



## Environmental Information System – Resource Partner

(Ministry of Environment, Forest and Climate Change, Govt. of India)

Indian Institute of Tropical Meteorology, Pune



# Art Book

Part III: Ozone Layer and our Earth





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## Preface

This is the 3<sup>rd</sup> publication in Art Book series which is published on the occasion of “World Ozone Day (WOD) 2021”.

Ozone Depleting Substances are stable manmade chemicals containing chlorine and bromine enter the atmosphere, reach the stratosphere and undergo a complex series of catalytic reactions, leading to destruction of ozone. These include Chlorofluorocarbons, Carbon tetrachloride, Halons, Methyl Bromide and Methyl Chloroform and Hydrochlorofluorocarbons.

The global phase-out of ozone depleting substances such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) has also made a significant positive contribution to the fight against climate change.

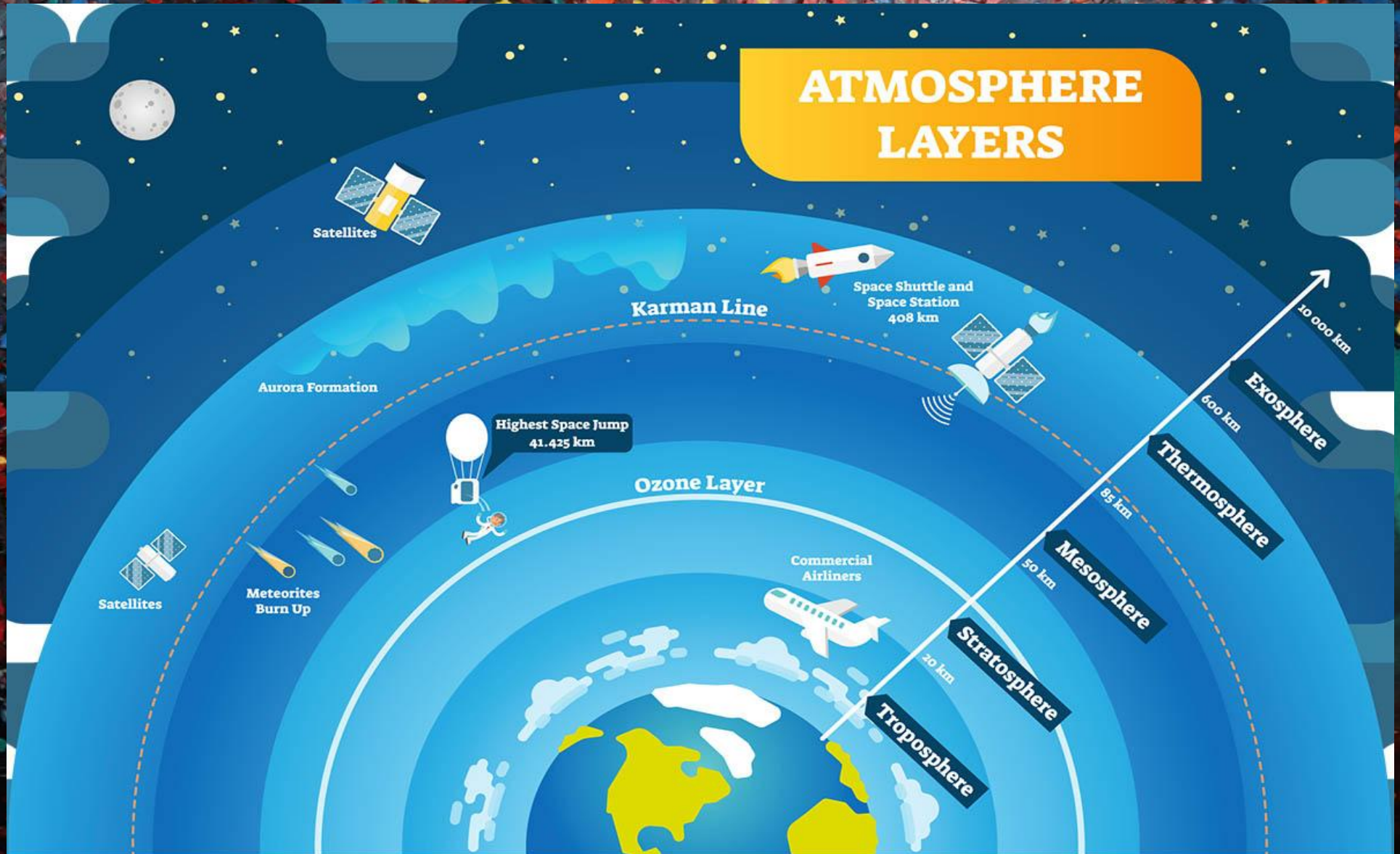
Children play an important role in spreading awareness on the protection of ozone layer.

The Art Book is made for children on the theme of the “Ozone layer and Earth”. The book consists of the beautiful drawing submitted during competition by school children held on the WOD events in current and past few years, illustration introducing basic concepts of ozone layer and few questions to “Test Your Knowledge”.

**- Dr. B.S. Murthy**

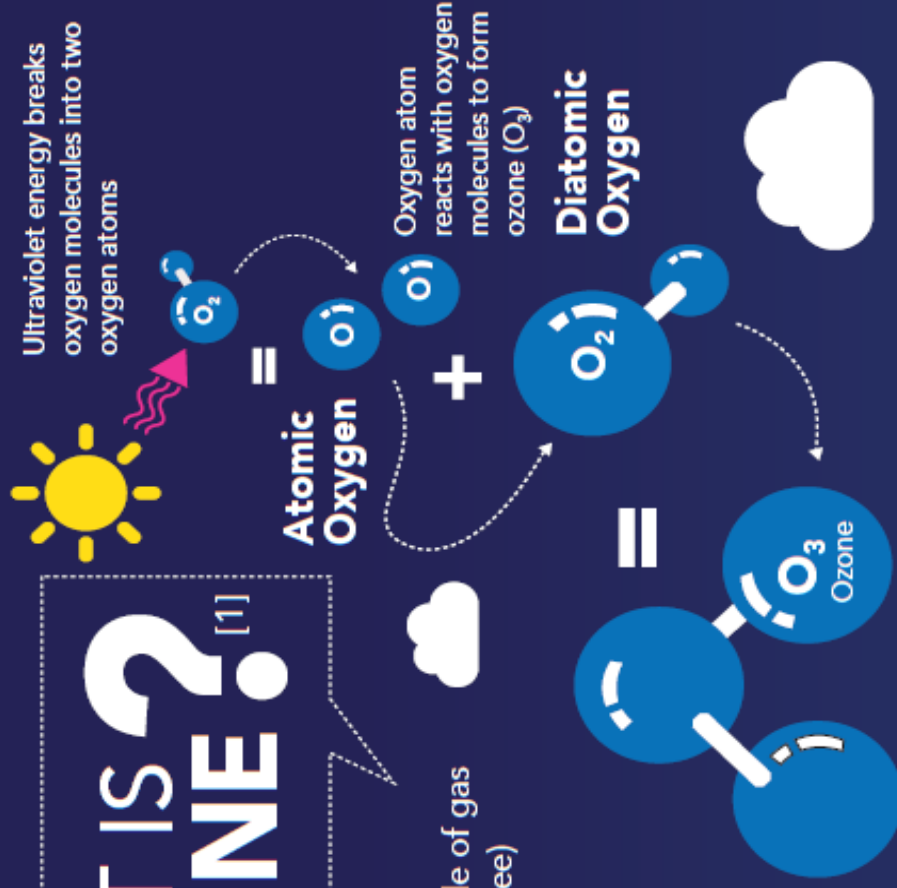


# ATMOSPHERE LAYERS



# WHAT IS OZONE?<sup>[1]</sup>

Ozone is a molecule of gas consisting of 3 (three) oxygen atoms.

