

**Teacher’s Guide**

**Mirror Reflections**

***December 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_1)

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. Before mirrors were invented, some people used a volcanic glass to reflect light. |
|  |  | 1. Metals have delocalized electrons that enhance reflection of light. |
|  |  | 1. Sodium is a good metal to use for mirrors because it polishes well. |
|  |  | 1. The round mirrors used by dentists have silver in them to reflect light. |
|  |  | 1. Copper and gold produce tinted reflections. |
|  |  | 1. Older mirrors were made using an amalgam of tin and mercury to coat glass. |
|  |  | 1. When you look at an image of yourself in a mirror, you appear to be behind the mirror. |
|  |  | 1. Most low-cost mirrors today are made with steel. |
|  |  | 1. The mirror on the Hubble Space Telescope is coated with silver. |
|  |  | 1. The first silvered mirrors were made using silver nitrate and ammonia. |

# Student Reading Comprehension Questions

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

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

1. List some of the first objects used as mirrors. What were the common traits of these objects?
2. What property do the best mirrors, which provide for a good reflection, have in common?
3. What does the term “luster” mean? What characteristic of metal atoms creates their luster?
4. Explain how metallic bonding occurs using delocalized electrons.
5. What is the chemical reaction that explains how silver tarnishes?
6. Is glass needed for a mirror? What is the reasoning for mirrors to have glass?
7. What happens when a metal is oxidized? What happens to the delocalized electrons in metals when oxidation occurs?
8. Explain, based on atomic bonding and structure, why nonmetal solids cannot create a reflection.
9. Why should a mirror be flat? What would happen to an image if the mirror is curved?
10. We say light is “reflected” (bounced off a mirror). That is technically incorrect. What happens to the photons of light when they come in contact with the atoms of the reflective surface?
11. What does your brain assume when you look at an object in a mirror? Why do letters and numbers look backwards then?

**Student Reading Comprehension Questions, cont.**

1. When you look into the front side of a spoon, you see an upside down image of yourself. Explain how that happens (think how light reflects). (Sketching a diagram of reflecting light waves would help answer this question.)
2. The best metals for reflection are silver, gold, and copper. (The article also mentions other metals, such as rhodium, aluminum, and sodium, can be used for mirrors.) What makes silver a better metal for mirrors than copper or gold (think absorbing/reflecting colors)?

**Questions for Further Learning**

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

1. Conduct some research on two-way mirrors. How do they work? Use this explanation to explain why it is easier for someone to look inside a window as opposed to outside a window when it is dark outside.
2. Metals typically bond with oxygen when they oxidize. Silver, however, more readily bonds with sulfur to make Ag2S. Why does sulfur oxidize with silver more readily than oxygen?
3. Tarnished silver is actually the compound Ag2S. Commercial tarnish removers remove the layer of silver sulfide to bring back the shiny look of pure silver. Unfortunately, this procedure removes the silver completely, so over time the object decreases in mass. There is another procedure that chemically removes tarnish without removing any of the silver. What is this procedure? What is the reaction, and why is it effective?

# 

# Graphic Organizer

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

**Directions**: As you read, complete the graphic organizer below to describe metals that could be used for the reflective surface of mirrors. Include descriptive words from the article such as luster, oxidize, amalgam, volatile, and sublimation.

|  |  |  |
| --- | --- | --- |
| **Metal** | **Advantage(s)** | **Drawback(s)** |
| **Chromium** |  |  |
| **Sodium** |  |  |
| **Rhodium** |  |  |
| **Aluminum** |  |  |
| **Mercury** |  |  |
| **Silver** |  |  |
| **Gold** |  |  |

**Summary:** Write a short email to a friend describing what you learned about the chemistry of mirrors.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **List some of the first objects used as mirrors. What were the common traits of these objects?**

*Original objects used for mirrors include shiny stones, metals, and obsidian. All had shiny, smooth, flat surfaces that provided the reflection.*

1. **What property do the best mirrors, which provide for a good reflection, have in common?**

*The best mirrors reflect the highest amount of incoming, or incident, light. This light will bounce back to form accurate images in a viewer’s eyes.*

1. **What does the term “luster” mean? What characteristic of metal atoms creates their luster?**

*Luster is how a surface interacts with light. The delocalized electrons in a metal move around and vibrate at the same frequency as the incident light.*

1. **Explain how metallic bonding occurs using delocalized electrons.**

*In metals, electrons move around from atomic orbital to atomic orbital. These electrons are not fixed on one atom. They flow like an “electron sea.”*

1. **What is the chemical reaction that explains how silver tarnishes?**

*Silver will tarnish when it reacts with sulfur compounds in the air. Hydrogen sulfide (H2S) is the most common molecule that silver reacts with. The reaction is: 2 Ag + H2S 🡪 Ag2S + H2.*

1. **Is glass needed for a mirror? What is the reasoning for mirrors to have glass?**

*The reason for using glass is that glass is one of the smoothest substances we have. This keeps the thin metal (silver, aluminum, etc.) from forming any imperfections that would alter the reflective image.*

