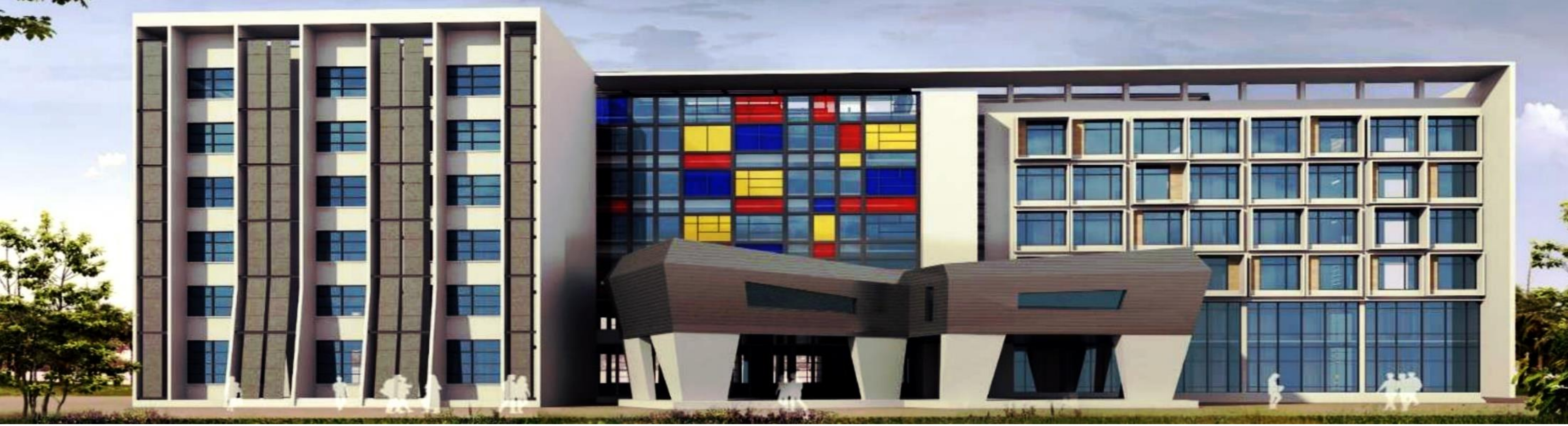


CY1018

भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

Department of Chemistry

Course Content

Know our environment (chemistry of lithosphere, energy balance, sustainability and recycle), Know about global warming (infrared absorption, molecular vibration, atmospheric window, residence time of greenhouse gases, evidences and effects of global warming)

Deeper analysis of atmospheric pollution (Chemistry of CO, NOx, VOCs, SO_2, Industrial smog, photochemical smog), Ozone depletion (production, catalytic destruction)

Organic Chemicals in the Environment, Insecticides, Pesticides, Herbicides and Insect Control, Soaps, Synthetic Surfactants, Polymers, and Haloorganics. Fate of organic/inorganic chemicals in natural and engineered systems (fate of polymers after use, detergents, synthetic surfactants insecticides, pesticides etc. after use)

Aspects of transformations in atmosphere (microbial degradation of organics-environmental degradation of polymers, atmospheric lifetime, toxicity). Green Chemistry and Industrial Ecology. **Future challenges (CO_2 sequestering, Nuclear energy)**. A project on environment related topic.

Catalytic destruction of Ozone

- Ozone is very reactive molecule and is termed a meta-stable molecule i.e., it decomposes slowly in contact with a molecule of another gas
- There are number of number of species react efficiently by abstracting an oxygen atom from the ozone molecule. Say "X" designates the reactive species. Thus, the reaction steps are

  i) $X + O_3 \longrightarrow XO + O_2$; ii) $XO + O \longrightarrow X + O_2$
- These are the additional steps for ozone destruction compare to the steps discussed earlier
- So, the sum of above two reactions is $O_3 + O \longrightarrow 2O_2$
- The overall reaction does not contain the X species, because X is not consumed in the reaction. It acts as a catalyst for the destruction of ozone
- "X" lowers the activation energy and atomic oxygen is required to regenerate X
- The catalytic species "X" can be:

i) Hydroxyl radical, ii) nitric oxide (NO), iii) Chlorine, and iv) bromine atoms

Catalytic destruction of Ozone

❖ Hydroxyl Radical Cycle

- Hydroxyl radical ($^{\bullet}OH$) can be produced by two different photochemical process. The first is hydrogen abstraction with either water or methane

  i) $O + H_2O \longrightarrow 2\,^{\bullet}OH$; ii) $O + CH_4 \longrightarrow {}^{\bullet}OH + {}^{\bullet}CH_3$

