LAD B4 (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 a 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 that 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 a drop 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 identifying number of the metal.

The two half-reactions are normally separated by a porous barrier or salt bridge. In this lab, the salt bridge will be the filter paper moistened with an aqueous solution of potassium or sodium nitrate. Voltmeters record electical potential by measuring magnitude and indicates direction of electrons through the voltmeter by reporting the sign.

The purpose of this lab is to construct a reduction potential table with the six metals.

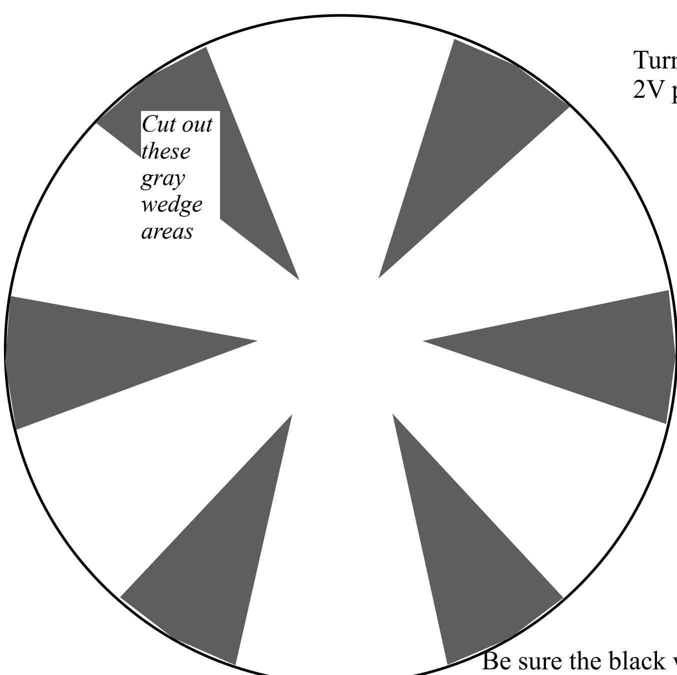
Materials on Tray (per lab group)

- filter paper to be cut as shown below, cutting out the gray pie-shaped sections
- scissors and forceps (tweezers)
- dish with metals to be tested: M_1 to M_6 cut in specific shapes as shown on the wheel
- dropping bottles with various 0.20 M metal nitrate solutions labeled with the corresponding numbers and color coded as shown in Table 1 below and dropping bottle with potassium nitrate “salt bridge” solution
- multimeter (to be used as a voltmeter)
- petri dish to set filter paper in when setting up the micro-cells

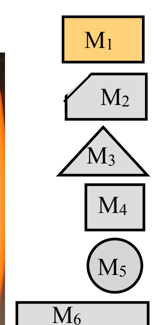
Preparation

1. Cut out 6 wedges (the shaded pie-shape area) leaving the filter paper with six “spokes” as shown below. Lay one metal on the very outer edge of each filter paper spoke as indicated on the next page, and their corresponding solutions around the outer edge of the petri dish. CAUTION: Handle these solutions with care. Some are poisonous and some will stain your hands or clothes.
2. LOOK CAREFULLY at your multi-meter, and be sure the black wire is inserted in the center (COM) port, and the red wire is inserted in the right port. Be sure you have turned your multi-meter on to the 2 V position (or 2000 mV if you have the red multi-meter).
3. Look carefully at your tray of metals and note that they have different shapes that correspond each with their own particular nitrate solutions

Table 1	
Metal Ion Solution	Color of Label on Solution
M_1	blue
M_2	green
M_3	orange
M_4	yellow
M_5	red
M_6	pink



