LAD B.4 (pg 1 of 2) Voltaic Cells and Reduction Potential Table

Name_______________Per____

Introduction

In electrochemistry, a voltaic cell is a specially prepared system in which an oxidation-reduction reaction occurs spontaneously. This spontaneous reaction produces an easily measured electrical potential which has a positive value. Voltaic cells have a variety of uses and we commonly refer to them as a "battery".

Half-cells are normally produced by placing a piece of metal into a solution containing a cation of the metal (e.g., Cu metal in a solution of a soluble salt that releases Cu^{2+} or Cu^{+} into solution). In this micro-version of a voltaic cell, the half cell will be a small piece of metal placed into three drops of a solution on a piece of filter paper. The solution contains a cation of the solid metal. The wheel below shows the arrangement of the half-cells on the piece of filter paper. Pay special attention to the shapes of the metals which corresponds to the particular number of the metal.

The two half-reactions are normally separated by a porous barrier or salt bridge. Here, the salt bridge will be the filter paper moistened with an aqueous solution of potassium or sodium nitrate. Using a voltmeter, the positive terminal (or lead) makes contact with one metal and the negative terminal with another. If a positive voltage is recorded on the meter, the cell you have constructed is spontaneous. When the voltage reading is positive, the metal having a higher, more positive, reduction potential is the cathode and will be connected to the red wire which is connected to the positive terminal. The metal attached to the negative terminal is the anode and has the lower, more negative, reduction potential.

The purpose of this LAD is to construct a reduction potential table with the eight metals.

Materials on Tray

- 2× filter paper to be cut as shown below, cutting out the gray pie-shaped sections
- 2× scissors
- 2× forceps (tweezers)
- 2× dish with metals to be tested: M_1 to M_8 cut in specific shapes as shown on the wheel
- 2× beaker with droppers with various 0.20 M metal nitrate solutions labeled with the corresponding numbers and color coded as shown in Table 1 below and short unlabeled dropper with potassium nitrate "salt bridge" solution
- 2× voltmeters
- 2× glass square to set filter paper on when setting up the micro-cells
- 2× tap water wash bottles

Table 1

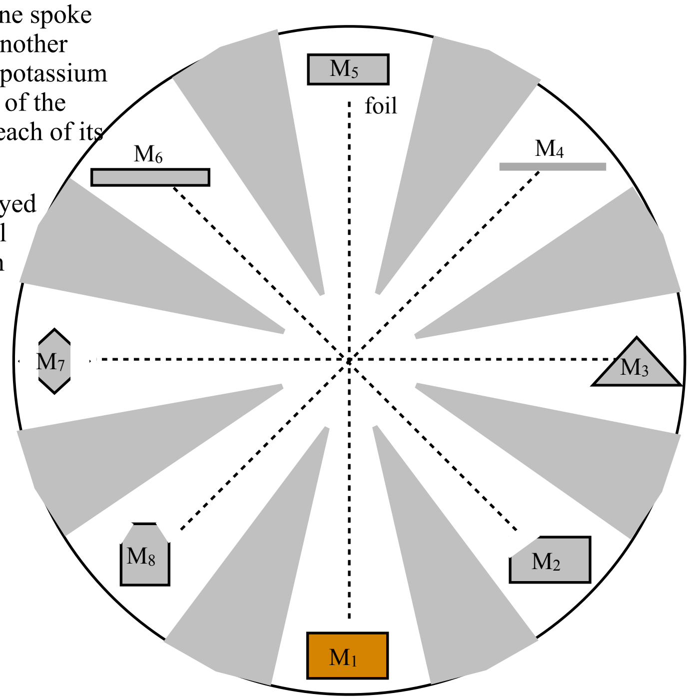
Metal Ion Solution	Color of Label on Solution
M_1	blue
M_2	bright green
M_3	pink
M_4	white
M_5	dark green
M_6	orange
M_7	red
M_8	yellow

Procedure

Goggles must be worn at all times.

