UNIT 11

AIR

Learning Objectives

A4P1Y8

After the completion of this lesson, students will be able to:

- know about the occurence and composition of oxygen, nitrogen and carbon dioxide in the atmosphere.
- understand the properties and uses of oxygen, nitrogen and carbon dioxide.
- understand nitrogen fixation.
- identify the causes of green house effect, global warming and acid rain.
- suggest remedial measures for the prevention and control of these effects.

Introduction

Air is a mixture of gases that surrounds our planet earth. It is essential for the survival of all the living things. Air contains 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.04% carbon dioxide and small amount of other gases. We breathe in oxygen and breathe out carbon dioxide. Plants in turn use carbon dioxde for photosynthesis and release oxygen into the atmosphere. Since men have been cutting down trees for their needs, the amount of carbon dioxide in the atmosphere is increasing. This is responsible for the raising of atmospheric temperature. Industries and vehicles release gases like carbon monoxide and sulphur dioxide into the atmosphere. This has resulted in effects like global warming and acid rain which affect us in many ways. In total, the quality of air is gone in the modern days. In this lesson we are going to study about the effects like green house effect, global warming and acid rain. We will also study about occurrence and properties of the gases oxygen, nitrogen and carbon dioxide.

11.1 Oxygen

All living things in the world need oxygen. We cannot imagine the world without oxygen. Swedish chemist C.W. Scheele first discovered oxygen in 1772. He called the gas **fire air** or **vital life** because it was found to support the process of burning. It was independently discovered by the British scientist Joseph Priestley in 1774. Lavoisier named oxygen. The name oxygen comes from the Greek word 'oxygenes' which means 'acid producer'. It is called so because early chemists thought that oxygen is necessary for producing acids.

11.1.1 Occurrence of Oxygen

Oxygen is the most abundant element on the earth by mass and the third most abundant element after Hydrogen and Helium in the universe. It occurs both in free state and combined state. It is present in free state as diatomic molecule (O_2) in the atmosphere. Most of this has been produced by photosynthesis in which the chlorophyll present in the leaves of plants uses solar energy to produce glucose.

Table 11.1 Percentage of Oxygen

Oxygen in free state		Oxygen in combined state	
Source	**Percentage**	**Source**	**Percentage**
Atmospheric air	21 %	Plants and animals	60 – 70 %
Water	88 – 90 %	Minerals in the form of silicates, carbonates and oxides	45 – 50 %

$$6CO_2 + 6H_2O \xrightarrow{\text{Energy from the Sun}} C_6H_{12}O_6 + 6O_2$$

In combined state it is present in the earth's crust as silicates and metal oxides. It is also found in water on the surface of the earth. Tri atomic molecule (O_3) known as ozone is present in the upper layers of the atmosphere.

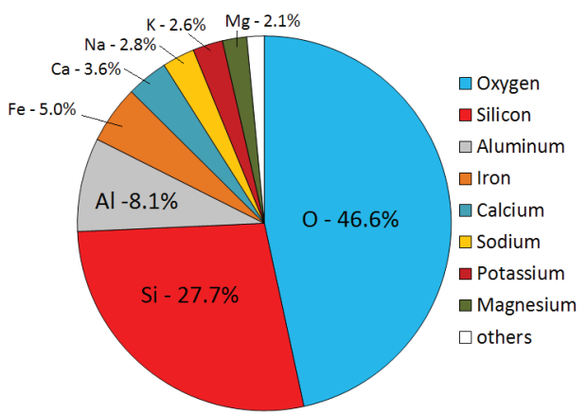

Figure 11.1 Percentage of elements in the Earth's crust

11.1.2 Physical properties of Oxygen

- Oxygen is a colourless, odourless and tasteless gas.
- It is a poor conductor of heat and electricity
- Oxygen dissolves readily in cold water.

DO YOU KNOW?

