatest amount of energy with which to "push" its electrons. While the cathode may resist this push, it has insufficient energy to "push" the electrons back to the anode.
- the cell potential is the remaining amount of energy that the electrons have after being "pushed" by the anode and "repelled" by the cathode. This energy is available to do work and is subsequent to the laws of thermodynamics. This push is the Electromotive Force, or EMF.

- Electromotive force literally means “the force of the moving electrons”
-It should be noted that it is impossible to discover the EMF for only 1 substance, so a standard of comparison is required. This standard is taken to be hydrogen in the form of a standard Hydrogen Electrode (SHE). SHE is always placed at the anode, test metal is cathode

CALCULATING VOLTAGES

- to calculate voltage of any voltaic cell, a simple equation can be used

$$E_{cell} = E_{cathode} - E_{anode}$$

- Wrights method
  - It’s a pushing match, Voltaic cells only have positive E_{cell}
  - Tables used are “reduction potentials” and you have to reverse ONE of the reductions to make an oxidation
  - Reduction potentials are independent of amount. Don’t multiply the Voltage by anything
- In Electrolytic cells, the natural tendency must be reversed. By “pushing” the reaction with more EMF than it would otherwise generate, it becomes electrolytic.

WRIGHT’S FOX TRICKS

- Reading the half equations correctly: Fe^{+3} vs. Fe^{+2}
- Products being bonded if they half opposite charges

$$2Li + F_2 \rightarrow 2LiF$$