<u>AP Lab: Electrochemical (Galvanic) Cells</u>

(Adapted from http://www.ccsd.k12.ny.us/carmelchemistry/AP%20Lab12-Electrochemical%20Cells.doc and from "Electrochemistry: Voltaic Cells." <u>Adavanced Chemistry with Vernier</u> - References included in the main report)

Introduction

Oxidation is when an atom loses electrons. **Reduction** is when an atom gains electrons. A chemical reaction where one species loses electrons and another species gains electrons is called a **redox reaction**. In such reactions, the substance that gets oxidized (loses electrons) is called the **reducing agent**. The substance that gets reduced (gains electrons) is called the **oxidizing agent**.

In many redox reactions, there is a complete transfer of electrons from the substance being oxidized to the substance being reduced. When these electrons travel through a conductor, such as a wire, electric current can be generated and measured in volts. In this arrangement, there are two half-reactions. There is an oxidation half-reaction and a reduction half-reaction. In this lab each reaction takes place in a different container. These containers are called half-cells. A wire connects the two half-cells through a device that measures current called a voltmeter. In order to complete the electrical circuit, ions must be free to travel from one half-cell to another. This is made possible by connecting the two half-cells with a **salt bridge**. A salt bridge is a tube (usually U-shaped) that connects the two half-cells of a redox reaction, and allows ions to migrate from one cell to another.

In each half-cell a conductor is needed to establish the electric current. These conductors are called **electrodes**. In the oxidation half-cell, the electrode is called the **anode**. The anode is considered to be a negative electrode because electrons are generated there. In the reduction half-cell, the electrode is called the **cathode**. The cathode is considered to be a positive electrode because electrons are attracted to it. The current generated by an electrochemical cell is called **electrochemical potential** (**E°**). Electrochemical potential is the difference in "potential" of the two half-reactions that can generate current. The difference is a comparative measurement (compared to a standard hydrogen half-cell) and is measured in volts.

In this experiment you will create an electrochemical cell, and observe a redox reaction. Measure electrochemical potential of a redox reaction and compare it to the accepted value for that redox reaction.

Objective: 1. Set up and test the voltage of an electrochemical cell.

Safety: Always wear safety goggles and a lab apron or coat when working in the lab. Wash hands before leaving the lab.

Materials

black coated wire with alligator clips
red coated wire with alligator clips
redox cell (a porous cup inside of a glass cup)
DC voltmeter
copper strip
zinc strip
iron strip
lead strip
sand paper
50mL graduated cylinder
250-mL beaker
0.10 M Solution of: $Cu(NO_3)_2$, $Fe(NO_3)_3$, $Pb(NO_3)_2$, $Zn(NO_3)_2$

Pre-lab Questions

1. Write out the half reaction for the <u>reduction</u> of every metal listed in the materials section. Using the table on page 481, write the corresponding reduction potential, Eº, for each reaction.

Electrodes	Half Reactions	Eº	$Eº_{cell}$
Zn Cu	$Zn(s) \rightarrow Zn^{2+} + 2e^-$ $Cu^{2+} + 2e^- \rightarrow Cu(s)$	+0.76 V +0.34 V	+1.10V
Fe Cu			

Electrodes	Half Reactions	Eº	$Eº_{cell}$
Zn Fe			
Fe Pb			
Pb Cu			
Pb Zn			

Procedure

1. If necessary, using sand paper, clean all the strips of metal.
2. Add about 50 mL of 0.10 M a nitrate solution to the small porcelain cup.
3. Add about 50 mL of 0.10 M another nitrate solution to the bigger glass cup.
4. Place the small porcelain cup into the glass beaker in that beaker.
5. Place the top of the redox cell onto the glass cup, making sure that the clips are above each solution.
6. Place the corresponding metal strip into the appropriate nitrate solution.
7. Attach the black clip onto the electrode of the anode.
8. Attach the red clip onto the electrode of the cathode.
9. Clip the black alligator clip to the black part of the voltmeter.
10. Clip the red alligator clip to the red part of the voltmeter.
11. Read the reading on the voltmeter and record the reading below.
12. Pour the nitrate solutions down the sink, making sure that you run enough water to dilute the solution.
13. Rinse both cups thoroughly to prepare for the next pair of solutions.
14. Repeat steps 2-13 for every combination.

Data - Voltage Data for a Voltaic Cell

Line notation	$Zn \vert Zn^{2+}\ \ Cu^{2+}\ Cu$					
$Eº_{cell}$						
$Eº_{cell}$ from book						

Questions

1. How well did your experimental voltage compare with the theoretical voltage calculated from the table.

2. An electrochemical cell in which the half cells are Ag/Ag^{+} and Cu/Cu^{2+} was made.
   a. Draw a picture of what this cell would look like. Label the anode, cathode, salt bridge, and where the ions are.
   b. Name the reducing and the oxidizing agents.
   c. Write out the half reactions for the oxidation and reduction half cells.
   d. Write out the net ionic equation for this redox reaction.
   e. Calculate the net cell potential for this redox reaction.

3. Draw a picture of the electrolytic cell you made in this lab. Show which wire was the anode and which was the cathode and write the oxidation and reduction ½ reactions under each.