

**Teacher’s Guide**

 **Are We Running Out of Helium?**

***April 2021***

**Table of Contents**

[Anticipation Guide](#_Anticipation_Guide) 2

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

[Reading Comprehension Questions](#_Student_Reading_Comprehension) 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 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](#_Additional_Resources) 9

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

[Chemistry Concepts, Standards, and Teaching Strategies](#_Chemistry_Concepts,_Standards,) 10

# 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. Helium is the most abundant element in the entire universe.
 |
|  |  | 1. Most of the helium consumed in the U.S. is used for balloons.
 |
|  |  | 1. Helium on Earth is produced by thermonuclear reactions.
 |
|  |  | 1. Scientists discovered helium on the sun before it was discovered on Earth.
 |
|  |  | 1. Helium on the Earth was first found in lava from a volcano that had recently erupted.
 |
|  |  | 1. Almost all of the helium on Earth is formed by radioactive decay of elements such as uranium or thorium.
 |
|  |  | 1. Helium and natural gas are often found together in the same types of rock.
 |
|  |  | 1. At 1 atm of pressure, liquid helium is 4 °C or colder.
 |
|  |  | 1. Helium does not burn.
 |
|  |  | 1. Helium is a renewable resource.
 |

# Student ReadingComprehension Questions

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

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

1. Besides party balloons, list some common uses for helium.
2. How was helium discovered on Earth?
3. How is helium trapped and stored in Earth’s crust?
4. What is meant when an element transmutes into a different element?
5. How does an alpha particle become a helium atom?
6. How do scientists determine what elements are present in stars and planets with spectroscopy?
7. What makes the bright line spectrum of helium different from hydrogen? What causes this difference?
8. Why would the isotope beryllium-6 be unstable? (Hint: what is the main purpose of a neutron?)
9. Why is it so hard to “make” helium through fusion?
10. When two protons combine to form one nucleus, the result is one proton and one neutron. How did the one proton become a neutron?
11. Compare the models of a helium atom and the molecule sulfur hexafluoride. If you had two balloons, one filled with helium and one filled with sulfur hexafluoride, what would the balloons do when you released them? Why?
12. When the periodic table was introduced by Dimitri Mendeleev in 1869, the noble gases were not present on the table. Why did it take so long to discover the noble gases compared to the other elements?

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

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

1. Research some bright-line spectra for some elements. Note the simplicity or complexity of these spectra. Why do you think some are more complex than others? What causes these lines to appear?
2. In Bangladesh, people take plastic bottles, cut them in half, and attach them through boards. These were attached to openings in the walls of the homes. The air flowed through the bottles, and entered the house about 5 °C (9 °F) cooler. This is called the Joule-Thompson effect. Explain how this works using basic gas laws. (YouTube video: <https://youtu.be/Fda7mj8ffdY>)

# Graphic Organizer

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

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

|  |  |  |
| --- | --- | --- |
|  | **On the sun** | **On Earth** |
| **Discovery** | **Who****When****Where****How** | **Who****When****Where****How** |
| **How produced (equations)** |  |  |
| **How is helium mined and separated from other chemicals?** |  |
| **Major uses & importance** | **1.****2.****3.** |

**Summary:** Write three new things you learned about helium.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **Besides party balloons, list some common uses for helium.**

*Cryogenics, welding, heat transfer, pressurization, airships, analysis, and others.*

1. **How was helium discovered on Earth?**

*Helium was first discovered in an eruption at Mt. Vesuvius, which produced the same bright line spectrum that was observed in stars. It was then discovered on in earth radioactive uranium compounds. William Ramsey thought he saw argon, but it was helium.*

1. **How is helium trapped and stored in Earth’s crust?**

*Helium is stored in places with granite, which has the radioactive materials that create helium. The helium is then stored in porous rocks, covered by a solid, nonporous rock that holds the helium underground.*

1. **What is meant when an element transmutes into a different element?**

*When an element transmutes, it emits a particle from its nucleus, which then causes the number of protons to change, thus creating another element.*

1. **How does an alpha particle become a helium atom?**

*An alpha particle is a helium nucleus, meaning it does not have its 2 electrons. The alpha particle is moving so fast, it emits ionizing radiation. This radiation is strong enough to pull off 2 electrons from a neutral atom and attach them to the helium nucleus*

1. **How do scientists determine what elements are present in stars and planets with spectroscopy?**

*Using spectroscopy, scientists can determine the elements present by observing the light emitted through a spectroscope. The scientists match the colored lines with the known emission spectra of the elements. Then they determine hat elements are present.*

1. **What makes the bright line spectrum of helium different from hydrogen? What causes this difference?**

*The difference is caused by the 2nd electron in a helium atom. This 2nd electron produces more colored emissions.*

1. **Why would the isotope beryllium-6 be so unstable? (Hint: what is the main purpose of a neutron?)**

*The nucleus of the beryllium isotope contains 4 protons, and only 2 neutrons. A neutron acts as a “buffer” between the protons and their strong positive charges. There are not enough neutrons in this isotope to buffer the positive charge of 4 protons. This is why the beryllium nucleus emits 2 protons, thus stabilizing the nucleus.*

1. **Why is it so hard to “make” helium through fusion?**

*Fusion requires lots of energy. To make a larger nucleus, we have to combine 2 or more protons into one small nucleus, which means overcoming the repulsion from their very strong positive charges. This is why stars, with their high temperatures and very large gravitational forces, are the only places capable of fusion.*

1. **When 2 protons combine to form one nucleus, the result is one proton and one neutron. How did the one proton become a neutron?**

*One of the 2 protons transmutates into a neutron by releasing a positron. A positron is the opposite of an electron (it is the same mass, but has a positive charge instead of a negative charge). This removes the positive charge of the proton, making it a neutron.*

