

**Teacher’s Guide**

**Clearing the Air**

***April 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 8](#_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. Smoke always rises. |
|  |  | 1. The Clean Air Act was enacted in 1960 in the U.S. |
|  |  | 1. There are two types of ozone, one harmful and one very important for life on Earth. |
|  |  | 1. Ozone is colorless. |
|  |  | 1. In 2015, all counties in the U.S. were in compliance with the national ozone standard to limit atmospheric ozone. |
|  |  | 1. Ozone levels rise in the winter. |
|  |  | 1. Normally, air temperature increases with altitude. |
|  |  | 1. Catalytic converters in cars and trucks lower ozone-producing chemicals in exhaust. |
|  |  | 1. Modern catalytic converters carry out three chemical reactions at the same time. |
|  |  | 1. The ozone hole over Antarctica has improved since 1987. |

# Student Reading Comprehension Questions

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

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

1. Briefly explain how ozone can both be harmful and critical to life.
2. Explain how harmful ground level ozone is produced.
3. What efforts have been made to control ground level ozone production, particularly in urban areas?
4. Explain one major obstacle we are facing in reducing the amount of ground level ozone produced globally.
5. How have humans impacted the “good” ozone in the stratosphere and what efforts have been made to repair the damage to the ozone layer.
6. Explain how a catalytic converter works and classify the three chemical reactions seen in the table on page 11 titled “Cleaner Cars.”
7. The coronavirus pandemic of 2019-2020 began in December of 2019. The amount of cases began to increase dramatically worldwide in March of 2020 when the weather was beginning to warm up. The virus is particularly dangerous to those with respiratory issues. Based on the info in this article, what additional dangers may be present for people fighting the coronavirus in urban areas as the weather begins to heat up?
8. On a separate sheet of paper, write a short opinion editorial (OP-ED) piece on whether you agree that human activities have influenced global temperatures on the planet. Be sure you to use facts and evidence, not politics, when you write your piece.

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

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

1. Observe the map of the United States titled “8-Hour Ozone Nonattainment Areas (Jan. 2020)” on page 11. Dangerous levels of ozone can be found predominantly in areas with a high population density. Create an argument based on evidence as to why California contains the greatest amount of land area with extreme levels of ground level ozone. There are many areas in the United States with high population density such as the Northeast U.S. What factor or factors may be causing the increased levels in California?
2. Suppose you were in charge of creating an updated Clean Air Law. What amendments would you make to reduce the amount of ground level ozone produced?
3. Use one of the many free infographic websites available online and create an infographic explain what ozone is and how ground level ozone is produced, the dangers of ground level ozone, and simple things everyone can do to help minimize ground level ozone production.

# Graphic Organizer

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

**Directions**: As you read, complete the graphic organizer below to describe issues related to air pollution and ozone.

|  |  |  |
| --- | --- | --- |
|  | **Ground-level Ozone** | **Stratospheric Ozone** |
| **Sources** |  |  |
| **Equations for how it is formed** |  |  |
| **Effect on human health** |  |  |
| **Solutions to problems** |  |  |

**Summary:** On the back of this sheet, write one thing you can do to reduce the amount of ground-level ozone, and why your choice would help.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **Briefly explain how ozone can both be harmful and critical to life.**

*Ozone in the stratosphere protects life on Earth by absorbing dangerous solar radiation.*

*Ground level ozone is a pollutant and causes health problems.*

1. **Explain how harmful ground level ozone is produced.**

*VOCs and NOx gases undergo a chain reaction, in the final steps a single oxygen atom is split from a VOC or NOx gas, which combines with an oxygen molecule (O2) producing ozone (O3)*

1. **What efforts have been made to control ground level ozone production, particularly in urban areas?**

*Major improvements in reducing ground level ozone production can be contributed to legislation introducing strict emission standards for cars and trucks and the evolution of the catalytic converter in cars.*

1. **Explain one major obstacle we are facing in reducing the amount of ground level ozone produced globally.**

*Ozone can travel long distances in global air currents. Therefore, ozone created in one county, state, country, or continent can travel to another. Reducing ground level ozone must be a national and global effort with everyone doing their part to control emissions in their state or country.*

1. **How have humans impacted the “good” ozone in the stratosphere and what efforts have been made to repair the damage to the ozone layer.**

*The emissions of chlorofluorocarbons (CFCs), which produces free radical chlorine atoms when exposed to radiation from the sun in the atmosphere catalyze the depletion of the ozone layer in the stratosphere. The UN adopted the Montreal protocol which limits or bans the emissions of gases that deplete the ozone layer.*

1. **Explain how a catalytic converter works and classify the three chemical reactions seen in the table on page 11 titled “Cleaner Cars.”**

