

**Teacher’s Guide**

**Save It for Later: Batteries Keep Us Energized**

***April 2024***

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Activate students’ prior knowledge and engage them before they read the article.

[***Reading Comprehension Questions***](#_3znysh7) ***3***

These questions are designed to help students read the article (and graphics) carefully. They can help the teacher assess how well students understand the content and help direct the need for follow-up discussions and/or activities. You’ll find the questions ordered in increasing difficulty.

[***Graphic Organizer***](#_fbh2674qb7v5) ***5***

Thishelps students locate and analyze information from the article. Students should use their own words and not copy entire sentences from the article. Encourage the use of bullet points.

[***Answers***](#_djipzn7z1r1b) ***6***

Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.

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Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.

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# Anticipation Guide

**Directions: *Before reading the article*,** in the first column, write “A” or “D,” indicating your **A**greement or **D**isagreement with each statement. Complete the activity in the box.

As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

| **Me** | **Text** | **Statement** |
| --- | --- | --- |
|  |  | 1. Solar powered chargers depend on batteries to store energy. |
|  |  | 2. Batteries that store energy for as long as two weeks may be the size of a car. |
|  |  | 3. About one-third of the energy produced worldwide is lost before reaching the consumer. |
|  |  | 4. Both electrolytic cells and voltaic cells are electrochemical cells. |
|  |  | 5. Electrolytic cells work spontaneously. |
|  |  | 6. Disposable batteries can hold a charge for years if they are not used. |
|  |  | 7. The anode of a lithium-ion battery is made of lithium. |
|  |  | 8. Lithium is more abundant than sodium. |
|  |  | 9. Fuel cells need a constant supply of fuel. |
|  |  | 10. Hydrogen fuel cells produce harmful emissions. |

# Student Reading Comprehension Questions

**Directions**: Use the article to answer the questions below.

1. Our lives require a constant supply of energy for powering appliances, transportation, as well as heating and cooling. How much energy produced globally is “lost”? List two ways that energy can be lost.
2. How do batteries generate electricity? What type of chemical reactions are involved?
3. Explain what happens in a redox reaction.
4. What are some similarities and differences between an electrolytic cell and a voltaic cell?
5. Is a rechargeable phone battery a voltaic or electrolytic cell? Explain.
6. Study the image of the electrolytic cell. Explain where oxidation occurs and what substance undergoes oxidation. Similarly, explain where reduction occurs and what substance undergoes reduction. Which way do electrons flow?
7. Explain the composition of Volta’s first battery. What are the two reactions that occur in Volta’s pile?
8. List some advantages of both disposable and rechargeable batteries.
9. The following questions relate to lithium-ion batteries.
   1. Where can graphite be found in this battery?
   2. What elements tend to be used for the mixed metal oxide compound?
   3. In which direction do lithium ions flow when the battery is being discharged?
10. Hydrogen fuel cells provide many advantages over gas-powered cars. Why have they been slow to develop?

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

***Write your answers on another piece of paper if needed.***

1. Research the environmental impacts of lithium-ion EV batteries.
2. Draw a diagram that shows how a voltaic cell works. Include the anode, cathode, voltage meter, and salt bridge. Use arrows to indicate the direction of the flow of electrons. Explain the function and significance of the salt bridge.

# Graphic Organizer

**Directions**: As you read, complete the graphic organizer below to summarize important points in the article.

| **Importance of batteries** |  |
| --- | --- |
| **Types of batteries described in the article** |  |
| **Problems with current batteries** |  |
| **Ideas for future batteries** |  |
| **Fuel Cell advantages** |  |
| **Fuel Cell disadvantages** |  |
| **How we can ease the environmental impact of batteries right now.** |  |

