/ /202 Day:

Environmental Science 2022

Q#07

What is ozone layer? Explain it depletion resulting from the atmospheric NO, H, OH, and Cl:

Ozone layer: Nature's Protective Shield

The ozone layer is a region of Earth's stratosphere, approximately 10-30km (6-9 miles) above the Earth's surface, where the concentration of ozone (O_3) molecules is relatively high. It plays a crucial role in protecting life on Earth by absorbing and blocking a significant portion of the sun's harmful ultra-violet (UV) radiations, particularly the most dangerous UV-B - and UV-C rays. Without ozone layer, these harmful rays would penetrate the Earth's surface and have detrimental effects on living organisms, including causing skin cancer, cataracts, and various other health and environmental problems.

Formation of Ozone Layer:

Ozone chemically, forms when

UV rays hits on stratosphere oxygen molecules dissociate into atmoic oxygen. And this atomic oxygen quickly combines with other oxygen molecules to form ozone.

$$O_2 + \text{Sunlight} \rightarrow O + O$$

$$O + O_2 \rightarrow O_3$$

- Importance of Ozone layer:-

i- Ultraviolet radiations and life on Earth:

The Ozone layer acts as a natural shield absorbing and deflecting ~~into~~ a significant portion of the sun's harmful UV radiation. Ultraviolet radiation is categorized into three type: **UVA, UVB and UVC**. While UVA and UVB rays reach the Earth's surface in varying degrees, UVC is almost entirely absorbed by the ozone layer and other atmospheric constituents. In this way ozone protect humans from different diseases like skin cancer, and also protect the damaging of aquatic ecosystem.

ii- Protection of Ecosystems:

Apart from safeguarding human health, the Ozone layer also plays a pivotal role in preserving terrestrial and aquatic ecosystems. It prevents the harmful effects of UV radiations on plant life and marine ecosystems, ultimately helping to maintain biodiversity.

One prominent example is the adverse impact of UV radiation on **Coral reefs.** Increased ultraviolet radiation's exposure can weaken coral's defenses against disease, leading to coral bleaching and the degradation of coral reefs.

Ozone depletion Mechanisms:

Ozone layer depletion, is simply the wearing out (reduction) of the amount of ozone in the stratosphere. The depletion of the ozone layer is primarily caused by the release of certain human-made chemicals known as Ozone-depleting substances **(ODS)**, such as chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform,

including NO, H, OH. When these substances are released into the atmosphere, they eventually reach the stratosphere. There, they are broken down by solar UV radiations, releasing chlorine (Cl) and bromin (Br) atoms. These molecules (Cl, Br) are highly reactive and participate in ozone-depleting cycles.

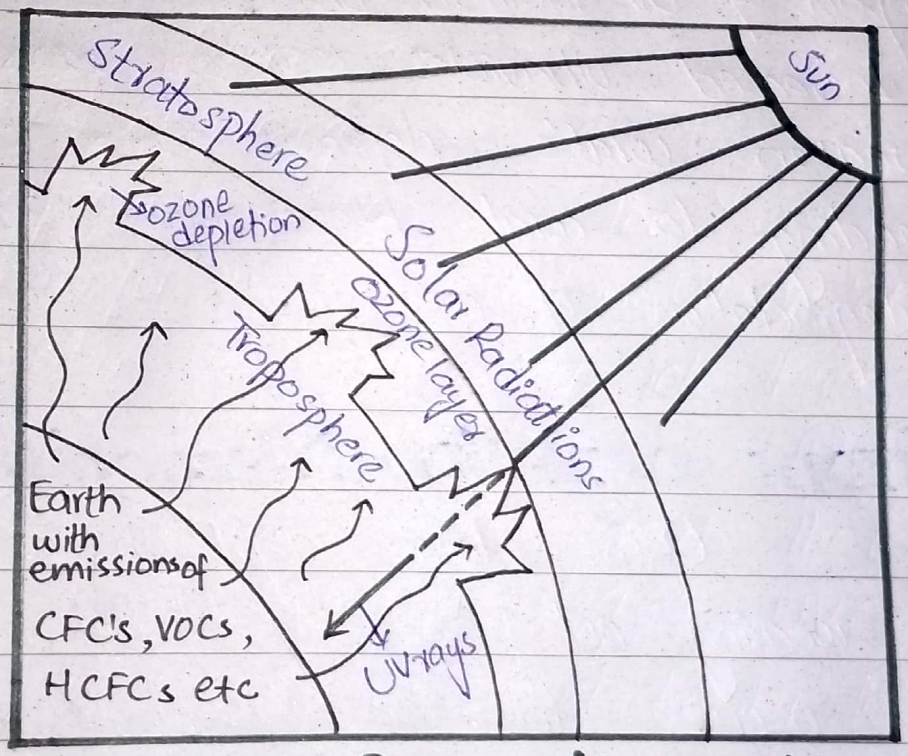

Fig:- Ozone layer depletion

1- Nitric Oxide: (NO)