$\begin{matrix}1\\1\end{matrix}H$🡪$\begin{matrix}0\\+1\end{matrix}e$ *+* $\begin{matrix}1\\0\end{matrix}n$

1. **Compare the models of a helium atom and the molecule sulfur hexafluoride. If you had two balloons, one filled with helium and one filled with sulfur hexafluoride, what would the balloons do when you released them? Why?**

*Helium has a molar mass of 4.0 g/mol. Xenon, another noble gas, has a molar mass of 131.29 g/mol. We know that helium, because of its low density (it is “light”), will float up into the air. Xenon, on the other hand, is about 33 times heavier. A balloon filled with xenon will immediately drop to the ground.*

1. **When the periodic table was introduced by Dimitri Mendeleev in 1869, the noble gases were not present on the table. Why did it take so long to discover the noble gases compared to the other elements?***Noble gases are very non-reactive. Since many elements were discovered through chemical reactions that resulted in decomposition of compounds. Because noble gases are rarely (if at all) found in compounds, they were very hard to discover.*

**Questions for Further Learning**

1. **Research some bright-line spectra for selected elements. Note the simplicity or complexity of these spectra. Why do you think some are more complex than others? What causes these lines to appear?**

*Electrons in an atom absorb energy from an outside source, allowing them to “jump” up into a higher energy level. The electrons then release this energy, and then they drop to a new, lower level. The energy that is released is in the form of visible light waves. The light waves create a distinct pattern in a spectroscope, which tells scientist what element they have. Hydrogen is the simplest bright line spectrum, because it has only 1 electron. As the elements increase in size, there are more electrons that jump from energy level to energy level. This creates many different colored lines.*

1. **In Bangladesh, people take plastic bottles, cut them in half, and attach them through boards. These were attached to openings in the walls of the homes. The air flowed through the bottles, and entered the house about 5 °C (9 °F) cooler. This is called the Joule - Thompson effect. Explain how this works using basic gas laws. (YouTube video:** [**https://youtu.be/Fda7mj8ffdY**](https://youtu.be/Fda7mj8ffdY)**)**

*The air goes into the wide end of the bottle. The air is squeezed closer together in a smaller volume. The decrease in volume also decreases the temperature of the air. This follows Charles’ Law that states volume and temperature of a gas is directly proportional.*

$$\frac{V1}{T1}=\frac{V2}{T2}$$

**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 Test (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>

**Flame Test – Going Further:** In this lab, students will investigate the colors produced when several mixtures of metallic ions are placed in a flame.<https://teachchemistry.org/classroom-resources/flame-test>

**Spectral Detective - Using a Spectroscope:** In this lab, students will use a spectroscope to view the atomic spectra of various unknown elements. Using their collected data in combination with known atomic spectra, they will identify the chemical elements. <https://teachchemistry.org/classroom-resources/spectral-detective>

**Making a Spectroscope:** In this lab, the students will make and use a spectroscope to identify the spectra within various types of light bulbs. The students will then develop an improved design for the spectroscope. <https://teachchemistry.org/classroom-resources/build-a-spectroscope>

**Comparing Gas Density:** In this demonstration, students will observe a reaction between baking soda and vinegar in the presence of a variety of different heights of lit candles. Students will analyze and compare the presence of the gases in the container and make determinations about the densities of each. <https://teachchemistry.org/classroom-resources/comparing-gas-density>

**Lessons and Activities**

**Half-life with Pennies:** Throw one hundred coins, remove all those that come up tails, place them in a pile, repeat—you've got yourself a hands-on model for radioactive decay. The piles graphically show the meaning of the term “half-life.” <https://www.exploratorium.edu/snacks/radioactive-decay-model>

**Fission vs. Fusion Reading:** In this activity, students will annotate an informational text about fission and fusion using the “text-in-the-middle” reading strategy. They will then compare and contrast the two types of nuclear reactions. <https://teachchemistry.org/classroom-resources/fission-vs-fusion-reading>

**Videos & Other Resources**

Sam Keane Helium Video: <https://teachchemistry.org/classroom-resources/helium-video>

Noble Gases in Balloons: <https://youtu.be/QLrofyj6a2s>

How to make your own Eco-Cooler: <https://youtu.be/Oh9LhrLGUc4>

Compound Chemistry Helium Infographic: <https://www.compoundchem.com/2019/02/07/iypt002-helium/>

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Electron configuration
* Separating mixtures
* Density
* Alpha decay
* Half-lives

**Correlations to Next Generation Science Standards**

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

**HS-PS1-1**

Use the periodic table as a model to predict the relative properties of elements based on the patterns of elections in the outermost energy level of atoms.

**HS-ETS1-1**

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

**Disciplinary Core Ideas:**

* PS1.A: Structure and Properties of Matter
* PS1.C: Nuclear Processes
* ETS1.A: Defining and Delimiting Engineering Problems

**Crosscutting Concepts:**

* Patterns
* Stability and Change
* Structure and Function

**Science and Engineering Practices:**

* Asking questions and defining problems

**Nature of Science:**

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

**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 what helium is used for and where it comes from.
	+ As they read, students can find information to confirm or refute their original ideas.
	+ After they read, ask students what they learned about helium’s uses, where it is found, and why it is not a renewable resource.
* After students read the article, considering showing the ACS Reactions Video “Are We running Out of Helium?” <https://youtu.be/h0Vz_AmKCPw> and challenge students to find information in the video that was not in the article.
* Try the helium puzzle, *Light Elements,* with your students! You can find a on the next page and online at [www.acs.org/chemmatters](http://www.acs.org/chemmatters).

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