"HOLE"-Y OZONE ! IT'S THE CFC'S!

AIR & WASTE MANAGEMENT ASSOCIATION

OBJECTIVES

The student will do the following:

1. Identify the major subdivisions of the atmosphere, including the ozone layer, and explain why the ozone layer is important.
2. Participate in a simulation of how CFCs are creating a hole in the ozone layer.
3. List various sources of CFCs in their daily lives.
4. Research alternatives to CFC products.
5. Develop a personal action plan to reduce his/her contribution to the CFC problem.

SUBJECTS:
Science, Social Studies

TIME:
2 class periods

MATERIALS:
bag of large size marshmallows
coffee stirrers
food coloring
small paint brush
scissors
5-6 foot sheet of newsprint
felt-tip markers
glue sticks
selection of magazines and newspapers
masking tape or tacks
student sheets (included)

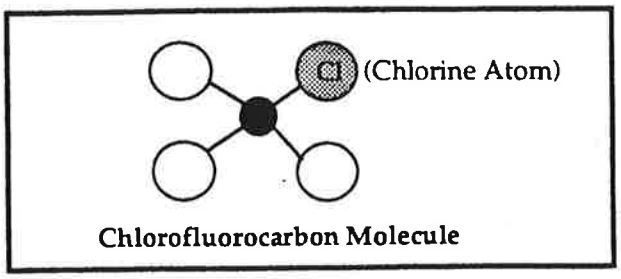
BACKGROUND INFORMATION

Chlorofluorocarbons (CFCs) or freons were discovered in the 1930s. They are compounds made of chlorine, fluorine, and carbon and are nonreactive, nontoxic, noncaustic, noncorrosive, and nonflammable. These properties make CFCs ideal for use as (1) coolants in refrigerators and air conditioners, (2) propellants in aerosol sprays, (3) plastic foam blowing agents (used in making, for example, styrofoam), and (4) cleaning solvents used in the electronics industry. However, in 1974 scientists discovered that the same qualities of stability that make CFCs desirable for so many uses can result in major environmental problems when these gases drift unaltered into the stratosphere.

The stratosphere contains a thin layer of a pale blue, poisonous gas called ozone. This ozone concentration in the stratosphere is commonly known as the ozone layer. Ozone gas forms when oxygen molecules interact with ultraviolet rays from the sun. Under normal circumstances, part of the ozone layer is continuously being depleted and regenerated. For this reason, the layer varies in thickness. The ozone layer is an important protective screen for life on earth, filtering out more than 99 percent of the ultraviolet rays before they can reach the ground.

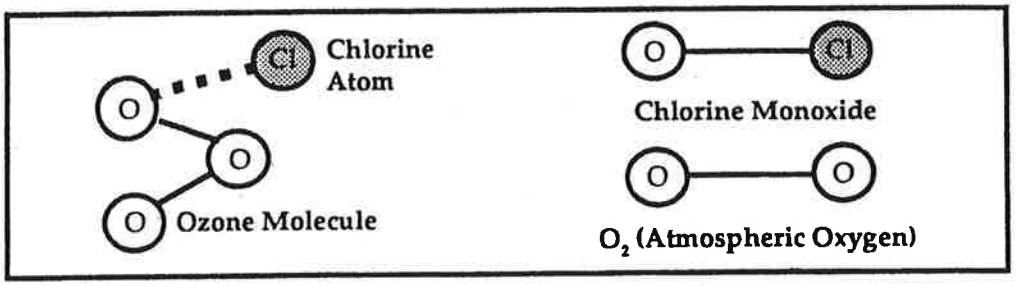
When CFCs are allowed to escape into the atmosphere, they rise until they reach the stratosphere where ultraviolet light breaks them down into chlorine and other chemicals. The chlorine atom (Cl) released in this process then reacts with an ozone molecule (O_3). An atmospheric oxygen molecule (O_2) and a molecule of chlorine monoxide (ClO) are formed in the process. ClO is relatively unstable and will react with any free oxygen atoms (O) to form O_2 and a free chlorine atom (Cl). The chlorine atom then reacts with another ozone molecule. One chlorine atom has the potential to destroy 10,000 or more molecules of ozone before it returns to the troposphere. As more and more of the ozone is depleted, the ozone layer gets thinner and lets more of the sun's ultraviolet rays reach the earth's surface. In 1985, British scientists reported that there is a hole about the size of the United States in the ozone layer over Antarctica. By 1987, scientists from four other countries concluded that the "hole" was caused by CFCs.

3. The one remaining student should construct a chlorofluorocarbon molecule model as shown below. To emphasize that this molecule is a CFC, color one marshmallow, using a paintbrush to apply food coloring, to represent the chlorine atom. Color the other marshmallows a different color to distinguish the fluorocarbon group. NOTE: Color these ahead of time so the colors can dry. Green is often used to denote chlorine.



