Inquiry Investigation 11-A

Skill Check

Initiating and Planning

✓ Performing and Recording

✓ Analyzing and Interpreting

✓ Communicating

Safety Precautions

- The electrolyte is a caustic liquid. You must wear safety goggles during this activity to protect your eyes. Wash any spills of electrolyte on your skin or clothing by using plenty of cold water.
- Wear gloves when using steel wool to clean the metal strips.

Materials

- variety of metal strips (for example, aluminum, copper, iron, zinc)
- steel wool
- small beaker (100 mL)
- electrolyte: vinegar or dilute sulfuric acid (about 40 mL)
- 2 large paper clips
- voltmeter or multimeter (if available, probeware may be used to measure voltages)
- connecting leads
- light-emitting diode (optional)
- paper towel

Science Skills

Go to **Science Skills Toolkit 10** to learn about using an ammeter and voltmeter.

Constructing and Comparing Voltaic Cells

In this investigation, you and your classmates will use a variety of metal strips to make different voltaic cells. You will make one or more cells (as directed by your teacher), and then combine the results to compare the potential difference produced by different cells.

Question

Which combination of metal electrodes forms a cell with the greatest voltage?

Prediction

The following metals are listed in order of decreasing ability of their atoms to hold on to electrons: aluminum, zinc, iron, nickel, copper. Predict which pair of metals will make a voltaic cell that generates the greatest voltage.

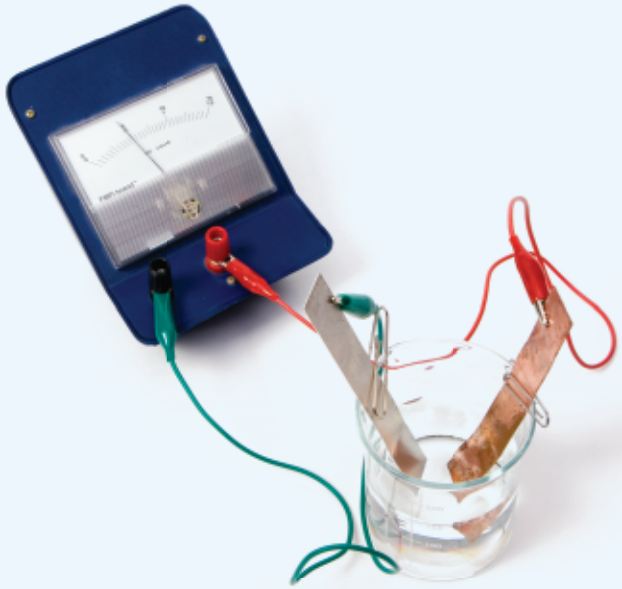
Procedure

1. In your notebook, prepare a table like the one shown below to record your results. The table will depend on the metals available for your class to use for electrodes, so you may need to change the entries shown.

Cell Voltage (V)

Metals	Aluminum	Zinc	Iron	Copper
Zinc				
Iron				
Copper				

2. Your teacher will assign one or more pairs of metal strips for you to use as electrodes. Wear gloves and clean each metal strip with a piece of steel wool to make the surface shiny.
3. Pour about 40 mL of the electrolyte solution into the beaker. Place a pair of metal strips into the beaker that contains the electrolyte. Use large paper clips to attach the metal strips to the beaker as shown. Record any observation that indicates a chemical reaction between the electrolyte and either of the electrodes.



4. Connect leads from the meter (or probeware) to the electrodes. Examine the meter carefully. If it appears that the needle is not moving, or is tending to move to a value less than zero, reverse the connections. The voltage produced by a cell may be less than 1.0 volt. Record the cell voltage in your table.
5. Remove the electrodes from the electrolyte solution. Rinse the electrodes in running water, and then dry them using a paper towel.
6. Repeat steps 2–5 for each pair of metal electrodes assigned for you to test.
7. Dispose of the electrolyte solution as directed by your teacher, and return the other materials.
8. Share your data with other groups to fill in the table with voltage data for every possible combination of electrodes.