**Summary:** On the back of this sheet, write a one-sentence (20 words maximum) of the article.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. Our lives require a constant supply of energy for powering appliances, transportation, as well as heating and cooling. How much energy produced globally is “lost”? List two ways that energy can be lost.  
   About 2/3 of energy produced globally is lost. The production of electricity involves significant heat loss. On a personal level, energy is lost when people don’t conserve it – by leaving on lights and using inefficient appliances and equipment.
2. How do batteries generate electricity? What type of chemical reactions are involved?  
   Inside batteries, electrons move from one element to another due to differences in the elements or compounds reduction potential. That is, one element or compound prefers to lose electrons while the other prefers to gain electrons, this potential difference causes electrons in a circuit to move. The movement of electrons is electricity. The reactions involved are known as oxidation-reduction reactions, or redox.
3. Explain what happens in a redox reaction.  
   A redox reaction involves both oxidation and reduction reactions. These reactions occur simultaneously. Electrons are lost in oxidation reactions (lose electrons oxidation – LEO) and electrons are gained in reduction reactions (gain electrons reduction – GER).
4. What are some similarities and differences between an electrolytic cell and a voltaic cell?  
   Similarities: Both electrolytic and voltaic cells have two electrodes; a cathode where reduction occurs (Reduction Cathode – RedCat), and an anode where oxidation occurs (Anode Oxidation – AnOx). Both also contain an electrolyte solution.

Differences: Voltaic cells undergo spontaneous chemical reactions based on the potential differences of the materials used; electrolytic cells need electricity to cause a nonspontaneous reaction to occur.

1. Is a rechargeable phone battery a voltaic or electrolytic cell? Explain.   
   Both! When not plugged into the wall or other source of electricity, the phone battery works as a voltaic cell, undergoing spontaneous chemical reactions. Eventually, the battery discharges enough electricity that it needs to be recharged. When you plug in your phone to a wall socket for example, a nonspontaneous reaction occurs (electrolytic cell) and electrons are sent in the opposite direction to build up stored energy.
2. Study the image of the electrolytic cell. Explain where oxidation occurs and what substance undergoes oxidation. Similarly, explain where reduction occurs and what substance undergoes reduction. Which way do electrons flow?  
   Oxidation occurs at the anode and reduction occurs at the cathode. Bromide ions are being oxidized and sodium ions are being reduced. Electrons flow from the anode to the cathode.
3. Explain the composition of Volta’s first battery. What are the two reactions that occur in Volta’s pile?  
   Volta’s voltaic cell was made up of alternating zinc and silver discs. The discs were separated with a cloth soaked in sodium hydroxide or salt water to serve as the electrolyte solution. The zinc (Zn0) is oxidized to zinc ions (Zn2+) and the hydrogen ions (H+) in the water are reduced to hydrogen gas (H2).

Zn –> Zn2+ + 2e- (oxidation occurs at the anode)

2H+ + 2e-  –> H2 (reduction occurs at the cathode)

1. List some advantages of both disposable and rechargeable batteries.   
   Disposable batteries are less expensive, can store a charge when not in use for long periods of time, and are useful in medical applications where recharging is not possible. Rechargeable batteries can be used numerous times, which reduces the environmental impact on landfills.
2. The following questions relate to lithium-ion batteries.
3. Where can graphite be found in this battery?  
   Graphite is the anode.
4. What elements tend to be used for the mixed metal oxide compound?   
   The mixed metal oxides used as the cathode are most commonly composed of lithium, oxygen, and cobalt.
5. In which direction do lithium ions flow when the battery is being discharged?

Lithium ions flow from the graphite, through the separator, to the metal oxide when the battery is being used but is not plugged into an electrical source.

