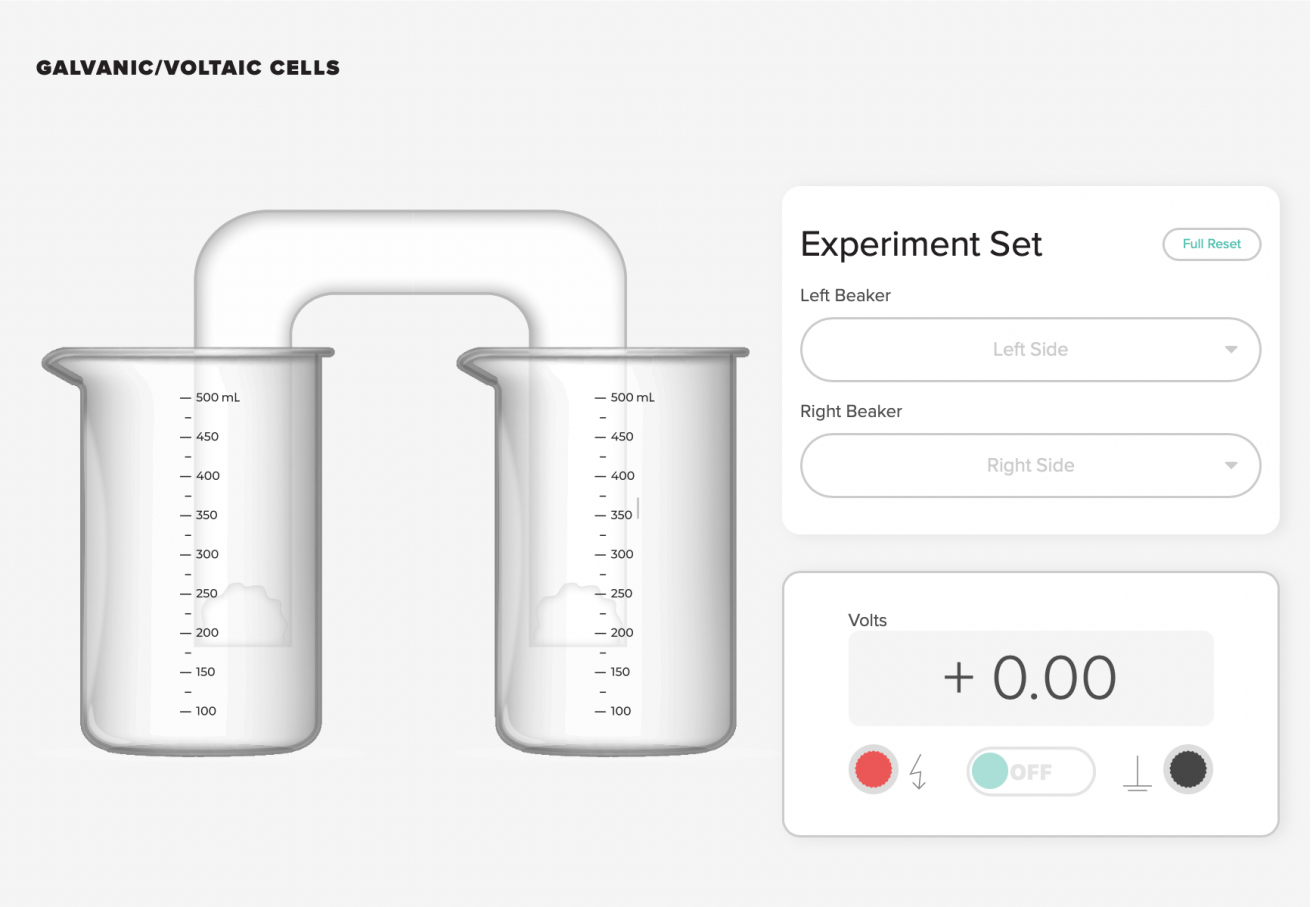
Voltaic Cells

Name_____ Lab Section_____

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

I. Data Collection:

A. Go to https://teachchemistry.org/classroom-resources/voltaic-cells and click on the Start → button. 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 for the Left Side electrode and for the Right Side electrode 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^o).

B. Click on the Left Side pop-out button for metals and select Silver (Ag) in $AgNO_3(aq)$ Click on the Right Side pop-up button and select Copper (Cu) and $Cu(NO_3)_2$ (aq). Click on the power switch to turn On the voltage meter. Click on the See Molecular Scale buttons on either electrode for a simulation of what occurs at the electrode surface. Observe the action of the simulation.

What is the voltage (E^o) generated by the chemical reaction?

What direction are the electrons flowing? (from left electrode to right electrode, or right electrode to left electrode)

II. Data Analysis and Interpretation

A. What happens to the electrons that are on to the Ag metal electrode?

B. What happens to the electrons that are on to 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 $Ag/AgNO_3$ system in the right beaker and the $Cu/Cu(NO_3)_2$ 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^o)	Direction	of Electrons
$Ag/AgNO_3$	$Cu/Cu(NO_3)_2$		From	to
$Ag/AgNO_3$	$Zn/Zn(NO_3)_2$		From	to
$Ag/AgNO_3$	H_2/HCl		From	to
$Cu/Cu(NO_3)_2$	$Zn/Zn(NO_3)_2$		From	to
$Cu/Cu(NO_3)_2$	H_2/HCl		From	to
$Zn/Zn(NO_3)_2$	H_2/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) an which loses electrons (called oxidation). The reactions for the $Ag/AgNO_3$ and $Cu/Cu(NO_3)_2$ is shown as an example.

$$Cu \rightarrow Cu^{2+}(aq) + 2e^- \qquad E^o = \qquad \text{volts}$$
$$Ag^+(aq) + 1e^- \rightarrow Ag \qquad E^o = \qquad \text{volts}$$

B. Assume that the H_2/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 three 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 Cu^{2+} react with Ag?

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

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

D. Does Ag^{+} react with 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.

G. Where does the half-reaction $Mg^{2+}(aq) + 2e^{-} \rightarrow Mg$ appear in your ranking in IV.C. above? Support your claim with a description of the experiment(s) you performed and the data you gathered.