Electrochemistry

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

You are expected to be familiar with using standard reduction potentials to determine cell potential 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 under "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—and it may quickly reform.

The sign and charge conventions used in electrical measurements may 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, then 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:

Work in pairs. Obtain from the designated point in the lab: Chem-Carrou-Cell, filter paper strips, sandpaper, tweezers, 1 mL pipet, medicine dropper, and voltmeter with red and black leads.

I. Setting up the Chem-Carrou-Cell

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

2. Use clean large test tubes from your drawer to obtain 10 mL each of 0.10 M $Al(NO_3)_3$ and $Zn(NO_3)_2$ solutions. Use a clean 50 mL beaker to obtain 20 mL of the 0.10 M $Cu(NO_3)_2$ solution. Use another clean 50 mL beaker to obtain 30 mL of the KNO_3 solution.

3. Pipet 1.00 mL of the 0.10 M $Cu(NO_3)_2$ solution into a clean large test tube. Use your graduated cylinder to add 9.00 mL of deionized water; mix carefully. This gives you a 0.010 M solution of $Cu(NO_3)_2$. Before using the pipet again, rinse it and remove the drop in the tip; then use the pipet to transfer 1.00 mL of the 0.010 M solution in the test tube to a second clean test tube. Add 9.00 mL de-ionized water to this tube and mix. This gives you a 0.0010 M solution of $Cu(NO_3)_2$.

4. Carefully use a medicine dropper to place KNO_3 solution into the center cup of the Chem-Carrou-Cell.

5. Note that the outer cups are numbered. Carefully add about 5 mL of the two solutions you are going to test into two non-adjacent cups. For example:

Cup 1. 0.10 M $Al(NO_3)_3$
Cup 3. 0.10 M $Zn(NO_3)_2$

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

7. Obtain short pieces of metal corresponding to each of the metal ions of the solutions. Each partner should clean the surface of one metal with sandpaper from the end to ~3 cm up the metal. Both ends of the metal should be cleaned with the sandpaper.

8. As quickly as possible, each partner should attach a lead to one polished surface of the metal and dip the other polished end into the corresponding solution for measurement, keeping the leads out of the solutions. Make sure the metal electrodes do not touch the sides of the Chem-Carrou-Cell cup or the filter paper ends. Be sure to record the sign as well as the magnitude of the measured voltage. If you are uncertain about a measurement, unclip and dry the metal, re-polish the surfaces with sandpaper, re-attach the leads, and re-measure.

9. Unclip and dry the metal, re-polish the surfaces with sandpaper, switch the leads, and read the second voltage for this pair of solutions.

10. Collect the solutions for proper waste disposal. Repeat Steps 4-9 for each cell listed in the two tables in sections II and III. Be sure to replace the KNO_3 solution and filter papers between each cell.

II. Cell Voltages for Different Metals

	Black Lead	Red Lead	Observed Voltage (E_{cell})
Cell 1	0.10 M $Al(NO_3)_3$	0.10 M $Zn(NO_3)_2$	
	0.10 M $Zn(NO_3)_2$	0.10 M $Al(NO_3)_3$	
Cell 2	0.10 M $Al(NO_3)_3$	0.10 M $Cu(NO_3)_2$	
	0.10 M $Cu(NO_3)_2$	0.10 M $Al(NO_3)_3$	
Cell 3	0.10 M $Zn(NO_3)_2$	0.10 M $Cu(NO_3)_2$	
	0.10 M $Cu(NO_3)_2$	0.10 M $Zn(NO_3)_2$	

III. Nernst Equation: Effect of Concentration on Cell Voltage

	Black Lead	Red Lead	Observed Voltage (E_{cell})
Cell 4	0.10 M $Cu(NO_3)_2$	0.010 M $Cu(NO_3)_2$	
	0.010 M $Cu(NO_3)_2$	0.10 M $Cu(NO_3)_2$	
Cell 5	0.10 M $Cu(NO_3)_2$	0.0010 M $Cu(NO_3)_2$	
	0.0010 M $Cu(NO_3)_2$	0.10 M $Cu(NO_3)_2$	
Cell 6	0.010 M $Cu(NO_3)_2$	0.0010 M $Cu(NO_3)_2$	
	0.0010 M $Cu(NO_3)_2$	0.010 M $Cu(NO_3)_2$	

Carefully disassemble the apparatus. Return the clean metal strips to their respective jars and place the solutions in the waste containers in the hoods.

After completing the procedure but before leaving lab, write in your notebook a brief statement (two to three sentences) on the quality and reasonableness of the data you collected. Note what you might do differently if you performed the lab again.