

**Teacher’s Guide**

**Lighting Up the Night Sky**

***October 2020***

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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 5](#_Graphic_Organizer)

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 6](#_Answers_to_Reading)

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

[Additional Resources 9](#_Additional_Resources_1)

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. Plasma is when electrons in an atom move freely around positively charged nuclei. |
|  |  | 1. It takes 8 minutes for solar wind to reach Earth. |
|  |  | 1. Earth’s magnetic field protects us from solar wind. |
|  |  | 1. Light from auroras is produced about 10 km above Earth’s surface. |
|  |  | 1. Auroral colors are produced when electrons transition from higher to lower orbitals. |
|  |  | 1. Nitrogen and oxygen atoms produce the same auroral colors. |
|  |  | 1. You can see the aurora even if the sky is very cloudy. |
|  |  | 1. Electrons stream along magnetic field lines. |
|  |  | 1. Solar flares can cause auroras and disrupt power grids. |
|  |  | 1. Auroras have been seen in Florida. |

# Student Reading Comprehension Questions

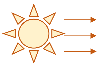
Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

1. Plasma and gas are both states of matter. How is a plasma different from a gas?
2. What is wind? What makes solar wind different from the wind we experience on Earth?
3. What is the difference between oxygen in the lower atmosphere where we breathe and oxygen in the much higher atmosphere where the aurora occurs?
4. What role does Earth’s magnetic field play in protecting Earth from the solar wind?
5. Why does Earth need to be protected from the solar wind?
6. Write the electron configuration for a neutral oxygen atom and for a neutral nitrogen atom.
7. Draw a Lewis structure, showing all bonding and nonbonding electrons, for the oxygen molecule and for the nitrogen molecule.
8. The colors of an aurora are attributed to electron transitions in atomic oxygen and in molecular nitrogen. Why does nitrogen maintain its molecular state in the upper atmosphere while oxygen molecules split into individual atoms?
9. Molecular nitrogen in the upper atmosphere can become ionized. What does this tell you about the magnitude of ionization energy vs. the magnitude of bond energy for N2?
10. Explain, in terms of energy transfer, the process that causes light to be emitted from atoms and molecules causing an aurora.

**Student Reading Comprehension Questions, cont.**

1. Use the symbols below to show each stage of the process described in question 10.

e- = electron in the atom

= energy from solar wind

= color observed in aurora

1. Write a documentary-style narrative for the animation referenced in the article.

**Questions for Further Learning**

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

1. The process of excitation and relaxation of electrons by energy absorption and emission is a common phenomenon in nature. Choose one of the phenomena below and explain how this explanation helps us understand it.
   1. The glow of fireflies
   2. The color and glow of neon lights
   3. Fluorescence in Puffins
2. Explore the connection between electric charges and magnetism and use this to explain why Earth has a magnetosphere.

# Graphic Organizer

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

**Directions**: As you read, complete the graphic organizer below to describe how each item contributes to the northern lights.

|  |  |
| --- | --- |
|  | **Contribution to northern lights** |
| **Earth’s magnetic field** |  |
| **Solar wind** |  |
| **Solar flares** |  |
| **Upper atmosphere** |  |
| **Why is the study of space weather important?** | |

**Summary:** What is the most interesting thing you learned about auroras and why do you find it interesting?

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **Plasma and gas are both states of matter. How is a plasma different from a gas?**

*Both are composed of particles that are spaced far apart, but a plasma is charged because many electrons have been separated from the atoms/molecules. This allows a plasma, but not a neutral gas, to be influenced by electromagnetic waves.*

1. **What is wind? What makes solar wind different from the wind we experience on Earth?**

*Wind is simply moving molecules. The molecules in air get pushed around by forces and when a mass of them passes you, you feel the wind. Solar wind is similar, but moves much faster and is composed mostly of electrons and positive ions. Charges moving at this speed would be very damaging to humans.*

1. **What is the difference between oxygen in the lower atmosphere where we breathe and oxygen in the much higher atmosphere where the aurora occurs?**

*Oxygen where we breathe is diatomic, O2. This is its natural state. However, in the upper atmosphere, ultraviolet radiation is energetic enough to break the bond and create atomic oxygen. Though a small amount of monatomic oxygen may be present in the air we breathe, a much larger portion of the oxygen in the upper atmosphere is monatomic.*

1. **What role does Earth’s magnetic field play in protecting Earth from the solar wind?**

*The magnetic field of the earth diverts the path of the solar wind because moving charges have a magnetic field. The particles in the solar wind are forced to go around Earth, thus missing the earth’s atmosphere.*

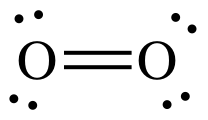
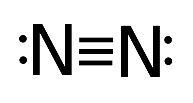
1. **Why does Earth need to be protected from the solar wind?**

*If the solar wind could pass through our atmosphere, it would gradually erode away, making Earth uninhabitable.*

1. **Write the electron configuration for a neutral oxygen atom and for a neutral nitrogen atom.**

*Oxygen: 1s22s22p4  Nitrogen: 1s22s22p3*

1. **Draw a Lewis structure, showing all bonding and nonbonding electrons, for the oxygen molecule and for the nitrogen molecule.**

1. **The colors of an aurora are attributed to electron transitions in atomic oxygen and in molecular nitrogen. Why does nitrogen maintain its molecular state in the upper atmosphere while oxygen molecules split into individual atoms?**

