

Lesson Two. The Ozone Layer, CFCs and Global Warming

OBJECTIVES

Subjects: Science/Health

The students will:

1. Identify the chemical make up of ozone.
Understand the difference between ground-level and stratospheric ozone
2. Define CFCs and name several sources of CFCs.
3. Explain the greenhouse effect and its potential harmful effects.

Time: 50 minutes

Materials: Student booklet, styrofoam cup, aerosol can

BACKGROUND INFORMATION

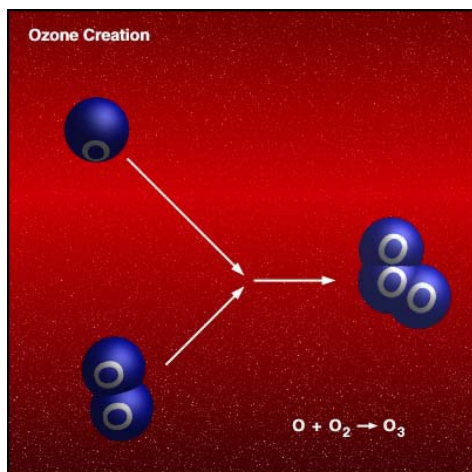
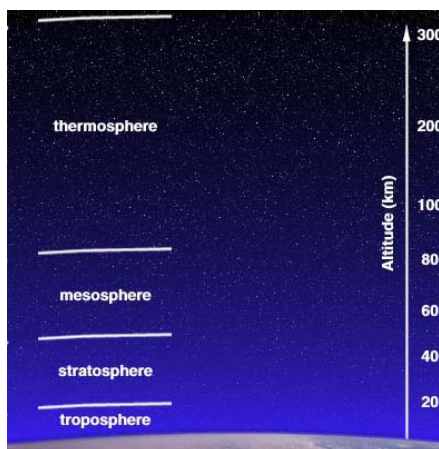
We are familiar with the most common form of oxygen, the form that we all breathe. It is made up of two oxygen atoms (O_2). Ozone is made up of three oxygen atoms (O_3) and can be beneficial or harmful, depending on where it is found in the atmosphere.

In the stratosphere, ozone protects us from ultraviolet radiation, so it is beneficial to human health. On the other hand, ground-level ozone is a pollutant, and as we learned in Lesson 1, is harmful to human health. Remember, the ozone chemical is the same, but where it is located determines if it is beneficial or a pollutant.

Stratospheric Ozone

As shown in the figure to the right, the stratosphere is the layer of atmosphere above the troposphere. The stratosphere contains a thin layer of ozone. The stratospheric ozone layer occurs naturally. It protects life on earth by filtering out the sun's harmful ultraviolet radiation.

Ozone gas (O_3) forms when oxygen molecules interact with ultraviolet rays from the sun. Ozone molecules absorb ultraviolet light and split into molecules of oxygen (O_2) and oxygen atoms (O). The ultraviolet light then splits some more of the O_2 to form more oxygen atoms. Oxygen atoms (O) combine with O_2 to create ozone, which is of course, O_3 .

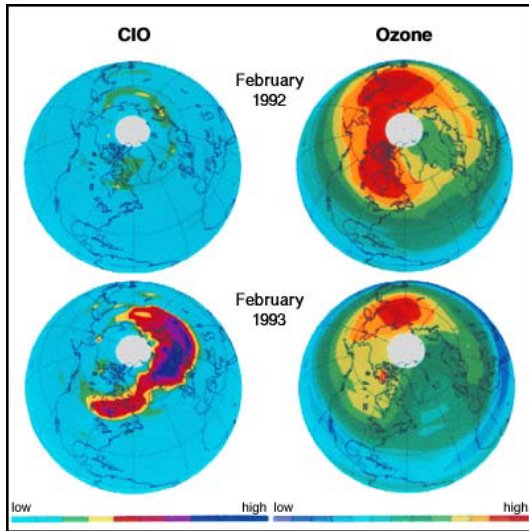


Under normal conditions this ozone layer is continuously being depleted and regenerated. UV light breaks down O_2 to single O atoms and then reforms to O_3 again and again. This process allows most of the ultraviolet light to be filtered out before it reaches the earth. Ultraviolet light, or UV radiation, can cause skin cancer in humans.

Chlorofluorocarbons (CFCs)

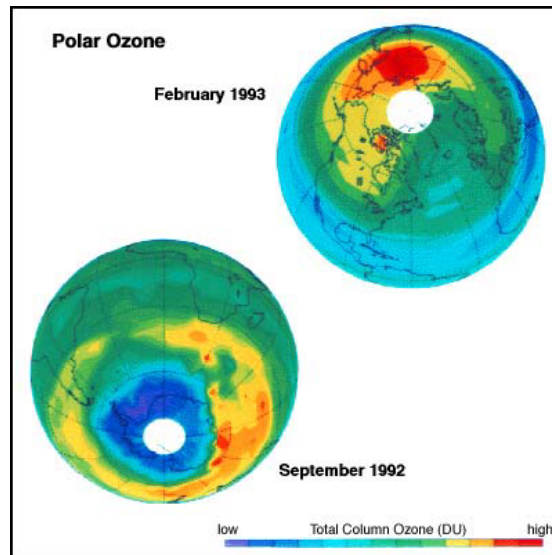
Now humans have introduced chlorofluorocarbons (CFCs) to the atmosphere and the chlorine in CFCs reacts with the ozone and changes the whole process. CFCs were first introduced in the 1920s. They were

very useful as coolants in air conditioners and refrigerators, propellants for aerosol sprays, and agents used to produce plastic foam. The CFC molecules are very stable close to the earth, but when they reach the stratosphere ultraviolet radiation breaks them up into their more-reactive components. These components then react with the ozone molecules breaking them apart, thus reducing the amount of available oxygen atoms necessary to form ozone. Before the chlorine is finally removed from the atmosphere (in one to two years by precipitation), each chlorine atom will have destroyed approximately 100,000 ozone molecules – exposing the earth to more harmful ultraviolet rays.



