

Measuring the cell potentials and obtaining the reduction potentials, E_{red} , from the measured E_{cell} .

$$E^{\circ}_{\text{cell}} = E^{\circ}_{\text{cathode}} - E^{\circ}_{\text{anode}}$$

$$E^{\circ}_{\text{cell}} = E^{\circ}_{\text{red}} + E^{\circ}_{\text{ox}}$$

Seven Electrode systems

1. $\text{Ag}^+(\text{aq}), \text{Ag}(\text{s})$
2. $\text{Cu}^{+2}(\text{aq}), \text{Cu}(\text{s})$
3. $\text{Zn}^{+2}(\text{aq}), \text{Zn}(\text{s})$
4. $\text{Fe}^{+2}(\text{aq}), \text{Fe}^{+3}(\text{aq}), \text{Pt}(\text{s})$
5. $\text{Br}^-(\text{aq}), \text{Br}_2(\text{aq}), \text{Pt}(\text{s})$
6. $\text{Cl}^-(\text{aq}), \text{Cl}_2(\text{aq}), \text{Pt}(\text{s})$
7. $\text{I}^-(\text{aq}), \text{I}_2(\text{aq}), \text{Pt}(\text{s})$

Electrode solutions

- A. 0.1 M ZnSO_4
- B. 0.1 M CuSO_4
- C. 0.05 M AgNO_3
- D. 0.1 M KI sat'd with I_2
- E. 0.1 M NaBr sat'd with Br_2
- F. 0.1 M NaCl sat'd with $\text{Cl}_2(\text{g})$
- G. 0.1 M $\text{FeSO}_4 + 0.1 \text{ M Fe}_2(\text{SO}_4)_3$

In this lab you will determine the $E^{\circ}_{\text{half-cell}}$ (2 -> 7) using the silver electrode as your reference electrode. $E^{\circ}_{\text{Ag}} = 0.00 \text{ V}$ You will measure E°_{cell} for the Zn-Ag cell and determine E°_{red} for $\text{Zn}^{+2} + 2\text{e}^- \rightarrow \text{Zn}$ from the measured E°_{cell} . By different cell systems you should be able to determine the E°_{red} for all seven systems.

NB: Where there is no metal involved in the half reaction an inert electrode is used. We will use Pt as our inert electrode. **Also never use a Ag electrode with a halide.**

Electrode system	anode	anode soln.	cathode	cathode soln.
$\text{Zn} \text{Zn}^{+2} \text{Ag}^+ \text{Ag}$	Zn	A	Ag	0.05M AgNO_3

All metal electrodes must first be clean if necessary clean with steel wool.

Use 50 mL beakers for the electrodes, be sure the electrodes are clamped to a ring stands while submerged in the electrolyte.

Use 15 mL of each electrolyte solutions.

To prepare the salt bridge, insert a small amount of cotton wool (an unfolded large paper clip helps) into the holes of the two 1-hole stoppers, which fit the U-tube. Pour 1 M KNO_3 solution into the U-tube and insert one of the stoppers. Fill the U-tube with the KNO_3 solution and then carefully insert the second stopper so that there is no air bubble in the U-tube.

When making measurements, keep the salt bridge (U-tube) dipping in the solutions in the beaker as short a time as possible. If the KNO_3 solution in the U-tube becomes discolored or cloudy at any time, discard the solution and prepare a new salt bridge.

To make measurements, set up your voltaic cells using 2 50-mL beakers, one for each electrode system. Use ~ 15 mL of the appropriate solution in each beaker. The metal electrode must dip in the solution. Connect the metal electrode wires to the voltmeter. Check to make sure all electrical connections are good. Insert the salt bridge so that one arm of the salt bridge is dipping into the solution in each beaker. Record the voltage reading. Remove the salt bridge. When finished with a solution discard into your waste beaker. Rinse the metal electrodes and the electrode beakers with distilled water in between usage.

Be sure to record which electrode is negative, that is the electrode which is connected to the gray (black) electrode of the voltmeter.

Reference electrode Ag electrode $E^{\circ}_{\text{red}} = 0.00\text{V}$

NB: The Silver electrode is not used with the halides.

For the laboratory assistant:

Please prepare four 100mL (or larger) bottles (so each table can have one set) of the following solutions:

- A. 0.1 M ZnSO_4
- B. 0.1 M CuSO_4
- C. 0.05 M AgNO_3
- D. 0.1 M KI sat'd with I_2
- E. 0.1 M NaBr sat'd with Br_2
- F. 0.1 M NaCl sat'd with Cl_2 (g)
- G. 0.1 M FeSO_4 + 0.1 M $\text{Fe}_2(\text{SO}_4)_3$

Please provide my class with as many electrodes as we have available of the following types: silver, copper, zinc and platinum.

We will need one large bottle of 1M potassium nitrate (or four smaller bottles) so that a total of 16 salt bridges can be made.

We will need 16 U-tubes, 36 one-holed rubber stoppers, cotton to plug the holes.

We will need 16 digital multimeters - please test them to ensure they are functioning correctly.

We will need 50 mL beakers. If they are not in the room we will need 32 at least. We have these beakers in room 3162 but not in room 3170.

We will need pieces of steel wool to clean the electrodes.