INTRODUCTION

Batteries are devices that supply electrons to a circuit. They function based on the chemical reaction of two half-cell reactions. Properly combining two half-cells is the basis for construction of a cell.

A half-cell contains an electrode and an electrolyte. One classic half-cell has a silver wire (the electrode) dipped in a solution of silver ion (the electrolyte). Another example of a half-cell would be a copper wire dipped in a solution of copper ion. To get an operational galvanic cell (a simple battery), the two cells must be united using a salt bridge between the two solutions, and an external circuit between the two electrodes. When all of these components are assembled, nothing perceptible is observed. Once a voltmeter is placed in the circuit between the two metal electrodes, an electrical potential is immediately observed (see diagram below).

PURPOSE

To determine the electrochemical potentials of several metals (and solutions of the metals) when they are set up as galvanic cells.

SAFETY CONSIDERATIONS

Wear safety goggles at all times. The solutions are dilute, but care should be taken to rinse any off if they come into contact with the skin.
PRE-LAB QUESTIONS

1. Write the half-reaction for the reaction of copper to copper (II).
2. Write the half-reaction for the reaction of nickel to nickel (II).
3. Combine the 2 half-cells above, into one balanced cell reaction.
4. What is a cathode?
5. What is an anode?

MATERIALS

electrodes (copper, cadmium, zinc, silver, lead)
0.1 M copper nitrate
0.1 M silver nitrate
0.1 M zinc nitrate
0.1 M zinc sulfate
voltmeter (pH meter equipped with ability to measure voltage)
cotton
50 mL beaker
2 M ammonium nitrate
steel wool
2 medicine droppers

PROCEDURE

PART A. - PREPARATION OF THE COPPER ELECTRODE

One of the half-cells consists of a medicine dropper tube containing a cotton plug, a wire of appropriate metal, and a solution of the electroactive species. The other half-cell is similar, using a different metal and a different solution

1. Weigh out about 0.04 grams of cotton (a 'fluffy' piece of cotton approximately 5 cm by 1 cm by 1 mm). Roll one end of the cotton into a fine point.

2. Force the pointed end of the cotton into the glass portion of a medicine dropper with a straightened paper clip and pack it down. Be certain that the cotton plugs extend out through the tips of the droppers.

3. Use steel wool to clean a piece of copper wire. Put the copper wire in the dropper and
fill the dropper about three-fourths full with 0.1 M copper (II) nitrate solution. Check for leaks. If the dropper leaks, the cotton plug must be packed more tightly.

PART B. - PREPARATION OF THE SILVER ELECTRODE

1. Repeat steps 1-3 to make the silver electrode, substituting a silver wire and silver nitrate.

PART C. - CONSTRUCTION OF COMPLETE CELL (SEE DIAGRAM)

1. Put about 20 mL of 2 M ammonium nitrate solution in a 50 mL beaker.
2. Place the electrodes in the beaker.
3. Connect the leads from the pH meter to the electrodes.
4. Take a reading from the pH meter by turning the function knob to <<mV>>. If the reading is negative, return the function knob to <<STANDBY>>, switch the leads and take a new reading.

PART D. - OTHER CELLS

Repeat the galvanic cell procedure (PARTS A-C) using copper as one half-cell and zinc for the
DATA TABLE

Design your own data table.

DATA ANALYSIS

Why do the values that you obtained for the cell reactions differ from the published values of the cell reactions?

CONCLUSIONS

1. Write the cell reaction for each of the reactions that you performed.

2. Of the reactions that you performed, which would make the best components for a battery (if maximum voltage is the only criterion)?

POST-LAB QUESTIONS

1. In the copper/zinc reaction, what would happen to the voltage if the copper solution had its concentration increased by a factor of ten?

2. In the copper/zinc reaction, what is the cathode?

3. In the copper/silver reaction, what would happen to the voltage if the copper solution had its concentration increased by a factor of ten?
TYPICAL CLASSROOM USAGE

Use during instruction on oxidation-reduction reactions.

PREPARATION

The pH meter must be set to read mV. To do this, follow the instructions on page 9 of instruction manual for the Fisher Accumet Model 910 pH Meter:

1. Set the FUNCTION selector to <<STANDBY>> position.
2. Connect the shorting cap to the INPUT jack of the meter.
3. Set the FUNCTION selector to <<mV>>.
4. Adjust the STANDARDIZE control until the display indicates 0 mv.
5. Remove the shorting cap and connect the electrodes.

You will also have to supply the solutions and electrodes.

TIME

Preparation time - 60 minutes to make the solutions and set up the equipment
Student activity time - 60 minutes

SAFETY AND DISPOSAL

The diluted waste products can be poured down the drain.

SAMPLE RESULTS

Cu^{2+} / Ag^{1+}  0.361 V
Cu^{2+} / Zn^{2+}  1.096 V
VARIATIONS

Use different metals.
Use different concentrations of solutions.
Add something to one of the solutions to precipitate one of the cations (example: adding ammonium hydroxide to the copper solution will precipitate copper hydroxide and increase the voltage).

REFERENCES

Instruction manual for the Fisher Accumet Model 910 pH Meter "Galvanic Cells".

Laboratory developed by Dr. Dennis Peters, Department of Chemistry, Indiana University.