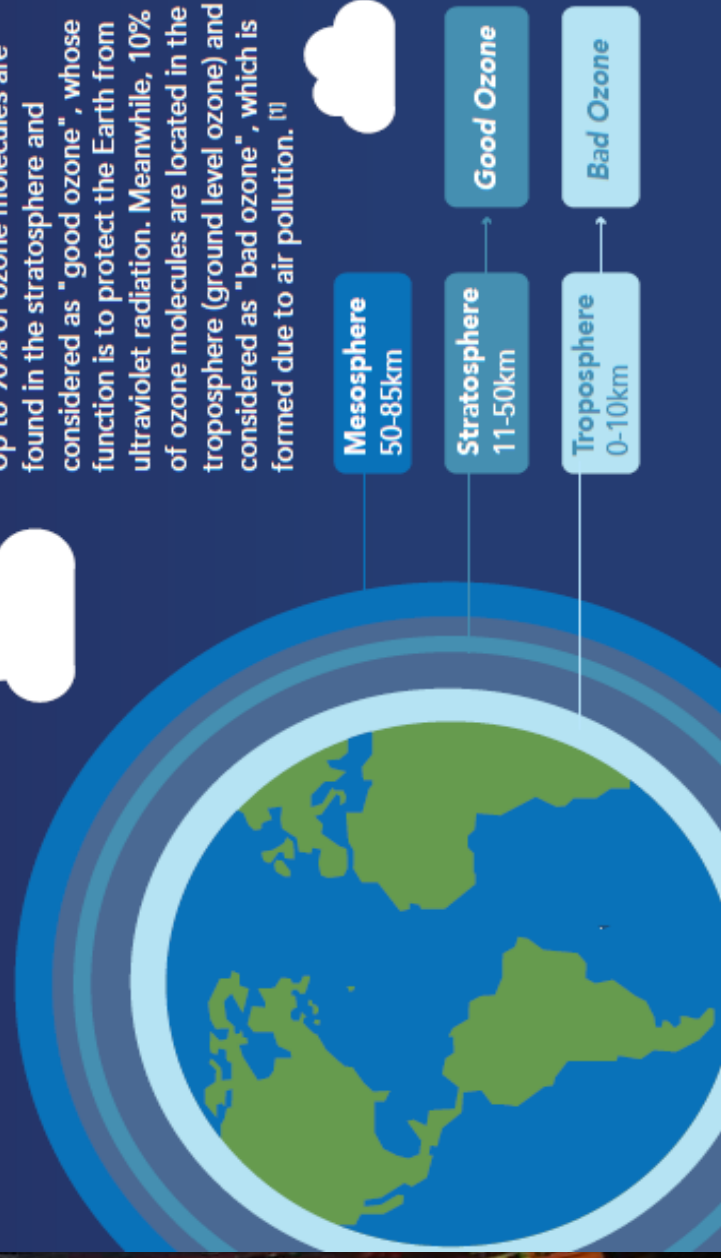


## 3 out of 10 million

Only 3 out of every 10 million molecules in the Earth's atmosphere are ozone, so these molecules are very rare.<sup>[2]</sup>

## WHERE ARE OZONE MOLECULES FOUND

Up to 90% of ozone molecules are found in the stratosphere and considered as "good ozone", whose function is to protect the Earth from ultraviolet radiation. Meanwhile, 10% of ozone molecules are located in the troposphere (ground level ozone) and considered as "bad ozone", which is formed due to air pollution.<sup>[1]</sup>





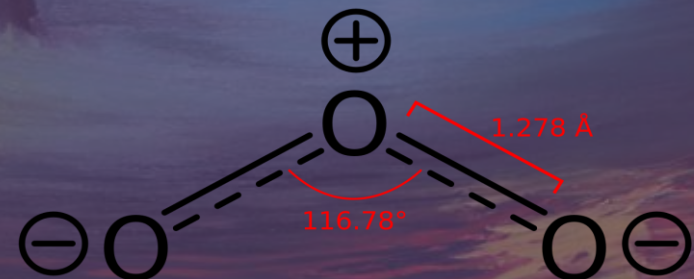


*Drawing By,*

*-Gauri Chandanshive  
H.H.C.P Pune*

## Ozone Facts

Ozone is a molecule that contains three oxygen atoms.







*Drawing By,*

*-Shrihari Chaughule  
 Bharati Vidyaapeeth,  
 Pune*

## Ozone Facts

Ozone layer, also called ozonosphere, region of the upper atmosphere, between roughly 15 and 35 km (9 and 22 miles) above Earth's surface, containing relatively high concentrations of ozone molecules (O<sub>3</sub>).

Approximately 90 percent of the atmosphere's ozone occurs in the stratosphere, the region extending from 10–18 km (6–11 miles) to approximately 50 km (about 30 miles) above Earth's surface.





*Drawing By,*

*-Neha Walawalkar  
Blue Rigde Public School,  
Pimpri-Chinchwad*

# Ozone Facts

The production of ozone in the stratosphere results primarily from the breaking of the chemical bonds within oxygen molecules ( $O_2$ ) by high-energy solar photons.

This process, called photodissociation, results in the release of single oxygen atoms, which later join with intact oxygen molecules to form ozone.



*Drawing By,*

*-Shravani Vishanu Kamble  
H.H.C.P, Pune*

## Ozone Facts

The photodissociation, or free radical annihilation, of an oxygen atom, turns life-giving oxygen gas into ultraviolet blocking ozone.

This occurs in the stratosphere, as it requires wavelengths of radiation shorter than 240nm.

Though ozone protects the stratosphere from the sun's radiation, it too can breakdown under high energy. When it does, it simply goes through the photodissociation process again and reforms.





