Chemistry of ozone layer depletion

Crop Diversification

- It refers to the raising of a number of crops in a given area at a given time(an agricuture year)
- It is opposite to crop specialization.
- It is an indicator of multiplication of crops.

Ozone layer and its depletion-

- "The **ozone layer** is a region in the earth's stratosphere that contains high concentrations of ozone and protects the earth from the harmful ultraviolet radiations of the sun."
- **Ozone layer depletion** is the gradual thinning of the earth's ozone layer in the upper atmosphere caused due to the release of chemical compounds containing gaseous bromine or chlorine from industries or other human activities."

Why is ozone necessary in stratosphere?

- The ozone layer exists at altitudes between about 10–50 km from Earth surface.
- The presence of ozone in stratosphere is essential because it absorbs the UV-B radiation (280–320 nm). UV-B radiation is absorbed only by O3 and by no other gas. It may be pointed that the UV-A (320 –400 nm) radiation are not absorbed by O3 . On the other hand UV-C (200–280 nm) radiation is absorbed by other gases as well as by O3 .
- Ozone also controls temperature profile of stratosphere. Any loss or depletion of ozone in stratosphere would lead to greater amounts of UV-B radiation reaching the Earth.
- This would create, among other problems, an increase in melanoma (skin cancer) in humans as these damage surface cells of animals and plants. Under such circumstances, the normal life cycles of animals and plants would be disturbed. The UV radiation may interrupt lower level of food chains also.

Ozone depleting substances-

The substances such as chlorofluorocarbons, halons, carbon tetrachloride, hydrofluorocarbons, etc. that are responsible for the depletion of ozone layer. Following is the list of some main ozone-depleting substances and the sources from where they are released:

Ozone-Depleting Substances	Sources
Chlorofluorocarbons (CFCs)	Refrigerators, air-conditioners, solvents, dry-cleaning agents, etc.
Halons	Fire-extinguishers
Carbon tetrachloride	Fire extinguishers, solvents
Methyl chloroform	Adhesives, aerosols
Hydrofluorocarbons	Solvent cleaning, fire extinguishers, solvent cleaning

The Chapman Cycle-

- The stratosphere is in a constant cycle with oxygen molecules and their interaction with ultraviolet rays. This process is considered a cycle because of its constant conversion between different molecules of oxygen.
- The ozone layer is created when ultraviolet rays react with oxygen molecules (O_2) to create ozone (O_3) and atomic oxygen (O). This process is called the ***Chapman cycle*.**
- It is important to keep in mind that ozone is constantly being created and destroyed by the Chapman cycle and because of this, the thickness the ozone layer at any particular time can vary greatly.
- It is also important to know that O_2 is constantly being introduced into the atmosphere through photosynthesis, so the ozone layer has the capability of regenerating itself.

The Chapman cycle-

Step 1: An oxygen molecules is photolyzed by solar radiation, creating two oxygen radicals:

- $h\nu + O_2 \rightarrow 2O.$

Step 2: Oxygen radicals then react with molecular oxygen to produce ozone:

- $O_2 + O. \rightarrow O_3$

Step 3: Ozone then reacts with an additional oxygen radical to form molecular oxygen:

- $O_3 + O. \rightarrow 2O_2$

Step 4: Ozone can also be recycled into molecular oxygen by reacting with a photon