Analyze and Interpret

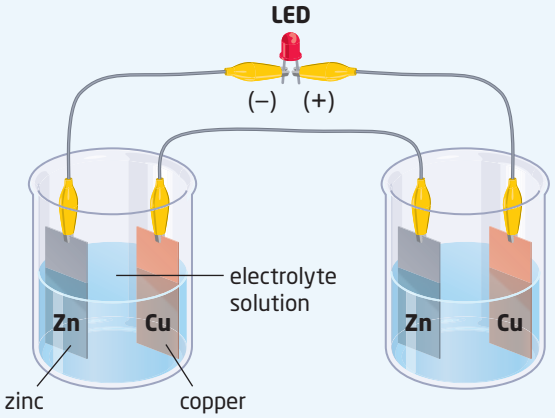
1. Identify the pair of electrodes that generated the greatest voltage. Did this pair match your prediction?
2. In step 4, what did you observe to indicate that a chemical reaction took place?

Conclude and Communicate

3. If you were planning to manufacture a voltaic cell, which factors would you consider when choosing the electrodes?

Extend Your Inquiry and Research Skills

4. **Inquiry** The figure below shows a battery consisting of two cells, each made using copper and zinc electrodes. Note that the zinc electrode in one cell is connected to the copper electrode in the next cell. If necessary, more cells can be connected in the same way. Conduct an experiment to find out how many cells are required to make a light-emitting diode (LED) glow. The light will only glow with the positive lead on the LED connected to the copper electrode as shown.



5. **Research** A thermocouple is another device that relies on two different metals to produce a potential difference. Research how thermocouples work, and list applications where these devices are used.

Inquiry Investigation 11-B

Skill Check

Initiating and Planning

✓ Performing and Recording

✓ Analyzing and Interpreting

✓ Communicating

Loads in Series

In this activity, you will observe and compare the brightness of identical bulbs as they are connected together in series. You will take measurements of potential difference and current, and use your data to make general statements about the properties of a series circuit.

Question

How are the current, potential difference, and resistance of a circuit affected as more loads (bulbs) are connected in series?

Predictions

a. Predict a relationship between the potential difference across a cell or battery and the potential difference across each load in a series circuit.

b. Predict a relationship between the current leaving the cell or battery and the current through each load in a series circuit.

c. Predict a relationship between total resistance and the resistance of each load in a series circuit.

Safety Precautions

- If a bulb is glowing very brightly, open the switch to prevent the bulb from burning out, and inform your teacher.

Materials

- battery (6 V)
- battery (9 V) (optional)
- switch
- 8 connecting leads
- 3 identical flashlight bulbs in holders
- ammeter
- voltmeter

Math Skills

Go to **Math Skills Toolkit 2** to learn about significant digits and rounding.

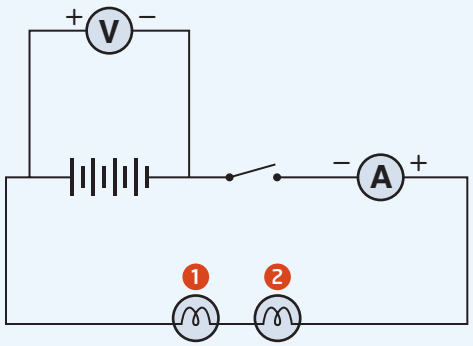
Procedure

If it is available, use probeware to measure the potential difference and current in place of a voltmeter and ammeter.