## Test your Knowledge

**This optical phenomenon, appearing on misty mountainsides, is called...**

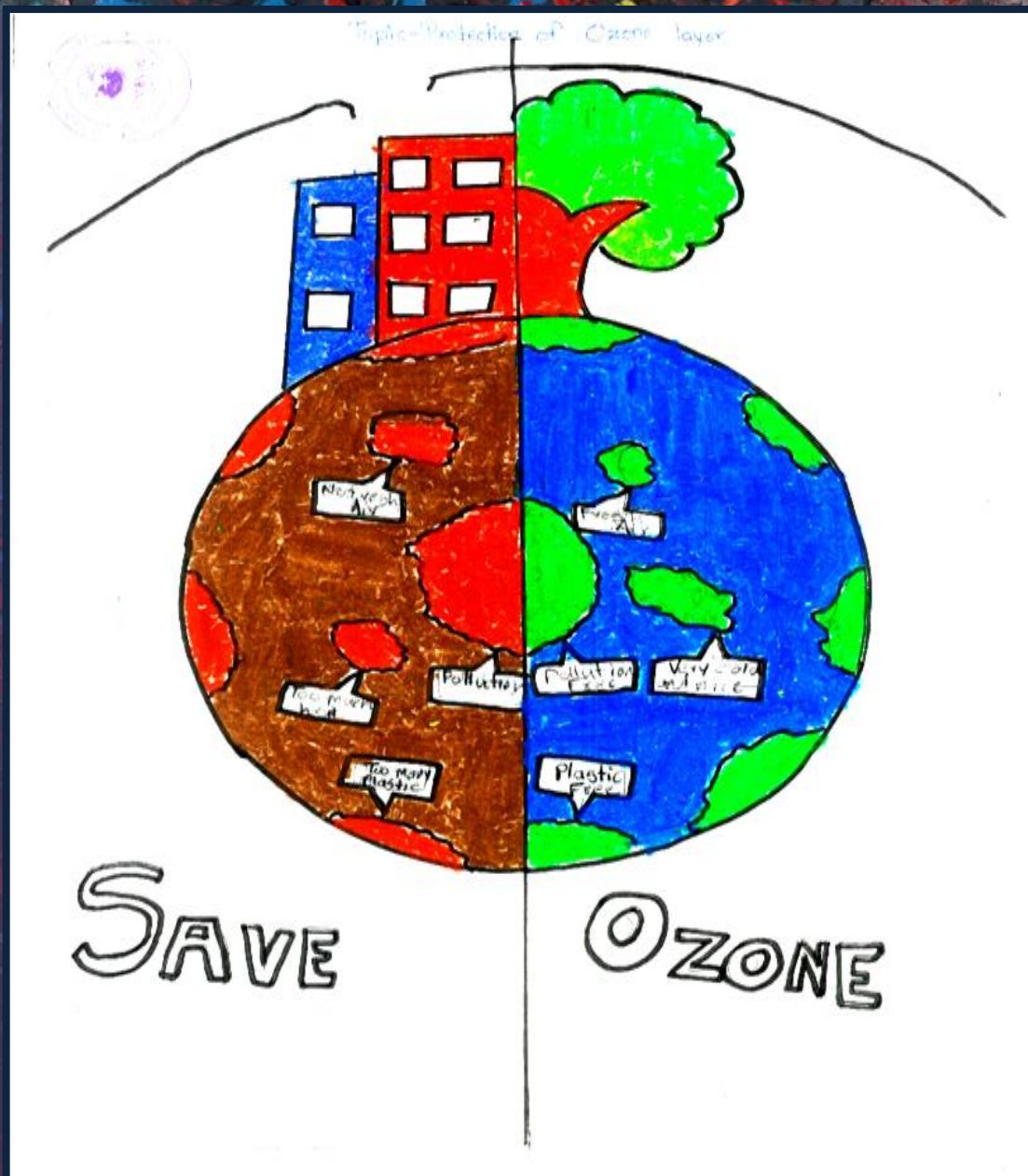
- a. Side rainbow**
- b. Halo**
- c. Brocken spectre**
- d. Sun Dogs**



Apparently enormous and magnified shadow of an observer, cast upon the surfaces of clouds opposite the sun. The head of the figure is often surrounded by the glowing halo-like rings of a glory—rings of coloured light that appear directly opposite the sun when sunlight meets a cloud of uniformly-sized water droplets. The phenomenon can appear on any misty mountainside or cloud bank.

Answer :- c





*Drawing By,*

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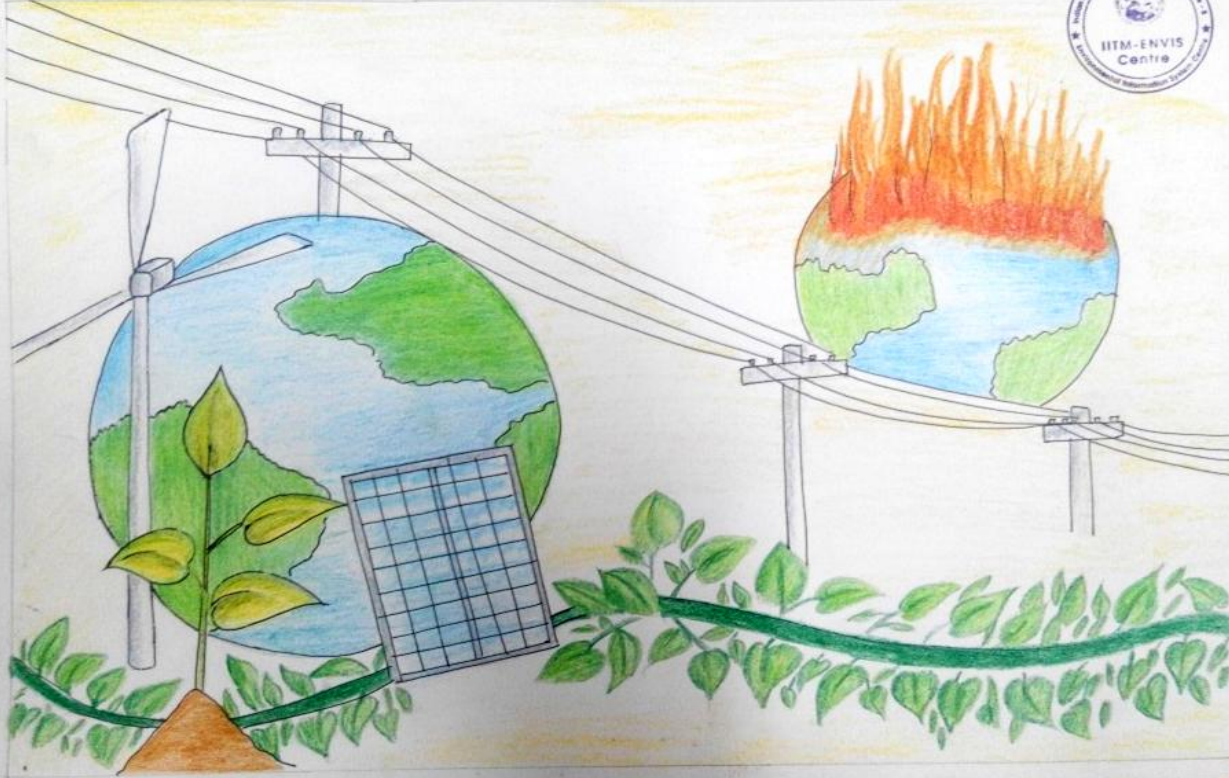
## Ozone Facts

The large ozone hole in 2020 has been driven by a strong, stable and cold polar vortex, which kept the temperature of the ozone layer over Antarctica consistently cold.



Devyani S. Gholap  
St. Mita's Secondary School  
VIII<sup>th</sup> A

Solution to climate change



*Drawing By,*

*-Devyani S. Gholap,  
Pune*

# Ozone Facts

The ozone column is measured by an ozone spectrophotometer that was first built by meteorology professor GMB Dobson in the 1920s.



Protect The  
Protector



*Drawing By,*

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## Ozone Facts

The ozone layer in the stratosphere absorbs a portion of the radiation from the sun, preventing it from reaching the planet's surface.

Most importantly, it absorbs the portion of UV light called UVB. UVB has been linked to many harmful effects, including skin cancers, cataracts, and harm to some crops and marine life.





