

Ozone Demonstration

Essential Question:

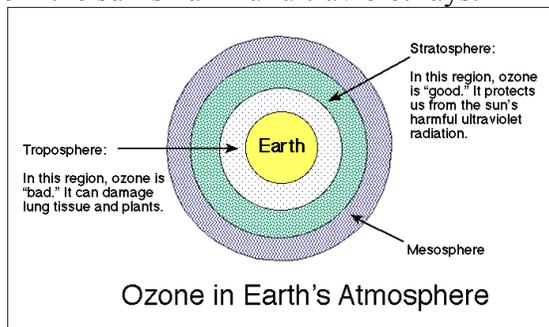
What is ozone? How do human activities affect the ozone layer?

At a Glance:

Learners will learn about the stratospheric ozone cycle and how the ozone layer is being destroyed by participating in an interactive role playing game.

Background:

Ozone occurs naturally in the Earth's upper atmosphere (stratosphere) - 10 to 30 miles above the Earth's surface - where it shields us from the sun's harmful ultraviolet rays.



http://spso.gsfc.nasa.gov/NASA_FACTS/ozone/fig1.gif

Location: Outdoors or Gym

Objectives: Learners will

- 1) describe how ozone is formed in the stratosphere.
- 2) identify some common ozone depleting substances (ODSs).
- 3) interpret how human-induced ODSs impact the ozone layer.

Skills: communication, cooperation, listening,

Supplies:

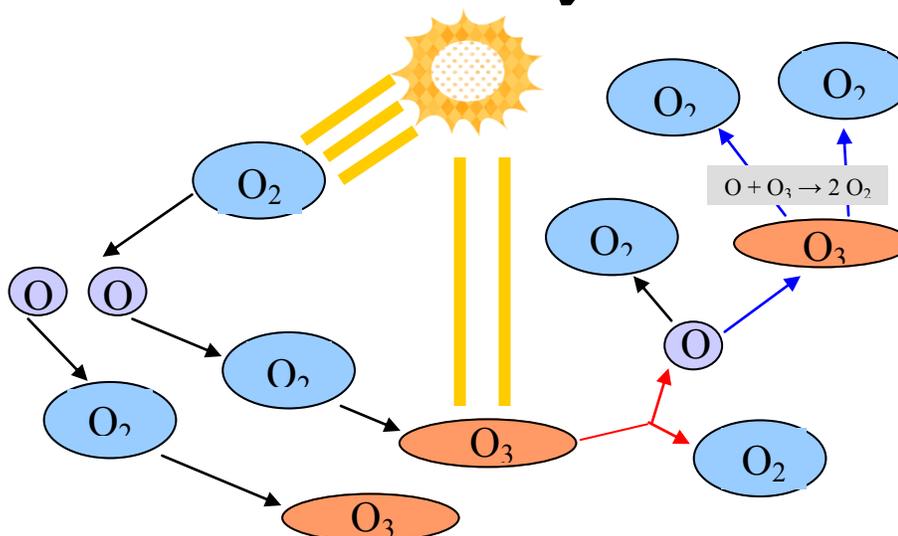
- chalk (pavement or chalkboard)
- ozone cycle diagram

Subjects: science

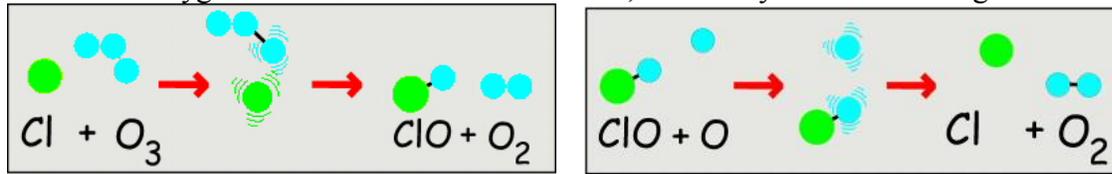
Time: 30 minutes

Oxygen atoms cycle between oxygen molecules and ozone. The sun's rays split oxygen molecules (O_2) apart into individual O atoms. These O atoms then join with an oxygen molecule (O_2) to make Ozone (O_3). As the ozone absorbs UV rays, it splits into O and O_2 . Then the atomic oxygen (single O atom) will either join back up with an oxygen molecule, O_2 , to make an ozone molecule again or 'recombine' with an ozone molecule, O_3 , to make two oxygen molecules ($O + O_3 \rightarrow 2 O_2$).

The Ozone Cycle



There are Ozone Depleting Substances, such as methyl bromide, HCFCs (hydrochlorofluorocarbons), CFCs (chlorofluorocarbons), and halons that deplete ozone. These substances break apart the ozone molecules, reducing this protective barrier. For example, when a CFC molecule, Chlorine (Cl) enters the stratosphere, it splits off and joins an oxygen atom from the ozone molecule. This leaves an oxygen molecule and a ClO molecule, eliminating the ozone molecule. A free oxygen atom then takes the oxygen away from the ClO, and the final result is an oxygen molecule and a chlorine atom, and the cycle starts over again.



<http://www.space.gc.ca/asc/eng/default.asp>

Here is a table of the most common Ozone Depleting Substances (ODS).