Turn on to 2V position

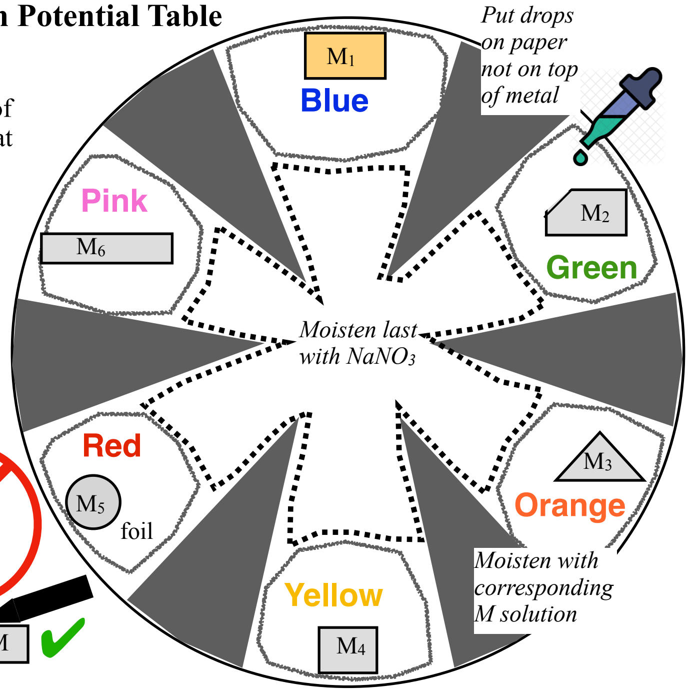


Be sure the black wire is placed in the COM port on the voltmeter.

Be sure the red wire is placed in the V•Ω•mA•Temp port on the voltmeter.

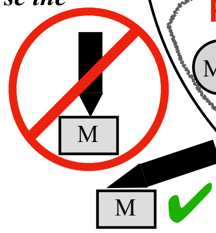
LAD B4 (pg 2 of 2) Voltaic Cells and Reduction Potential Table

Procedure *Goggles must be worn at all times.*



4. Place your metals on the filter paper at the outside edge of the "spokes." Put 1 drop of M_1 solution on the the paper at the far *outside edge* of one spoke and 1 drop of M_2 solution on the *outside* of another spoke…and so on with each of the six solutions. Connect the solutions by dropping a trail of sodium (or 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 positive, then reverse the terminals so that the voltage reads negative.***



6. Be sure to press down on the metal piece *at an angle* in order to make good contact. Take a voltage reading and record the value to 2 decimal places in Table 2.

7. For the next four measurements, **do NOT change the electrode you have "attached" to M_1.** Measure the potential of the other four cells , M_1 to M_3, M_1 to M_4, M_1 to M_5, and M_1 to M_6. *Be sure and use M_1 as the reference electrode,* ***thus M_1 remains connected to the same terminal (same colored wire as in step #4). Negative and positive voltage readings will occur.*** Record the + or − voltage readings in Table 2.

8. When you have finished collecting data, discard the filter paper in the trash. Add water to the dish to wash off the the pieces of metal. Remove each of the pieces of metal and place on to a paper towel using the forceps as necessary. Pat the the metals dry and return them to the rinsed and dried plastic dish. 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	

Process the Data

A. We will arbitrarily choose Metal 1 as the *reference*, and thus assign M_1 a half reaction potential of 0.0 V. Because, we read the M_1M_2 combo as **negative voltage**, and because we set M_1 as the reference with a half reaction potential as zero, all the resulting combinations with M_1 attached to the same wire forces all the measured voltages in Table 2 to be the **reduction** potentials of each of the metals. Rewrite the $E_{reduction}$ values for all the metals from Table 2, arranging the metals in descending order from more positive to negative into Table 3. Don't forget to include $M_1 = 0$ in Table 3. Voilà …. you have just established Table 3 as a Relative Reduction Potential Table.

B. Share your results with your teacher who will reveal the actual identity of each metal which you can list in the least column. Find each of the metals in the ***standard*** reduction potential table and determine if your Table 3 metals have lined up in the same relative order.

C. In the standard reduction table, look for the half reaction that has been set as zero. Write that reaction in the space below.

D. Explain why your reduction potentials do not match the reduction potentials in the ***standard*** reduction potential table. *(Beware, because of lab error (oxidized metals, poor contact, drying solutions, resistance of salt bridge) attempts to recalibrate your experimental values to the* ***standard*** *table values will be unsatisfying.)*

Table 3
Relative Reduction Potentials

Metal #	$E_{reduction}$ relative	*chemical symbol revealed later*
	more +	
	more −	