Oxygen is about two times more soluble in water than nitrogen. If it had the same solubility as nitrogen, then less oxygen would be present in seas, lakes and rivers that will make life much more difficult for living organisms.

- It is denser than air.
- It can be made into liquid (liquified) at high pressure and low temperature.
- It supports combustion.

11.1.3 Chemical properties of Oxygen

1. Combustibility

Oxygen is a non-combustible gas as it does not burn on its own. But, it supports the combustion of other substances.

DO YOU KNOW?

If oxygen has the capacity to burn itself, striking a match stick will be enough to burn all the oxygen in our planet's atmosphere.

2. Reaction with metals

Oxygen reacts with metals like sodium, potassium, magnesium, aluminium, iron etc., to form their corresponding metal oxides which are generally basic in nature. But the metals differ in their reactivity towards oxygen.

$$\text{Metal} + \text{Oxygen} \longrightarrow \text{Metal oxide}$$

Example

$$4Na + O_2 \longrightarrow 2Na_2O$$

Sodium Oxygen Sodium oxide

Activity 1

Heat a strip of magnesium ribbon in the flame till it catches fire and introduce it into the jar containing oxygen. It burns with a dazzling bright light and white ash of magnesium oxide is formed.

Table 11.2 Reactivity of Oxygen with metals

Metal	Temperature	Product formed
K	Room temperature	Potassium Oxide (K_2O)
Mg	Heating slightly	Magnesium Oxide (MgO)
Ca	Heating slightly	Calcium Oxide (CaO)
Fe Cu Ag	High temperature	Iron Oxide (Fe_3O_4) Cupric Oxide (CuO) Silver Oxide (Ag_2O)
Au Pt	Even at high temperature	No action

3. Reaction with non metals

Oxygen reacts with various non-metals like hydrogen, nitrogen, carbon, sulphur, phosphorus etc., to give corresponding non metallic oxides, which are generally acidic in nature.

Non-metal + Oxygen ⟶ Non-metallic oxide

Example

$$\underset{\text{Carbon}}{C} + \underset{\text{Oxygen}}{O_2} \longrightarrow \underset{\text{Carbon dioxide}}{CO_2}$$

Table 11.3 Reaction of Oxygen with non metals

Non metal	Products formed
C	Carbon dioxide (CO_2)
N	Nitric oxide (NO)
S	Sulphur dioxide (SO_2)
P	Phosphorus trioxide (P_2O_3) or Phosphorus pentoxide (P_2O_5)

Activity 2

Heat a small piece of phosphorous and introduce it into the oxygen jar. Phosphorous burns with suffocating smell and gives phosphorous pentoxide (white fumes).

4. Reaction with Hydrocarbons

Hydrocarbons (compounds containing C and H) react with oxygen to form carbon dioxide and water vapour. E.g. Wood, Petrol, Diesel, LPG, etc. When they burn in oxygen, they produce heat and light energy. Hence they serve as fuel.

$$\text{Hydrocarbon} + O_2 \longrightarrow \underset{\text{vapour}}{CO_2 + \text{Water}} + \text{Heat} + \text{Light energy}$$

5. Rusting

The process of conversion of iron into its hydrated form of oxide in the presence of air and moisture (humid atmosphere) is called rusting. Rust is hydrated ferric oxide.

$$4Fe + 3O_2 \longrightarrow 2Fe_2O_3$$

$$Fe_2O_3 + x\,H_2O \longrightarrow \underset{\text{(rust)}}{Fe_2O_3 \cdot x\,H_2O}$$

(x is the number of water molecules which is variable)

11.1.4 Uses of Oxygen

- It is used as oxy-acetylene cylinder for cutting and welding metals.
- It is used to remove carbon impurities from steel.

Figure 11.2 Uses of Oxygen

- Plants and animals use oxygen from the air for respiration.
- It is used as rocket fuel.
- It is used for artificial respiration by scuba divers, mountaineers, astronauts, patients etc.
- Mixed with powdered charcoal it is used as explosives.
- It is used in the synthesis of methanol and ammonia.