1. Copy the table below into your notebook and give it a title.

Number of Bulbs	Comparative Brightness	Current (A)	Potential Difference (V)			
			Across the Cell	Across Each Bulb		
				1	2	3
2						
3						

2. Connect the circuit diagram shown below, using a 6 V battery. Make sure the switch is in the open position.



3. Close the switch long enough to compare the brightness of the bulbs and take readings on the ammeter and voltmeter. Record your observations of the current in the circuit and the potential difference across the battery.
4. With the switch open, disconnect the voltmeter and connect it across bulb 1. Close the switch and record the potential difference across the bulb. Repeat this procedure to measure and record the potential difference across bulb 2.
5. Open the switch. Add a third bulb in series with the others, between bulb 2 and the ammeter.
6. Reconnect the voltmeter across the battery, then repeat step 3.
7. Measure and record the potential difference across each bulb.
8. Use the ammeter to measure and record the current between bulbs 2 and 3.

Analyze and Interpret

1. As more bulbs are connected in series in a circuit, what happens to
   - **a.** the brightness with which each glows?
   - **b.** the current leaving the source?
   - **c.** the potential difference across the source?
   - **d.** the potential difference across each load?
2. In a series circuit, how does the current between two loads compare with the current from the source?
3. Calculate the total resistance in the circuit, using the ammeter and voltmeter readings from step 6.
4. Calculate the resistance of each bulb, using the potential difference measurements from step 7 and the current through each bulb that you measured in step 8.
5. Evaluate your predictions. Do your data support or refute your predictions? Explain.

Conclude and Communicate

6. Summarize the relationship between the current leaving the source and the current through each load in a series circuit.
7. Write a word equation for the relationship between the potential difference across the source and the potential difference across each load in a series circuit that has three loads.
8. Write a word equation for the relationship between the total resistance and the resistance of each load in a series circuit that has three loads.

Extend Your Inquiry and Research Skills

9. **Inquiry** Predict the effect of replacing the 6 V battery with a 9 V battery on the
   - **a.** brightness of the bulbs
   - **b.** potential difference across each bulb
   - **c.** current through each bulb

   If time permits, perform the experiment using three bulbs in series.
10. **Research** A dimmer switch, like an ordinary on-off switch, is in series with the light it controls. Older dimmer switches use a variable resistance to control the light level. Use the Internet or library resources to find out how they work, and why this type of switch wastes energy. Write a summary of your findings.

Inquiry Investigation 11-C

Skill Check

Initiating and Planning

✓ Performing and Recording

✓ Analyzing and Interpreting

✓ Communicating

Loads in Parallel

In this activity, you will take measurements of potential difference and current, and use your data to make general statements about the properties of a parallel circuit.

Question

How are the current, potential difference, and resistance of a circuit affected as more loads (bulbs) are connected in parallel?

Predictions

a. Predict a relationship between the potential difference across a source and the potential difference across each load in a parallel circuit.

b. Predict a relationship between the current leaving a source and the current through each load in a parallel circuit.

c. Complete the following sentence: The total resistance of a circuit containing loads connected in parallel should be (greater/smaller) _____ than the resistance of any load in the circuit.

Procedure

Note: If available, use probeware to measure the potential difference and current in place of a voltmeter and ammeter.

1. Copy the table below into your notebook and give it a title.

Measurements of Potential Difference and Current			
Potential Difference (V)		**Current (A)**	
Across Cell	Across Each Bulb	Leaving Cell	Through Each Bulb
	#1		#1
	#2		#2
	#3		#3

2. Connect the circuit shown on the left in stages, as indicated by the colour scheme. Make sure the switch is in the open position.

3. Close the switch and compare the brightness of the bulbs. Record your observation.

Safety Precautions

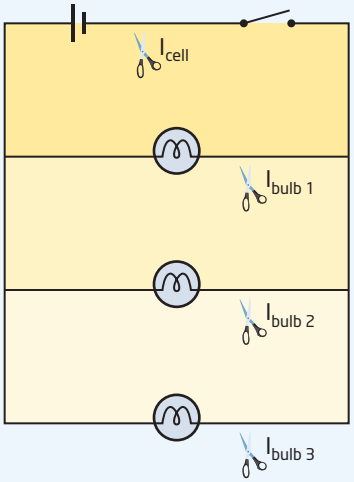
- If a bulb is glowing very brightly, open the switch to prevent the bulb from burning out.

