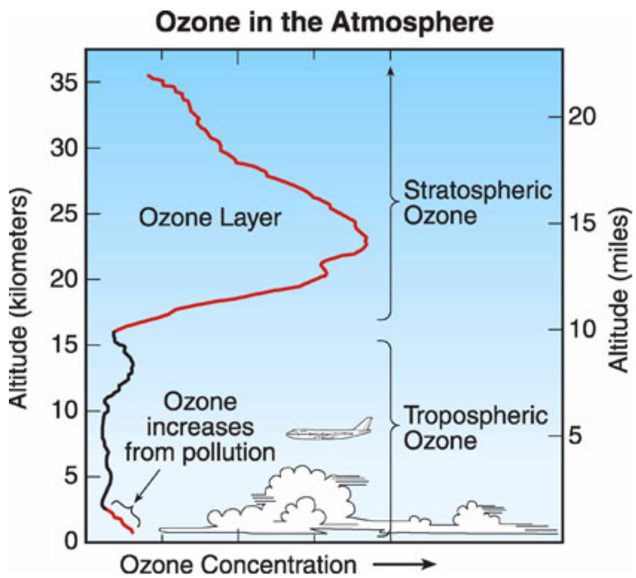
G10 Science: Class 14 Homework

Read the following excerpt and answer the questions below. Adapted from http://www.ozonelayer.noaa.gov/science/basics.htm and http://mdriscoll.pbworks.com/w/file /fetch/90925674/Depletion%20of%20the%20ozone%20layer%20article.pdf

THE OZONE LAYER



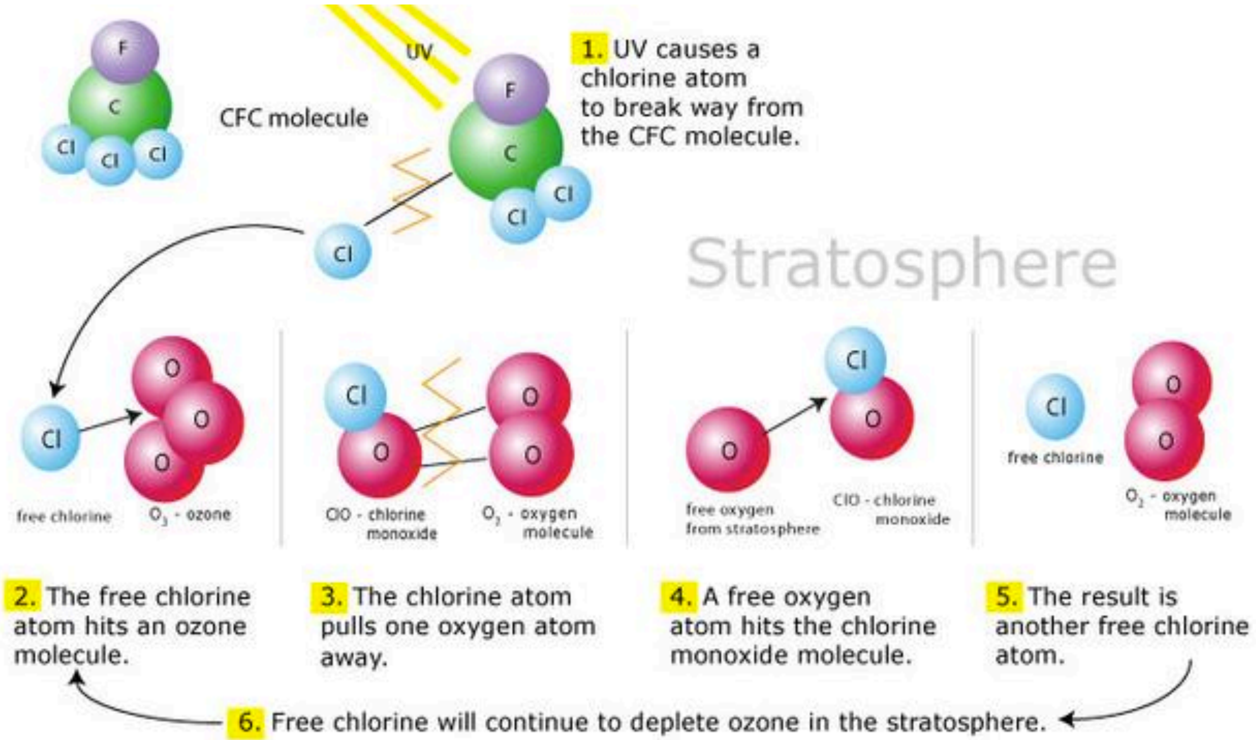
Ozone is very rare in our atmosphere, averaging about three molecules of ozone for every 10 million air molecules. In spite of this small amount, ozone plays a vital role in the atmosphere. Ozone is mainly found in two regions of the Earth's atmosphere. Most ozone (about 90%) resides in a layer that begins between 10 and 17 kilometers above the Earth's surface and extends up to about 35 kilometers. This region of the atmosphere is called the stratosphere. The ozone in this region is commonly known as the ozone layer. The remaining ozone is in the lower region of the atmosphere, which is commonly called the troposphere.

The ozone molecules in the upper atmosphere (stratosphere) and the lower atmosphere (troposphere) are chemically identical, because they all consist of three oxygen atoms and have the chemical formula O_3. However, they have different roles in the atmosphere and different effects on humans and other living beings.