*Drawing By,*

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## Ozone Facts

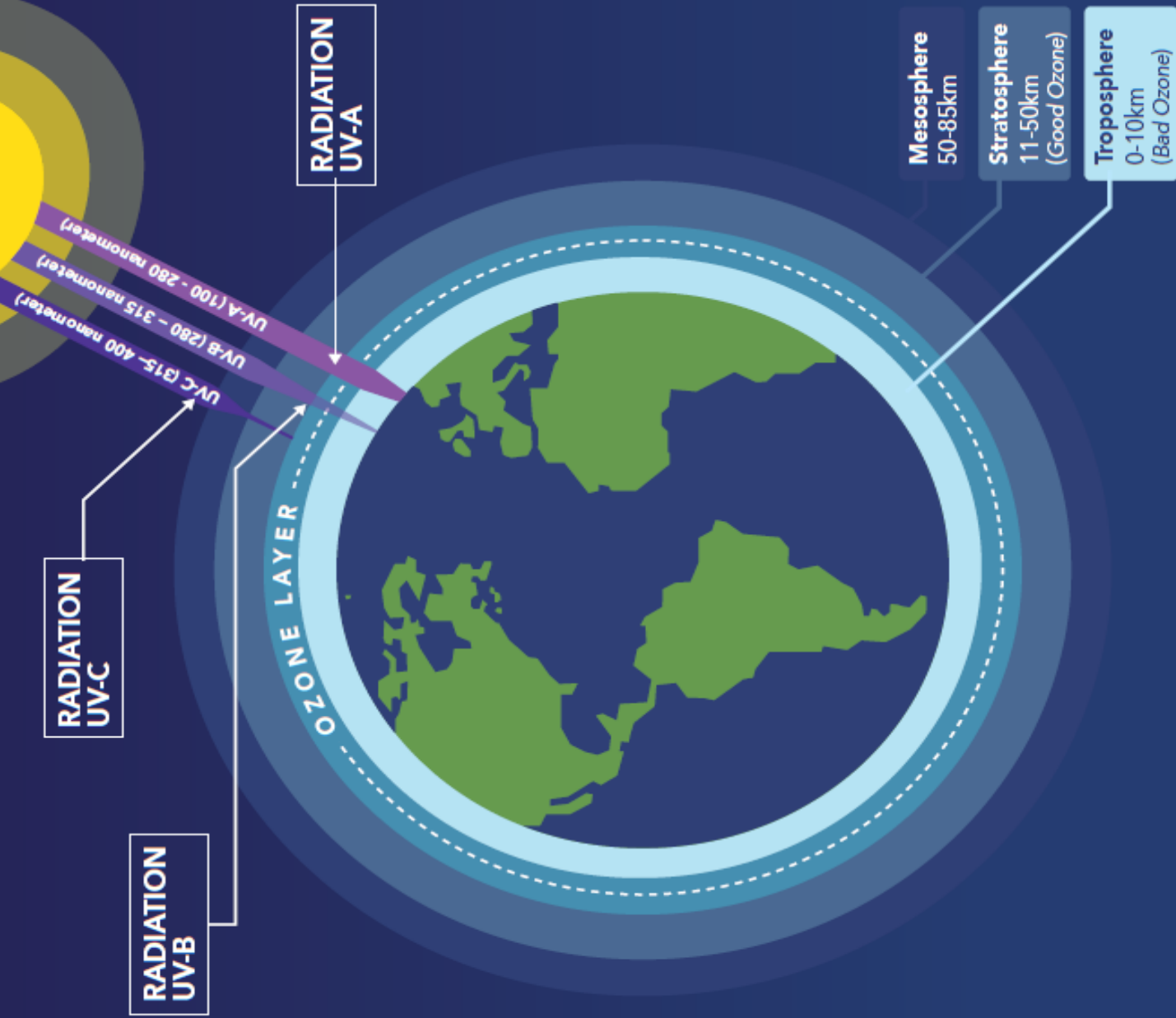
Ozone hole and global warming are separate climate-related issues, they do have several similarities. First of these are the ozone-damaging chemicals, like CFCs.

These chemicals, of course, increase the size of the ozone hole by destroying the ozone in the Antarctica stratosphere. They, too, are greenhouse gases and help drive up the average global temperature each year.



# STRATOSPHERIC OZONE LAYER FUNCTION

The stratospheric ozone layer filters Ultraviolet B (UV-B) radiation, absorbing most of it before it hits the surface of the Earth .<sup>[1]</sup>





## Test your Knowledge

**In which layer of the atmosphere the aurora is created?**

- a. In the Troposphere**
- b. In the Stratosphere**
- c. In the mesosphere**
- d. In the Thermosphere**



Auroras are produced when the magnetosphere is sufficiently disturbed by the solar wind that the trajectories of charged particles in both solar wind and magnetospheric plasma, mainly in the form of electrons and protons, precipitate them into the upper atmosphere (thermosphere/exosphere) due to Earth's magnetic field, where their energy is lost.

Answer :- d





*Drawing By,*

*-Vaibhav Kapase  
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# Ozone Facts

During the beginning of the lockdowns imposed world-wide owing to COVID-19, the depleted ozone layer over the arctic healed itself and is now closed completely, as per the UN World Meteorological Organization (WMO).



CHLORO-FLUORO CARBON EMISSIONS  
DESTROY THE OZONE LAYER  
STOP!!!

Save the earth



*Drawing By,*

*-Manjiri Pote  
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## Ozone Facts

Ozone depletion, gradual thinning of Earth's ozone layer in the upper atmosphere caused by the release of chemical compounds containing gaseous chlorine or bromine from industry and other human activities.

The thinning is most pronounced in the polar regions, especially over Antarctica.





*Drawing By,*

*-Aryan Akre  
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## Ozone Facts

Ozone depletion is a major environmental problem because it increases the amount of ultraviolet (UV) radiation that reaches Earth's surface, which increases the rate of skin cancer, eye cataracts, and genetic and immune system damage.



*Drawing By,*

*-Shravani Vishanu Kamble  
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## Ozone Facts

Carbon tetrachloride and methyl chloroform, used for applications such as solvents, foam-blowing, refrigeration, and air conditioning, are also ozone-depleting gases that have been created by humans.

Fortunately, many of these applications now have safer, ozone-friendly alternatives.



