

# VOLTAIC CELLS

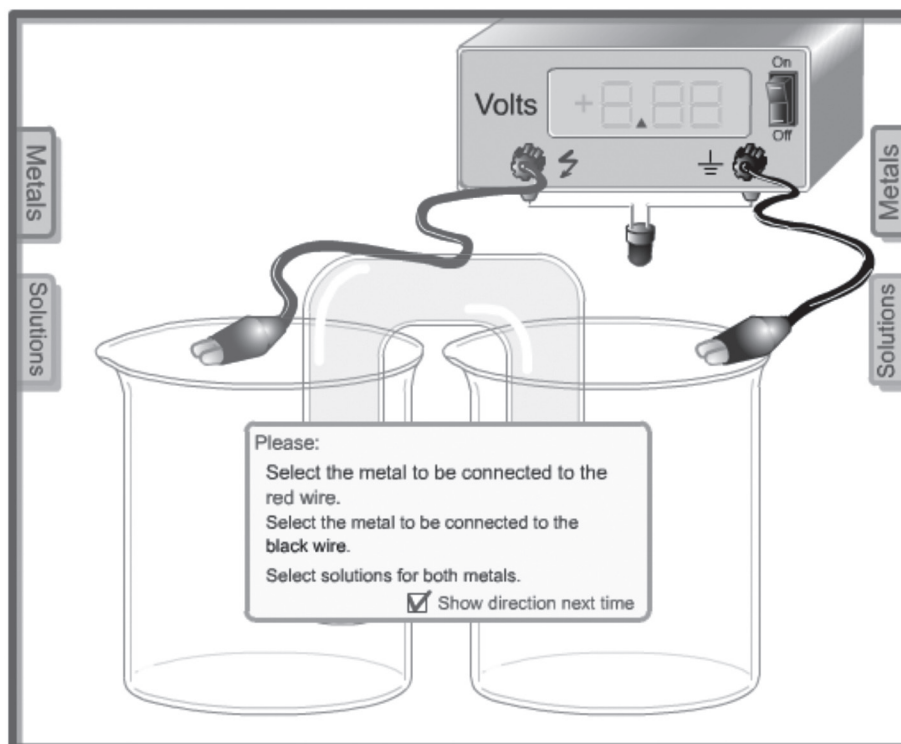
NAME \_\_\_\_\_

SECTION \_\_\_\_\_

**Problem Statement: What are the electrical properties of chemical reactions?**

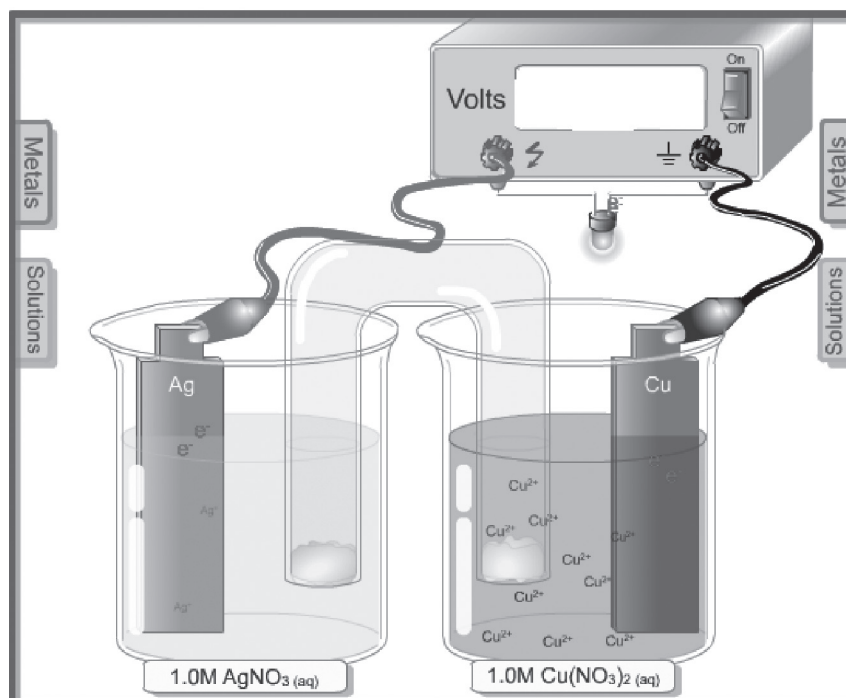
## I. Data Collection

- A. Go to <http://introchem.chem.okstate.edu/DCICLA/voltaicCell20.html> and open the Voltaic Cells Simulation. Your screen should look like the figure.



