

Introduction to Voltaic Cells

Why?

Voltaic cells, also known as batteries, are used to store energy and provide power on demand. In a voltaic cell there is a flow of ions and a flow of electrons. Because batteries are so common you should understand how batteries function.

Learning Objectives

- Recognize the parts of a voltaic cell.
- Understand how a voltaic cell functions.

Success Criteria

- Identify and label the parts of a voltaic cell, identifying the anode, cathode, and salt bridge, given the reaction equation.
- Identify the direction of electron flow in the external circuit and the direction of ion diffusion through the salt bridge, given the reaction equation.
- Identify each half-cell as the site of oxidation or reduction by interpreting the reaction equation.
- Explain the function of each cell component.

Prerequisites

- Rules for assigning oxidation numbers
- Ability to write oxidation and reduction half-reactions

Requirements

- Computer and internet access for the following sites:
<http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/galvan5.swf>

Vocabulary

- Reduction
- Oxidation
- Half-reaction
- Half-cell

Information

A voltaic cell consists of a cathode, and anode, a salt bridge. When the voltaic cell is operating, electrons flow through an external circuit, and ions diffuse through the salt bridge.

Model 1: The Zn/Cu Cell

Go to the Internet site: <http://www.mhhe.com/physsci/chemistry/essentialchemistry/flash/galvan5.swf>

[Be patient, it may take a moment or two for all elements of the diagram to appear.] Look carefully at the working model; explore each of the buttons at the bottom of the cell to see a “close-up view” of each electrode and the salt bridge opening in each beaker. Answer the following questions about the model shown on the web site.

Key Questions

1. In the model shown on the web site, which label (anode or cathode) is attached to the zinc metal and to the copper metal?
2. Which way do electrons flow through the wire, from the anode to the cathode or from the cathode to the anode?
3. What is happening to the zinc atoms in the zinc half-cell? Zinc ions?
4. What is happening to the copper atoms in the copper half-cell? Copper ions?
5. Is the reaction occurring at the anode oxidation or reduction?
6. Is the reaction at the cathode oxidation or reduction?
7. Which ions move through the salt bridge?
8. Why do you think positive ions move through the salt bridge from the anode compartment to the cathode compartment?
9. Why do you think negative ions move through the salt bridge from the cathode compartment to the anode compartment?

Exercises

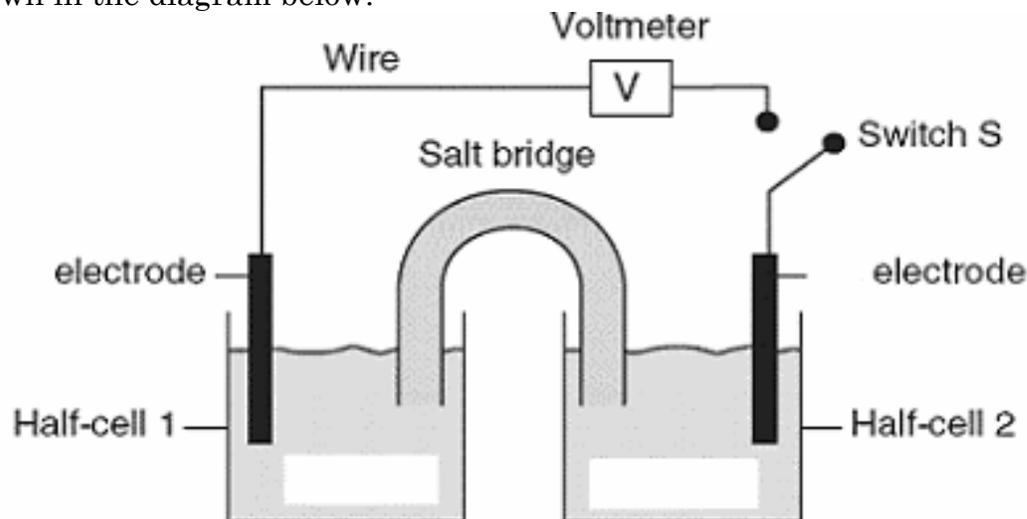
1. Write the half-reaction to show the change in zinc as the cell is running.
2. Write the half-reaction to show the change in copper as the cell is running.
3. List the ions that flow into and out of the salt bridge in each half-cell.

Key Questions

1. What would happen if the salt bridge were to be removed from the set-up?
Explain your answer.
2. What characteristic of NaNO_3 (aq) makes it useful as the solution in the salt bridge?

Problem

Two half-cells are prepared by a student in the laboratory and are connected as shown in the diagram below:

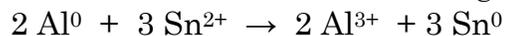


Half-cell 1 contains a tin electrode in a solution of $\text{Sn}(\text{NO}_3)_2(\text{aq})$.

Half-cell 2 contains an aluminum electrode in a solution of $\text{Al}(\text{NO}_3)_3(\text{aq})$.

The salt bridge contains a solution of $\text{NaNO}_3(\text{aq})$.

When the switch is closed the following reaction occurs:



1. Label the electrode and solution in each of the half-cells.
2. Write the oxidation half-reaction as shown in the equation above.
3. Write the reduction half-reaction as shown in the equation above.
4. Based on your answers to previous questions, decide which electrode is the anode and which electrode is the cathode. Place the appropriate label in the diagram.
5. When the switch is closed the circuit will be completed. Use an arrow to mark the direction of electron flow in the cell.