- $O_3 + h\nu \rightarrow O_2 + O.$

Chemistry of Ozone Depletion-

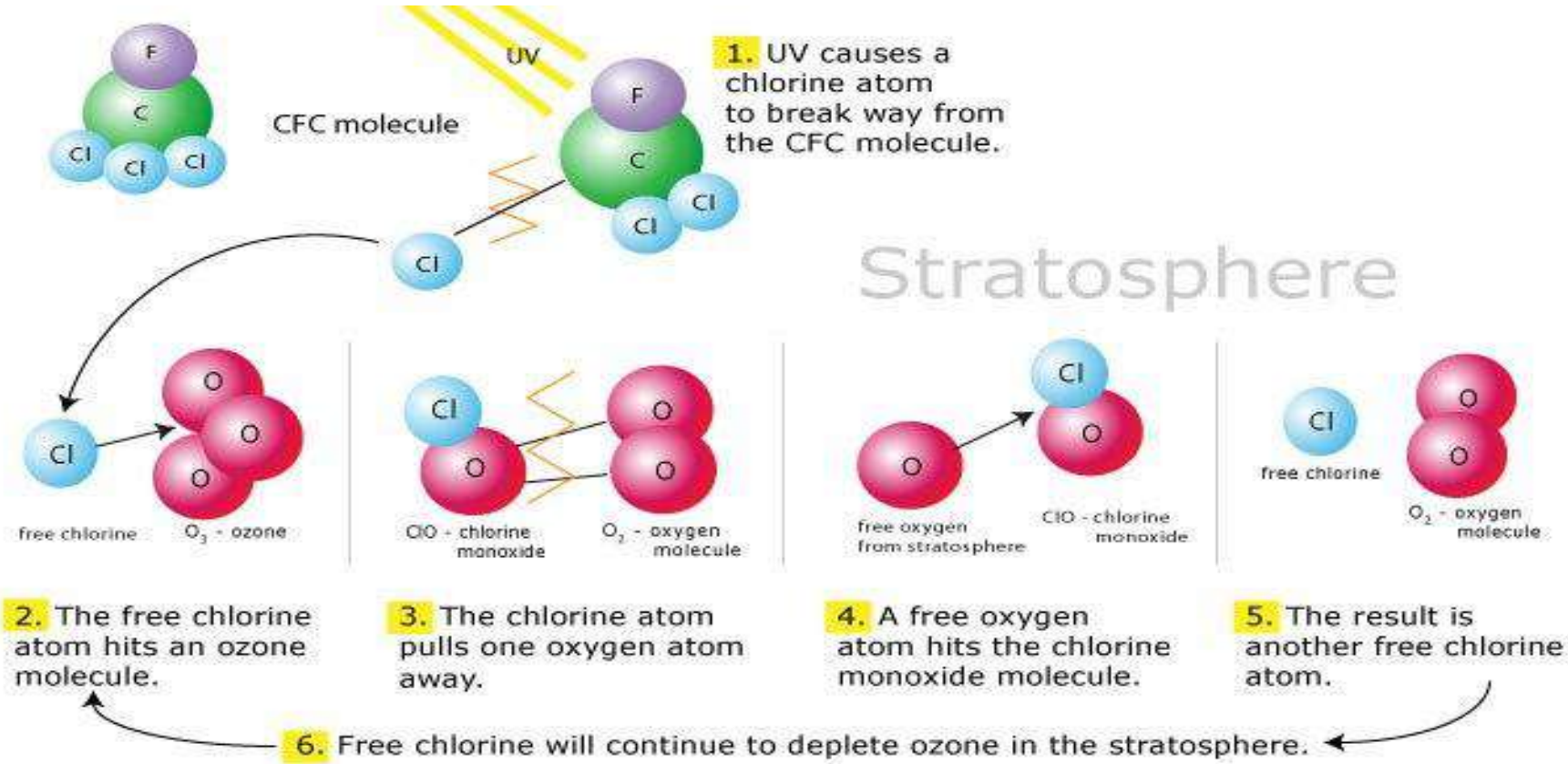
- CFC molecules are made up of chlorine, fluorine and carbon atoms and are extremely stable. This extreme stability allows CFC's to slowly make their way into the stratosphere.
- This prolonged life in the atmosphere allows them to reach great altitudes where photons are more energetic.
- When the CFC's come into contact with these high energy photons, their individual components are freed from the whole. The following reaction displays how Cl atoms have an ozone destroying cycle:

$$Cl + O_3 \rightarrow ClO + O_2 \quad \textbf{(step 1)}$$

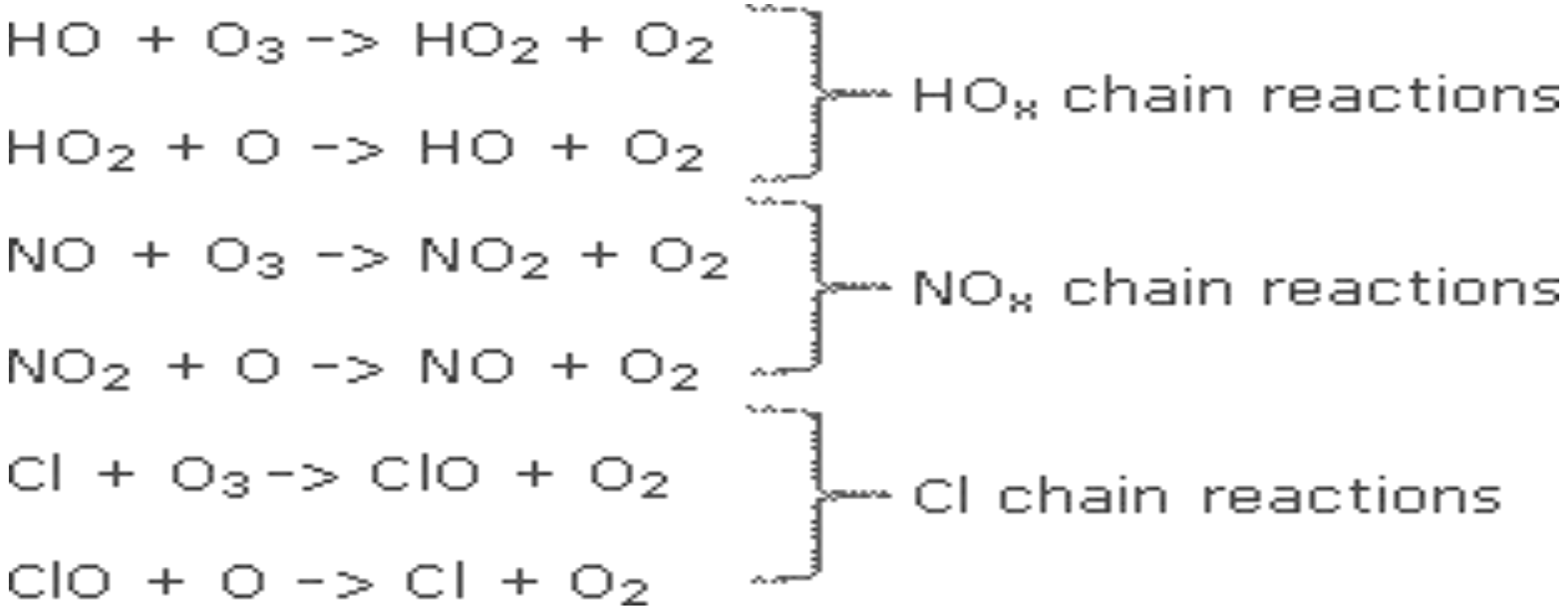
$$ClO + O. \rightarrow Cl + O_2 \quad \textbf{(step 2)}$$

$$O_3 + O. \rightarrow 2O_2 \quad \textbf{(overall reaction)}$$

Chemistry of Ozone Depletion-



Role of Hydrogen, NOx and Chlorine in Ozone depletion-



Role of Chlorine Compounds-

- Chlorine is able to destroy so much of the ozone because it acts as a catalyst.
- Chlorine initiates the breakdown of ozone and combines with a freed oxygen to create two oxygen molecules.
- After each reaction, chlorine begins the destructive cycle again with another ozone molecule.
- One chlorine atom can thereby destroy thousands of ozone molecules. Because ozone molecules are being broken down they are unable to absorb any ultraviolet light so we experience more intense UV radiation at the earths surface.

Antarctic Ozone Hole-

- Farman et al. (1985), whose group has been measuring stratospheric ozone at Antarctica for many years, found that the development of the ozone hole started with the appearance of the Sun over Antarctica after the long winter, and ozone reached a minimum around mid-October.
- Through measurement of total columnar ozone with the help of Dobson spectrophotometer, Farman et al. (1985) were able to show that the total ozone concentrations over the Antarctic region had been depleting during September-October, with subsequent recovery during the November- December, and this has been going on since 1979.

Control Strategies:

- Alarmed by the possible harmful effects of ozone depletion, at a historic meeting of several countries in Montreal in Sept. 16, decision was taken to phase out the use of CFCs, and freeze the consumption of halons at 1986 level.
- Montreal Protocol It is an international treaty on substances that deplete the ozone layer. It is designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion.
- Now, the CFCs are being replaced by HCFCs.

THANKYOU