1. **What happens when a metal is oxidized? What happens to the delocalized electrons in metals when oxidation occurs?**

*When a metal is oxidized, the metal gives up one or more of its valence electrons to a nonmetal (i.e. oxygen) to become a positive ion. The positive ion forms an ionic bond with the negative ion of oxygen. The loss of electrons from the metal means that there are no delocalized electrons around the metal (which in turn takes away the metal’s reflective properties).*

1. **Explain, based on atomic bonding and structure, why nonmetal solids cannot create a reflection.**

*Nonmetals bond through covalent bonding. These covalent bonds consist of shared electrons between two atoms. Because these valence electrons are shared, and not freely moving like delocalized electrons, they cannot reflect light like metals.*

1. **Why should a mirror be flat? What would happen to an image if the mirror is curved?**

*A mirror must be flat so that the light hitting the mirror will reflect at the correct angle, providing an accurate image. If the mirror is not flat, it will reflect the light at odd angles, creating a distorted reflection. An example of this is funhouse mirrors.*

1. **We say light is “reflected” (bounced off a mirror). That is technically incorrect. What happens to the photons of light when they come in contact with the atoms of the reflective surface?**

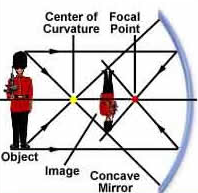
*When the photons of light hit the atoms in the mirror, they vibrate the electrons in them. The electrons then release the same amount of energy as the incident light, so the same color of light is released back to the viewer’s eyes (so, instead of reflecting, the mirror is “recreating” the image). (Link for explanation:* [*https://youtu.be/iE6I52Th9DE*](https://youtu.be/iE6I52Th9DE)*).*

1. **What does your brain assume when you look at an object in a mirror? Why do letters and numbers look backwards then?**

*Your brain still assumes you are looking at something directly ahead. It cannot distinguish light reflecting. Your eyes sees letters backwards because the mirror reflects the light at the same angle the mirror receives it. So your eyes see the reverse image. (A good visual is for kids to look at the writing on their t-shirts from the inside. That is what the mirror is receiving.) This website is a good source:* [*https://science.howstuffworks.com/question415.htm*](https://science.howstuffworks.com/question415.htm)

1. **When you look into the front side of a spoon, you see an upside down image of yourself. Explain how that happens (think how light reflects). (Sketching a diagram of reflecting light waves would help answer this question).**

*Because of the curvature of the spoon, when light hits the spoon, the reflection happens at a much different angle. All these reflected light beams converge into a focal point, and then continue in their opposite directions, causing a flipped image. See the diagram below:*



1. **The best metals for reflection are silver, gold, and copper. (The article also mentions other metals, such as rhodium, aluminum, and sodium, can be used for mirrors.) What makes silver a better metal for mirrors than copper or gold (think absorbing/reflecting colors)?**

*When someone sees the color white, what they see is a reflection of all the colors of the visible spectrum. When someone sees a specific color, that means the object reflects just that color, but absorbs the others. In metals, the color silver is very similar to the color white. So silver will reflect all colors it absorbs. Gold and copper already reflect their respective colors, which will tint the colors of the original object.*

**Questions for Further Learning**

1. **Conduct some research on two-way mirrors. How do they work? Use this explanation to explain why it is easier for someone to look inside a window as opposed to outside a window when it is dark outside.**

*A two way mirror is a piece of glass that will reflect like a mirror on one side, but is transparent when looked through the other side. This works when one side of the glass is in a very well lit room, and the other side is in a dark room. In the lighted room, some of the light (and images) passes through to the other side, while some reflects back. On the dark side, you cannot see a reflection, because there is not enough light to reflect. This is also why it is hard to look out a window at night, but someone outside can see in easily.*

1. **Metals typically bond with oxygen when they oxidize. Silver, however, more readily bonds with sulfur to make Ag2S. Why does sulfur oxidize with silver more readily than oxygen?**

*Silver reacts with sulfur more readily than oxygen. The main reason is that sulfur compounds break down more quickly than oxygen when they come into contact with silver.*

1. **Tarnished silver is actually the compound Ag2S. Commercial tarnish removers remove the layer of silver sulfide to bring back the shiny look of pure silver. Unfortunately, this procedure removes the silver completely, so over time the object decreases in mass. There is another procedure that chemically removes tarnish without removing any of the silver. What is this procedure? What is the reaction, and why is it effective?**

*Another common way to remove tarnish is to rub the affected silver with aluminum foil. Aluminum is higher on the activity series, so it will replace the silver in the sulfide compound. Thus, no silver will be lost. The reaction for this is:*

3 Ag2S(*s*) + 2 Al(*s*) 🡪 6 Ag(*s*) + Al2S3(*s*)

**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**

**Silver to Black - and Back:** This activity allows students to remove tarnish from silver using the reaction of tarnish with aluminum. <https://pubs.acs.org/doi/10.1021/ed077p328A>