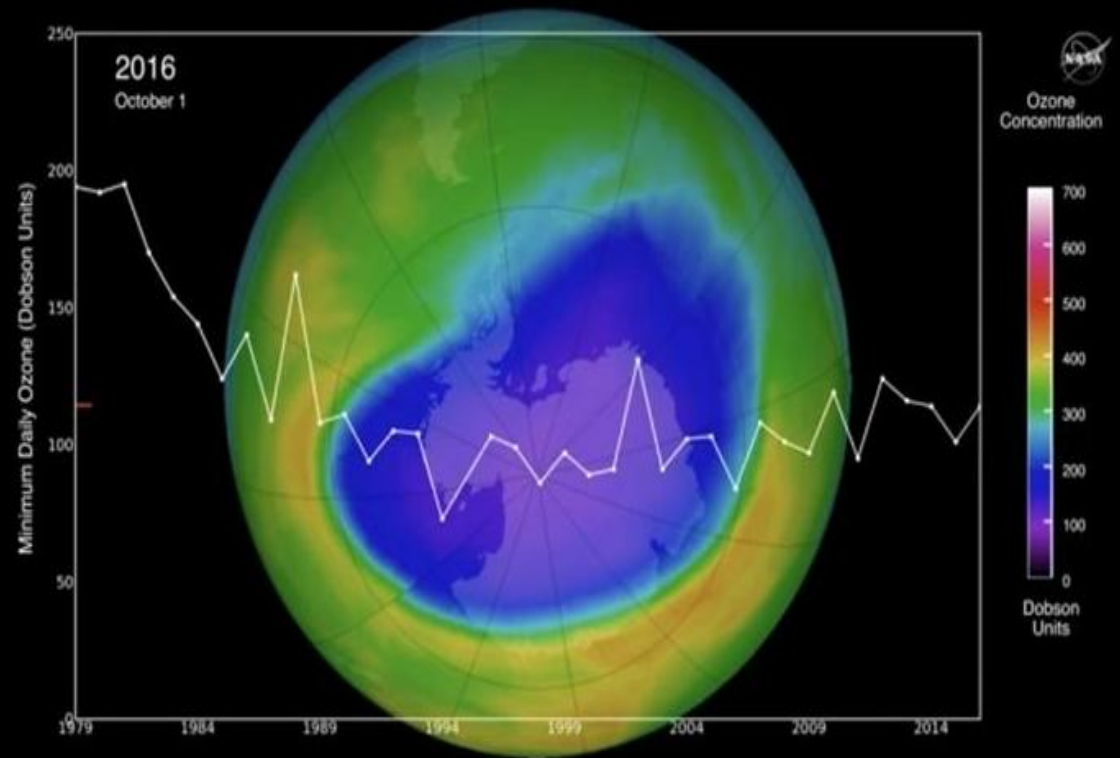


The image is a view of the Antarctic ozone hole, derived from NASA's satellite measurements that monitor the ozone layer. The larger the OZONE HOLE, the greater is the amount of the HEAT and Ultraviolet Rays from the Sun to enter the Earth's atmosphere. This abnormal situation increase the Temperature near the Ground Level (Global Warming) and decrease the Temperature high above in the atmosphere causing Climate Change Disasters.

The ozone depletion process begins when CFCs and other ozone-depleting substances (ODS) are emitted into the atmosphere.

Ozone depleting substances include:

- chlorofluorocarbons (CFCs)
- halon
- carbon tetrachloride ( $\text{CCl}_4$ )
- methyl chloroform ( $\text{CH}_3\text{CCl}_3$ )
- hydrobromofluorocarbons (HBFCs)
- hydrochlorofluorocarbons (HCFCs)
- methyl bromide ( $\text{CH}_3\text{Br}$ )
- bromochloromethane ( $\text{CH}_2\text{BrCl}$ )

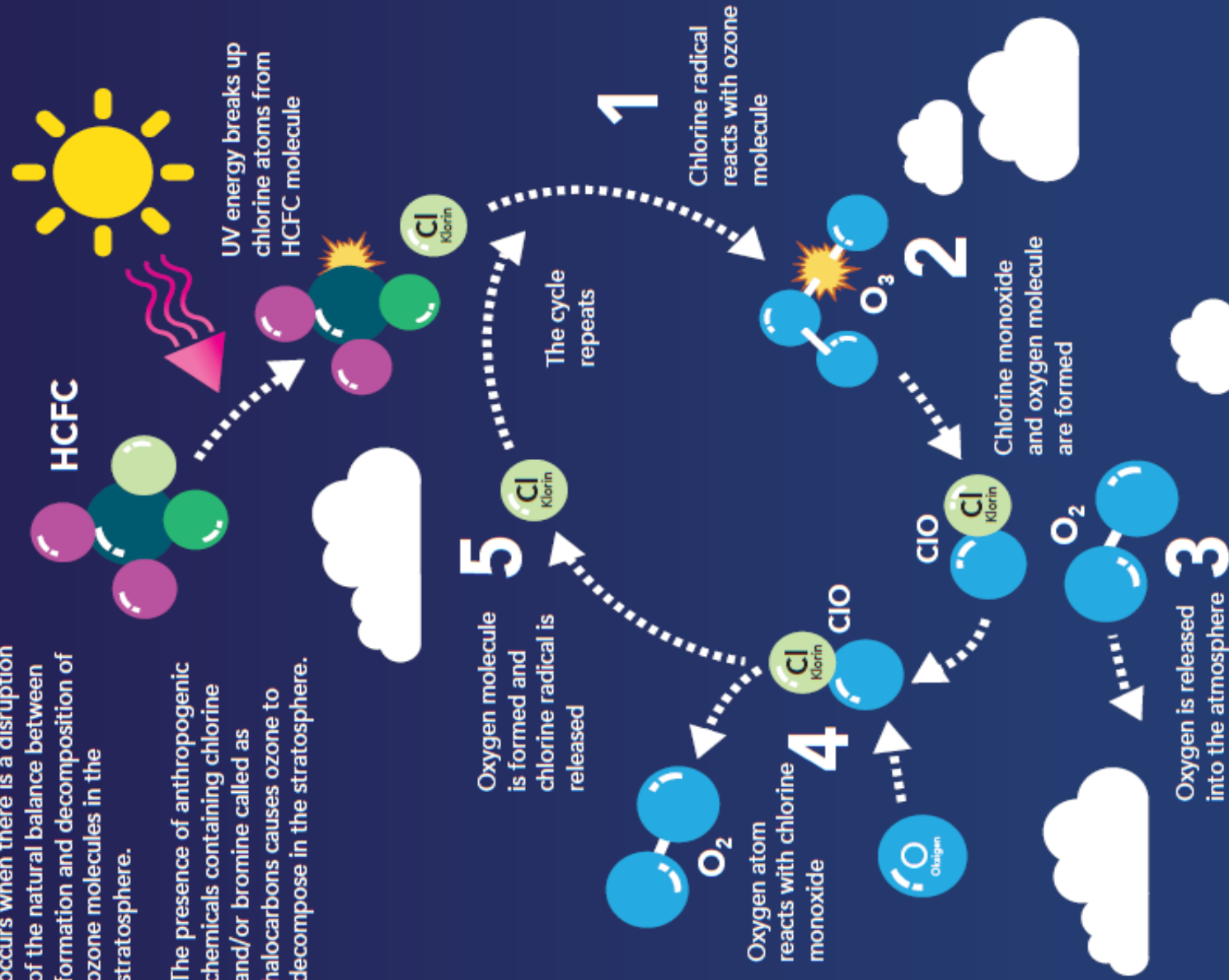




# HOW DOES OZONE DEPLETION OCCUR? [7]

Depletion of the ozone layer occurs when there is a disruption of the natural balance between formation and decomposition of ozone molecules in the stratosphere.

The presence of anthropogenic chemicals containing chlorine and/or bromine called as halocarbons causes ozone to decompose in the stratosphere.

