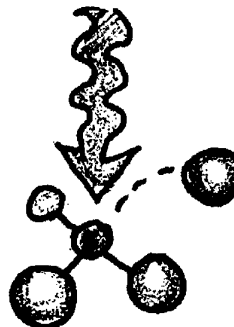


The Ozone Game

Lesson by Mike Arensen, Santa Cruz, CA and Bob Olona, Watsonville, CA

Key Concepts

1. Ozone is a part of the stratosphere that acts as a natural filter of ultraviolet radiation which is damaging to most life.
2. Ozone is being destroyed by compounds (including chlorofluorocarbons, "CFCs") released into the atmosphere by human activities.



Background

Background information for "The Ozone Game" can be found in the preceding activity, "Ozone Models".

Materials

- Cast of Characters*:
 - carbon atom, 1
 - fluorine atom, 1
 - chlorine atoms, 3
 - UV radiation, 1
 - oxygen atoms (O), oxygen molecules (O₂), ozone molecules (O₃); 10, or more
- * (This is a minimum, more can play. Adjust the number of "players" to suit the size of your class.)
- index cards, 3x5, one for each character
- felt pen
- paper clip, safety pin, or string, one for each card

Teaching Hints

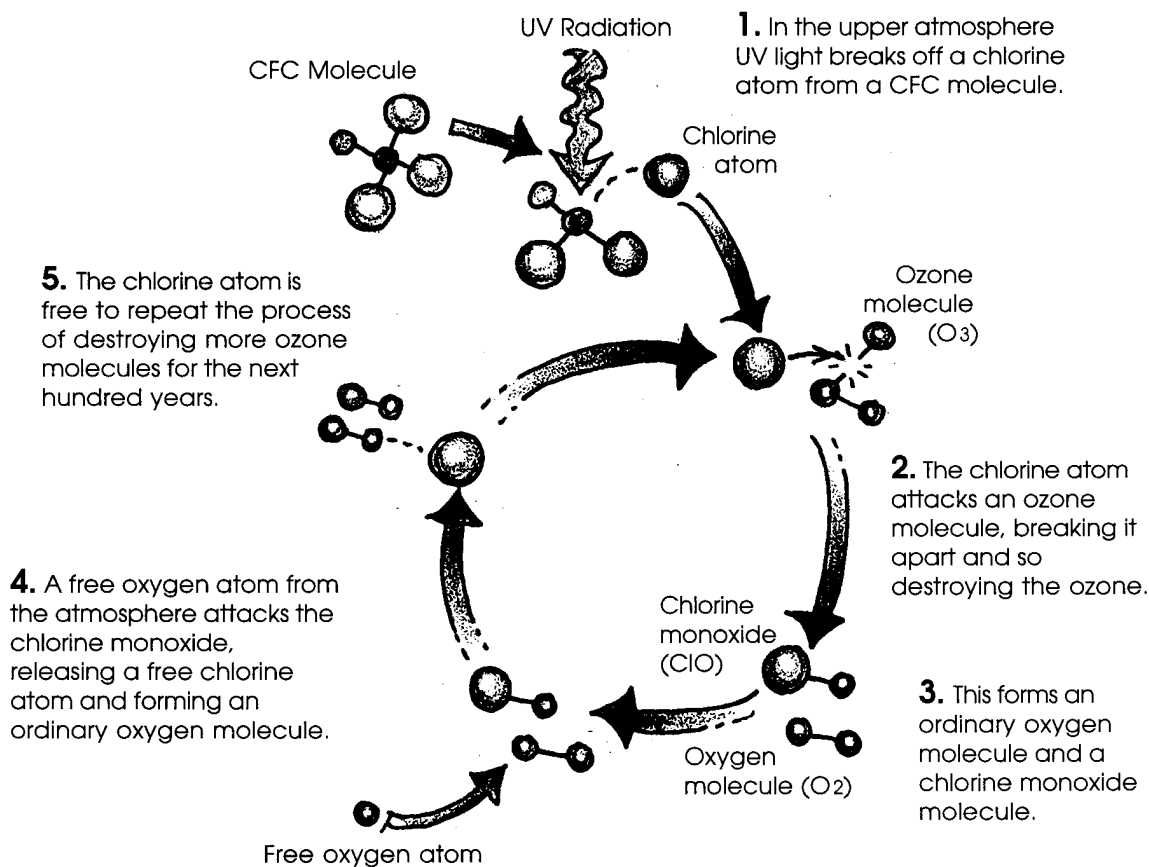
"The Ozone Game" is a role-play game in which students portray the destruction of ozone by taking the parts of ultraviolet (UV) radiation, chlorine, oxygen, carbon, and fluorine. This activity may be used to re-enforce the preceding activity, "Ozone Models".

Procedure:

Before class begins: In large, bold print, write the name of each character on a separate 3x5 card. These will be used as name tags to facilitate identification of the players. Decide how you would like students to affix the cards to themselves. You may wish to provide safety pins or paper clips or to punch the ends and tie a string through the holes to make a loop to fit over a player's head.