Stratospheric ozone (sometimes referred to as "good ozone") plays a beneficial role by absorbing most of the biologically damaging ultraviolet sunlight (called UV-B), allowing only a small amount to reach the Earth's surface. The absorption of ultraviolet radiation by ozone creates a source of heat, which actually forms the stratosphere itself (a region in which the temperature rises as one goes to higher altitudes). Ozone thus plays a key role in the temperature structure of the Earth's atmosphere. Without the filtering action of the ozone layer, more of the Sun's UV-B radiation would penetrate the atmosphere and would reach the Earth's surface. Many experimental studies of plants and animals and clinical studies of humans have shown the harmful effects of excessive exposure to UV-B radiation leading to skin cancer, eye damage and aging.

At the Earth's surface, ozone comes into direct contact with life-forms and displays its destructive side (hence, it is often called "bad ozone"). Because ozone reacts strongly with other molecules, high levels of ozone are toxic to living systems. Several studies have documented the harmful effects of ozone on crop production, forest growth, and human health. The substantial negative effects of surface-level tropospheric ozone from this direct toxicity contrast with the benefits of the additional filtering of UV-B radiation that it provides.

Depletion of the Ozone Layer



Ozone depletion is the term commonly used to describe the thinning of the ozone layer in the stratosphere. Human activity is the major factor in tipping that natural balance, mostly from releasing artificial chemicals, known as ozone-depleting substances (ODS), to the atmosphere. These are stable substances that do not break down in the lower atmosphere and contain either/both chlorine and/or bromine.

The theory about ozone depletion was first put forward in 1974 by American scientists Mario Molina and F. Sherwood Rowland. They were concerned about the impact of CFCs on the ozone layer. Their hypothesis was met with a great deal of skepticism, but scientific work over the next 20 years proved them correct and prompted almost every country in the world to action. In 1995, Molina and Rowland were given a Nobel Prize in Chemistry, along with a third ozone researcher, Paul Crutzen from the Netherlands.

Ozone-depleting substances containing chlorine include chlorofluorocarbons (CFCs), carbon tetrachloride, methyl chloroform and hydrochlorofluorocarbons (HCFCs). Halons, methyl bromide and hydrobromofluorocarbons (HBFCs) are ODSs that contain bromine.

The best-known and most abundant of the ODS are the CFCs which are found in aerosol cans, air conditions and refrigerants. A single atom of chlorine from a CFC can destroy 100,000 or more molecules of ozone. Ozone depletion only stops when the chlorine randomly reacts with another molecule to form a long-lived, stable substance. At that point it is no longer free to react with ozone.

Status of Ozone Depletion

The ozone layer over southern Canada has thinned by an average of about 7% since the 1980s. In the late 1990s, average ozone depletion in the summer over Canada was between 3% and 7%. Ozone depletion in Canada is usually greatest in the late winter and early spring. In 1993, for example, average ozone values over Canada were 14% below normal from January to April.

In their assessment of ozone depletion in 2006, the Scientific Assessment Panel, a group of experts established under the Montreal Protocol, made the following key findings:

1. The total abundances of human-made ozone-depleting gases in the troposphere continue to decline from the peak values reached in the 1992-1994 time period.
2. The total abundances of human-made ozone-depleting gases in the stratosphere show a downward trend from their peak values of the late 1990s.
3. Large Antarctic ozone holes continue to occur. The severity of Antarctic ozone depletion has not continued to increase since the late 1990s and, since 2000, ozone levels have been higher than in some preceding years.
4. Arctic ozone depletion shows large year-to-year variability, driven by meteorological conditions. Over the past four decades, these conditions contributed to severe ozone depletion.
5. The decline in stratospheric ozone over mid-latitude (between 60°S and 60°N) seen in the 1990s has not continued.

Recovery of the Ozone Layer

No one knows for certain how much more ozone depletion will occur. There is a substantial time lag between the time when ODS emissions begin to decline and the point at which the ozone layer begins to recover. It takes years for CFCs and other ozone-depleting compounds to reach the stratosphere. Many of them can persist in the stratosphere for centuries; some have life spans of 25 to 400 years. Almost all of the CFCs and halons ever released are still in the atmosphere and will continue to destroy ozone for many years to come.

In spite of these uncertainties and substantial time lag, the natural balance between ozone creation and destruction can be restored if concentrations of ozone-destroying chemicals are reduced. However, this might require the complete elimination of ozone-destroying chemicals. In addition, there is some concern that the increase in greenhouse gas concentrations may result in delayed ozone layer recovery. Scientists estimate that they will not be able to measure any recovery until 2030.

QUESTIONS

1. Differentiate ozone's role in the stratosphere and the troposphere. **[4 marks]**

2. "Ozone is like the Earth's natural sunscreen". Explain this statement. **[3 marks]**

3. Explain how CFCs deplete the ozone layer. **[6 marks]**

4. List two health effects of ozone depletion. **[2 marks]**

5. List two environmental effects of ozone depletion. **[2 marks]**

6. Based on the findings from the Scientific Assessment Panel, is the ozone recovering? Justify your answer. **[3 marks]**

7. Suggest three ways to reduce ozone-destroying chemicals. **[3 marks]**

8. Suggest three ways to protect yourself from harmful UV radiation. **[3 marks]**