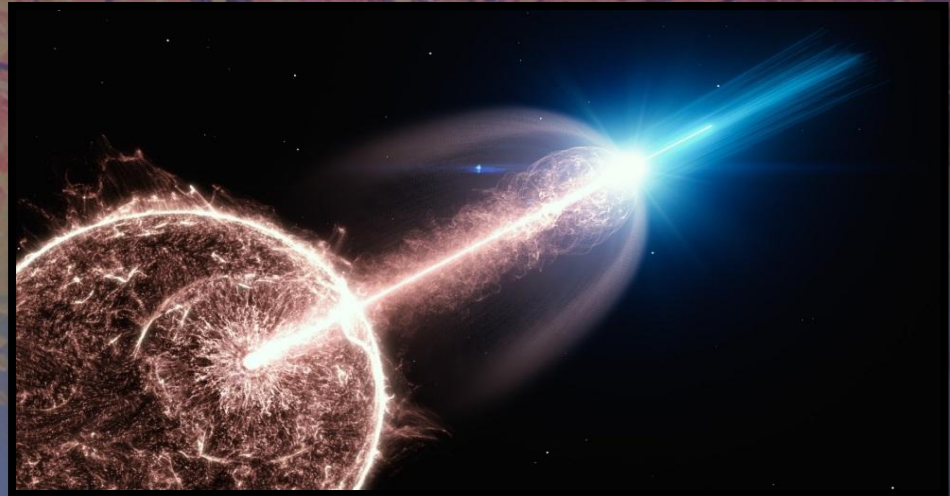




## Test your Knowledge

**What is the source of the most powerful release of energy in the universe, second in scale only to the Big Bang?**

- a. supermassive stars**
- b. quasars**
- c. gamma-ray burst**
- d. supernova**



They are the brightest in the universe, even brighter than the glare of quasars, second only to the brightness and power of the Big Bang. It is believed that arise during disruption of stars by black holes.

Answer :- c





*Drawing By,*

*-Nachiket Kamtekar, City  
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## Ozone Facts

In a great show of solidarity, the Montreal Protocol was signed by several countries in 1987 promising to limit the use of CFCs, HCFCs and other substances that are harmful to the ozone layer.

Nearly 100 harmful substances were phased out and production and consumption of these substances went down by 98%. The treaty not only saved the ozone layer, it has delayed climate change.





# Ozone Facts

World Ozone Day was first observed in the year 1995. This day is celebrated to create awareness about the importance of the ozone layer.

*Drawing By,*

*-Vartika D.Mulay  
M.J.T School, Pune*





# Ozone Facts

The date was chosen because the Montreal Protocol on Substances that Deplete the Ozone Layer was signed on September 16, 1987.

*Drawing By,*

*-Rachana P.  
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*Drawing By,*

*--Vividha Ingawale  
Blue Public Ridge School ,  
Pimpri-Chinchwad*

## Ozone Facts

On 16th September 2009, the Vienna Convention and the Montreal Protocol became the first treaties in the history of the United Nations to achieve universal ratification.



## Test your Knowledge

**In what process sky colors (including blue sky and red sun) are created ?**

- a. Iridescence**
- b. Rayleigh scattering**
- c. Mirage**
- d. Atmospheric refraction**



It is an elastic scattering of light or other electromagnetic radiation by particles much smaller than the wavelength of the radiation.

Answer :- b





*Drawing By,*

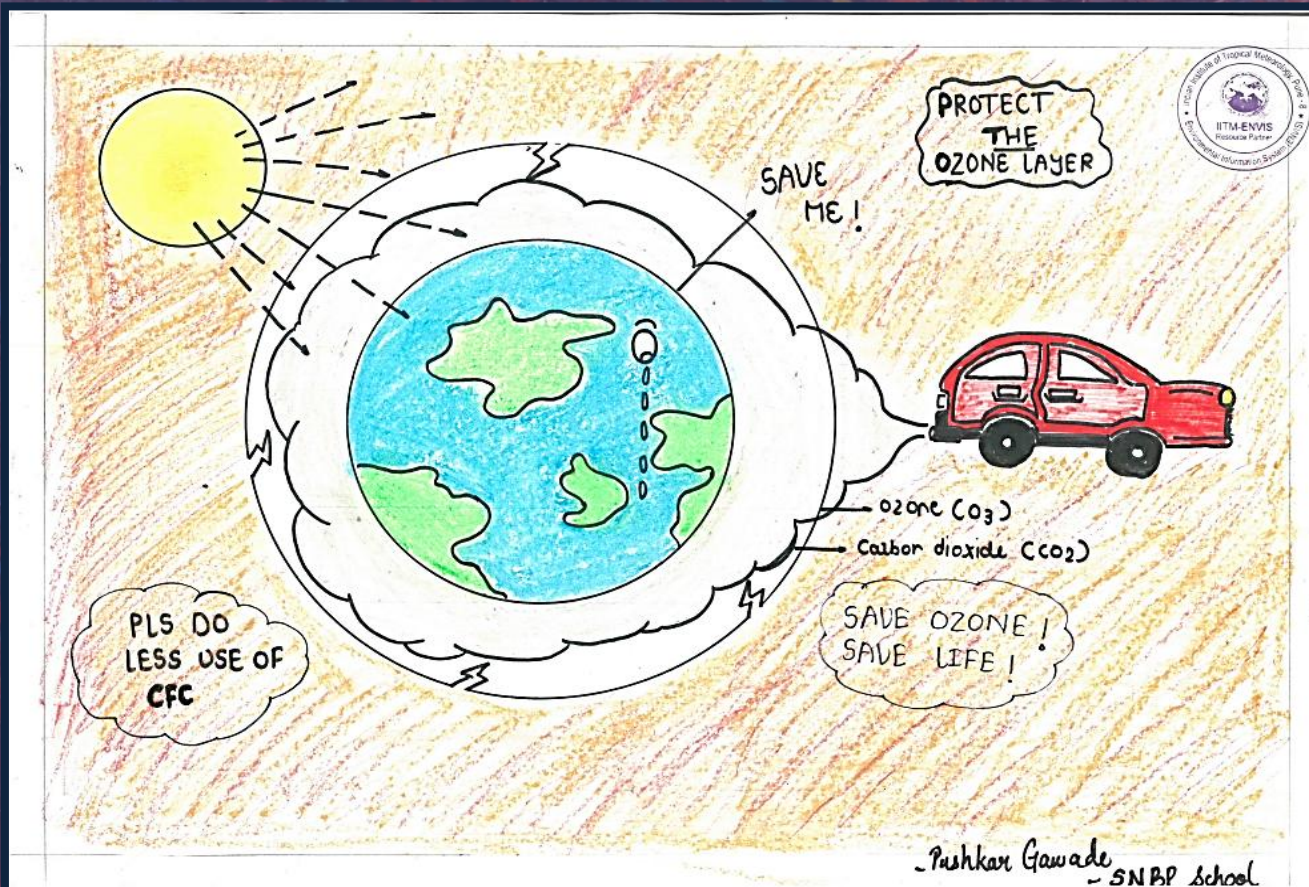
*-Rishi Rangrej  
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## Ozone Facts

Ozone protection efforts have contributed significantly to slowing climate change by avoiding an estimated 135 billion tonnes of carbon dioxide (CO<sub>2</sub>) equivalent emissions from 1990 to 2010.

This is five times larger than the annual emissions reduction target for the first commitment period (2008-2012) of the Kyoto Protocol, the predecessor to the Paris Agreement on Climate Change.