This figure shows the relationship between chlorine and ozone. The left side of the photo shows where chlorine gasses from CFCs are located. In the northern hemisphere, there is little chlorine (top image left) and there is a lot of ozone (top image, right). In the southern hemisphere, however, there is a large concentration of chlorine gas (bottom picture left) and the ozone levels are lower (bottom picture right). This is no accident!

The amount of ozone has been so depleted in some areas that scientists now refer to “holes” in the ozone. Look at the two globes at right. The lower globe shows the southern hemisphere and the bright blue portion of this globe is an area of very low ozone gas right over Antarctica. Depletion of the stratospheric ozone layer is of great concern since it protects the earth's surface by absorbing 99 percent of the ultraviolet light energy coming from the sun.



Greenhouse Gases

Chlorofluorocarbons are also part of a group of chemicals known as greenhouse gases. These gases contribute to the greenhouse effect. The greenhouse effect is the rise in temperature that the Earth experiences because certain gases in the atmosphere (water vapor, carbon dioxide, nitrous oxide, and methane, for example) trap energy from the sun. Without these gases, heat would escape back into space and Earth's average temperature would be about 60°F colder. Because of how they warm our world, these gases are referred to as greenhouse gases.

Greenhouse gases in the atmosphere behave much like the glass panes in a greenhouse. Sunlight enters the Earth's atmosphere, passing through the blanket of greenhouse gases. As it reaches the Earth's surface, land, water, and biosphere absorb the sunlight's energy. Once absorbed, this energy is sent back into the atmosphere. Some of the energy passes back into space, but much of it remains trapped in the atmosphere by the greenhouse gases, causing our world to heat up. Carbon dioxide is the most important greenhouse gas.

The greenhouse effect is important. Without the greenhouse effect, the Earth would not be warm enough for humans to live. But if the greenhouse effect becomes stronger, it could make the

Earth warmer than usual. Even a little extra warming may cause problems for humans, plants, and animals.

TERMS

- **Chlorofluorocarbons (CFCs):** a group of chemicals used for a wide variety of products such as aerosols and refrigerants
- **Emissions:** discharge from incomplete burning of fossil fuels, especially gasoline
- **Ozone:** a colorless gas composed of three oxygen atoms.
- **Stratosphere:** the layer of the atmosphere overlying the troposphere to about 30 miles in altitude.
- **Volatile organic compounds (VOCs):** chemical compounds made up of carbon, oxygen, hydrogen, and other atoms that can form gases easily. VOCs contribute to the formation of ground-level ozone.
- **Nonattainment areas:** metropolitan areas that do not meet the standards set by the EPA for ground level ozone levels.

PROCEDURE

- I. Setting the stage
 - A. Put these questions on the board:

Ozone, what is it? Where does it come from? What is the ozone layer? Why is the ozone layer important? What are CFCs? Where do they come from? What is the greenhouse effect? Explain what is good about the greenhouse effect and how it might be harmful. Discuss briefly. Answers to these questions are part of the objectives for this lesson.
- II. Activity
 - A. Have students read the first paragraph in their student booklet. Discuss the difference between an oxygen atom, an oxygen molecule, and an ozone molecule.
 - B. Refer to the illustration in lesson one of the earth's layers to note the troposphere and the stratosphere. Note that there is an Ozone layer in the stratosphere. Share background information.
 - C. Introduce the term chlorofluorocarbon to students. Ask them how many of them have a refrigerator in their homes, home and automobile air conditioners. Show them the Styrofoam cup and ask what other plastic foam products they can name. How many have ever used an aerosol can? The chlorofluorocarbons used for these products are damaging to stratospheric ozone.
 - D. (Author' note: At this point include Activity II from ERG – Air Quality pages 74 through 76)
- III. Follow-up
 - A. Have students read the lesson material in their booklet on ozone.
 - B. Assign the independent activities in the student booklet.
- III. Assessment
 - A. Use a general activity rubric to assess students during the ozone activity. Consider participation and cooperation.
 - B. Give credit for completion of the independent activities in the student booklet for the lesson.
- IV. Extensions

RESOURCES

- Images from NASA's Ozone and the Atmosphere Website:
http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/ATM_CHEM/ozone_atmosphere.html
- Greenhouse effect information, including an animation of how it would contribute to global warming: <http://www.epa.gov/globalwarming/kids/greenhouse.html>
- Doing Our Share for Cleaner Air, Southwest PA OZONE ACTION Partnership, Pennsylvania, 1996.
- Environmental Resource Guide Air Quality, Tennessee Valley Authority, 1990.
- Lesson Plans & Resources for Teaching Environmental Science, Texas Natural Resource Conservation Commission, 2001.
www.tnrcc.state.tx.us/exec/sbea/education/air/lessons/lesson_plans.html

TEKS

Sci. 8.14 Science concepts. The student knows that natural events and human activities can alter Earth systems.

Sci. 8.14C Science concepts. The student is expected to describe how human activities have modified soil, water, and air quality.