

**Teacher’s Guide**

**Can You Power Devices With Your Body?**

***April 2022***

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

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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 4](#bodypowerorganizer)

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 5](#bodypoweranswers)

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

[Additional Resources 8](#bodypowerresources)

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

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**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. Static attraction occurs when dissimilar materials are separated after being in contact with each other. |
|  |  | 1. Research to develop consumer devices using constant everyday body movement has stalled. |
|  |  | 1. Insulators can conduct electricity. |
|  |  | 1. Electrons in metals can easily jump from one orbital to another. |
|  |  | 1. Human hair is a good insulator. |
|  |  | 1. The element germanium is an insulator. |
|  |  | 1. A conduction band and a valence band are the same for all materials. |
|  |  | 1. If you rub cotton on wood or rubber, electrons would load up on the wood or rubber. |
|  |  | 1. Power generated using soft materials would leak into the environment if it were not harnessed. |
|  |  | 1. Wearables using soft materials like knits are being developed to track heart or brain activity. |

# Student Reading Comprehension Questions

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

**Reading Comprehension Questions**

1. In simple terms, explain triboelectrification.

2. Compare and contrast the properties of conductors, semiconductors, and insulators.

3. Describe how the “band gap” influences a substance's ability to conduct electricity.

4. Describe how insulators can exchange surface charges.

5. Use the triboelectric series figure on pg 14 to explain the importance of material pairings when attempting to generate triboelectricity.

**Making Connections**

6. Examine the triboelectric series on page 14 again. Do you notice any trends in the types of materials that tend to lose or gain electrons. Meaning, can you categorize these types of materials?

7. The article mentions mechanical energy created by sound waves (energy of movement). Provide an example of real world phenomena or example of sound creating mechanical energy of movement.

8. Triboelectricity and static electricity have a good deal in common. Explain how static electricity is created and provide a real world example.

9. The goal of any new energy source is to replace or reduce the consumption and reliance on fossil fuels. Provide advantages and disadvantages of both fossil fuels and triboelectricity.

10. Is triboelectricity a completely clean and renewable energy?

11. Create an advertisement for a theoretical device that uses tribo-electrical power. For example, a t-shirt or pants that can charge your cell phone. The advertisement can either be a printed advertisement (similar to an advertisement you would see on a billboard or in a magazine) or a video advertisement (as you would see on TV).

# Graphic Organizer

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: As you read, complete the graphic organizer below to describe triboelectrification.

|  |  |
| --- | --- |
| **Definition in your own words** | **Examples from the article** |
| **Importance of Band Gap** | **Future uses**  **mentioned in the article** |

**Summary:** On the back of this sheet, write a short summary (20 words or less) explaining the chemistry of triboelectrification.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

**Reading Comprehension Questions**

1. In simple terms, explain triboelectrification.

Triboelectrification involves harnessing energy from movement when two objects rub or move past one another. This energy is based on the flow electrons from one material to another, similar to static electricity but more controlled and calculated.

2. Compare and contrast the properties of conductors, semiconductors, and insulators.

Conductors: Materials that readily conduct electricity and heat, contain a sea of electrons or delocalized electrons that allow electrons to move freely.

Semiconductors: Materials that can conduct electricity with some assistance (boosted energy), a hybrid of conductors and insulators.

Insulators: Materials with fixed or localized electrons that do not conduct electricity.

3. Describe how the “band gap” influences a substance's ability to conduct electricity.

The band gap is the energy difference between the valence electrons that bond and the electrons not involved in bonding. In conductors the energies of the valence band and non-bonding electrons band overlap and allows electrons to move freely between the bands and therefore conduct electricity. Semiconductors and insulators have a wider gap between the two bands which either causes the electrons to need more energy to “bridge the gap” (as in semiconductors) or not flow at all between the two bands (as in insulators).