*Decomposition Reaction: NOx gases are reduced to oxygen and nitrogen gas*

*Synthesis reaction: carbon monoxide is combined with oxygen to produce carbon dioxide*

*Combustion Reaction: unburned hydrocarbons are combined with oxygen to produce carbon dioxide and water vapor*

*All three reactions convert harmful gases to less harmful products.*

1. **The coronavirus pandemic of 2019-2020 began in December of 2019. The amount of cases began to increase dramatically worldwide in March of 2020. The virus is particularly dangerous to those with respiratory issues. Based on the info in this article, what additional dangers may be present for people fighting the coronavirus in urban areas as summer approaches in the northern hemisphere.**

*Summer months typically bring stronger and more prevalent sunshine to areas in the northern hemisphere, which will increase ground level ozone production. If individuals with respiratory issues are exposed to high levels of ground level ozone it could cause complications for their body trying to fight the virus or even worsen the symptoms of the virus.*

1. **On a separate sheet of paper, write a short opinion editorial (OP-ED) piece on whether you agree that human activities have impacted global temperatures on the planet. Be sure to use facts and evidence, not politics, when you write your piece.**

*Answers will vary, remind students to use data and evidence in their piece.*

**Questions for Further Learning**

1. **Observe the map of the United States titled “8-Hour Ozone Nonattainment Areas (Jan. 2020)” on page 11. Dangerous levels of ozone can be found predominantly in areas with a high population density. Create an argument based on evidence as to why California contains the greatest amount of land area with extreme levels of ground level ozone. There are many areas in the United States with high population density such as the Northeast U.S. What factor or factors may be causing the increased levels in California?**

*Answers may vary. Due to the topography of California with a large number of mountains adjacent to low level valleys, temperature inversions are very common. Temperature inversions cause the air to become stagnant, thus not allowing the smog or pollutants to diffuse. California also has a very high population density and very little rain. Rain has the ability to “wash” out some the air pollutants and clear the air, the lack of rain in the area may also contribute to the high levels of ground level ozone.*

1. **Suppose you were in charge of creating an updated Clean Air Law. What amendments would you make to reduce the amount of ground level ozone produced?**

*Answers may vary. Things to consider: Car emissions, clean energy solutions, global collaboration.*

1. **Use one of the many free infographic websites available online and create an infographic explain what ozone is and how ground level ozone is produced, the dangers of ground level ozone, and simple things everyone can do to help minimize ground level ozone production.**

*Venngage.com, pitkochar.com, and canva.com are examples of some of the free infographic making websites. Answers will vary.*

**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

**Lessons and lesson plans**

Catalysis & Catalytic Converters: In this lesson, students will be introduced to catalysts while expanding their knowledge of chemical reactions and stoichiometry. They will first learn about catalytic converters and then be challenged to create the best “catalytic converter” of hydrogen peroxide to oxygen gas in an inquiry-based activity.

<https://teachchemistry.org/classroom-resources/catalysis-catalytic-converters>

The Downside to Catalysts - An Exploration of CFC's on the Ozone Layer: In this lesson students will make observations of a colorful homogenous catalyst and intermediate in a reaction demonstration that will spark their interests.

<https://teachchemistry.org/classroom-resources/the-downside-to-catalysts>

The Ozone Layer: In this lesson, students will develop an explanation for the consequences of ozone depletion on Earth by planning and carrying out an investigation. Students will use analysis and interpretation of data to develop a model to explain the cause and effect of Ozone depletion on the planet Earth.

<https://teachchemistry.org/classroom-resources/the-ozone-layer>

**Videos**

Catalytic Converters Video: This video investigates the role of a catalytic converter and its corresponding chemical reactions within a vehicle. Students will learn about both oxidation and reduction reactions and how they, in combination with a catalyst, can impact the molecules released in a car’s exhaust.

<https://teachchemistry.org/classroom-resources/catalytic-converters-video>

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Gases: Density
* Reactions & Stoichiometry

**Correlations to Next Generation Science Standards**

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

**HS-ESS3-4**

Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

**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:**

* ESS3.c: Human Impacts on Earth Systems
* ETS1.B: Developing Possible Solutions

**Crosscutting Concepts:**

* Cause and Effect: Mechanism and explanation.
* Scale, Proportion, and Quantity
* Systems and System Models
* Stability and Change

**Science and Engineering Practices:**

* Analyzing and interpreting data
* Constructing explanations and designing solutions

**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 about their ideas about smog, and if they have ever seen it. Ask what pollutants are found in smog, and what problems they think smog might cause (health and otherwise). As they read, students can find information to confirm or refute their original ideas.
* After they read, ask students what weather and pollutant conditions promoted the deadly smog in Donora, Pennsylvania in 1948.