Allotrope of O

O_2 – Diatomic Oxygen

O_3 – Ozone – Tri-atomic allotrope of Oxygen

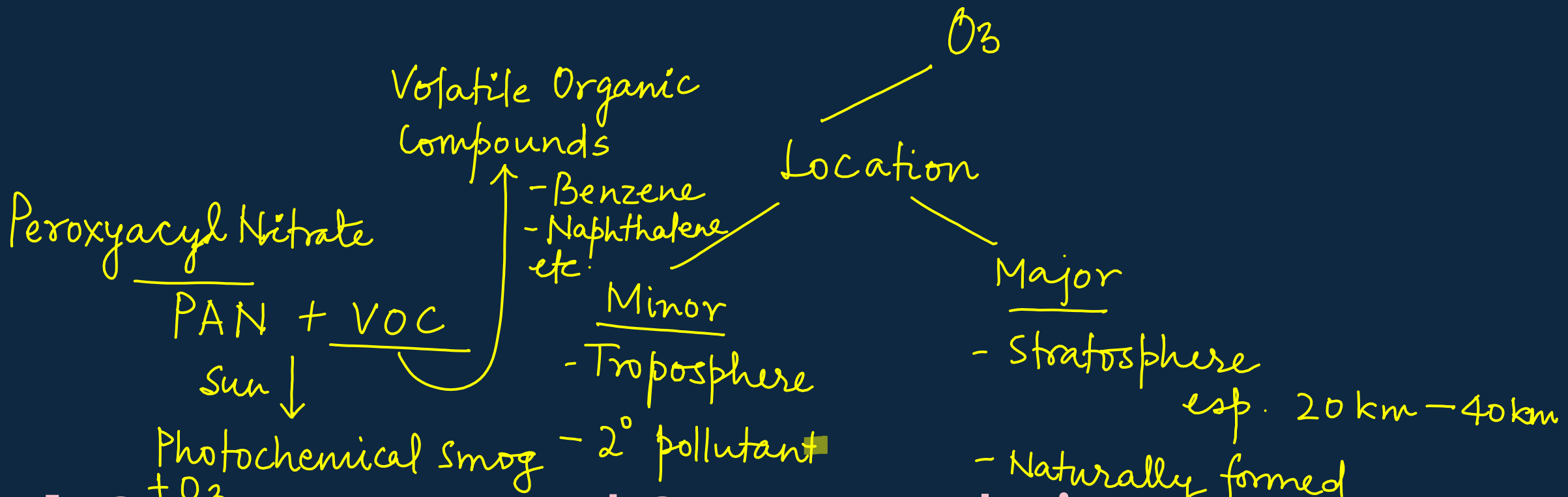
Ozone Layer and Acid Rain

Allotrope – Diff. elemental forms of the same element

↓

a substance made of a single element

- H_2
- Graphite, Diamond (C)
- N_2
- O_2, O_3 (O)



1. Ozone Layer and Ozone Depletion

1.1. Ozone Layer: Introduction and Need

Normal amount

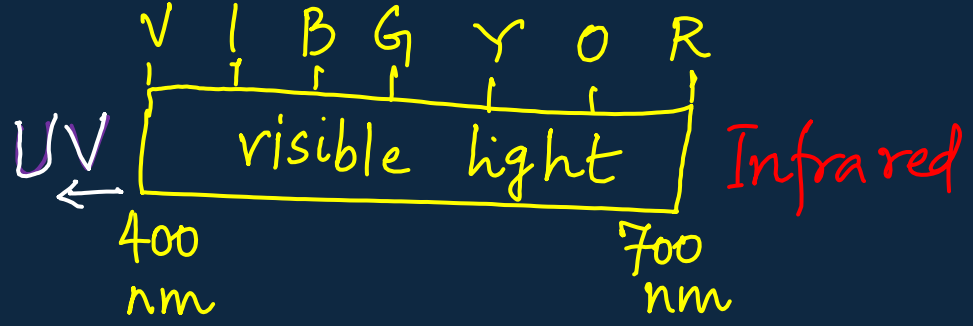
300 – 500 Dobson Unit

Less than 100 D.U. ⇓ Ozone hole

A unit to quantify stratospheric ozone.

- **Ozone (O3)** is an allotrope of oxygen.
- **90%** of atmospheric ozone is in the **stratosphere** (10 to 50 km above Earth), with the highest concentrations between 20 and 40 km. } Ozone Layer
- The **Ozone Layer** absorbs harmful **UV-B** and **UV-C** rays.

Discovered in 1913 by **Charles Fabry and Henri Buisson**; properties explored by **G.M.B. Dobson**.



