Electrochemistry: Voltaic Cells

In electrochemistry, a voltaic cell is a specially prepared system in which an oxidation-reduction reaction occurs spontaneously. This spontaneous reaction produces an easily measured electrical potential. Voltaic cells have a variety of uses.

In this experiment, you will prepare a variety of semi-microscale voltaic cells in a 24-well test plate. A voltaic cell is constructed by using two metal electrodes and solutions of their respective salts (the electrolyte component of the cell) with known molar concentrations. In Parts I and II of this experiment, you will use a Voltage Probe to measure the potential of a voltaic cell with copper and iron electrodes. You will then test two voltaic cells with the same electrodes, but with solutions of different concentrations and, through careful measurements of the cell potentials, determine the effect of concentration on the voltage produced.

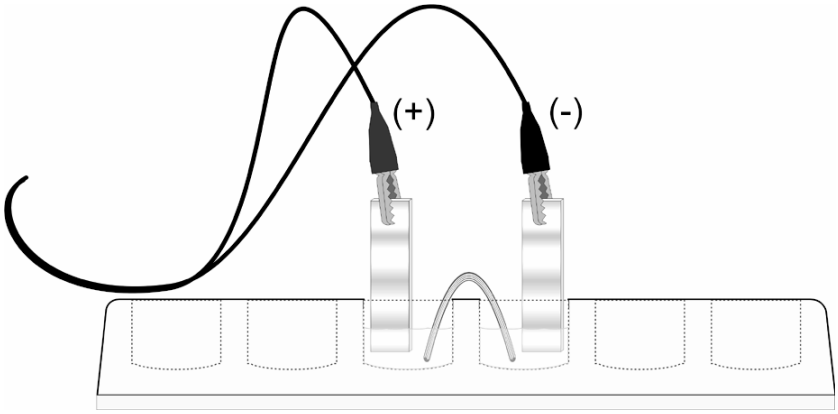

Figure 1

OBJECTIVES

In this experiment, you will

- Prepare a Cu-Fe voltaic cell and measure its potential.
- Test the same cell with different concentrations to determine effect of concentration.

MATERIALS

Vernier computer interface
computer
$Fe(NO_3)_2$, solution
Voltage Probe
1.0 M KNO_3 solution
string
Cu and Fe electrodes
150 mL beaker
1.0 M, 0.10 M and 0.01M copper (II) nitrate, $Cu(NO_3)_2$, solutions
1.0 M, 0.10 M 0.01 M Fe (II) nitrate, $Fe(NO_3)_2$ solutions
three 10 mL graduated cylinders
24-well test plate
steel wool
plastic Beral pipets

PROCEDURE

Part I Determine the E^o for a Cu-Fe Voltaic Cell

1. Obtain and wear goggles.

2. Use a 24-well test plate as your voltaic cell. Use Beral pipets to transfer small amounts of 1.0 M $Cu(NO_3)_2$ and 1.0 M $Fe(NO_3)_2$ solution to two neighboring wells in the test plate. **CAUTION:** *Handle these solutions with care. If a spill occurs, ask your instructor how to clean up safely.*

3. Obtain one Cu and one Fe metal strip to act as electrodes. Polish each strip with steel wool. Place the Cu strip in the well of $Cu(NO_3)_2$ solution and place the Fe strip in the well of $Fe(NO)_3$ solution. These are the half cells of your Cu-Fe voltaic cell.

4. Make a salt bridge by soaking a short length of string in a beaker than contains a small amount of 1 M KNO_3 solution. Connect the Cu and Fe half cells with the string.

5. Connect a Voltage Probe to Channel 1 of the Vernier computer interface. Connect the interface to the computer with the proper cable.

6. Start the Logger *Pro* program on your computer. Open the file “20 Electrochemistry” from the *Advanced Chemistry with Vernier* folder.

7. Measure the potential of the Cu-Fe voltaic cell. Complete the steps quickly to get the best data.
   a. Click Collect to start data collection.
   b. Connect the leads from the Voltage Probe to the Cu and Fe electrodes to get a positive potential reading. Click Keep immediately after making the connection with the Voltage Probe.
   c. Remove both electrodes from the solutions. Clean and polish each electrode.
   d. Put the Cu and Fe electrodes back in place to set up the voltaic cell. Connect the Voltage Probe to the electrodes, as before. Click Keep immediately after making the connection with the Voltage Probe.
   e. Remove the electrodes. Clean and polish each electrode again.
   f. Set up the voltaic cell a third, and final, time. Click Keep immediately after making the connection with the Voltage Probe. Click Stop to end the data collection.
   g. Click the Statistics button, . Record the mean in your data table as the average potential. Close the statistics box on the graph screen by clicking the X in the corner of the box.

Part II Determine the E^o for Two Voltaic Cells Using different concentrations of solutions.

8. Repeat steps 2-7, using 1.0 M $Cu(NO_3)_2$ and 0.1 M $Fe(NO_3)_2$

9. Repeat steps 2-7, using 1.0 M $Cu(NO_3)_2$ and 0.01 M $Fe(NO_3)_2$

Optional: Steps 10, 11 and 12. Repeat steps 2-9 using 1.0 M $Fe(NO3)2$ and 1.0 M, 0.1 M and 0.01 M $Cu(NO_3)_2$

13. Discard the electrodes and the electrolyte solutions as directed. Rinse and clean the 24-well plate. **CAUTION:** *Handle these solutions with care. If a spill occurs, ask your instructor how to clean up safely.*

DATA TABLE - RESULTS

Cells	Cu/Fe (1.0 M/1.0 M)	Cu/Fe (1.0 M/0.1 M)	Cu/Fe 1.0 M/0.01M)	Fe/Cu 1.0 M/1.0 M)	Fe/Cu 1.0 M/0.1 M)	**Fe/Cu 1.0 M/0.01 M)**
Average cell potential (V)						

DATA ANALYSIS

1. Compare the average cell potential in Step 7, 8 and 9. Is there a difference? Does concentration of solutions effect voltage of cell? Is there a trend? Also, if you did the optional part, compare the average cell potential in Step 10.11 and 12.