- The second is photolysis of water $H_2O + h\nu \longrightarrow H^{\bullet} + {}^{\bullet}OH$
- Hydroxyl radical is responsible for nearly one half of the total ozone destruction in the lower stratosphere

$$^{\bullet}OH + O_3 \longrightarrow {}^{\bullet}OOH + O_2$$

$$^{\bullet}OOH + O \longrightarrow {}^{\bullet}OH + O_2$$

Net reaction $O + O_3 \longrightarrow 2O_2$

One $^{\bullet}OH$ radical can have as many as 40 cycles i.e., 40 ozone molecule can decompose

Catalytic destruction of Ozone

❖ Nitric Oxide Cycle

- Auto mobiles and truck engines releases large quantities of nitric oxide (NO) into the troposphere
- Nitric oxide is converted to NO_2 and eventually to HNO_3 which fall down as rain fall before reaching to stratosphere
- N_2O is much less reactive than NO and reaches to stratosphere
- Above 30 km the N_2O can absorb high energy photons to produce molecular nitrogen and an excited oxygen atom (O*)

  i) $N_2O + h\nu \longrightarrow N_2 + O^*$

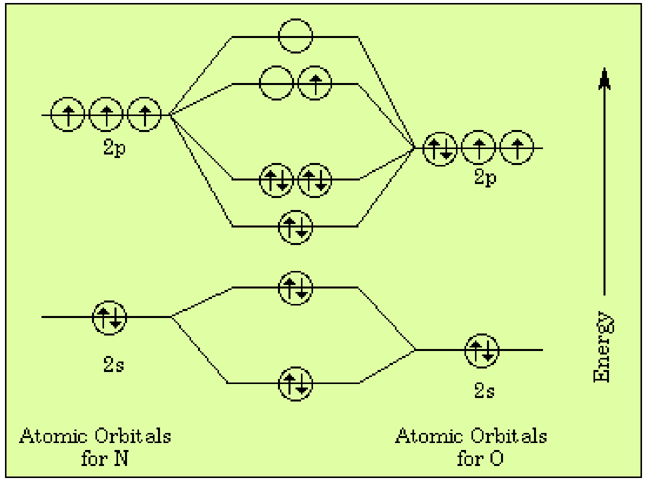
- Below 30 km in the stratosphere, the excited state oxygen reacts with the N_2O to produce NO

  ii) $N_2O + O^* \longrightarrow 2\,NO^\bullet$

- NO can act as X in the catalytic process

$$NO + O_3 \longrightarrow NO_2 + O_2$$
$$NO_2 + O \longrightarrow NO + O_2$$

$$\text{Net } O + O_3 \longrightarrow 2O_2$$



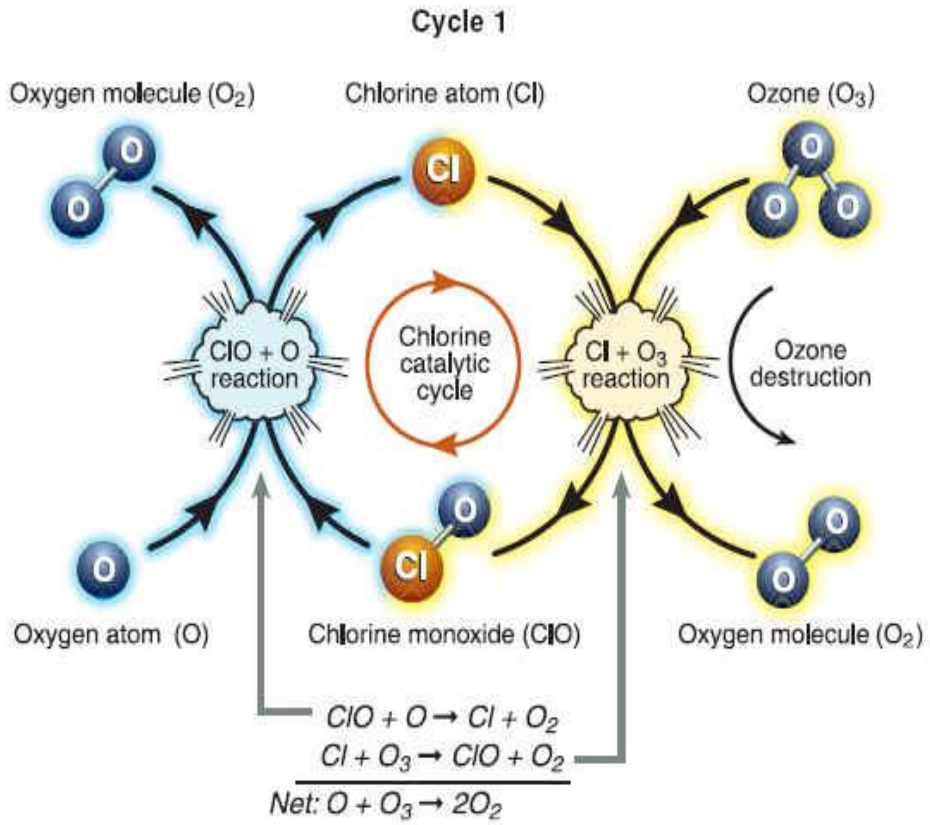
1 NO_x radical can catalyze the destruction of 10,000 ozone molecules