Ozone Depleting Substances (ODSs)	Use
Chlorofluorocarbons (CFCs)	Refrigerants, solvents, and foam blowing agents.
Hydrochlorofluorocarbons (HCFCs)	Used to replace CFCs. Still have ozone depleting properties, but much lower than CFCs.
Methyl bromide (CH ₃ Br)	Agricultural pesticide
Carbon tetrachloride (CCl ₄)	Fire extinguishers, industrial solvent, agricultural fumigant, and industrial processing
Methyl Chloroform (CH ₃ CCl ₃)	Industrial solvent
Halons	Fire extinguishers

You've probably heard of the holes in the ozone layer. When the ozone is not there to protect Earth, too many dangerous UV rays reach Earth. This puts us at more risk for getting sunburn (possibly leading to skin cancer), can burn and dry up plants, interferes with ocean productivity, and may be contributing to global climate change. The disruption of photosynthesis and plant metabolism can impact food production, which affects all of us. Global warming is being attributed with the melting of polar icecaps and the rise of sea levels, and is possibly linked to the increase of weather-related natural disasters.

But I've heard ozone is bad? In the Earth's lower atmosphere (troposphere), near ground level, ozone is formed when pollutants emitted by cars, power plants, chemical plants, and other sources react chemically in the presence of sunlight. Ozone pollution is a concern during the summer months when there is lots of sun and hot temperatures. At ground level, ozone is a poisonous gas that can cause inflammation of the respiratory system in animals, including humans, and reduce plant growth.

Though the good and bad ozone are essentially the same thing, it is their location that determines their impact on the Earth. Ozone is poisonous to breathe, but only if in the lower tropospheric zone. Ozone does not impact us, other animals, or plants high up in the stratosphere. For this activity, we will be focusing on the good ozone located in the stratosphere.

Procedure:

Part 1: The Oxygen-Ozone Cycle Game

1. Draw a diagram of the Earth's layers and where the ozone layer is located with chalk on the pavement or on a chalkboard (review diagram from Background section). Explain the importance of the stratospheric ozone layer and where it is located prior to starting the game.
2. Give a brief overview of the Oxygen-Ozone Cycle. Use the diagram provided as a visual aid, or draw out the cycle on the pavement with chalk.
3. Explain that two (to four) learners will be sun rays, while the rest of the group will be oxygen atoms.
4. Pick two (to four) learners to be sun rays.
5. Ask learners to partner up. Groups of two will hold hands or link arms, making oxygen molecules (O_2).
6. The learners who are sun rays touch/tag an oxygen molecule (pair of two) to split it.
7. When split, each learner (oxygen atom) of the split oxygen molecule must join another group of two. They will hold hands or link arms with the oxygen molecule to make a group of three. These groups now become ozone molecules (O_3).
8. To show the cyclical nature of ozone, you may make this addition. Once there are enough ozone molecules, the sun rays may tag either oxygen or ozone. If ozone is tagged, the single oxygen atom may either join up with another oxygen molecule to make ozone (O_3) or 'recombine' with an ozone molecule, O_3 , to make two oxygen molecules. This foursome would split into two separate oxygen molecules (2 pairs of learners). If learners are able to spread out a bit, it will be easier to see who is an O_2 and who is an O_3 . In reality, there are many more O_2 molecules than ozone in the stratosphere, so it is important that all the learners aren't converted to ozone permanently.

Part 2: Hole in the Ozone

1. First review what Ozone Depleting Substances are and go over some of the most common ones (see the ODS table in Background section). Mention how most of them are being phased out due to their negative environmental impact. Provide an example of how Chlorine, from CDC's, is able to break up ozone molecules, reducing the protection of the ozone layer.
2. To start the second part of the activity, pick three learners to be sun rays and three learners to be ODSs. The rest of the learners will join up in groups of three to make ozone molecules.
3. Have the ozone molecules form a line or wall, representing the ozone layer (still in groups of 3). The sun rays will be behind the ozone layer and the ODSs will be in front.
4. The ODSs will touch an ozone molecule, which will split an oxygen atom from the ozone molecule. This leaves a free oxygen atom and an oxygen molecule, eliminating the ozone molecule completely.
5. The single atomic oxygen must now find another single oxygen atom to combine with ($= O_2$) or an ozone molecule to recombine with and then split into 2 oxygen molecules ($O + O_3 \rightarrow 2 O_2$). *In actuality, the O atom first joins with an ODS molecule/atom and splits off later.*

6. Tell the kids that all of this splitting and recombining greatly decreases the amount of protective ozone. This allows harmful UV rays to pass through and reach Earth's surface.
7. Once there is a large enough hole in the ozone layer/wall (less than 2 ozone molecules in a row), the UV rays can get through. The UV ray learners must pay attention and look for their opportunity to pass through a hole in the ozone. Only one UV ray learner may go through a hole at a time.
 - ** To help differentiate the O₂ and O₃ molecules, hula hoops could be spaced out along the ground and O₃ molecules (3 learners) would stand in the hoop. Oxygen molecules would be paired up outside the hoops. This may not be necessary, however may be implemented if in a smaller space where learners aren't able to spread out.
8. Allow the shifting of atoms and molecules and reduction of ozone until all the sun rays have reached Earth.
9. Discuss what happened in the game and talk through the Discussion questions.

Discussion:

How is ozone formed?

What are some human behaviors that impact the ozone layer?

What does a hole in the ozone layer mean to us and the rest of Earth's inhabitants?

What can we do to help stop the reduction of ozone in the stratosphere?