

**Teacher’s Guide**

**Is Iron the Most Important Element?**

***February 2020***

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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 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. Earth would be lifeless without iron. |
|  |  | 1. By weight, iron is one of the least abundant elements in the universe. |
|  |  | 1. As a star’s core starts producing iron, the star begins to collapse, eventually forming a supernova that releases iron into space. |
|  |  | 1. Seismic waves were used to confirm the hypothesis that most of Earth’s core is made of iron. |
|  |  | 1. Earth’s core is very cool by comparison to Earth’s surface. |
|  |  | 1. Earth’s magnetic field protects life on Earth in several ways. |
|  |  | 1. Most refined iron is processed into steel. |
|  |  | 1. Steel is made of iron and carbon. |
|  |  | 1. Iron processing helps remove greenhouse gases from the atmosphere. |
|  |  | 1. Only animals need iron to survive; plants and bacteria do not need iron. |

# Student Reading Comprehension Questions

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

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

1. What are some of the physical properties of iron?
2. Describe how a metallic bond works.
3. What was the procedure that determined that Earth’s core was made of iron?
4. Give examples of how iron is needed for plants and animals to live.
5. There are two ways to get the required iron to live. What are those two ways?
6. List the effects of having too much and too little iron in our bodies.
7. Describe an ionic bond. What would be some properties in ionic bonds that are different from metallic bonds?
8. Describe the process of converting iron oxides to pure iron. How could this process be detrimental to the environment?
9. There is very little pure iron in Earth’s crust. How is iron typically found? What does that tell you about the reactivity of iron, compared to other metals that are typically found in pure form? (Hint: look up the activity series of metals.)
10. Sketch particle diagrams of pure iron, and of iron/carbon (steel) alloy. Use these diagrams to show how the alloy is stronger than pure iron.

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

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

1. The core of the planet is over 10,000 oF. Research the ways people are using this heat as an alternative energy source (called geothermal energy).
2. Research and describe how seismic waves are detected and measured. How do these waves travel through the planet?
3. Research and report any alternative methods to produce steel that reduces the CO2 production, or how steel producers try to limit the amount of CO2 produced.
4. Research and list what metals are found in the human body. What are the primary uses/functions of these metals?

# Graphic Organizer

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

**Directions**: As you read, complete the graphic organizer below to describe the importance of iron.

|  |  |
| --- | --- |
| **How is iron formed?** |  |
| **Where is iron found on Earth?** |  |
| **What ores contain iron?** |  |
| **How is iron obtained from ores?** |  |
| **What compounds in living things contain iron?** |  |
| **How can you obtain iron from food?** |  |
| **What can happen if you do not eat enough iron?** |  |

**Summary:** On the back of this paper, write a tweet (280 characters or less) describing the importance of iron.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **What are some of the physical properties of iron?**

*Silver/grey, malleable, ductile, conducts electricity and heat. The atoms are held closely together by metallic bonds.*

1. **Describe how a metallic bond works.**

*Metallic bonds happen when the electron shells of the metal atoms overlap, and the electrons move freely throughout the atoms.*

1. **What was the procedure that determined that Earth’s core was made of iron?**

*Scientists measured the seismic waves, created by earthquakes, and how they travelled through Earth.*

1. **Give examples of how iron is needed for plants and animals to live.**

*For plants, enzymes that contain iron are needed to help them produce chlorophyll. For humans, iron is needed in the blood cells as hemoglobin. This chemical helps transport oxygen throughout the body, and transports carbon dioxide out of the body to the lungs.*

1. **There are two ways to get the required iron to live. What are those two ways?**

*Two forms of needed iron are heme and non-heme. The heme is found in meat, poultry and fish. The non-heme is found in dark green leafy vegetables, as well as cereals, lentils, beans and rice.*

1. **List the effects of having too much and too little iron in our bodies.**

*Too much iron in the body will lead to iron poisoning, and hemochromatosis (causing fatigue and joint pain and other symptoms. Too little iron causes anemia, which results in fatigue and shortness of breath.*

1. **Describe an ionic bond. What would be some properties in ionic bonds that are different from metallic bonds?**

*Ionic bonds occur when electrons are transferred from metal atoms to nonmetal atoms, creating positive and negative attractions, which form ordered crystal structures. One difference from metallic bonds is that ionic bonds cannot conduct electricity or heat, because there are no free flowing electrons. The ionic bonds also create a structure that cannot be malleable or ductile, because the ions remain in a fixed position.*

1. **Describe the process of converting iron oxides to pure iron. How could this process be detrimental to the environment?**

*Coke (impure carbon) is reacted with oxygen to make carbon dioxide.*

*C + O2 🡪 CO2*

*The resulting carbon dioxide reacts with more coke to make carbon monoxide.*

*C + CO2 🡪 2CO*

*The carbon monoxide reacts with the iron ore to make pure iron and carbon dioxide*