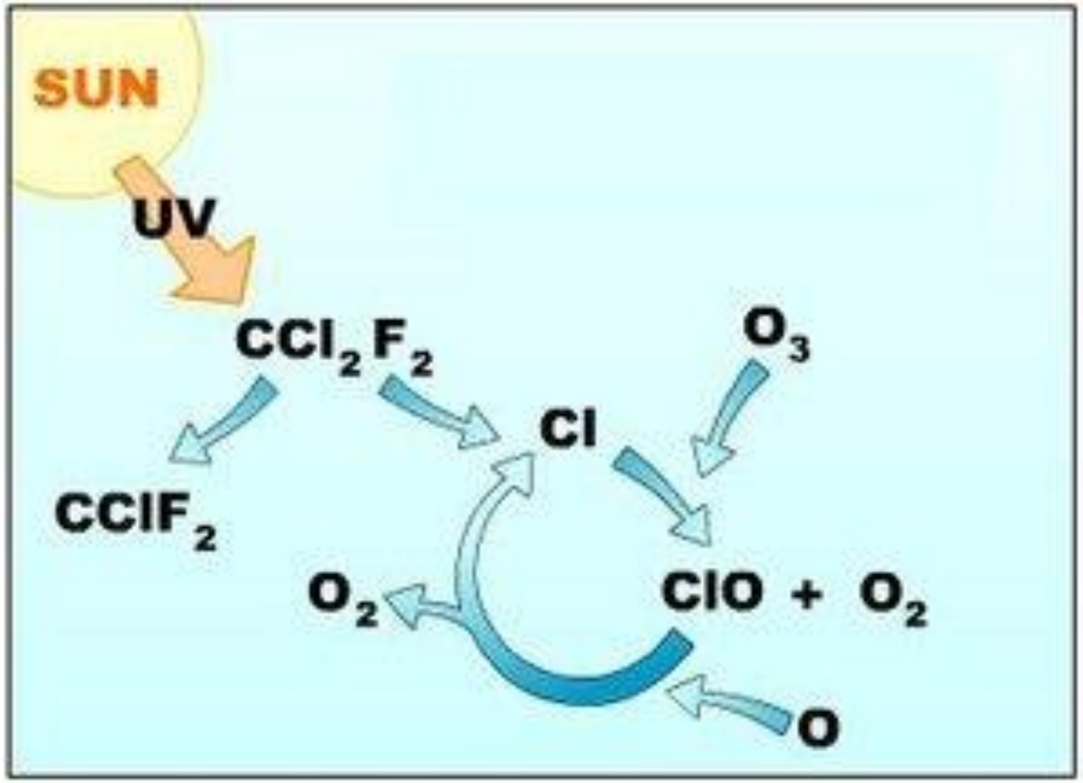
Catalytic destruction of Ozone

❖ The Chlorine Cycle

- The major sources of stratospheric chlorine and bromine have been the anthropogenic chlorofluoro carbons (CFCs) and bromine containing halons (haloalkanes)
- CFCs used as refrigerants, propellant for aerosol spray and solvents for cleaning electric circuit
- Halons are used in commercial fire extinguisher systems
- CFCs and halons are non toxic and nonflammable which make them superior to other gases that were used for the same application
- CFCs are so un-reactive, they don't break down when released and can persist in the troposphere for more than 100 years. Over time, air currents carry them into stratosphere
- In 1974, two chemists F. S. Rowland and Mario Molina predicted that when exposed to UV radiation in stratosphere, CFCs would break down to form chlorine radical ($Cl^{\bullet}$)
- Each chlorine radical involved in a chain reaction has the potential to destroy 100,000 molecules of ozone before winds carry it back to the troposphere
- Bromine containing compounds are more efficient to destroy the ozone

Catalytic destruction of Ozone





DESTRUCTION OF OZONE BY CFC

CO_2 sequestering

According to the **Intergovernmental Panel on Climate Change (IPCC)**, improved agricultural practices and forest-related mitigation activities can make a significant contribution to the removal of carbon dioxide from the atmosphere at relatively low cost.

To mitigate global warming

- Proposed new technologies of carbon sequestration

These technologies include a geoengineering proposal called **carbon capture and storage** **(CCS)**. In CCS processes, carbon dioxide is first separated from other gases contained in industrial emissions. It is then compressed and transported to a location that is isolated from the atmosphere for long-term storage.

- Although CCS typically refers to the capture of carbon dioxide directly at the source of emission before it can be released into the atmosphere, it may also include techniques such as the use of scrubbing towers and "artificial trees" to remove carbon dioxide from the surrounding air.

- There are many economic and technical challenges to implementing carbon capture and storage on a large scale.