The Ozone Hole Explained

This simple guide explains the ozone hole using information primarily from mainstream sources which support the thesis that chlorofluorocarbons are the primary cause for the depletion of ozone in the upper atmosphere.

What is ozone?

Ozone is simply another term for trioxygen or O_3.

https://en.wikipedia.org/wiki/Ozone#Location_and_production

Why do we need ozone?

We need Ozone to filter out ultraviolet light from sunlight.

Ozone in the ozone layer filters out sunlight wavelengths from about 200 nm UV rays to 315 nm, with ozone peak absorption at about 250 nm. This ozone UV absorption is important to life, since it extends the absorption of UV by ordinary oxygen and nitrogen in air (which absorb all wavelengths < 200 nm) through the lower UV-C (200–280 nm) and the entire UV-B band (280–315 nm). The small unabsorbed part that remains of UV-B after passage through ozone causes sunburn in humans, and direct DNA damage in living tissues in both plants and animals.

https://en.wikipedia.org/wiki/Ozone#Location_and_production

Where does Ozone come from and where does it go?

It is mostly produced from short-wave ultraviolet rays between 240 and 160 nm. The process of ozone creation and destruction is called the Chapman cycle and starts with the photolysis of molecular oxygen

$$O_2 + \text{ultraviolet light} \rightarrow O + O$$

followed by reaction of the oxygen atom with another molecule of oxygen to form ozone.

$$O + O_2 \rightarrow O_3$$

The highest levels of ozone in the atmosphere are in the stratosphere, in a region also known as the ozone layer between about 10 km and 50 km above the surface. However, even in this "layer", the ozone concentrations are only two to eight parts per million, so most of the oxygen there is dioxygen, O_2, at about 210,000 parts per million by volume.

https://en.wikipedia.org/wiki/Ozone#Location_and_production

The total mass of ozone produced per day over the globe is about 400 million metric tons. The global mass of ozone is relatively constant at about 3 billion metric tons, meaning the Sun produces about 12% of the ozone layer each day

https://en.wikipedia.org/wiki/Ozone%E2%80%93oxygen_cycle

Ozone is a very reactive and also unstable molecule. It reacts with free radicals in the atmosphere and reverts then back to regular O_2.

The oxygen atoms produced in the photolysis of ozone then react back with other oxygen molecule as in the previous step to form more ozone. In the clear atmosphere, with only nitrogen and oxygen, ozone can react with the atomic oxygen to form two molecules of O_2

$$O_3 + O \rightarrow 2\ O_2$$

An estimate of the rate of this termination step to the cycling of atomic oxygen back to ozone can be found simply by taking the ratios of the concentration of O_2 *to* O_3.

https://en.wikipedia.org/wiki/Ozone#Location_and_production

There are some chemicals that have an influence on this reaction.

The termination reaction is catalysed by the presence of certain free radicals, of which the most important are hydroxyl (OH), nitric oxide (NO) and atomic chlorine (Cl) and bromine (Br).

https://en.wikipedia.org/wiki/Ozone#Location_and_production

How does chlorine enter into the atmosphere?

Most chlorine (around 600 million tons) evaporates from sea water and gets to the stratosphere through thunderstorms, hurricanes, etc. After that come volcanoes and forest fires. Meanwhile 750.000 tons of chlorine enter the atmosphere in the form of chlorofluorocarbons.

ISBN 978-0-06-097490-9.

What are chlorofluorocarbons?

Chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are fully or partly halogenated paraffin hydrocarbons that contain only carbon (C), hydrogen (H), chlorine (Cl), and fluorine (F), produced as volatile derivative of methane, ethane, and propane. They are also commonly known by the DuPont brand name Freon.

Every permutation of fluorine, chlorine and hydrogen based on methane and ethane has been examined and most have been commercialized. CFCs and HCFCs are used in a variety of applications because of their low toxicity, reactivity and flammability. Uses include refrigerants, blowing agents, propellants in medicinal applications and degreasing solvents.

https://en.wikipedia.org/wiki/Chlorofluorocarbon#Commercial_development_and_use

Do chlorofluorocarbons react with ozone?

CFCs and HCFCs have no direct contact with ozone because they have molecular weights which are about four times greater that the principal components of the Earth's atmosphere, nitrogen and oxygen.

Any gas that is four times heavier than air, such as CFCs, can do only one thing: sink. It is actually possible to pour CFCs from a container into another container beneath it.

https://www.americanthinker.com/blog/2019/10/the_cfc_ban_has_nothing_to_do_with_the_closing_of_the_ozone_hole.html#ixzz6C5VygKqs

CFCs and HCFCs also do not react with other chemicals in general and are very stable molecules. This is precisely the reason for their low toxicity and flammability. It is however often claimed that CFCs and HCFCs decompose under the influence of light.

The most important reaction of the CFCs is the photo-induced scission of a C-Cl bond:

$CCl_3F \rightarrow CCl_2F\cdot + Cl\cdot$

https://en.wikipedia.org/wiki/Chlorofluorocarbon#Commercial_development_and_use

The chloride that supposedly emerges from that reaction then further reacts with the ozone in the upper atmosphere. This theory is however most likely false due to the fact that photo-induced scission has never been observed under naturally occurring conditions. It has been neither observed to occur in the real world nor under laboratory conditions simulating nature. The previously inserted passage from Wikipedia also lacks a citation.