11.2 Nitrogen

Nitrogen is one of the most important elements. Animals and plants need nitrogen for their growth. All living organisms (including us) contain nitrogen. It is an essential element present in proteins and nucleic acids which are the 'building blocks' of all living things. It was first isolated from the air by Daniel Rutherford in 1772. The name 'nitrogen' is derived from the Greek words 'nitron' and 'gene' meaning 'I produce nitre'. Nitre is potassium nitrate compound of nitrogen. Antoine Lavoisier suggested the name *azote*, from the Greek word meaning 'no life'.

11.2.1 Occurrence of Nitrogen

Nitrogen is the fourth most abundant element in the human body. It accounts for about three percent of the mass of the human body. It is thought to be the seventh most abundant element in the universe. Titan, the largest moon of Saturn, has an atmosphere made up of 98% Nitrogen. Nitrogen occurs both in free state and combined state. Nitrogen exists in free state in the atmospheric air as dinitrogen (N_2). It is present in volcanic gases and gases evolved by burning of coal. Nitrogen is present in combined state in the form of minerals like nitre (KNO_3) and chile salt petre ($NaNO_3$). It is present in organic matters such as protein, enzymes, nucleic acid etc.

11.2.2 Physical properties of Nitrogen

- It is a colourless, tasteless and odourless gas.
- It is slightly lighter than air.
- It is slightly soluble in water.
- Nitrogen becomes a liquid at low temperature and looks like water.
- When it freezes, it becomes a white solid.
- It is neutral to litmus like oxygen.

11.2.3 Chemical properties of Nitrogen

1. Chemical reactivity

Nitrogen is inactive at ordinary conditions. It combines with many elements at high temperature and pressure or in the presence of catalyst.

2. Combustion

Nitrogen is neither combustible nor a supporter of combustion. So nitrogen in the air moderates the rate of combustion.

3. Reaction with metals

Nitrogen reacts with metals like lithium, calcium, magnesium etc., at high temperature to form their corresponding metal nitrides.

$$\text{Metal} + \text{Nitrogen} \xrightarrow{\Delta} \text{Metal nitride}$$

Example

$$3Ca + N_2 \xrightarrow{\Delta} Ca_3N_2$$

Calcium Nitrogen Calcium nitride

4. Reaction with non metals

Nitrogen reacts with non-metals like hydrogen, oxygen etc., at high temperature to form their corresponding nitrogen compounds.

$$\text{Non-metal} + \text{Nitrogen} \xrightarrow{\Delta} \text{Nitrogen compound}$$

Example

$$3H_2 + N_2 \xrightarrow{\Delta} 2NH_3$$

Hydrogen Nitrogen Ammonia

11.2.4 Uses of Nitrogen

- Liquid nitrogen is used as a refrigerant.
- It provides an inert atmosphere for conducting certain chemical reactions.
- It is used to prepare ammonia (by Haber's process) which is then converted into fertilizers and nitric acid.
- Nowadays it is used as a substitute for compressed air in tyres.
- It is used for filling the space above mercury in high temperature thermometer to reduce the evaporation of mercury.
- Many explosives such as TNT (Trinitrotoluene), nitroglycerin, and gun powder contain nitrogen.
- It is used for the preservation of foods, manufacturing of stainless steel, reducing fire hazards, and as part of the gas in incandescent light bulbs.

Figure 11.3 Uses of Nitrogen

DO YOU KNOW?

Now-a-days nitrogen is used as a substitute for compressed air in tyres. Have you noticed it? Why do people prefer nitrogen instead of compressed air in tyres?

11.2.5 Nitrogen fixation

Nitrogen gets circulated in the air, soil and living things as the element itself or in the form of its compounds. Just as there is a circulation of carbon in nature so also there is a circulation of nitrogen. It is essential for the proper growth of all plants. The plants cannot make use of the elemental nitrogen from the air as such. The plants require soluble compounds of nitrogen. Thus, plants depend on other processes to supply them with nitrates. Any process that converts nitrogen in the air into a useful nitrogen compound is called nitrogen fixation. Fixation of nitrogen is carried out both naturally and by man.