1. Say: **“Today, we’re going to play ‘The Ozone Game’**”, and provide each player with a 3x5 index card name tag. Tell students to wear the role card in plain sight, attached by the method upon which you have decided.
2. Ask the class to look at the cast of characters and to recall what role each has in atmospheric breakdown of ozone. You may wish to have the class briefly discuss the roles at this point, or you may wish to save the discussion for inclusion as part of the wrap-up after the game is played.
3. Say: **“‘Bonds’ are formed between atoms by joining hands.”** Show this by having 3 chlorine atoms join hands with 1 carbon and 1 fluorine. Ask: “What does this group represent?” (The group represents a CFC molecule (Cl₃FC), the process represented joining chemical bonds).
4. Ask some of the oxygen atoms to join hands to become either ozone (O₃) or atmospheric oxygen (O₂), be sure to have a few oxygen atoms (O).
5. Say: **“Once we begin, you will act out the interactions and form new molecules as the story proceeds.”**
6. Ask the class: **Describe what role UV light has in this game.** (UV breaks the bond between chlorine and carbon in the CFC molecule, releasing a chlorine atom.)
7. Say: **“Let’s see this in action.”** Have the chlorine “attack” an ozone molecule by squeezing between an oxygen to oxygen bond, taking hold of one “oxygen wrist”, and releasing the other. This squeezing breaks the bond apart, destroying it and forming an ordinary oxygen molecule (O₂) and a chlorine monoxide molecule (ClO).
8. Say: **“Chlorine monoxide is stable until it runs into an oxygen atom.”** At this point, have a free oxygen atom “attack” the chlorine monoxide, releasing a free chlorine atom and forming an ordinary oxygen molecule.

9. Say: "Wow! Look! (or something to that effect). The chlorine is free to repeat the process of destroying more ozone molecules for the next hundred years."
10. Allow students to repeat the process until all the ozone is destroyed. You may choose to have students change roles and repeat the game.
11. When you feel the students have a sense of the role of chlorine as a catalyst, have the class briefly discuss the roles of the various characters in the degradation of atmospheric ozone. You may wish to diagram the interactions using the following as a guide:



12. Ask the following questions as a review and wrap up for the activity.

Analysis and Interpretation Questions

1. What are CFCs?

(CFCs or chlorofluorocarbons are chemical compounds of carbon, chlorine and fluorine used as refrigerants, in fire extinguishers, and other industrial uses.)

2. What role do they play in the destruction of atmospheric ozone?

(CFCs, when struck by UV rays release chlorine atoms which combine with ozone to form oxygen gas and chlorine monoxide. The chlorine monoxide can combine with an oxygen atom to create another oxygen molecule and freeing the chlorine to begin the process all over again.)

3. Which element within the chlorofluorocarbon is the actual decomposer of ozone?

(The chlorine is the actual decomposer element within the chlorofluorocarbon.)

4. How can a single chlorine atom be so destructive to the Earth's ozone layer?

(Single chlorine atoms can be so destructive because they act as a catalyst and are continually “recycled”, being regenerated when the chlorine monoxide bond is broken by an oxygen atom. The chlorine atom is then free to “steal” another oxygen atom from another ozone molecule and begin the process again.)

5. How might we reduce our impact on the ozone layer?

(Answers will vary. Use this question as a springboard to emphasize that the day-to-day choices we all make can have far-reaching consequences.)

Key Words

chlorofluorocarbon - chemical compounds of carbon, chlorine and fluorine used as refrigerants, in fire extinguishers, and other industrial uses; and which are a primary source of the chlorine found to be destroying ozone in the upper atmosphere

chlorine monoxide - a molecule composed of one atom of chlorine and one atom of oxygen which plays a role in the degradation of ozone; chlorine monoxide is formed when a chlorine atom strikes an ozone molecule, “stealing” one of the oxygen atoms and destroying the ozone.

ozone - a form of oxygen whose molecule is composed of three atoms of oxygen (O₃) and which is a powerful oxidizing agent and is therefore biologically corrosive; found mainly in the stratosphere where it absorbs ultraviolet rays thereby preventing them from reaching the Earth.

stratosphere - the region of the atmosphere (15-45 km up) extending up from the troposphere characterized by little vertical change in temperature; 90% of atmospheric ozone is in the stratosphere

ultraviolet radiation - electromagnetic radiation with shorter wavelengths than the color violet, beyond the visible spectrum

Extensions

1. Have students research and explain how scientists theorize ozone has been maintained at a constant level in the atmosphere for millions or billions of years.
2. For more information on global systems studies:

NASA's Mission to Planet Earth

NASA Public Affairs Officer
National Aeronautics and Space Administration
Washington, D.C. 20546
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UCAR Office for Interdisciplinary Earth Studies

P.O. Box 3000
Boulder, Colorado 80307-3000
(303) 497-1682
Ask for Fall 1992 booklet: "Reports to the Nation: Our Ozone Shield"

NOAA Office of Global Programs

Education Program Manager
1100 Wayne Ave, Suite 1225
Silver Springs, MD 20910
Ask for "The Resource Guide"