*The N2 bond is a very strong triple bond. It would take a much higher energy photon to split this into atoms, thus most of the nitrogen is diatomic. The O2 double bond is strong, but the UV photons are energetic enough to break it.*

1. **Molecular nitrogen in the upper atmosphere can become ionized. What does this tell you about the magnitude of ionization energy vs the magnitude of bond energy for N2?**

*Since the photons are energetic enough to separate an electron from the molecule, but not to separate the atoms in the molecule, the ionization energy must be lower in magnitude than the bond energy.*

1. **Explain, in terms of energy transfer, the process that causes light to be emitted from atoms and molecules causing an aurora.**

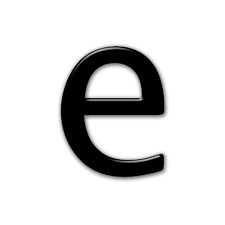
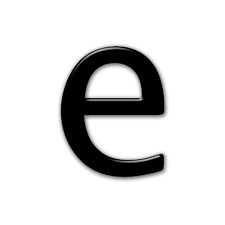
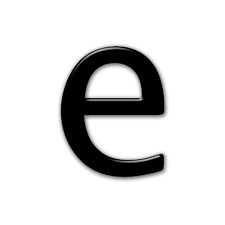
*The particles in the solar wind are moving very fast. When these particles interact with a particle in Earth’s magnetic field, they transfer some of their energy, either directly or indirectly, to this new particle. (Indirect transfer happens if this new particle is an electron because it will eventually collide with a molecule and transfer its gained energy to that molecule.) The energy from the solar wind is absorbed by an electron in the atom or molecule, causing it to excite to a higher energy level. It can then release this energy as a photon by relaxing back down to any of the available lower energy levels. If the energy released falls in the visible range, then we would see a color.*

1. **Use the symbols below to show each stage of the process described in question 9.**

 e- = electron in the atom

= energy from solar wind

= color observed in aurora

1. **Write a documentary-style narrative for the animation referenced in the article.**

*Answers will vary. Look for:*

* *Solar flare or mass ejected from sun*
* *Travels outward and toward Earth*
* *Interacts with Earth’s magnetic field*
  + *Distorts Earth’s field and is also deflected by it*
  + *Energizes particles in Earth’s field which travel to the poles*
* *This then undergoes the process described above to cause the aurora*

**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

**Labs and demos**

Flame tests (Rainbow demo): In this demonstration, students will observe the variety of colors produced when different metals or metallic salts are heated in a flame.

<https://teachchemistry.org/classroom-resources/flame-test-rainbow-demo>

Mystical Fire Investigation: In this lab, students will create several testable questions based upon their observations of a mystical fire. Students then direct their own laboratory experience as they safely investigate these testable questions through the use of multiple flame tests. <https://teachchemistry.org/classroom-resources/mystical-fire-investigation>

**Simulations**

PhET – Neon Lights and Other Discharge Lamps: <https://phet.colorado.edu/en/simulation/legacy/discharge-lamps>

Bohr Model of an Electron Simulations: <https://interactives.ck12.org/simulations/chemistry/bohr-model-of-electron/app/index.html?hash=faf0aab26a3c06de33f5f80bb9bf2dd4&source=ck12&artifactID=5658500&referrer=concept_details&encodedID=SCI.CHE.206>

Exciting Electrons simulation: <https://teachchemistry.org/classroom-resources/exciting-electrons-simulation>

**Lessons and lesson plans**

Electrons and Orbitals: In this lesson, students will differentiate between energy levels, sublevels, orbitals, and electrons. <https://teachchemistry.org/classroom-resources/electrons-and-orbitals>

Let it Glow: In this lesson students will investigate the fluorescence of a variety of everyday items as well as prepared samples under a black light. <https://teachchemistry.org/classroom-resources/let-it-glow>

**Projects and extension activities**

As a project, have students investigate examples of man-made plasma:

* Plasma TV screens
* Fluorescent lamps
* Arc lamp (like welder’s torch)
* Tesla coil

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Atomic structure
* States of matter
* Gases

**Correlations to Next Generation Science Standards**

This article can be used to achieve the following performance expectations and dimensions of NGSS:

**HS-PS2-5**

Plan and conduct an investigation to provide evidence that an electrical current can produce a magnetic field and that a changing magnetic field can produce an electric current.

**Disciplinary Core Ideas**

* PS1.A: Structure and Properties of Matter

**Crosscutting Concepts:**

* Cause and Effect: Mechanism and explanation.
* Systems and System Models
* Stability and Change

**Science and Engineering Practices:**

* Constructing explanations and designing solutions

**Nature of Science:**

* Science models, laws, mechanisms, and theories explain natural phenomena.

**Correlations to Common Core State Standards**

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

**Teaching Strategies**

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

* **Alternative to Anticipation Guide:** Before reading, ask students if they have ever seen the northern lights, and where they were at the time. Ask what they think causes the northern lights. As they read, students can find information to confirm or refute their original ideas.
* Use the aurora as a phenomenon for students to question. After questioning, students read the article and see what questions were answered and what new questions arise. Then move to lab observations of spectrum tubes with spectroscopes. Then do flame test lab to see if students can apply the same principles.
* After they read, ask students what causes the northern lights, and what they have seen locally that is similar to the northern lights.
* After the reading, you can show the ACS Reactions Video that summarizes information from the article and has some photos of different aurora colors: “What Causes Auroras (and where you should see them)”: <https://youtu.be/8S_LPFOa-zs>