This simulation contains an apparatus for measuring the voltage generated by chemical reactions. This apparatus is called a voltaic cell. Pop-out menus will allow you to select metals (electrodes) and ionic solutions to be placed into two beakers that are connected by a salt bridge. You can then connect the metals to a voltmeter to measure the cell voltage ( $E^\circ$ ).

- B. Click on the left pop-out tab for metals and select silver. Click on the left pop-out tab for solutions and select  $\text{AgNO}_3(aq)$ . Use the right tabs and select Cu and  $\text{Cu(NO}_3)_2(aq)$ . Click on the power switch of the voltage meter. Observe the action of the simulation. Use the following drawing to sketch and label what is happening and to answer the following questions.



What is the voltage ( $E^\circ$ ) generated by the chemical reaction?

In what direction are the electrons flowing?

**II. Data Analysis and Interpretation**

- A. What happens to the electrons that are on the Ag metal electrode?
- B. What happens to the electrons that are on the Cu metal electrode?
- C. Write a net ionic equation representing what is happening in the left beaker. (This is called a half-reaction.)
- D. Write a net ionic equation representing what is happening in the right beaker. (This is called a half-reaction.)
- E. Combine the two half-reactions into a complete reaction.
- F. Determine what happens if you reverse the cell by placing the Ag/AgNO<sub>3</sub> system in the right beaker and the Cu/Cu(NO<sub>3</sub>)<sub>2</sub> system in the left beaker. Explain what you observe.

### III Data Collection

Repeat the procedure of section I for all the combinations in the following table. Record the cell voltages for each condition. Record the direction of electron flow from electrode to electrode.

Left Cell	Right Cell	Voltage ( $E^\circ$ )	Direction of Electrons
Ag/AgNO <sub>3</sub>	Cu/Cu(NO <sub>3</sub> ) <sub>2</sub>		From      to
Ag/AgNO <sub>3</sub>	Zn/Zn(NO <sub>3</sub> ) <sub>2</sub>		From      to
Ag/AgNO <sub>3</sub>	H <sub>2</sub> /HCl		From      to
Cu/Cu(NO <sub>3</sub> ) <sub>2</sub>	Zn/Zn(NO <sub>3</sub> ) <sub>2</sub>		From      to
Cu/Cu(NO <sub>3</sub> ) <sub>2</sub>	H <sub>2</sub> /HCl		From      to
Zn/Zn(NO <sub>3</sub> ) <sub>2</sub>	H <sub>2</sub> /HCl		From      to

### IV. Data Analysis and Interpretation

- A. For each of the six combinations in the table in section III., write the two half-reactions that are combined to generate the overall reaction. Write the half-reaction equations to accurately represent which half-reaction gains electrons (called reduction) and which loses electrons (called oxidation). The reactions for the Ag/AgNO<sub>3</sub> and Cu/Cu(NO<sub>3</sub>)<sub>2</sub> are shown as an example.



B. Assume that the  $\text{H}_2/\text{HCl}$  half-reaction is assigned a voltage of 0.0 v. This means that the voltage of the other three half-reactions can be assigned relative to it. Use the information from section III to assign a voltage to each of the half-reactions in the previous section. Record the voltage in the previous section. Make sure the sum of the half-reaction voltages for each cell adds up to the cell voltages that you measured in section III.

C. Rank the four half-reactions as reductions in order from highest to lowest voltage.

## V. Conclusions

A. Does  $\text{Cu}^{2+}$  react with Ag?

B. Does  $\text{Ag}^+$  react with Cu?

C. Does  $\text{Cu}^{2+}$  react with Zn?

D. Does  $\text{Ag}^+$  react with  $\text{Zn}$ ?

E. How is the sign of the voltage for an overall reaction connected to whether or not a reaction will take place?

F. Make a generalization about how you could use the ranking developed in section IV.C. to predict which combinations of half-reactions will react and which will not.