1.2. Types of UV Rays

- **UVA (315–399 nm)**: Least harmful, causes skin aging and DNA damage; penetrates almost 100% through the ozone layer.
- **UVB (280–314 nm)**: Causes skin cancer, DNA damage, and impairs photosynthesis; 95% absorbed by the ozone layer.
- **UVC (100–279 nm)**: Most dangerous, causes severe burns; completely absorbed by the ozone layer.

✓ Higher energy ← UVB

✓ More harmful

✓ maximum energy ← UVC

✓ most harmful.

+ many cancers
+ kills microorganisms instantly – Germicidal Rays

1.3. Formation of Ozone Layer

Chapman's Process

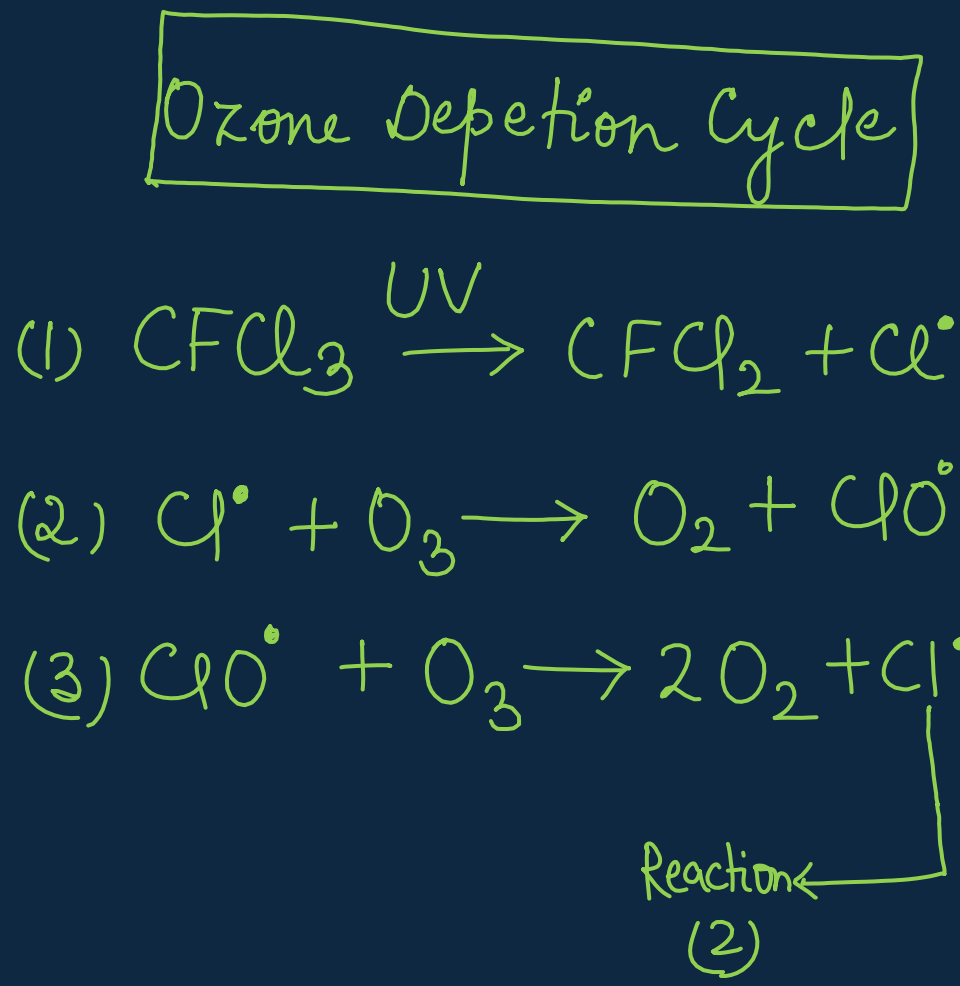
- Ozone forms when **ultraviolet radiation** splits an oxygen molecule (O2) into two oxygen atoms, which then combine with another oxygen molecule to form ozone (O3).

