Societal Issue *Disappearing Ozone*

In 1985, a team of British scientists in Antarctica reported a hole in the ozone layer. At ground level, ozone (O_3) is a major pollutant and a health hazard. You may have noticed it as an electrical smell. But in the stratosphere, 30 km (18.6 miles) above the earth, ozone absorbs 95-99% of the dangerous UV coming from the sun. When the ozone absorbs UV radiation, it breaks into O_2 and an O· radical.

$$O_3 + \text{UV energy} \text{ -------> } O_2 + \text{O· radical}$$

The O_2 is then photodissociated by UV from the sun to produce two more oxygen radicals, O·.

$$O_2 + \text{UV energy} \text{ -------> } 2\text{O· radical}$$

The highly reactive O· radicals produce ozone, O_3. This balance between formation and photochemical destruction maintains a stable O_3 layer (*Chemical Principles* by Masterton and Slowinski).

Without the ozone layer, life would be impossible. Photons of UV (wavelength < 2000 Å) damage plants and animal tissue. Over Antarctica and New Zealand, ozone levels have fallen almost 50% since 1985. Even a 5% decrease of ozone in the stratosphere over the U.S. would cause 8,000 additional skin cancer cases each year.

Scientists say that CFCs (chlorofluorocarbons) are responsible for the "hole in the sky." High levels of chlorine radicals have been found in the atmosphere of Antarctica. It is the chlorine radicals which break down ozone. When exposed to UV radiation (wavelength 2000 Å), CFCs break down to form Cl· radicals. The chlorine radicals catalyze the formation of O_2 from O_3 and O· radicals, so no new ozone can be formed. This can also happen with Br· radicals from Halons.

$$\text{CFC} + \text{UV energy} \text{ -------> } \text{CFC radical·} + \text{Cl·}$$

$$\text{Cl·} + O_3 \text{ -------> } \text{ClO·} + O_2$$

$$\text{ClO·} + \text{O·} \text{ -------> } \text{Cl·} + O_2$$

$$O_3 + \text{O·} \text{ -------> } 2O_2$$ (This reaction does not occur unless catalyzed by Cl· or Br· radicals.)

Because Cl· radicals are not used up in the reaction, they can go on to catalyze the destruction of thousands of O_3 and O· radicals. In fact, studies have shown that one chlorine radical can catalyze the destruction of more than 100,000 molecules of ozone. If uncontrolled, CFCs could destroy the ozone layer within a hundred years (*Chemical Principles* by Masterton and Slowinski).

CFCs escape into the atmosphere during manufacturing, when styrofoam that was blown with CFCs is crushed, when refrigerators are thrown away, and when coolant escapes from air-conditioners. CFCs also escape when they are sprayed from cans that contain CFC propellants.

Some CFCs	IUPAC Name	Use
Freon 11	trichlorofluoromethane	aerosol propellant
Freon 12	dichlorodifluoromethane	blowing foam
Freon 14	tetrafluoromethane	insulator and refrigerant
Freon 22	chloro-difluoromethane	air conditioners and refrigerators
Freon 113	1,1,2-trichloro-1,2,2-trifluoroethane	to clean metals and circuit boards
Freon 114	1,1,2,2-tetrafluoro-1,2-dichloroethane	dry-cleaning chemical
Halon 1211	bromo-chloro-difluoromethane	fire extinguisher propellant
Halon 1301	bromo-trifluoromethane	fire extinguisher propellant

Eliminating CFCs is not a simple matter, because CFCs are some of the most widely used chemicals in the world. They are so widely used that a nation's GNP (gross national product) directly correlates with its use of CFCs. About $135 billion worth of products in the U.S. is dependent on CFCs ("Ozone Update Issues Consumer Tips About Auto Air Conditioners").

The largest use of CFCs is as coolants in automobile air conditioners. Up to 20% of the CFCs in the U.S. are manufactured to use in automobile air conditioners. There are an estimated 150 million auto air conditioners in use in the U.S. An automobile air conditioner has 2.5 lbs of CFCs, which is five times more than home refrigerators use ("Ozone Update Issues Consumer Tips About Auto Air Conditioners").

One of the reasons why CFCs are so useful is that they are nontoxic and incredibly stable. Many of the substitutes for CFCs are carcinogenic (Starr 28). Stability is what makes CFCs such a threat to the ozone layer; CFCs resist breakdown and drift into the stratosphere where they destroy the ozone.

In 1978, the U.S. government banned the use of CFC propellent aerosol cans. Deodorants and hair sprays are now propelled by chemicals such as CO_2, propane, butane, or pentane, or use air pumps which do not damage the ozone layer. Not all aerosol cans were covered by the ban. You can still buy bug sprays, fabric protectors, spot removers, and waterproofing sprays that contain CFCs. You should check the label of these cans before buying, because they must be marked ("Ozone Update Issues Consumer Tips About Auto Air Conditioners").

Both Congress and the Environmental Protection Agency (EPA) are considering stronger controls on CFCs. Many businesses are also showing interest as well. DuPont, the world's largest manufacturer of the chemicals, has spent millions of dollars on research to develop less harmful CFCs that are not fully halogenated (Starr 28). The most promising CFC alternatives break down more quickly in the troposphere and so do not get into the stratosphere. In 1987, McDonald's stopped using fully halogenated CFCs and switched to the safer, partially halogenated CFCs in manufacturing their styrofoam food containers (*McDonald's and the Environment*). A company in Madera, California, that manufactures white styrofoam coffee cups says that it has never used CFCs. It has been blowing the styrofoam with pentane for years. Union Carbide has developed a new chemical for making foam for sofas and mattresses that feels the same as the product on the market today but does not use CFCs. Union Carbide is not the only company supplying such chemicals to foam manufacturers ("Foam-maker Tries to Contain Critics"). Hopefully, others will follow.

