Electrochemistry

The purpose of this experiment is to measure the voltage of several electrochemical cells.

You are expected to be familiar with using standard reduction potentials to determine cell voltages and with using the Nernst equation for other than standard conditions. For the purposes of this experiment, you do not need to measure the temperature and may assume "standard" room temperature. You do need to account for the concentrations of the solutions being "non-standard" conditions.

The quality of the experimental data depends on many factors; including being careful not to contaminate the reagents and being careful with the voltmeter. The solution-electrode junction is most important; the metal electrode needs to be a clean surface of pure metal. You will use sandpaper to polish the metals, but it is possible that all the oxide coating may not be removed or it may quickly reform.

The sign and charge conventions used in electrical measurements can be confusing, due to the negative charge of the electron. Voltmeters are usually constructed with black ("common") and red (+) leads. If the voltmeter reads a positive value - the black lead is connected to the Anode and the red to the Cathode. Naturally the opposite is the case if the meter indicates a negative voltage. (A negative voltage does not indicate that a non-spontaneous reaction is occurring.)

Procedure: **<u>Work in pairs.</u>**

Obtain from the stockroom: Chem-Carrou-Cell, filter paper strips, sandpaper, tweezers, 1 mL pipet, voltmeter.

I. Standard Cell Voltages

1. Place the Chem-Carrou-Cell on top of a 600 mL beaker.

2. Use clean test tubes from your drawer to obtain the various salt solutions. For this part use only 0.10 <u>M</u> solutions. The KNO_3 is to be carefully poured into the center cup of the Chem-Carrou-Cell. Note that the outer cups are numbered; carefully pour about 5 mL of the following solutions into the appropriate cup.
   1. $SnCl_2$
   2. $AgNO_3$
   3. $Cu(NO_3)_2$
   4. $Zn(NO_3)_2$
   5. $Al(NO_3)_3$

   Use the tweezers to carefully place the filter paper strips between the center cup and each of the outer cups. (Do not handle them with your fingers.) First dip one end into the KNO_3 solution, in the center cup; then dip the other end into one of the outer cups. Repeat this for each of the five outer cups.

Obtain the short pieces of metal; corresponding to each of the metal ions of the solutions. One by one clean the surface of the metal with sandpaper and bend down one end so that it will be immersed in the corresponding solution. The other end of the metal points to the outer edge of the Chem-Carrou-Cell and may be bent over the edge to help hold it in place.

You now have five metal/metal ion half cells, in the outer cups, which are connected together by the filter paper strips through the KNO_3 solution. Any two metal electrodes can be connected to make a complete electrochemical cell.

3. Connect the black (negative) lead of the voltmeter to the metal from cup 1. Connect the red (positive) lead to each of the other metals. Be sure to record the sign as well as the magnitude of the measured voltage. Move the black lead to cup 2 and measure the voltage to cups 3, 4 , and 5. Move the black lead to cup 3 and measure the voltage to cups 4 and 5. Move the black lead to cup 4 and measure the voltage to cup 5.

II. Nernst Equation: Effect of Concentration on Cell Voltage

1. Pipet 1.0 mL of the $Cu(NO_3)_2$ solution from cup 3 into a clean large test tube. Use your graduated cylinder to add 9.0 mL of de-ionized water; mix carefully. Before using the pipet again, remove the drop in the tip; then use the pipet to transfer 1.0 mL of the solution in the test tube to a second clean test tube. Add 9.0 mL de-ionized water to this tube and mix. You should now have the two dilute solutions required later.

2. Carefully disassemble the apparatus: the metal strips are to be rinsed off and returned to the containers in the hoods; the paper strips may be thrown away. The solutions may be mixed but are to be collected in the waste containers in the hoods. Rinse off the Chem-Carrou-Cell and dry it with a paper towel.

3. Reassemble the Chem-Carrou-Cell with fresh KNO_3 in the center cup and the following around the outside;

1.	0.10 <u>M</u> $Cu(NO_3)_2$	4.	0.10 <u>M</u> $Mg(NO_3)_2$
2.	0.01 <u>M</u> $Cu(NO_3)_2$	5.	0.10 <u>M</u> $FeSO_4$
3.	0.001 <u>M</u> $Cu(NO_3)_2$		

Again use the tweezers to install the filter paper bridges between the center and the outer cups. Obtain, clean with sandpaper, and install the appropriate metal electrodes. The iron nail will not bend to fit into a cup; polish it and hold it in the solutions when you are ready to measure a voltage.

4. Attach the black lead of the voltmeter to cup 1 and measure the voltage to each of the other cups. Move the black lead to cup 4 and measure the voltage between cups 4 and 5.

5. Carefully disassemble the apparatus; returning the metal strips and collecting the solutions for disposal in the waste containers in the hoods.

<u>Results</u>

1. From the experimental voltage, circle the cathode for the cell that would be occurring spontaneously.

2. For the cell that would be spontaneous, give the anode and cathode reactions.

3. Calculate the theoretical voltage for the spontaneous cell reaction.