In Stratosphere

(1) $O_2 \xrightarrow{\text{UV-C}} O^{\cdot} + O^{\cdot}$

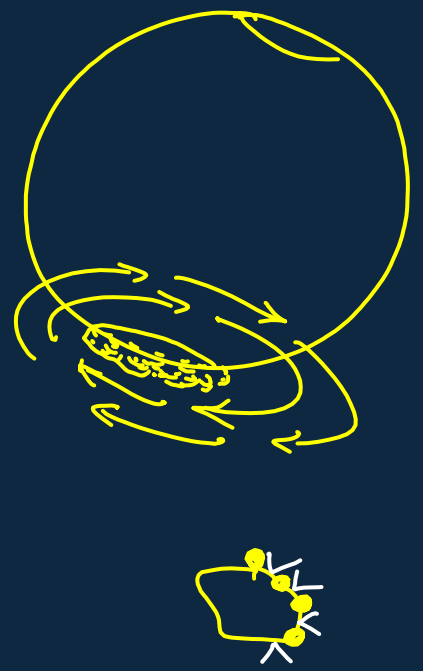
(2) $O_2 + O^{\cdot} \xrightarrow{\text{UV-B}} O_3$

1.4. Degradation of the Ozone Layer



- Ozone is destroyed by free radicals such as **hydroxyl (OH·)**, **nitric oxide (NO·)**, **chlorine (Cl·)**, and **bromine (Br·)**.
- **Chlorofluorocarbons (CFCs)** release Cl and Br atoms in the stratosphere, which catalyse the destruction of ozone.
- Each Cl/Br atom can destroy **100,000** ozone molecules before being removed by forming reservoir species like **hydrogen chloride (HCl)** and **chlorine nitrate (ClONO2)**.

1.5. Formation of Ozone Hole



- The **ozone ~~hole~~** depletion zone is a region over Antarctica with a total ozone of **220 Dobson Units** or lower. (O_3 Hole = 100 D.U. or lower)
- Strong westerly **circumpolar winds** and polar stratospheric clouds (PSC) below −80°C (−112°F) facilitate ozone destruction.
- Largest recorded ozone hole was in 2023, averaging **8.9 million square miles**.

1.6. Consequences of the Ozone Hole

- Increase in **UV-B radiation** leads to skin problems, immune system depression, and corneal cataracts.
- **Phytoplankton** die-off increases global warming.
- Changes in atmospheric circulation and increased greenhouse gas effects.

2. Efforts to Protect the Ozone Layer

2.1. Vienna Convention

- First international conference in 1985 addressing ozone layer depletion.
- Established the **Vienna Convention for the Protection of the Ozone Layer**, effective in 1988.

adopted in 1985

2.2. Montreal Protocol

- **Montreal Protocol** on Substances That Deplete the Ozone Layer, adopted in 1989.
- Aimed at phasing out **ozone-depleting substances (ODS)**.
- Developed countries to phase out **HCFCs** by 2020, developing countries by 2030.
- **Kigali Amendment** (2016) targets **HFCs** phase-down due to high global warming potential.
- **India**: Phased out CFCs, Halons, Methyl Bromide; current focus on phasing out **HCFCs** by 2025 and reducing HFCs from 2032 onwards.

Halons & Freons totally phased out by 2000

Next Phase

2.3. 35th Meeting of the Parties to the Montreal Protocol (2023)

- Replenishment of **Multilateral Fund** with almost $1 billion.
- Decisions on updated scientific and technical information.

3. Acid Rain

3.1. Introduction

- **Acid rain**: Precipitation with pH below **5.6** caused by **SO2** and **NOx** emissions.

3.2. Types of Acid Precipitation

- **Wet Acid Precipitation**: Acidic compounds in rain, snow, fog.
- **Dry Acid Precipitation**: Direct deposition of acidic pollutants on surfaces.

3.3. Causes of Acid Rain

- **Anthropogenic sources**: Fossil fuel combustion, industrial processes, agriculture.
- **Natural sources**: Volcanic eruptions, forest fires, lightning.

3.4. Effects of Acid Rain

- **Environment**: Damages forests, acidifies soil and water, mobilizes toxic metals.
- **Human Health**: Respiratory issues, cardiovascular problems, exposure to toxic metals.

3.5. Prevention and Control

- **Regulatory Measures**: Clean Air Act, pollution control technology, stricter emission standards.
- **Individual Actions**: Energy conservation, public transport, proper waste disposal.
- **Alternative Energy Sources**: Renewable energy, energy efficiency.

3.6. Acid Rain in India: Causes, Effects, and Solutions

- **Causes**: Industrialisation, inefficient power plants, vehicular emissions.
- **Effects**: Damage to the **Taj Mahal**, soil acidification, water contamination.
- **Solutions**: Stricter emission standards, public awareness, restoration projects, promoting sustainable development.

3.7. The Taj Trapezium Zone (TTZ)

- **TTZ**: 10,400 sq km area around the Taj Mahal established to protect from pollution.
- Measures: Relocating polluting industries, cleaner fuels, emission standards, green spaces, public transportation infrastructure.