

Periodic Table of the Elements

Nonmetals

Teacher's Guide

Grade Level: 9–12

Curriculum Focus: Physical Science

Lesson Duration: Two class periods

Program Description

Nonmetals are essential to the world around us, from the air we breathe to the ground we walk on to the very building blocks of our bodies. Go back in time to discover how oxygen went from pollution to evolution. Then uncover how sulfur led to the accidental discovery of gunpowder. Learn how hydrogen may be a fuel source for cars of the future. And then descend into the depths of caves to see how nonmetals have played a vital role in shaping underground caverns.

Lesson Summary

Students work in pairs to explore how limestone caves and their unique features form. First they draw a picture of a limestone cave and its formations or find a descriptive image online. Then they write a detailed caption describing how the cave and its features formed. Next, students locate the elements involved in these processes on the periodic table of the elements to discover that they are nonmetals. Students learn that hydrogen and oxygen combined form water; carbon and oxygen combined form carbon dioxide; and carbon and oxygen combined with the mineral calcium form calcite.

Onscreen Questions

Part 1, "Exploring Nonmetals," "Hydrogen: Fuel of the Future," "Oxygen: From Pollution to Revolution," and "Sulfur: Life or Death"

- What properties do the nonmetals share?
- How do hydrogen and oxygen work together to create electricity?

Part 2, "The Chemistry of Caves"

- How does a limestone cave form?
 - Why is it important to protect caves and cave formations?
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Lesson Plan

Student Objectives

- Describe the chemical processes involved in cave formation.
- Explain the chemistry behind the development of at least two features found in caves.
- Identify the elements involved in cave formation on the periodic table of the elements.
- Describe how these elements combine to form the compounds that contribute to the formation of caves.

Materials

- *Nonmetals* program
- Computer with Internet access
- Poster board
- Markers and colored pencils
- Index cards
- Tape
- Copy of the periodic table of the elements

Procedures

1. Begin the lesson by asking students if they have ever visited a cave. If so, ask them to write down any distinctive features they remember from their visit. Then tell students to put the paper away until the end of the lesson.
2. Have students watch the segment "The Chemistry of Caves" in the program *Nonmetals*. Ask students to focus on limestone caves and how they form, as well as on how unique features found inside the caves form.
3. Divide the class into pairs. Tell each pair to either draw a picture of a limestone cave or find a picture online. Then ask students to develop a detailed caption describing the chemical processes involved in the formation of the cave. Their cave image should include at least two unique features, such as stalactites and stalagmites, and students should write a description of how these features form as well. Students can write their descriptions on index cards and tape them below their image.
4. Give students time in class to work on their projects. The Web sites below provide information.

Cave Formation

<http://www.nps.gov/wica/Speleothems.htm>

<http://www.geocities.com/jdfahn/caves.html>

<http://www.reference.com/browse/wiki/Speleothem>
<http://www.goodearthgraphics.com/virtcave/stalmite/stalmite.html>

5. For your information, below is a brief description of how limestone caves and two features inside caves form.
 - Limestone caves form when water seeps into cracks in the rock. Because the water has been exposed to carbon dioxide from the air and soil, the water forms a mild acid, called carbonic acid. Over a long period of time, the carbonic acid causes the rock to dissolve, resulting in the formation of a cave.
 - As the water travels through the cave, it loses the carbon dioxide that has been dissolved in it. As a result, the water cannot hold as much of the dissolved calcium. The excess calcium then falls out of the solution and ends up on the cave walls and ceilings as the mineral calcite. The result is interesting formations inside the caves. These formations are called speleothems.
 - Stalactites are speleothems that hang from the ceiling of the cave. Stalagmites grow up from the floor of the cave. Other formations, called popcorn, develop on cave walls. As water drips out of the walls, the calcite falls out of the solution and clusters on the cave walls, creating shapes that resemble popcorn.
6. During the next class period, give students a little more time to finish their captions and drawings. Then ask for volunteers to share their ideas about how caves and their unique features form.
7. Refer students to the periodic table of the elements. Ask for volunteers to identify the elements involved in cave formation. Students should now know that hydrogen, oxygen, and carbon—all nonmetals—combine to form the compounds that lead to the formation of caves. Ask students to name the compounds and the elements that caves are made from. If students need prompting, remind them that water and carbon dioxide are involved in cave formation. (*Hydrogen and oxygen combine to form water. Carbon and oxygen combine to form carbon dioxide. Carbon dioxide and water create the acid that causes caves to form.*)
8. Conclude the lesson by asking students to look at the ideas about caves that they recorded before they began work on this project. If students had visited a cave, do they now understand how its features formed? If not, can they now explain to family and friends how nonmetals combine to form limestone caves?

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- 3 points: Students demonstrated a clear understanding of the chemistry behind the formation of caves and their unique features; identified all the nonmetals on the periodic table that combine to form the compounds involved in the formation of caves; were able to identify all the compounds involved in cave formation.