1. Hydrogen fuel cells provide many advantages over gas-powered cars. Why have they been slow to develop?   
   Fuel cells need a constant supply of reactants, in this case, hydrogen and oxygen gas. Oxygen can come from the air, but elemental hydrogen is harder to produce. California is the only state to offer hydrogen-fuel stations. Until hydrogen gas is readily available, it will be difficult to replace the gasoline fuel system.
2. Research the environmental impacts of lithium-ion EV batteries.   
   Answers will vary depending on student research. Some examples include toxic chemical leaks especially in landfills, risk of fire due to improper storage, use of large quantities of water involved in lithium mining.
3. Draw a diagram that shows how a voltaic cell works. Include the anode, cathode, voltage meter, and salt bridge. Use arrows to indicate the direction of the flow of electrons. Explain the function and significance of the salt bridge.  
   The diagram should show two breakers each with an electrode submerged in a solution connected with an inverted U-tube (salt bridge). Electrons flow from the anode to the cathode. The voltage meter can be drawn to show that some current is flowing. The salt bridge allows for the flow of ions that reduces the charge buildup that occurs in both cells. Without the salt bridge, the reaction would stop as too much charge would quickly build up in both cells - (positive ions in the oxidation cell and negative ions in the reduction cell).

**Graphic Organizer Rubric**

If you use the Graphic Organizer to evaluate student performance, you may want to develop a grading rubric such as the one below.

| **Score** | **Description** | **Evidence** |
| --- | --- | --- |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

# 

# Additional Resources and Teaching Strategies

**Additional Resources**

* **Labs and demonstrations**
  + Lab: Students will investigate the relative reactivity of three metals. They will use this knowledge to relate the activity series to cell potential.

<https://teachchemistry.org/classroom-resources/reactivity-electrochemistry>

* + Lab: Students investigate how to build a galvanic cell and compare collected data to theoretical values of cell potential.

<https://teachchemistry.org/classroom-resources/four-way-galvanic-cell>

* + Animation: Students will view an animation of a galvanic cell, focusing on the particulate level. There is an accompanying worksheet for them to describe the parts of the galvanic cell and identify the reactions that took place within.

<https://teachchemistry.org/classroom-resources/animation-activity-galvanic-cells>

* + Map: Students can investigate their state battery recycling laws using this interactive map.

<https://www.call2recycle.org/recycling-laws-by-state/>

* + Lithium Mining in Utah: Students design and carry out an experiment to collect a mineral from a solution in a way that simulates how lithium is mined.

<https://energy.utah.gov/wp-content/uploads/OED-LESSON-3.5_-Lithium-Mining-in-Utah-1.pdf>

* **Lessons and lesson plans**
  + Lesson: Students learn more about lithium-ion batteries and how its developers were awarded the 2019 Nobel Prize in Chemistry.

<https://www.compoundchem.com/2019/10/09/2019nobelchemistry/>

**Teaching Strategies**

Consider the following tips and strategies for incorporating this article into your classroom:

* **Alternative to Anticipation Guide:** Before reading, ask students where they use batteries in their everyday lives. Ask if they have ever thought about the chemistry involved in making and using batteries. Their initial ideas can be collected electronically via Jamboard, Padlet, or similar technology.
  + As they read, students can find information to confirm or refute their original ideas.
* After they read, ask students what they learned about the importance of batteries in our lives, problems caused by battery use, and possible solutions to these problems. Ask how they might use the information in the future.
* **Note:** Safe battery disposal is not specifically addressed in this issue, but students may have questions. In most municipalities, disposal of regular alkaline batteries (such as AAA, AA, C, D, 9V) in the regular trash is OK, some municipalities do recycle these batteries as well. However, rechargeable batteries should always be taken to a hazardous waste disposal site because they pose a fire hazard.

# Chemistry Concepts and Standards

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Electrochemistry
* Electrolytic cells
* Oxidation
* Reduction
* Redox reaction
* Spontaneous vs. nonspontaneous reactions

**Correlations to Next Generation Science Standards**

This article relates to the following performance expectations and dimensions of the NGSS:

**HS-PS3-3.** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

**HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

**Disciplinary Core Ideas:**

* PS.3.D: Energy in Chemical Processes
* ETS1.B: Developing Possible Solutions

**Crosscutting Concepts:**

* Systems and system models
* Energy and matter: Flows, cycles, and conservation

**Science and Engineering Practices:**

* Constructing explanations (for science) and developing solutions (for engineering)

**Nature of Science:**

* Science is a human endeavor.

See how *ChemMatters* correlates to the[**Common Core State Standards** online](https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/teachers-guide.html).