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***Lecture 1 Notes, Immaculata Week, July-August 2013, Charles H. Mahler, Lycoming College***

My email address is [mahler@lycoming.edu](https://mail.lycoming.edu/owa/redir.aspx?C=ab05c5cbaa4a4ba88781c5c6d6c17bd7&URL=mailto%3amahler%40lycoming.edu) – please contact me if you have questions.

Our topic was oxidation-reduction chemistry and we started with the “Silver Tree” demonstration, where a piece of copper (Cu) wire was placed into an aqueous solution of silver nitrate (AgNO3). Over time, silver (Ag) metal deposited on the wire, and the solution turned blue from Cu2+ ions. The balanced reaction equation is

Cu (s) + 2 AgNO3 (aq) 🡪 Cu(NO3)2 (aq) + 2 Ag (s) OR, showing the ions in solution

Cu (s) + 2 Ag+ (aq) + 2 NO3- (aq) 🡪 Cu (aq) + 2 NO3- (aq) + 2 Ag (s) OR, focusing on metals

Cu (s) + 2 Ag+ (aq) 🡪 Cu2+ (aq) + 2 Ag (s)

(Note that in the third equation we ignore nitrate, NO3-, as it does not react and is just a “spectator ion” present to balance the charge – since it is the same on both sides it cancels out.) We noted that the copper goes from a charge of 0 (zero) to +2, so it becomes more positive and is losing electrons, or oxidized. The silver goes from -1 to 0 (zero), so it becomes less positive (or more negative) and is gaining electrons, or reduced (recall that electrons are negatively charged). A mnemonic to recall these is “LEO the lion says GER” where LEO stands for “Lose Electron(s) Oxidized” and GER is “Gain Electron(s) Reduced”.

We briefly reviewed the basics of atomic structure. The nucleus in the center of the atom has the positive charge from the protons, as well as the neutral neutrons and almost all of the atom’s mass. Negative charges are in the electrons, which surround the nucleus and are equal in number to the protons (so the overall atom has no net charge).

Since Chemistry is largely the sharing or transfer of electrons, we looked at covalent bonds, where the electrons are shared between atoms. These usually form when non-metals react with non-metals (non-metals are in the upper right corner of the Periodic Table, plus hydrogen). An example is water, where two hydrogen atoms share their electrons with one oxygen atom (H2O). Chemical bonds are usually formed by two electrons shared between two atoms.

If electrons are transferred, then ions form – an example is salt, NaCl, which contains positive sodium ions (Na+) and negative chloride ions (Cl-). Positive ions like Na+ are called cations (the “t” looks like a plus sign) and negative ions like Cl- are called anions (the “n” reminds us of negative). Ionic compounds do not really have bonds as the positive and negative charges are held together by electrostatic attraction (not shared electrons).

Next we looked at the Periodic Table and saw how it could help us understand the kind of ions and bonds that atoms form. Group 18 (the noble or inert gases, He, Ne, Ar, Kr, Xe, Rn) have especially stable numbers of electrons and so do not react (as they do not need to add or lose electrons). Other elements that are either end of the periodic table will often form ions to get to a noble gas shell configuration (same number of electrons). For example, chlorine has 17 electrons and if it can add one electron, it will be at 18, the same number of electrons as the noble gas argon. So chlorine likes to make chloride ions (Cl-). Similarly, sodium has 11 electrons and loses one to get to 10, like the noble gas neon’s electron count, so sodium forms Na+ ions.

Similarly, we can use this “octet rule” to predict covalent bonding. In water, the oxygen has 8 electrons and would like to get to 10 (neon), so it shares one electron from each of the two hydrogens it bonds with. Each hydrogen has 1 electron to start, and by sharing one of oxygen’s electrons, it gets to 2 (like the noble gas helium). Each covalent bond is usually formed by two electrons shared between two atoms. We can also rationalize and see why halogen (F, Cl, Br, I) form compounds with one bond, chalcogens (O, S, Se, Te) form compounds with two bonds, nitrogen and its group form compounds with three bonds, and carbon and its group form compounds with four bonds.

We then turned to Rules for finding the Oxidation State (number) for atoms:

**Oxidation State (number) Rules**  
1) A pure element’s oxidation state is zero (examples Cu, O2, P4)  
2) A simple ion’s oxidation states equals its charge (examples Na+ = +1, Cl- = -1, Cu2+ = +2)  
3) Hydrogen (H) in compounds is usually +1 (high school teachers learned about metal hydrides where it is -1)  
4) Oxygen (O) in compounds is usually -2, the exception is peroxides where it is -1 (H2O2 is hydrogen peroxide)  
5) The sum of all oxidation states in (neutral) molecules is zero, the sum in complex ions equals the ion’s charge  
6) We can use Periodic Table to predict other atoms’ simple oxidation states in compounds (so Na +1, F -1, Mg +2)

We then looked at the silver tree reaction and saw that the copper and silver metals have oxidation states of zero (pure metal) while the silver ion is +1 and the copper ion is +2 (simple ions). We looked at the nitrate ion, NO3-, and found that each oxygen atom has an oxidation state of -2, the overall charge is -1, so nitrogen has an oxidation state of +5.

Next we looked at five carbon compounds to find the oxidation state of carbon in each. In CO (carbon monoxide) it is +2, in CO2 (carbon dioxide) it is +4, in CH4 (methane) it is -4, in CH3OH (methanol) it is -2, and in CH2O (formaldehyde) it is zero.

Final demonstration was the exploding Pringles can, where the reaction is also an oxidation-reduction (or redox) reaction, where hydrogen is oxidized (each H goes from 0 to +1) and oxygen is reduced (0 to -2).

2 H2 (g) + O2 (g) 🡪 2 H2O (l)

Demos: Silver Tree, Exploding Pringles Can

Activity: Glue, food color and dish soap