Materials

- 1.5 V cell
- switch
- 10 connecting leads
- 3 identical flashlight bulbs in holders
- voltmeter
- ammeter

Science Skills

Go to **Science Skills Toolkit 4** to learn about estimating and measuring.



4. Open the switch. Connect a voltmeter between the terminals of the cell. Imagine cutting the circuit at the location marked I_{cell}, and insert an ammeter there.
5. Check the terminal connections for both meters. Close the switch. Record the potential difference across the cell, and the current leaving the cell.
6. Open the switch and disconnect both meters. Reconnect the basic circuit.
7. Measure the potential difference between the connections for each bulb, and the current entering each bulb. If you are unsure of how to do this, refer to the circuit diagram and look over steps 4 to 6 and follow similar procedures for each bulb.

Analyze and Interpret

1. When loads (in this case, flashlight bulbs) are connected in parallel to a cell, how does the potential difference across each load compare with the potential difference across the cell?
2. In a parallel circuit, how does the current through each path compare with the current entering the parallel connection?
3. Calculate the resistance of each bulb. Show your calculations.
4. Evaluate your predictions. Do your data support or refute your predictions? Explain.

Conclude and Communicate

5. Summarize the relationship between the current leaving the source and the current through each load in a parallel circuit that has three loads.
6. Write a word equation for the relationship between the potential difference across the source, and the potential difference across each load, in a parallel circuit that has three loads.

Extend Your Inquiry and Research Skills

7. **Inquiry** Determine a way to use your data to find the resistance of the circuit as a whole.
8. **Research** Conduct research to find a relationship between the resistance of the circuit and the resistance of each load connected in parallel. Check your data to see if they show the same relationship, and show your work.

Inquiry Investigation 11-D

Testing Ohm's Law

In this investigation, you will measure the potential difference across a resistor in a circuit and the current through the resistor. By changing the potential difference, you will learn about the relationships among current, potential difference, and resistance.

Skill Check

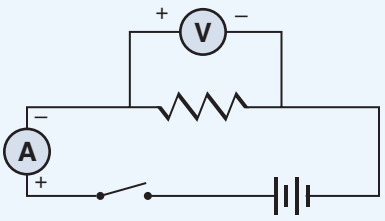
- ✓ Initiating and Planning
- ✓ Performing and Recording
- ✓ Analyzing and Interpreting
- ✓ Communicating

Safety Precautions

- Before taking the first measurement, ask your teacher to check your circuit.
- As you do this activity, bring a finger close to the resistor, without touching it. If the resistor is hot, open the switch and tell your teacher.

Materials

- resistor
- ammeter
- voltmeter
- cells, batteries, or a variable power supply
- 6 connecting leads



Question

If you change the potential difference in a circuit, how does it affect the current and resistance?

Procedure

1. Design a table to record the potential difference between the ends of the resistor and the current through it. Include the units.
2. Record the colour bands on the resistor in order. The last colour you record will probably be gold or silver.
3. Connect a basic circuit as shown in the diagram.
4. Make sure the range selector switch on both the ammeter and voltmeter are set to the highest values.
5. Close the switch and dial the range selector on the ammeter to smaller values to take a reading. Record the current through the resistor. Repeat this procedure for the voltmeter, and record the potential difference between the ends of the resistor.
6. Open the switch and select the highest range on both meters. Change the potential difference of the source of electricity.
7. Repeat steps 5 and 6 until you have at least four sets of data.

Analyze and Interpret

1. Explain the relationship between the slope of your graph and the resistance of the resistor.

Conclude and Communicate

2. How does changing the potential difference in a circuit affect the current and resistance?

Extend Your Inquiry and Research Skills

3. **Inquiry** Compare and contrast this experiment with the experiments that Ohm performed.
4. **Research** Conduct research to learn about non-ohmic resistors. Write a brief paragraph explaining their applications.