- 2 points: Students demonstrated a satisfactory understanding of the chemistry behind the formation of caves and their unique features; identified most of the nonmetals on the periodic table that combine to form the compounds involved in the formation of caves; identified most of the compounds involved in cave formation.
- 1 point: Students demonstrated a poor understanding of the chemistry behind the formation of caves and their unique features; were not able to identify the nonmetals on the periodic table that combine to form the compounds involved in the formation of caves; were not able to identify the compounds involved in cave formation.

Vocabulary

limestone cave

Definition: An underground opening formed when water, mixed with carbon dioxide from the air and soil, seeps into limestone rock, causing the rock to dissolve; this process takes place over very long periods of time

Context: Mammoth Cave in Kentucky is an example of a limestone cave that has a large underground chamber and many tunnels and passageways.

nonmetals

Definition: A group of elements, many of which are gases at room temperature, that make up many of the materials found on Earth

Context: Oxygen is an example of a nonmetal that is highly reactive and can combine with almost every other element on Earth.

periodic table of the elements

Definition: An organization of Earth's elements arranged according to atomic number, the number of protons each element's nucleus contains

Context: Dmitri Mendeleev, a Russian scientist, developed the first periodic table of the elements in 1869, and it was organized according to the atomic mass of each element.

speleothem

Definition: A distinctive feature that forms in a cave

Context: Speleothems encompass a wide variety of cave formations, including popcorn and flowstone.

stalactite

Definition: A type of cave formation that forms from the ceiling of a cave and hangs down

Context: Stalactites look like icicles, but instead of forming from water, they form from the mineral calcite.

Academic Standards

Mid-continent Research for Education and Learning (McREL)

McREL's Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education addresses 14 content areas. To view the standards and benchmarks, visit <http://www.mcrel.org/>.

This lesson plan addresses the following national standards:

- Physical Sciences: Understands the structure and property of matter
- Language Arts – Viewing: Uses viewing skills and strategies to understand and interpret visual media

National Academy of Sciences

The National Academy of Sciences provides guidelines for teaching science in grades K-12 to promote scientific literacy. To view the standards, visit this Web site: <http://books.nap.edu/html/nses/html/overview.html#content>.

This lesson plan addresses the following national standards:

- Physical Science: Chemical reactions
 - Physical Science: Structure and properties of matter
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Support Materials

Develop custom worksheets, educational puzzles, online quizzes, and more with the free teaching tools offered on the Discoveryschool.com Web site. Create and print support materials, or save them to a Custom Classroom account for future use. To learn more, visit

- <http://school.discovery.com/teachingtools/teachingtools.html>
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DVD Content

This program is available in an interactive DVD format. The following information and activities are specific to the DVD version.

How To Use the DVD

The DVD starting screen has the following options:



Play Video—This plays the video from start to finish. There are no programmed stops, except by using a remote control. With a computer, depending on the particular software player, a pause button is included with the other video controls.

Video Index—Here the video is divided into sections indicated by video thumbnail icons; brief descriptions are noted for each one. Watching all parts in sequence is similar to watching the video from start to finish. To play a particular segment, press Enter on the remote for TV playback; on a computer, click once to highlight a thumbnail and read the accompanying text description and click again to start the video.

Curriculum Units—These are specially edited video segments pulled from different sections of the video (see below). These nonlinear segments align with key ideas in the unit of instruction. They include onscreen pre- and post-viewing questions, reproduced below in this Teacher's Guide. Total running times for these segments are noted. To play a particular segment, press Enter on the TV remote or click once on the Curriculum Unit title on a computer.

Standards Link—Selecting this option displays a single screen that lists the national academic standards the video addresses.

Teacher Resources—This screen gives the technical support number and Web site address.

Video Index

I. Exploring Nonmetals (6 min.)

Far fewer than metals on the periodic table, the nonmetals are essential components of many of Earth's natural resources. Explore their properties and uses.

II. Hydrogen: Fuel of the Future (7 min.)

Hydrogen is the simplest element in the universe—and the most abundant. Discover why it may become a fuel alternative in the 21st century.

III. Oxygen: From Pollution to Revolution (5 min.)

When first released into the atmosphere about 2.5 billion years ago, oxygen was lethal. Now it's an essential component of the air we breathe.

IV. Sulfur: Life or Death (5 min.)

A key ingredient in gunpowder, sulfur is a nonmetal element found in several different forms, or allotropes.

V. The Chemistry of Caves (23 min.)

Investigate the unusual ecosystems inside caves and discover the role limestone plays in their formation.

Curriculum Units

1. Properties of Nonmetals

Pre-viewing question

Q: What elements are commonly found in nature?

A: Answers will vary.

Post-viewing question

Q: What does the position of the nonmetals on the periodic table indicate?

A: The nonmetals are on the far right of the periodic table. Not including hydrogen, they span groups 14 to 16 and have between four and six valence electrons. Hydrogen is in group 1 above the alkaline metals, but it behaves like the nonmetals in most circumstances.

2. Properties and Uses of Hydrogen

Pre-viewing question

Q: What do you know about hydrogen?

A: Answers will vary.

Post-viewing question

Q: What are some common uses of hydrogen?