4. Spread newspapers in the center of the room. On the papers, place a single marshmallow with a coffee stirrer attached for each ozone molecule (all the students except one). These single marshmallows represent free oxygen (O). Free oxygen is produced when ultraviolet rays in the upper atmosphere break apart atmospheric oxygen (O_2) molecules. One free oxygen atom joins with O_2 to form ozone.

5. Have all the ozone molecules (students) spread out in the room. They represent the ozone layer. When the activity starts, they should start moving around, since the gases in the atmosphere drift freely. Explain to the class that a CFC molecule is going to be introduced by spraying an aerosol container. The CFC student, carrying the CFC molecule model, is to run into the room from the hallway. Ultraviolet rays in the upper atmosphere split the CFC atom apart, leaving a free chlorine atom (Cl). The first job of the CFC student is to detach the atom of chlorine (the colored marshmallow and its coffee stirrer) from the CFC molecule. The student will hold the chlorine atom and drop the rest of the molecule (the fluorocarbon group) on the newspaper.



6. Free chlorine atoms are very unstable and will immediately react with the first ozone molecules they find. Have the student playing the chlorine atom (formerly the CFC) catch an ozone and insert the chlorine atom into an oxygen on the ozone molecule as shown below. When this happens, the ozone (O_3) is destroyed. The chlorine becomes chlorine monoxide (ClO), which is also unstable, and O_2, which is stable. Have the student who represented the ozone put the stable O_2 molecule on the floor (newspaper) and take a seat on the sidelines.

4. Next, assign each student or group of students one source of CFCs and have them do library research to find out what is being done or could be done to reduce or eliminate this source. You might also have them write letters to various companies or manufacturers for information.

5. When the students find the information, have them add it to the right half of the poster across from the source.

6. When all the information has been added, display the poster in a prominent place. You might arrange to display it in a school hallway, the library, or the cafeteria.

B. Ask the students to develop their own personal action plans to reduce CFCs by looking at what CFC products they use and how they can eliminate, change, or modify their uses.

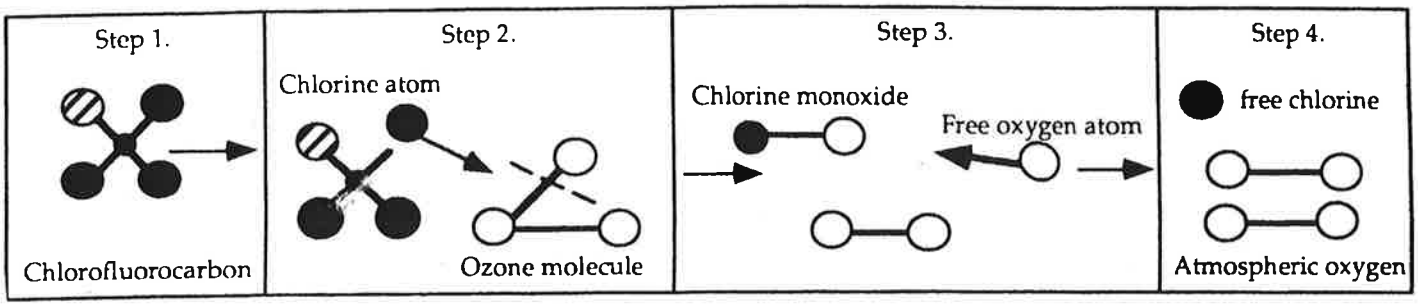
RESOURCES

National Issues Forum Institute. The Environment At Risk: Responding to Growing Dangers [by The Public Agenda Foundation]. Dubuque, IA: Kendall/Hunt, 1989.

U.S. Environmental Protection Agency. Environmental Progress and Challenges: EPA's Update. Office of Planning and Evaluation, EPA/230/07/88/033. Washington: GPO, 1988.

_____. "Our Fragile Atmosphere: The Greenhouse Effect and Ozone Depletion," EPA Journal, Vol. 12, No. 10, 1986.

HOW OZONE IS DESTROYED



Step 1

Chloroflourcarbon emitted into the atmosphere.

Step 2

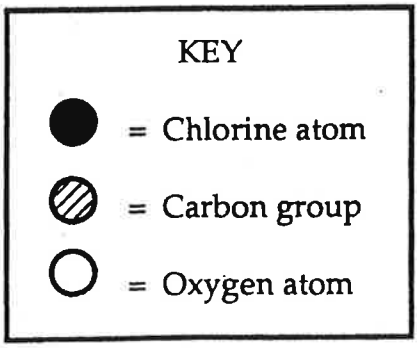
Chloroflourocarbon reacts with ozone in the upper atmosphere to form chlorine monoxide.

Step 3

Free oxygen reacts with chlorine monoxide to form a free chlorine and an atmospheric oxygen molecule.

Step 4

Free chlorine will continue to react with up to 10,000 more ozone molecules before re-entering the troposphere.



Source: Environmental Progress and Challenges: EPA's Update, 1988.