*Drawing By,*

*-Pushkar Ashok Gawade  
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Pimpri - Chinchwad*

## Ozone Facts

Ground-level, "bad," ozone forms when nitrogen oxide gases from vehicle and industrial emissions react with volatile organic compounds (carbon-containing chemicals that evaporate easily into the air, such as paint thinners).





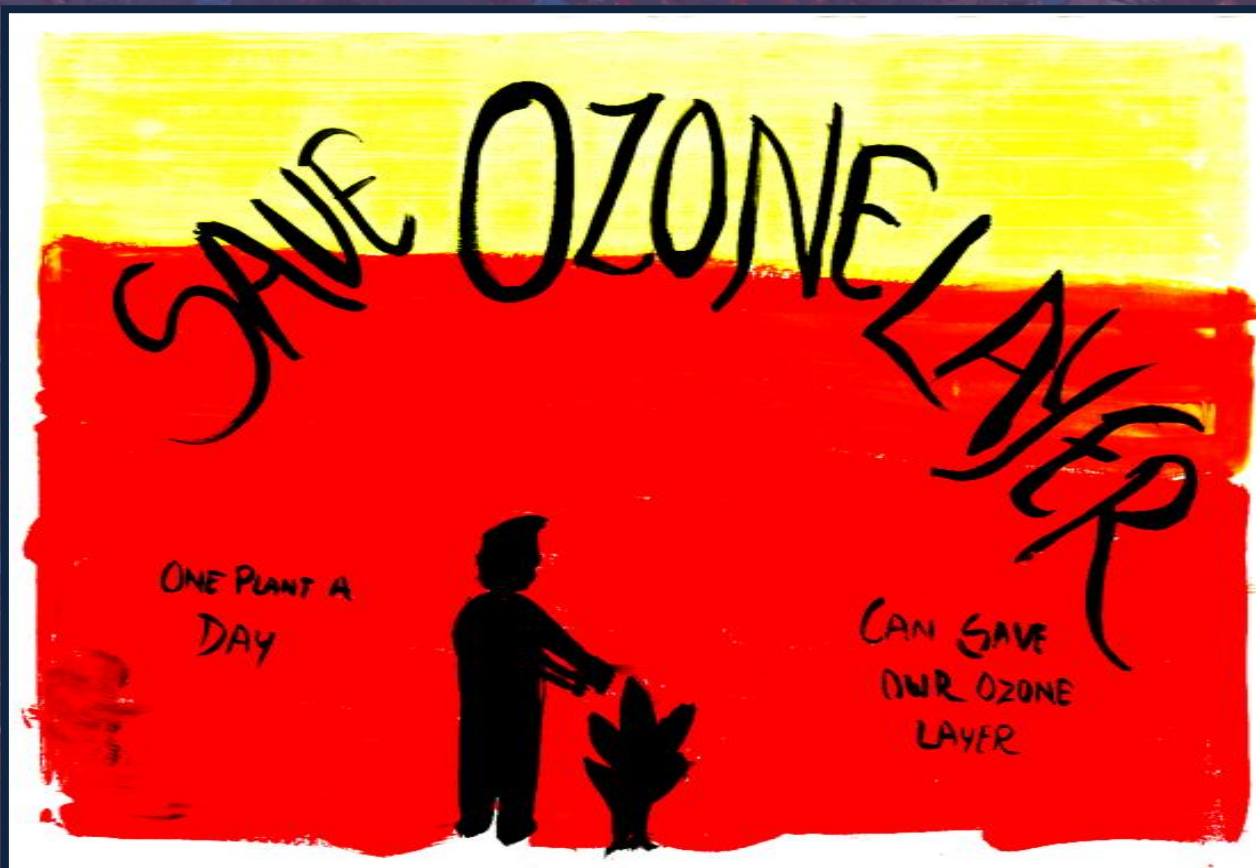
*Drawing By,*

*-Rutuja Sabale  
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## Ozone Facts

As the level of Ozone Depleting Substances decline throughout the world in the coming decades, the evolution of the ozone layer will be increasingly influenced by future abundances of greenhouse gases and climate change.





*Drawing By,*

*-Shrishti Bhamre  
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## Ozone Facts

Without an ozone layer, the earth would turn into a barren wasteland of very little life – only single celled organisms and perhaps deep ocean creatures would remain.

The sun's radiation would kill off all plants, animals, and humans without the ozone layer to protect us.



## Test your Knowledge

**What are the most luminous objects in the universe?**

- a. supergiant stars**
- b. novae**
- c. supernovae**
- d. Quasars**



It is an extremely energetic source of radiation powered by accretion disc around galaxy's central supermassive black hole. They were much more common in the early universe.

Answer :- d



## Test your Knowledge

**What, excluding water vapour, do night shining clouds consist?**

- a. micrometeors' remains**
- b. rocket engines' exhaust gases**
- c. volcanic dust**
- d. all of above**



Noctilucent clouds, or night shining clouds, are tenuous cloud-like phenomena in the upper atmosphere of Earth. They are first known to have been observed in 1885, two years after the eruption of Krakatoa volcano. Noctilucent clouds require water vapour, dust and exhaust. The dust is believed to come from micrometeors, although particulates from volcanoes and dust from the troposphere are also possibilities. The exhaust are from Space Shuttles.

Answer :- d





*Drawing By,*

*-Gauri Mahendra Savant  
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## Ozone Facts

The nitrogenous compounds that result in production of ozone also break it down, so there is more smog in villages than cities, because cities have higher concentrations of nitrogenous compounds in the air.

This is called the "ozone paradox" by scientists, and is the reason for the "weekend effect," when ozone levels rise due to less traffic on weekends



*Drawing By,*

*-Soham Pawar  
Rosary School , Pune*

## Ozone Facts

Good vs. Bad ozone - Ozone in the upper atmosphere is called stratospheric ozone and helps protect living things from UV-B radiation and is widely called "good ozone."

Ozone in the lower atmosphere, the troposphere, functionally acts as a contaminant, and is the "Bad ozone."







*Drawing By,*

*-Bhakti Sanjay Bhomaj  
HHCP School, Pune*

## Ozone Facts

Sunlight makes life, but the ozone layer creates life as we know it today.

When scientists working in the late 1970s discovered that humanity was making a hole in this protective shield, they voiced out their concerns.



## Test your Knowledge

**The bright circle around the Sun seen in the picture is known as a halo.**

**What causes it?**

- a. refraction of light in ice crystals**
- b. refraction in the lens of the eye or lens**
- c. refraction of light in water drops**
- d. reflections from the water surface**



Halo is the name for a family of optical phenomena produced by light interacting with ice crystals suspended in the atmosphere. Halos can have many forms, ranging from colored or white rings to arcs and spots in the sky. Among the best known halo types are the circular halo (properly called the  $22^\circ$  halo), Other common optical phenomena involving water droplets rather than ice crystals include the glory and the rainbow.