Nitric oxide (NO) is a crucial contributor to ozone depletion. It is primarily released into the atmosphere

through human activities such as combustion processes, including those in vehicles and industrial facilities.

Mechanism:

NO participates in a complex cycle of reactions in the stratosphere. It reacts with ozone (O_3), leading to the formation of Nitrogen dioxide (NO_2) and oxygen (O_2).

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

Subsequently, NO_2 can further interact with solar UV radiations, leading to the release of oxygen atoms:

$$NO_2 + UV \rightarrow NO + O$$

The free oxygen atom(O) then react with Ozone (O_3).

$$O + O_3 \rightarrow 2O_2$$

This process effectively reduces the concentration of Ozone in the stratosphere.

Increased NO emissions from the burning of fossil fuels have ~~controlled~~ contributed to the depletion of the ozone layer. **For instance,** the use of nitrogen-containing fertilizers in

agriculture can lead to the release of NOx (Nitroge oxides), exacerbating ozone layer depletion.

2- Hydrogen (H):

Hydrogen(H) is another atmospheric component that can contribute to ozone depletion, although its impacts are relatively minor as compared to other factors.

Mechanism:

Hydrogen atom can be released into the stratosphere through various natural processes, such as methane (CH_4) oxidation. Once in the stratosphere, hydrogen can participate in reactions that lead to ozone destruction.

$$H + O_3 \rightarrow OH + O_2$$

OH (hydroxyl radical) is formed and it can subsequently react with ozone, further reducing its concentration.

$$OH + O_3 \rightarrow HO_2 + O_2$$

$$HO_2 + O \rightarrow OH + O_2$$

While overall impacts of hydrogen on ozone depletion is limited, it remains a part of the complex chemistry involved.

Hydrogen contribution to the ozone depletion is [illegible], it remains a part of the complex chemistry involved. primarily from natural sources. However, human activities that release methane, a precursor to hydrogen in the stratosphere, can indirectly influence this process.

3- Hydroxyl Radical(OH):

The hydroxyl radical(OH) is a highly reactive molecule in the stratosphere and can contribute to ozone depletion.

Mechanism:

OH is formed through a series of reactions that (results to the depletion of ozone) involves water vapours (H_2O) and O_2 in the stratosphere:

$$H_2O + O \rightarrow 2OH$$

Once formed, OH can participate in a chain reaction that results in the depletion of ozone:

$$OH + O_3 \rightarrow HO_2 + O_2$$

$$HO_2 + O \rightarrow OH + O_2$$

This process is known as catalytic ozone destruction cycle, can lead to

the loss of ozone molecules in the stratosphere.

While OH is primarily formed through natural processes, the release of greenhouse gases, particularly methane can indirectly influence the concentration of OH in the stratosphere and, therefore, contribute to ozone depletion.

4- Chlorine (Cl):

Chlorine is perhaps the most notorious contributor to ozone depletion, primarily due to human-made CFCs and related compounds.

Mechanism:

CFCs, once released into atmosphere, can eventually reach the stratosphere. There, they are broken down by solar UV radiations, releasing chlorine atoms:

$$CFC + UV \longrightarrow Cl + CFCl_2$$

Chlorine atoms are highly reactive and can catalyze the destruction of ozone through a series of reactions:

$$Cl + O_3 \longrightarrow ClO + O_2$$

$$ClO + O \longrightarrow Cl + O_2$$

The chlorine atom is regenerated

in the process, allowing it to continue depleting ozone molecules.

The use of CFCs in refrigeration, air conditioning and aerosol propellants in the 20th century led to a significant depletion of the ozone layer. The discovery of the ozone hole over Antarctica in the 1980s highlighted the severe consequences of chlorine induced ozone depletion.