OZONE DEPLETION

Ozone depletion describes two distinct but related phenomena observed since the late 1970s: a steady decline of about 4% per decade in the total volume of ozone in the ozone layer, and a much larger springtime decrease in stratospheric ozone over Earth's polar regions. Note that the Antarctic would be in darkness (no sunshine) for the winter months, sunshine returning in springtime (September). The latter phenomenon is referred to as the ozone hole.

The most important process in depletion is catalytic destruction of ozone by atomic halogens. The main source of these halogen atoms in the stratosphere is photodissociation of man-made halocarbon refrigerants, solvents, propellants, and foam-blowing agents (CFCs, HCFCs, freons, halons), substances that are referred to as ozone-depleting substances (ODS).

In the simplest example of such a cycle, a chlorine atom reacts with an ozone molecule, taking an oxygen atom with it (forming ClO) and leaving a normal oxygen molecule. The chlorine monoxide (ClO) produced can react with a second molecule of ozone to yield another chlorine atom and two molecules of oxygen. These gas-phase reactions can be written such that in the first step a chlorine atom changes an ozone molecule to ordinary oxygen:

$$Cl^{\cdot} + O_3 \rightarrow ClO + O_2$$

The ClO generated can then destroy a second ozone molecule and recreate the original chlorine atom, which can repeat the first reaction and continue a cycle to destroy ozone.

$$ClO + O_3 \rightarrow Cl^{\cdot} + 2\ O_2$$

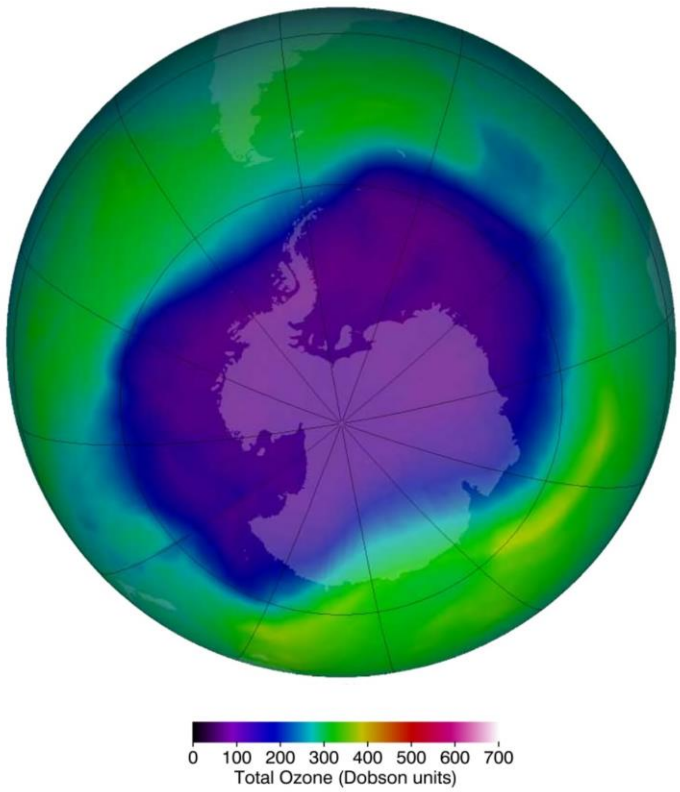
In theory, a single chlorine atom could keep on destroying ozone (acting as a catalyst) for up to two years (the time scale for transport back down to the troposphere) were it not for reactions that remove Cl by forming reservoir species such as hydrogen chloride (HCl). In practise, the average chlorine atom reacts with 100,000 ozone molecules before it is removed from the catalytic cycle.

On a per atom basis, bromine is even more efficient than chlorine at destroying ozone, but at present there is much less bromine in the atmosphere. Both chlorine and bromine significantly contribute to the overall depletion of ozone.

The Montreal Protocol on Substances that Deplete the Ozone Layer (a protocol to the Vienna Convention for the Protection of the Ozone Layer) is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion. It was agreed on in 1987, and entered into force on January 1, 1989, with numerous revisions since then.

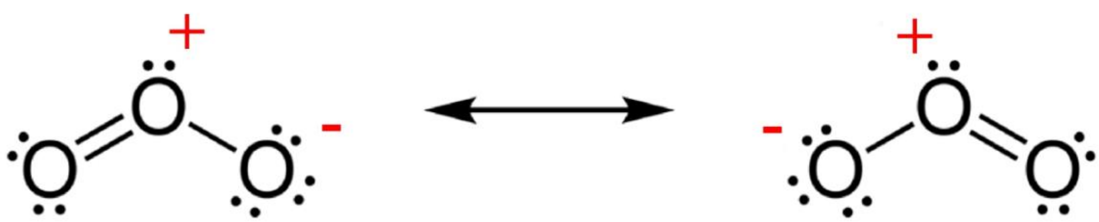
The bans on the production of CFCs, halons, and other ozone-depleting chemicals such as carbon tetrachloride and trichloroethane have led to the expectation of a recovery of the ozone layer to 1980 values somewhere between 2050 and 2070. This was the estimate given in a summary document of the Scientific Assessment of the Ozone Depletion 2014 published by the UN Environment Programme (UNEP) and the UN World Meterological Organization (WMO).

Among the key findings of the report were that the authors noted that what happens after 2050 will then largely depend on concentrations of CO_2, methane and nitrous oxide - the three main long-lived greenhouse gases in the atmosphere.



NASA view of the largest ozone hole observed above the Antarctic on 24 Sep 2006.

Ozone is much less stable than the diatomic allotrope O_2, breaking down in the lower atmosphere to normal dioxygen. The O - O distances in O_3 are 127.2 pm and the O - O - O angle is 116.78°. The bonding can be expressed as a resonance hybrid with a single bond on one side and double bond on the other producing an overall average bond order of 1.5 for each side.



Ozone is a powerful oxidant (far more so than dioxygen) and has many industrial and consumer applications related to oxidation. This same high oxidizing potential, however, causes ozone to damage mucous and respiratory tissues in animals, and also tissues in plants, above concentrations of about 100 ppb. This makes ozone a potent respiratory hazard and pollutant near ground level.

Ozone oxidizes nitric oxide to nitrogen dioxide:

$$NO + O_3 \rightarrow NO_2 + O_2$$

This reaction is accompanied by chemiluminescence. The NO_2 can be further oxidized:

$$NO_2 + O_3 \rightarrow NO_3 + O_2$$

The NO_3 formed can react with NO_2 to form N_2O_5.

Ozone does not react with ammonium salts, but it oxidizes ammonia to ammonium nitrate:

$$2\ NH_3 + 4\ O_3 \rightarrow NH_4NO_3 + 4\ O_2 + H_2O$$

Ozone reacts with carbon to form carbon dioxide, even at room temperature:

$$C + 2\ O_3 \rightarrow CO_2 + 2\ O_2$$

Source :

http://wwwchem.uwimona.edu.jm:1104/courses/CHEM1902/IC10K_MG_oxygen.html