Answer :- a



# Ozone Board Games...

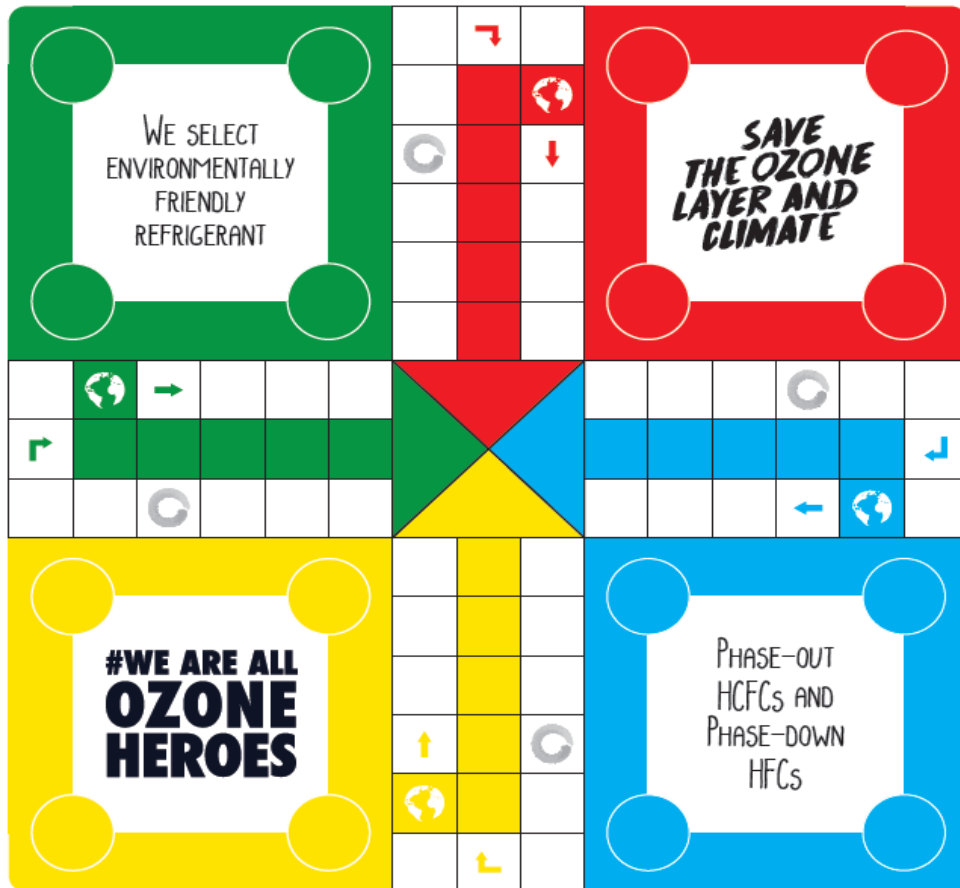






# LUDOZONE

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START



SAFE ZONE

→ WAY



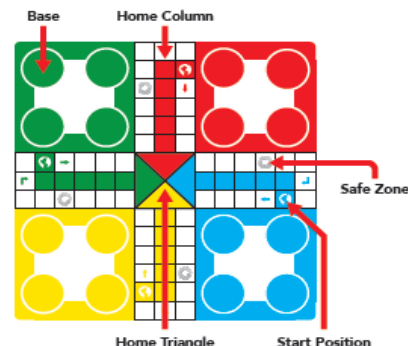
HOME

Directorate General of Climate Change (Ministry of Environment and Forestry Republic of Indonesia)  
United Nation Environment Programme (UNEP)  
Compliance Assistance Programme, Asia and the Pacific Office, Bangkok, Thailand

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A Ludo is a strategy board game for two to four players in which the players race their four playing pieces or tokens from start to finish clockwise, according to the rolls of a single die. The Ludo board is typically coloured yellow, green, red, and blue. Each player chooses a colour and has four playing pieces/tokens in their colour. The board is normally square with a cross-shaped play space, with each arm of the cross having three columns of squares, usually six squares per column. The middle columns usually have five squares coloured; these represent a player's home column. A sixth coloured square not on the home column is a player's starting square where the playing pieces/tokens are placed to begin. At the centre of the board is a large finishing square, composed of coloured triangles atop the players' home columns (thus depicting "arrows" pointing to the finish). The middle column for each colour cannot be landed by other colours.

Playing Pieces or Tokens



## How to play!

- Each player places the 4 pieces of that colour in the corresponding base. A single die is thrown to determine movement. Everyone rolls the die once. The highest roller takes the first turn to start. Turns of the other players is in a clockwise order around the game board.
- In order to get the piece into start position, each player must roll a 6 on their turn. If the starting person doesn't roll a 6, the turn passes to the next player. Until you roll a 6, you can bring a piece onto the start position. Then you get an additional roll for a second time to determine how many spaces that piece may move. Move the piece as many spaces as the number you roll. If you roll a 6 on your second dice roll, then you get to choose either to bring out another piece on the board or move ahead with an existing piece on the board. And you get additional turn to roll again to move either piece.
- Rules for the 6's: You get an extra turn or "bonus" roll every time you roll a 6. You can opt to bring out a fresh piece into the game or move ahead with an existing piece on the path. However, if the third roll is also a 6, the player may not move, and the turn immediately passes to the next player.
- Each throw, the player decides which piece to move. A piece simply moves in a clockwise direction around the path given by the number thrown. If no piece can be moved according to the number thrown, the turn passes to the next player.
- If another player's piece is blocking your pathway, you need to land on the same space as that piece in order to move, otherwise you cannot move your piece and must pass your turn. If your piece lands on another player's piece of different colour exact same space, you capture another player's piece and it is sent back to their base where he must roll a six again to re-enter onto the starting square.
- If a piece lands on a piece of his own with the same colour and becomes double pieces, this forms a block. This block cannot be passed or landed on by a single piece of the other players. A block is ended by an opponent's block (double pieces of the different colour) that lands on the same space which returns the owner's block to its base. A block (double pieces with the same colour) moves by half of the number of dice roll. The odd number of die cannot move the block.
- A safe zone is where the two pieces of different players land on the square with special mark but no sent back to the base takes effect.
- Winning the game: when a player's piece has reached the home column of its own colour, the piece continues its moves toward the center to its home triangle. A player's home column squares are always safe since no opponent may enter them. In the home column, you cannot jump over your own piece. A piece can only be moved to the home triangle with an exact roll. When a player's die roll lands its piece on the home triangle, that piece has completed its journey. The first player to have all four pieces finish into the home triangle wins.



DIRECTORATE GENERAL OF CLIMATE CHANGE  
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THE REPUBLIC OF INDONESIA



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**WORLD OZONE DAY**



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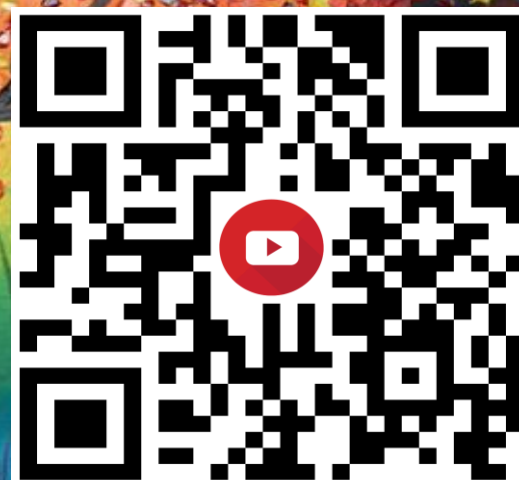
# Watch Videos



Success story on HCFC  
Phase out in foam  
manufacturing sector



Precious Ozone –  
The Size of it



Animated short  
film, Ozzy Ozone  
(an ozone molecule)



# Art Book

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