*Fe2O3 + 3CO 🡪 2Fe + 3CO2*

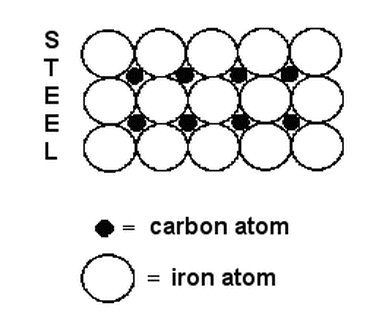
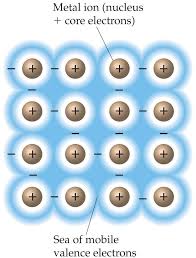
*This process is not environmentally friendly because CO2 (a greenhouse gas) is produced. Also, there may be some excess CO remaining (a poisonous gas). Also, some of the impurities of the coke could be hazardous to the environment.*

1. **There is very little pure iron in the earth’s crust. How is iron typically found? What does that tell you about the reactivity of iron, compared to other metals that are typically found in pure form? (Hint: look up the activity series of metals.)**

*Iron is typically found as iron oxide. Very little pure iron is found in nature. Iron is not very stable reactivity-wise, compared to other metals. It is easy for oxygen to react with it. (Iron is oxidized).*

1. **Sketch particle diagrams of pure iron, and of iron/carbon (steel) alloy. Use these diagrams to show how the alloy is stronger than pure iron.**

*Carbon atoms fill in the gaps between iron atoms (the interstices), which gives the alloy stronger structure.*



**Questions for Further Learning**

1. **The core of the planet is over 10,000 oF. Research the ways people are using this heat as an alternative energy source (called geothermal energy).**

*Get started with geothermal energy basics:* [*www.energy.gov/eere/geothermal/geothermal-basics*](https://www.energy.gov/eere/geothermal/geothermal-basics)

1. **Research and describe how seismic waves are detected and measured. How do these waves travel through the planet?**

*Get started with this article about seismic waves:* [*www.sciencelearn.org.nz/resources/340-seismic-waves*](https://www.sciencelearn.org.nz/resources/340-seismic-waves)

1. **Research and report any alternative methods to produce steel that reduces the CO2 production, or how steel producers try to limit the amount of CO2 produced.**

*Get started with this C&EN article about this:* [*https://cen.acs.org/environment/greenhouse-gases/Steel-plant-waste-mop-CO2/97/web/2019/08*](https://cen.acs.org/environment/greenhouse-gases/Steel-plant-waste-mop-CO2/97/web/2019/08)

1. **Research and list what metals are found in the human body. What are the primary uses/functions of these metals?**

*You can point students here to get started:* [*https://askabiologist.asu.edu/content/atoms-life*](https://askabiologist.asu.edu/content/atoms-life)

**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**

Metallic Breakfast: In this lab, students will separate iron filings from iron-fortified breakfast cereals. Students will use the recorded data to conduct percent composition calculations. <https://teachchemistry.org/classroom-resources/metallic-breakfast>

Iron Nail Redox: In this lab, students perform a simple redox reaction using an iron nail and copper(II) chloride solution. They will consider both quantitative and qualitative data collected during the reaction in order to attempt to explain what happened. <https://teachchemistry.org/classroom-resources/inquiry-redox-investigation>

Separating Mixtures: In this lab, students devise their own method to separate a mixture of sand, salt, poppy seeds, and iron filings. <https://teachchemistry.org/classroom-resources/separation-of-a-mixture>

Mineral Investigation: In this lab, students will put their problem solving skills to work as a team to determine how many specific samples of ore can be made from a lode equivalent to the size of their classroom. <https://teachchemistry.org/classroom-resources/mineral-investigation>

**Other Resources**

A clearer look at how iron reacts in the environment: <https://www.anl.gov/article/a-clearer-look-at-how-iron-reacts-in-the-environment>

Steel production & environmental impact: <http://www.greenspec.co.uk/building-design/steel-products-and-environmental-impact/>

Environmental impact of steel production processes: <https://www.jernkontoret.se/en/the-steel-industry/production-utilisation-recycling/environmental-impact-of-the-processes/>

Periodic Table of Videos – Iron: <https://youtu.be/euQUgp5AY-Y>

Infographic- Iron: Blood, Mars, and magnetic fields: <https://www.compoundchem.com/2019/05/03/iypt026-iron/>

Infographic – The Chemistry of Spinach: <https://www.compoundchem.com/2018/07/17/spinach/>

Metals in the body: <https://www.livescience.com/18247-metals-human-body-health-nigms.html>

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Chemistry Basics – Elements
* Molecules & bonding – alloys; metallic bonding; ionic bonding; molecular structure
* Reactions & Stoichiometry – combustion

**Correlations to Next Generation Science Standards**

This article can be used to achieve the following performance expectations of 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-ESS1-3.**

Communicate scientific ideas about the way stars, over their life cycle, produce elements.

**Disciplinary Core Ideas**:

* PS1.A: Structure and Properties of Matter
* ESS1.A: The Universe and Its Stars

**Crosscutting Concepts:**

* Patterns
* Cause and Effect: Mechanism and explanation
* Stability and Change

**Science and Engineering Practices:**

* Analyzing and interpreting data
* Constructing explanations (for science) and designing solutions (for engineering)
* Engaging in argument from evidence

**Nature of Science:**

* Scientific knowledge is based on empirical evidence.
* 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 the Anticipation Guide: Before reading, ask students why iron is important to life on Earth.
* After reading, ask students what they found most interesting or surprising from reading the article.
* After reading, ask students to identify occurrences of iron in their day-to-day lives. Classify each occurrence of iron as an element or an ion.