This theory also assumes that the chlorine is able to reach the upper atmosphere. However free chlorine from any source is too reactive to exist in the atmosphere. It is also twice as heavy as air and thus also sinks to the ground reacting before ever making contact with stratospheric ozone.

https://en.wikipedia.org/wiki/Chlorine

Chlorine is too reactive to occur as the free element in nature but is very abundant in the form of its chloride salts.

https://en.wikipedia.org/wiki/Chlorine

Most CFC and HCFC molecules have in fact never been broken down and still exist in our atmosphere without ever having reacted with anything.

https://www.nodc.noaa.gov/ocads/oceans/CFC_ATM_Hist2015.html

What is the ozone hole and where does it come from?

An ozone hole is a geographical area with a reduced concentration of ozone in the atmosphere. There have always been two big ozone holes on this planet. There is one at the north pole and another one at the south pole.

https://airnow.gov/index.cfm?action=ozone_facts.index

There is much less ozone created at the poles due to the relative lack of sunlight in these areas. Ozone is also too unstable to reach the poles from other parts of the earth before breaking down. Because of this each ozone hole grows and shrinks with each respective summer and winter.

https://airnow.gov/index.cfm?action=ozone_facts.index
https://en.wikipedia.org/wiki/Ozone#Location_and_production

Are there places with very high concentrations of ozone?

Ozone has many industrial uses and is also created as a byproduct from the use of electrical devices. In many cities and industrialized areas ozone has reached concentrations that are considered dangerous to human health.

Low level ozone, or tropospheric ozone, is the most concerning type of ozone pollution in urban areas and is increasing in general. Ozone pollution in urban areas affects denser populations, and is worsened by high populations of vehicles, which emit pollutants NO_2 and VOCs, the main contributors to problematic ozone levels. Ozone pollution in urban areas is especially concerning with increasing temperatures, raising heat-related mortality during heat waves. During heat waves in urban areas, ground level ozone pollution can be 20% higher than usual Ozone pollution in urban areas reaches higher levels of exceedance in the summer and autumn, which may be explained by weather patterns and traffic patterns

https://en.wikipedia.org/wiki/Ozone#Ozone_in_Earth%27s_atmosphere

This situation also exists due to the aforementioned inability of chlorofluorocarbons to alleviate the problem. This is also despite the fact that these chlorofluorocarbons are primarily produced in those affected areas.

Why were chlorofluorocarbons banned?

Chlorofluorocarbons were made responsible for the depletion of ozone in the atmosphere.

In the second half of the 20th Century the amount of ozone in the stratosphere was discovered to be declining, mostly because of increasing concentrations of chlorofluorocarbons (CFC) and similar chlorinated and brominated organic molecules. The concern over the health effects of the decline led to the 1987 Montreal Protocol, the ban on the production of many ozone depleting chemicals and in the first and second decade of the 21st Century the beginning of the recovery of stratospheric ozone concentrations.

https://en.wikipedia.org/wiki/Ozone_depletion#Ozone_hole_and_its_causes

Does this make sence to you?

What happened to DuPont?

Kinetic Chemicals was the brand within DuPont that produced Freon.

In 1930, General Motors and DuPont formed Kinetic Chemicals to produce Freon. Their product was dichlorodifluoromethane and is now designated "Freon-12", "R-12", or "CFC-12".

https://en.wikipedia.org/wiki/Freon

DuPont originally made then monopolistic profits from the sales of Freon due to the fact that it owned the patents to it. When the patent ran out it supported the ban of Freon to prevent competitors to produce it,

Together with other companies in the chemical industry, DuPont contributed some $3-5 million towards a multi year research program. While this research was undertaken, DuPont sought to persuade members of Congress and the regulatory agencies that it was safe to delay any regulatory actions for 2-3 years until the scientific uncertainties could be resolved (Dotto and Schiff 1978). At the same time, DuPont officials pledged that they would cease production of the suspect chemical`if credible research demonstrated a significant threat to health or the environment'(Lubkin 1975).

By the late 1970s, DuPont scientists had identified an umber of replacements for the then existing CFCs, but they all proved either too toxic or too costly. As long as existing chemicals were available, customers would resist as witch to higher priced alternatives.

DuPont's decision to support a CFC ban was based on the belief that it could obtain a significant competitive advantage through the sales of new chemical substitutes because of its proven research and development capabilities to develop chemicals, its (limited) progress already made in developing substitutes, and the potential for higher profits in selling new specialty chemicals. Although some observers have speculated on the relevance of patent expiration to the decision to support a CFC ban, DuPont officials reported no such influence.

DuPont, the world's dominant CFC producer, played a key role in the development of the Montreal Protocol on Ozone Depleting Substances.

https://onlinelibrary.wiley.com/doi/epdf/10.1002/%28SICI%291099-0836%28199711%296%3A5%3C276%3A%3AAID-BSE123%3E3.0.CO%3B2-A

After the ban on chlorofluorocarbons DuPont produced alternative chemicals for which only DuPont had the patents.

The new chemical substitutes were projected to sell for 5-10 times the costs of CFC 11 and 12.

https://onlinelibrary.wiley.com/doi/epdf/10.1002/%28SICI%291099-0836%28199711%296%3A5%3C276%3A%3AAID-BSE123%3E3.0.CO%3B2-A

Data that the current replacement substances are an actual environmental improvement over Freon does not exist.