A: Combining easily with other elements, common hydrogen compounds include water, table sugar, ammonia, and hydrogen peroxide. Liquid hydrogen is often combined with liquid oxygen to make rocket fuel.

3. Alternative Fuel Source

Pre-viewing question

Q: What are some drawbacks of using gasoline to fuel automobiles?

A: Answers may include that gasoline is a nonrenewable resource; it causes air pollution and acid rain; it is expensive; and pollution from gasoline emissions may contribute to global warming.

Post-viewing question

Q: Why is hydrogen being considered to fuel the cars of the future?

A: The Earth's supply of hydrogen is limitless because it is the most abundant element in the universe, and it is odorless, tasteless, and nontoxic. The only waste product of hydrogen fuel cells would be water. Hydrogen fuel cells have no mechanical parts, do not operate at high temperatures, and do not need lubricating oils. Maintaining hydrogen-fueled cars should be cheaper and easier than traditional vehicles.

4. Properties and Uses of Oxygen

Pre-viewing question

Q: What are some uses of oxygen?

A: Answers will vary.

Post-viewing question

Q: Describe the properties of oxygen.

A: A highly reactive element, oxygen is a colorless, odorless, tasteless, nonflammable gas. In its most common form, an atom of oxygen has eight positively charged protons and eight neutral neutrons in its nucleus; its eight negatively charged electrons circle the nucleus in orbital shells to balance its eight protons.

5. Prehistoric Air Pollution

Pre-viewing question

Q: How does air pollution affect people?

A: Answers will vary.

Post-viewing question

Q: How did oxygen released into the atmosphere about 2.5 billion years ago change life on Earth?

A: The oxygen introduced into the atmosphere about 2.5 billion years ago was lethal to many bacteria, and many organisms died out. Those that could adapt to the oxygen-rich atmosphere found that the element could be used to produce energy more efficiently. Once deadly, oxygen eventually became necessary for nearly living organisms on Earth.

6. Properties and Uses of Sulfur

Pre-viewing question

Q: What do you know about sulfur and its uses?

A: Answers will vary.

Post-viewing question

Q: What are some forms of sulfur?

A: Sulfur exists in allotropes, or a number of different forms. The most common at room temperature is yellow sulfur; it begins to melt at 115° Celsius, turning into an orange liquid. As the temperature rises above 175° Celsius, sulfur becomes black and viscous, similar to molasses. Poured into water, the viscous form turns into a flexible mass known as plastic sulfur.

7. Alchemy and Gunpowder

Pre-viewing question

Q: What were the goals of medieval alchemy?

A: Alchemy was a chemical philosophy with three goals: to turn base metal into gold, to find the universal cure for all diseases, and to prolong life indefinitely.

Post-viewing question

Q: How does gunpowder work?

A: The explosion of gunpowder is a simple reaction. Charcoal works as fuel, and sulfur is a stabilizer. Its main ingredient is potassium nitrate, which provides extra oxygen and allows the mixture to explode instead of burn slowly.

8. Exploring Caves

Pre-viewing question

Q: What might be interesting about exploring a cave?

A: Answers will vary.

Post-viewing question

Q: Why do scientists explore caves?

A: Archeologists study prehistoric art and artifacts. Geologists consider them as windows into the history of our planet. Biologists study their unique ecological communities; a single cave may house creatures that exist nowhere else on the planet.

9. Exploring Mammoth Cave

Pre-viewing question

Q: Have you ever explored a cave?

A: Answers will vary.

Post-viewing question

Q: Describe the layout of Mammoth Cave.

A: The longest known cave in the world, Mammoth Cave is a three-dimensional system with multilevel galleries and 356 miles of passages, some of which may run 600 feet deep. Scientists estimate that up to 500 additional miles might exist in this cave system.

10. The Formation of Mammoth Cave

Pre-viewing question

Q: Why might early humans have explored caves?

A: Answers will vary.

Post-viewing question

Q: How long did it take Mammoth Cave to form?

A: Mammoth Cave took some three to five million years to form.

11. Cave Formations

Pre-viewing question

Q: How does water help shape the landscape of our planet?

A: Answers will vary.

Post-viewing question

Q: What is the difference between a stalactite and a stalagmites?

A: A stalactite is a mineral formation hanging from the ceiling of a cave like an icicle. A stalagmite grows upward. Both grow very slowly, in some cases only one-stenth of a millimeter a year.

12. Specialized Ecosystem

Pre-viewing question

Q: What kinds of ecosystems exist on Earth?

A: Answers will vary.

Post-viewing question

Q: Why do caves exhibit specialized ecosystems?

A: A cave's ecosystem had adapted to the conditions in its environment, which includes no sunlight, nearly 100 percent humidity at all times, and very limited food sources. A cave's temperature range is usually about one degree, regardless of the outside temperature.

13. Florida's Underwater Caves

Pre-viewing question

Q: What would you expect to find in an underwater cave?

A: Answers will vary.

Post-viewing question

Q: What are chemosynthetic bacteria?

A: Found in underwater caves, chemosynthetic bacteria are a newly discovered form of bacteria that synthesize energy from metals and minerals instead of from organic food. They may resemble the earliest forms of life on Earth.