Experiment
29

Lead Storage Batteries

Two or more wet or dry cells connected in series make a battery. A car battery is generally a lead storage battery containing lead and lead oxide plates in sulfuric acid solution. In this experiment, you will construct a lead storage cell and use a direct-current power supply to charge it as shown in Figure 1. You will use the computer and a Voltage Probe to measure the cell's voltage (see Figure 2), and then use the cell to power an electric motor.

OBJECTIVES

In this experiment, you will

- Construct a lead storage cell.
- Use a Voltage Probe to measure a cell's voltage.
- Use the cell to power an electric motor.

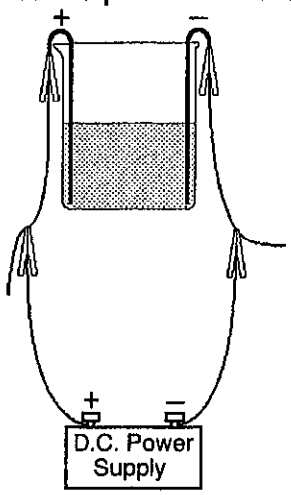

Figure 1

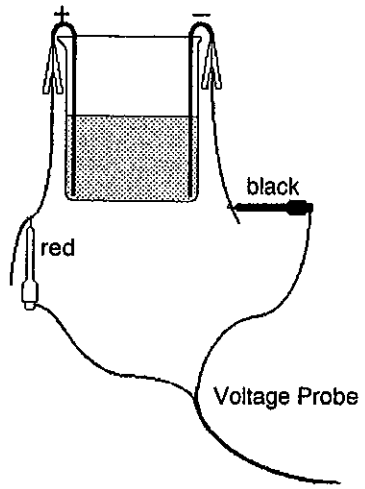

Figure 2

MATERIALS

computer
Vernier computer interface
Logger *Pro*
Vernier Voltage Probe
direct-current power supply
2 lead strips (2 cm × 12 cm)
apron
250 mL beaker
2 alligator clips
sulfuric acid, H_2SO_4
clock (with second hand)
small electric motor
2 test leads

PROCEDURE

1. Obtain and wear goggles and an apron. **CAUTION:** The battery acid, H_2SO_4, used in this experiment can damage eyesight and make holes in clothing!

2. Obtain two lead strips. If the strips have been used before, get one labeled (+) and one labeled (–). If the strips are not marked, label one (+) and the other (–). Bend the strips and place them in a 250 mL beaker as shown in Figure 1. Attach an alligator clip to each lead strip.

3. Add 125 mL of sulfuric acid, H_2SO_4, to the beaker. Handle this strong acid with care!

4. Connect the probe to the computer interface. Prepare the computer for data collection by opening the file "29 Lead Batteries" from the *Chemistry with Computers* folder of Logger *Pro*.

5. Charge the cell using the direct-current power supply:
   a. Attach the (–) lead from the power supply to the alligator clip on the (–) Pb electrode as shown in Figure 1.
   b. Attach the (+) lead of the power supply to the alligator clip on the (+) Pb electrode to begin the charging process.
   c. Time the charging process and disconnect the power supply leads after 4 minutes. Record observations during the charging process. **CAUTION:** *Make sure the lead strips do not touch each other while connected to the power supply.*

6. Attach the *red clip* of the Voltage Probe to the alligator clip on the (+) electrode (the black clip should still be attached to the (–) electrode via an alligator clip). Read the voltage value displayed in the meter. Record the reading after it stabilizes.

7. Disconnect the black and red voltage leads from the cell. Use two wire leads to connect the cell to a small electric motor. Use a clock to measure the number of seconds the charged cell runs the motor. Record the results. The cell is said to be *discharging* during this process.

8. Attach the red voltage lead to the alligator clip on the (+) electrode and its black clip to the alligator clip on the (–) electrode. Measure the voltage of the *discharged* cell. Record this value.

9. Repeat Steps 5-8 using a 2-minute charging time.

10. Observe the two lead electrodes and record your observations.

11. Return the H_2SO_4 solution to the "Used H_2SO_4" container supplied by your instructor. Wash and dry the beaker and the lead strips.

PROCESSING THE DATA

1. From the voltage values for the 1st and 2nd charging, calculate the average voltage of your cell when charged.

2. Cars generally have 12 volt batteries. How many lead storage cells, similar to the one you built, does a car battery contain? Explain.

3. Using a Table of Standard Reduction Potentials, write the equation occurring at the anode and cathode when the battery was discharging and behaving as a voltaic (electrochemical) cell. Write the standard potential value, $E°$, in the blank following the equation. In the third blank, write the net equation for the reaction by combining the two half-reactions. Find the $E°_{total}$ (or $E°_{cell}$) by adding the $E°$ values for the two half-reactions.

4. Find the percent error for the cell potential by comparing your experimental voltage value in Step 1 of Processing the Data with the accepted $E°_{total}$ value in Step 3.

5. What was the gas you saw being produced at the (–) electrode, during charging? What was the gas being produced at the (+) electrode? Account for the danger of an explosion after car battery charging.

6. Explain why "run-down" car batteries sometimes freeze up and break open in extremely cold weather. Hint: Examine the equation for the net reaction in the Data and Calculations table below.

7. When you charged and discharged the battery in this experiment, which process was electrolytic? Which was electrochemical (voltaic)? Explain.

DATA AND CALCULATIONS

	1st Charging	2nd Charging
Voltage after charging	_____ V	_____ V
Time motor ran after charging	_____ s	_____ s
Voltage after discharge	_____ V	_____ V

Average potential of charged cell

_____ V

	Equation	E°
Anode (–)	_____	_____ V
Cathode (+)	_____	_____ V
Net Reaction	_____	_____ V

Percent error

_____ %

OBSERVATIONS