Use the cleaner on top of the cabinet if there are too many fingerprints on your goggles.

1. Cut the filter paper with eight "spokes" as shown below. Lay out the metals and their corresponding solutions around the wheel. CAUTION: Handle these solutions with care. Some are poisonous and some cause hard to remove stains.
2. Cut the filter paper with eight "spokes" as directed in class.
3. Be sure you have turned your multi-meter on, set to DC not AC, be sure the plugs are in the center and the Volt side, and turn the dial to the 2 V position.
4. Put one drop (maybe 2) of M_1 solution on the outside of one spoke and one drop (maybe 2) of M_2 solution on the outside of another spoke. Connect those two solutions by dropping a trail of potassium nitrate solution between the metal ion solutions at the end of the spokes. Place the corresponding Metal 1 and Metal 2 on each of its own solution, and test with the multi-meter.
5. For this first M_1 and M_2 combination, if the voltage displayed on the meter is negative, then reverse the terminals. Recall that the red wire terminal is the cathode and that reduction takes place there.
6. Be sure to press down on the metal piece in order to make good contact. Take a voltage reading and record the value in Data Table 1.
7. Measure the potential of the other six cells , M_1 to M_3, M_1 to M_4, and all the way through M_1 to M_8. Be sure and use M_1 as the reference electrode, thus M_1 remains connected to the same terminal (same colored wire) and thus negative voltage readings are possible. Record the voltage readings in Data Table 2.



 Voltaic Cells and Reduction Potential Table

8. Measure the potential of the remaining possible spontaneous cell combinations as shown in Data Table 4. If the salt bridge solution has dried (or if any of the other solutions have dried), you may have to re-moisten them with a drop of the appropriate solution. **Switch the wires if the voltage reading is negative.** Record each measured spontaneous (positive) cell potential in Data Table 4 and be sure and identify which metal was the cathode (attached to red wire) by circling the cathodic metal on the data table.

9. When you have finished collecting data, use the forceps to remove each of the pieces of metal from the filter paper. Rinse each piece of metal with tap water. Dry the metals and return them to the dry plastic dish. Discard the filter paper in the trash and rinse the glass plate with tap water. Wash your hands after the lab.

Table 2

Metals	Measured Voltage
M_1M_2	
M_1M_3	
M_1M_4	
M_1M_5	
M_1M_6	
M_1M_7	
M_1M_8	

Table 3

Metal #	$E_{reduction}$ relative
	more +
	more −

Table 4

Metals (Circle the Cathode (red))	Measured Voltage	Calculated voltage (Based on Data Table 3 Show the Work $E_{reduction} + E_{oxidation} = E_{cell}$)	% error
M_2M_3			
M_2M_4			
M_2M_5			
M_2M_6			
M_2M_7	*Do not record the results of this combination.*		
M_2M_8			
M_3M_4			
M_3M_5			
M_3M_6			
M_3M_7			
M_3M_8			
M_4M_5			
M_4M_6			
M_4M_7			
M_4M_8			
M_5M_6			
M_5M_7			
M_5M_8			
M_6M_7			
M_6M_8			
M_7M_8			

Process the Data

A. We will set Metal 1 as the reference, and thus assign M_1 a reduction potential of 0.0 V. Since you made all the M_1 combinations with M_1 attached to the cathode (reduction), all of the other metals were attached to the oxidation wire. Arrange the the $E_{reduction}$ for all the metals in descending (more positive to negative) in Data Table 3. Since M_1 will be 0.0 V, and was the reduction, you will need to change the sign of the voltage reading to represent the $E_{reduction}$ of all the other metals

B. Using your Reduction Potential table established in Data Table 3, calculate the cell voltages for all of the metal combinations and record in Data Table 4. Compare your calculated value with the actual measured value calculating a percent error and record in Data Table 4.

C. The teacher will reveal the identities of Metals 1 − 8. Pull out your orange published reduction potential table and compare the relative locations. How does your experimental ranking line up with the published ranking?