ELECTROCHEMISTRY: VOLTAIC CELLS

Introduction:

When a strip of zinc is placed in a solution containing copper ions, a spontaneous reaction takes place. The zinc atoms lose electrons and become zinc ions. The copper atoms in solution gain the electrons from zinc and form neutral copper atoms. Chemical reactions that proceed by transfer of electrons from one species to another are called oxidation - reduction (redox) reactions. The substance that is losing electrons is said to be oxidized and the substance gaining electrons is reduced. The reaction between zinc and copper may be written as:

$$Zn \rightarrow Zn^{2+} + 2\ e^-$$

$$Cu^{2+} + 2\ e^- \rightarrow Cu$$

These reactions may also be referred to as half reactions. If these half reactions were separated, the flow of electrons from zinc to the copper ions could be monitored. The construction of half-cells allows this to be done. A half-cell contains a metal in a solution containing ions of that metal. If two half-cells are connected by an external path for the electrons to flow and a salt bridge to complete the circuit, a voltaic cell is formed. A voltmeter allows the potential difference between the two cells to be measured. This potential difference is the force that drives the electrons from the zinc half-cell to the copper half-cell. This flow of electrons from a voltaic cell is the basis for batteries which we use on a daily basis.

Purpose:

The purpose of this experiment is to build a set of voltaic cells and measure the potential difference (voltage) produced by them. These values will then be compared to the accepted values for these reactions.

Equipment/Materials:

multimeter
clip leads
strips of metals (Cu, Zn, Mg, Pb, Ag)
solutions of Cu, Zn, Mg, Pb, Ag
tubes containing agar and electrolyte
vials large enough to hold agar tubes

Safety:

- Always wear goggles and an apron in the lab.
- Multimeters are sensitive instruments and can be easily damaged. Follow your instructors directions for their use.

Procedure:

1. Obtain a tube containing an agar plug and electrolyte. The electrolyte was dissolved in the agar solution when it was prepared. Pour a few ml of one of the metal solutions in the tube. Place a piece of corresponding metal in the tube. Label the tube to make it easier to identify.

2. Place a few ml of another metal solution and a piece of the corresponding metal in another vial. Label the tube.

3. Place the tube containing the metal and its solution in the vial. Use clip leads to connect the two strips of metal to the multimeter. The multimeter should be set in the 2 or 3 volt DC position. If your meter does not have one of these settings, ask for assistance before proceeding. Do not place the clip leads or the terminals from the multimeter in the metal solutions.

4. Note the voltage produced by this electrochemical cell, and record it in the data table.

5. Prepare another voltaic cell using two different metals and their solutions. Again record the observed voltage in the data table.

6. Continue preparing the cells until all of the combinations have been built. If the tube containing the agar plug and electrolyte is to be placed in a different vial, wash off the original solution with some distilled water.

7. When the measurements have been completed, dispose of the solutions as instructed by your teacher.

Name _____

Date _____

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Data:

In the table below, record the voltages measured for each of the voltaic cells.

	Zn/Zn^{2+}	Mg/Mg^{2+}	Cu/Cu^{2+}	Ni/Ni^{2+}	Pb/Pb^{2+}
Zn/Zn^{2+}					
Ma/Mg^{2+}					
Cu/Cu^{2+}					
Ni/Ni^{2+}					
Pb/Pb^{2+}					

Questions

1. Write the equation for each of the half-cell reactions.

    a.

    b.

    c.

    d.

    e.

2. Calculate the potential that should be observed for each of the voltaic cells that were constructed. Place these values in the data table and circle them.

3. For three of the voltaic cells that you constructed, draw a diagram of the cell that includes the following:
    a. anode
    b. cathode
    c. substance oxidized
    d. substance reduced
    e. salt bridge
    f. direction of flow of electrons
    g. direction of flow of ions
    h. potential for the reaction