

ELECTROCHEMISTRY

In part A of this experiment you will develop a table of standard reduction potentials based on the the arbitrary assignment of the Cu/Cu^{2+} half reaction as having a potential of 0.00 V. You will come up with your own procedure for this portion of the experiment.

In part B of this experiment you will build and experiment with a concentration cell by varying the concentration of the Cu^{2+} ion in the cells.

In part C of this experiment you will couple individual galvanic cells in series and measure the potential.

EQUIPMENT

You will have available a 50 mL volumetric flask, a digital voltmeter, alligator clips, and slices of filter paper to use as salt bridges.

CHEMICALS

Copper, zinc, tin, magnesium, silver, platinum (for the manganese half-cell), silver, and iron electrodes. A 1.0 M solution of KNO_3 (for your salt bridges). $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ and 0.10 M solutions of CuSO_4 , FeCl_3 , AgNO_3 , SnCl_2 , $\text{Al}(\text{NO}_3)_3$, $\text{Mg}(\text{NO}_3)_2$, MnCl_2 , and ZnSO_4 .

WASTE DISPOSAL

All solutions should go in the provided waste containers. Do not throw out the electrodes.

SAFETY

Wear your goggles the entire time. Do not ingest any of the solutions used in this lab as they are toxic.

PROCEDURE

Part A: Development of a Table of Standard Reduction Potentials Relative to Cu.

You will come up with your own procedure for this section of the laboratory. Your goal is to develop a procedure for determining the standard reduction potentials for

the metals used in this lab with the copper half reaction being assigned a potential of 0.00 V and the standard concentrations taken as 0.1 M (instead of 1 M). After completing this portion of the experiment you will be able to fill in the following table:

Half-reaction	<i>E</i>(V)
$\text{Zn}^{2+}(\text{aq}) + 2 \text{e}^{-} \rightarrow \text{Zn}(\text{s})$?
$\text{Fe}^{3+}(\text{aq}) + 3 \text{e}^{-} \rightarrow \text{Fe}(\text{s})$?
$\text{Mn}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Mn}(\text{s})$?
$\text{Sn}^{2+}(\text{aq}) + 2 \text{e}^{-} \rightarrow \text{Sn}(\text{s})$?
$\text{Al}^{3+}(\text{aq}) + 3\text{e}^{-} \rightarrow \text{Al}(\text{s})$?
$\text{Ag}^{+}(\text{aq}) + \text{e}^{-} \rightarrow \text{Ag}(\text{s})$?
$\text{Cu}^{2+}(\text{aq}) + 2 \text{e}^{-} \rightarrow \text{Cu}(\text{s})$	0
$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^{-} \rightarrow \text{Mg}(\text{s})$?

Using the list of materials and chemicals write your own procedure which you will follow in lab.

Do not worry about describing how to set up a half-cell, your professor will show you that at the beginning of the lab. You need only describe which half-cells you will set up and measure the voltage of.

You may make modifications to your procedure, but document all changes. Your original procedure and modifications made will be submitted. You will then type up the final procedure you used.

As part of your procedure make sure you record each measured cell potential in your data table.

Part B: Concentration Cell

Use the Nernst equation to calculate the $[\text{Cu}^{2+}]$ you will need in a half cell to produce a measured cell potential of 0.05 V when the other half cell has $[\text{Cu}^{2+}] = 0.10 \text{ M}$.

Calculate the mass of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ you will need to measure out to make 50.00 mL of that solution and make the solution in a 50 mL volumetric flask.

Set up the cell and measure the potential. Record the potential in your data table.

Part C: Galvanic Cells in Series

You will connect 2 cells in series (that means one after the other). Each cell will be based on the copper and zinc half reactions.

To connect the cells in series connect the anode of one cell to the cathode of the other.

Measure the cell potential. Record this in your data table.

Add a third cell to the series and measure the potential. Record this in your data table.

CALCULATIONS

Part A: Show the calculation of the potential of each half reaction based on the copper half reaction being assigned a value of 0.00 V. Make your own table with your standard reduction potentials listed from most positive (on top) to most negative (on bottom).

Part B: Show the calculations for finding the $[\text{Cu}^{2+}]$ needed for the concentration cell (use the Nernst equation) with a cell potential of 0.050 V. Show the calculation for the actual $[\text{Cu}^{2+}]$ in the 50 mL volumetric flask. Calculate, using the Nernst equation, the expected potential of your concentration cell.

Part C: Calculate the voltages expected for the 2 cell and the 3 cell set-ups. For cells connected in series the overall voltage is just the sum of the individual voltages.

CONCLUSION

Part A:

Show your standard reduction potential table that you developed.

Show line notation describing each electrochemical cell you set up, including measured voltage.

Part B:

Show line notation for your electrochemical cell.

Report your expected voltage and actual voltage.

Part C:

Report your expected voltage and measured voltage for the 2 cell and the 3 cell set-up.

Comment on any discrepancy.