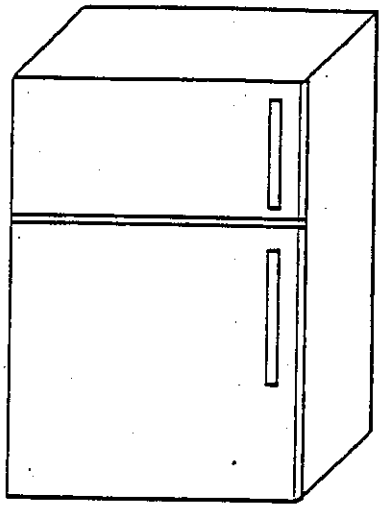
What You Can Do (Starr, 28)

1. Stop having clothes dry cleaned. Buy clothes that can be washed in water.
2. Have your car air conditioning professionally serviced every year, and *insist* that old air-conditioning fluid be recycled. Do not use kits to change your own fluid. Better yet, buy cars that do not have air conditioning!
3. Write to auto and chemical companies to urge them to develop and use safer alternatives for automobile air-conditioners.
4. Buy spring mattresses and non-foam furniture or furniture with foam made from CFC substitutes.
5. Use styrofoam cups and containers which have been made from foam blown with pentane or safer CFCs. Let companies know that you are willing to spend a little more for products that are safe for the environment.
6. Use fiberglass or cellulose insulation and home insulation instead of foam insulation.
8. Buy fire extinguishers for home use that do not use CFC propellants.
9. Check aerosol cans for the "ozone friendly" label before buying.
10. Pressure Congress to push for tougher international and domestic controls.

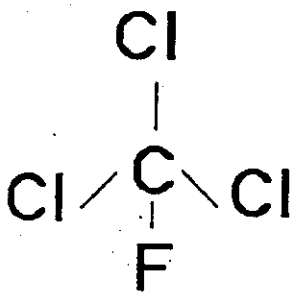
How a Refrigerator (or Air Conditioner) Works

CFCs are used as the coolant in refrigerators and air conditioners. The CFCs are compressed together using electricity, and dispersion bonds form between the CFC molecules. A small pin hole opens to release the CFC into coils. When the CFCs move from the compression chamber into the coils, the dispersion bonds break. Heat from inside the refrigerator is used to break the dispersion bonds, and so the refrigerator is cooled. The CFCs are recompressed and bonds are reformed. This process gives off energy which is released into the room; feel under your refrigerator for this heat. (An air conditioner, which workslike a refrigerator,

actually heats up the outdoors as it cools the house!) CFCs are useful as coolants because, under pressure, they form dispersion bonds that break easily when the pressure is decreased. Few other chemicals work so well this way. (You might try removing the back from your refrigerator to see the cooling coils. Note that they run over the back of the refrigerator and are more numerous near the freezer part of the refrigerator.)



trichlorofluoromethane



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2. Dotto, Lydia and Harold Schiff. *The Ozone War*. New York: Doubleday. 1978.
3. "Foam Fast-food Containers: The Scapegoat, Not the Problems." *Time Magazine* 29 Feb. 1988: 30.
4. "Foam-maker Tries to Contain Critics." *Minneapolis Star Tribune* 13 Sept. 1989.
5. Masterton, William L and Emil J. Slowinski. Chemical Principles 4th Ed. Saunders, 1977.
6. *McDonald's and the Environment*. McDonald's Corporation. 1990.
7. "Ozone Update Issues Consumer Tips About Auto Air Conditioners." *Minneapolis Star Tribune* 21 Feb. 1992.
8. Starr, Douglas. "How to Protect the Ozone Layer." *National Wildlife*. Sept./Nov.: 26-28.
9. "The Silent Summer: Ozone Loss and Global Warming: A Looming Crisis." *Newsweek* 23 Jun. 1986: 64.

Answer the questions based on the reading.

1. Explain how a refrigerator works.

2. What are the uses of CFCs?

3. What can you personally do to help save the ozone layer?

OZONE

1. The _____ is located 18.6 mi above the earth.

2. The hole in the ozone was detected above which continent?

3. Ozone is important because it absorbs ___ radiation.

4. Is life possible without ozone? ____

5. A decrease of 5% of the ozone results in approximately _____ additional skin cancer deaths.

6. What do scientists believe is responsible for the depletion of ozone? -_____

7. Are chlorine (Cl-) radicals used up when they react with ozone? _____
8. Of what consequence is this then?

9. List 5 sources of CFC's
   a.
   b.
   c.
   d.
   e.

10. How dependent on CFC's is the United States?

11. Where are CFC's used most often?_____

12. Why are CFC's preferred over substitutes?

13. What are some propellant alternatives that do not harm ozone?
   a.
   b.
   c.
   d.

14. Are CFC's outlawed?

15. How have major businesses dealt with the CFC problem? give 2 examples.
   a.
   b.

(answer the questions on p. 178 1-3)