4. Describe how insulators can exchange surface charges.

Movement or rubbing of an insulator such as hair that gets brushed or wool socks on a carpet causes electrons to transfer between materials. However, since the materials involved are non-conducting insulators, the charge has nowhere to go until a conductor is introduced such as a door handle.

5. Use the triboelectric series figure on pg 14 to explain the importance of material pairings when attempting to generate triboelectricity.

Materials tend to either gain electrons or lose electrons when subjected to rubbing or movement. It is important to select a material that tends to lose electrons and pair it with a material that tends to gain electrons to generate a flow of electrons.

**Making Connections**

6. Examine the triboelectric series on page 14 again. Do you notice any trends in the types of materials that tend to lose or gain electrons. Meaning, can you categorize these types of materials?

Answer may vary

Lose Electrons: FIbrous materials such as hair and fur

Gain Electrons: Plastic materials

7. The article mentions mechanical energy created by sound waves (energy of movement). Provide an example of real world phenomena or example of sound creating mechanical energy of movement.

Answers may vary

Examples: House shaking after loud thunder

Singer breaking a wine glass

Feel vibrations in your chest at a loud concert

8. Triboelectricity and static electricity have a good deal in common. Explain how static electricity is created and provide a real world example.

Static electricity is created when two objects rub together and electrons are transferred to one object and there is nowhere for the additional charge to go until a conductor is introduced. An example of static electricity is shocking yourself on a doorknob after you walk across a carpeted floor or touching a child after they go down a plastic slide on the playground.

9. The goal of any new energy source is to replace or reduce the consumption and reliance on fossil fuels. Provide advantages and disadvantages of both fossil fuels and triboelectricity.

Answers may vary

Example:

Fossil fuels: Produce a great deal of energy, however pollute the environment and are non-renewable.

Triboelectricity: Produce a small amount of energy, however is relatively clean and is renewable.

10. Is triboelectricity a completely clean and renewable energy?

Answers may vary.

Not presently, many of the materials needed to create triboelectricity require fossil fuels or animal products to create.

11. Create an advertisement for a theoretical device that uses tribo-electrical power. For example, a t-shirt or pants that can charge your cell phone. The advertisement can either be a printed advertisement (similar to an advertisement you would see on a billboard or in a magazine) or a video advertisement (as you would see on TV).

Answers will vary. The teacher may decide expectations and grading criteria.

**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

**Static Electricity Activity**

<https://teachchemistry.org/classroom-resources/understanding-static-electricity>

**Electrochemistry Lesson Plan**

<https://teachchemistry.org/classroom-resources/understanding-static-electricity>

**Carbon Footprint Activity**

<https://teachchemistry.org/classroom-resources/calculating-your-carbon-footprint>

**Hybrid and Electric Cars**

<https://teachchemistry.org/classroom-resources/hybrid-and-electric-cars-video-questions>

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Electrons
* Electrostatic forces
* Electron transfer
* Valence electrons

**Correlations to Next Generation Science Standards**

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

|  |
| --- |
| **HS-PS1-3.** Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.  **HS-ETS1-2.**  Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. |

**Disciplinary Core Ideas:**

* PS.1.A: Structure and Properties of Matter
* ETS1.B: Developing Possible Solutions

**Crosscutting Concepts:**

* Patterns
* Cause and effect
* Stability and change
* Systems and System Models

**Science and Engineering Practices:**

* Constructing explanations and designing solutions

**Nature of Science:**

* Scientific knowledge assumes an order and consistency in natural systems.

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).

**Teaching Strategies**

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

* **Alternative to Anticipation Guide:** Before reading, ask students how they think their bodies can be used to produce electricity, including what materials might be needed. 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 triboelectrification.
* After students have read and discussed the article, ask students if they think they might use triboelectric devices in the future, and how.
* ***Note:*** Novice chemistry students may not be familiar with antibonding orbitals, which is important to understanding the band gap described in the article. Reviewing molecular orbital theory may aid understanding.