**Silver Test Tube Holiday Ornament:** In this lab, students will carry out a reduction reaction in order to create a silver-plated test tube that can be used as a holiday ornament. <https://teachchemistry.org/classroom-resources/silver-test-tube-holiday-ornament>

Metallic Bonding & Magnetics: In this demonstration students will observe how electrons flow through a metal in an example of metallic bonding. Using tubes made of different metal materials as well as one made of plastic, in combination with a rare earth magnet (neodymium magnet) the teacher will demonstrate how electrons will flow freely through a metal and create a magnetic field. <https://teachchemistry.org/classroom-resources/metallic-bonding-magnetics>

**Simulations/Videos**

Why do I look upside down in a spoon? <https://youtu.be/prWjk8UlRPs>

How does light bounce off a mirror? <https://youtu.be/iE6I52Th9DE>

How do two-way mirrors work? <https://youtu.be/4kKL32opewI>

Aluminum Video <https://teachchemistry.org/classroom-resources/aluminum-video>

**Lesson Plans**

Observing Properties of Metals – observe different metals and learn about fundamental properties of elements and alloys. <https://teachchemistry.org/classroom-resources/observing-properties-of-those-marvelous-metals>

**Informational Website**

Chemistry world tarnish explanation

[https://www.chemistryworld.com/news/simulations-solve-mystery-of-why-silver-tarnishes/3010299.article#/](https://www.chemistryworld.com/news/simulations-solve-mystery-of-why-silver-tarnishes/3010299.article" \l "/)

Infographic: Making Silver mirrors

<https://www.compoundchem.com/2017/09/06/silver-mirror/>

Compound Interest: Removing tarnish

<https://www.compoundchem.com/2013/12/16/removing-tarnish-silver/>

Chemistry of Silver Tarnish & Solutions | Educational Innovations

<http://blog.teachersource.com/2014/01/18/chemistry-of-tarnished-silver/>

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Atomic Structure: electrons
* Chemistry Basics: physical properties
* States of Matter: sublimation
* Electrochemistry: redox reaction

**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 electrons in the outermost energy level of atoms.

**HS-ETS1-3.**

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

**Disciplinary Core Ideas:**

* PS1.A: Structure and Properties of Matter
* ETS1.C: Optimizing the Design Solution

**Crosscutting Concepts:**

* Patterns
* Structure and Function

**Science and Engineering Practices:**

* Obtaining, evaluating, and communicating information

**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, what they think is on the back of mirrors.
  + As they read, students can find information to confirm or refute their original ideas.
  + After they read, ask students what they learned about making mirrors.
* There is an interesting ACS Reactions video (about 5 minutes long) that relates to some articles in this issue: “Space Mirrors and Other Weird Ways to Fight Climate Change.” suggested in the video. <https://youtu.be/9agoVDFJs8A>
  + Consider showing the video after the students have read “Mirror Reflections” and “How to Raise a Jellyfish.” Ask students to think about the risks and benefits of the solutions

Mirror Mysteries

A variety of materials and methods have been used over the years to make mirrors. Five of the more common ones are listed below, but each letter has been randomly substituted with another letter of the alphabet. The letter substitutions are the same for each word. Can you identify all the materials and methods to make mankind’s magnificent mirrors?

(Starting hint: Q stands for U and Y stands for M)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
|  |  |  |  |  |  |  |  |  |  |  |  | Y |  |  |  |  |  |  |  | Q |  |  |  |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| ***Materials*** |  | ***Methods*** |  |
| DOUBLE |  | WZUODNOAX |  |
| ZVDOIOTA |  | TYTUXTYTPOZA |  |
| XUTDD |  | LULFPEZWUTPOAX |  |
| YLEFQEC |  | DQVUOYTPOZA |  |
| TUQYOAQY |  | BTFQQY ILWZDOPOZA |  |

Mirror Mysteries – Answer Key

A variety of materials and methods have been used over the years to make mirrors. Five of the more common ones are listed below, but each letter has been randomly substituted with another letter of the alphabet. The letter substitutions are the same for each word. Can you identify all the materials and methods to make mankind’s magnificent mirrors?

(Starting hint: Q stands for U and Y stands for M)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| **T** | **V** | **F** | **I** | **L** | **K** | **X** | **N** | **O** | **M** | **R** | **U** | **Y** | **A** | **Z** | **W** | **J** | **E** | **D** | **P** | **Q** | **B** | **H** | **S** | **C** | **G** |

|  |  |  |  |
| --- | --- | --- | --- |
| ***Materials*** |  | ***Methods*** |  |
| DOUBLE | **SILVER** | WZUODNOAX | **POLISHING** |
| ZVDOIOTA | **OBSIDIAN** | TYTUXTYTPOZA | **AMALGAMATION** |
| XUTDD | **GLASS** | LULFPEZWUTPOAX | **ELECTROPLATING** |
| YLEFQEC | **MERCURY** | DQVUOYTPOZA | **SUBLIMATION** |
| TUQYOAQY | **ALUMINUM** | BTFQQY ILWZDOPOZA | **VACUUM DEPOSITION** |