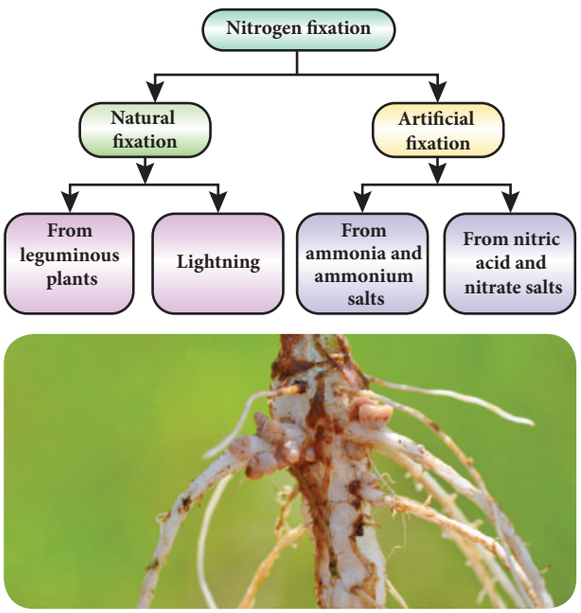

Figure 11.4 Nitrogen fixation in leguminous plants

11.3 Carbon dioxide

Carbon dioxide is a chemical compound in which one carbon and two oxygen atoms are bonded together. It is a gas at room temperature. It is represented by the formula CO_2. It is found in the earth's atmosphere and it sends back the solar energy which is reflected by the surface of the earth, to make it possible for living organisms to survive. When carbon dioxide accumulates more in the atmosphere it produces harmful effects.

11.3.1 Occurrence of Carbon dioxide

Carbon dioxide is present in air to the extent of about 0.03% by volume. It is evolved by the plants and animals during respiration and is produced during fermentation reactions. Much of the naturally occurring CO_2 is emitted from the magma through volcanoes. CO_2 may also originate from the bio degradation of oil and gases. Carbon dioxide emitted by human upset the natural balance of the carbon cycle. Man-made CO_2 in the atmosphere has increased global temperatures which is warming the planet. While CO_2 derived from fossil-fuel is a very small component of the global carbon cycle, the extra CO_2 is cumulative because the natural carbon exchange cannot absorb all the additional CO_2.

11.3.2 Physical properties of Carbon dioxide

- Carbon dioxide is a colourless and odourless gas.
- It is heavier than air.
- It does not support combustion.
- It is fairly soluble in water and turns blue litmus slightly red. So it is acidic in nature.
- It can easily be liquified under high pressure and can be solidified. This solid form of CO_2 is called dry ice which undergoes sublimation.

The process of conversion of solid into vapour without reaching liquid state is called sublimation.

11.3.3 Chemical properties of Carbon dioxide

1. Combustibility

It is non-combustible gas and not a supporter of combustion.

2. Reaction with metals

Lighter metals like sodium, potassium and calcium, combine with CO_2 to form corresponding carbonates whereas magnesium gives its oxide and carbon.

Example

$$4Na + 3CO_2 \longrightarrow 2Na_2CO_3 + C$$

Sodium — Sodium carbonate

$$2Mg + CO_2 \longrightarrow 2MgO + C$$

Magnesium — Magnesium oxide

3. Reaction with sodium hydroxide (Alkali)

Sodium hydroxide (base) is neutralized by carbon dioxide (acidic) to form sodium bicarbonate (salt) and water.

$$NaOH + CO_2 \longrightarrow NaHCO_3 + H_2O$$

Sodium bicarbonate

4. Reaction with Lime water (Calcium hydroxide)

When a limited amount of CO_2 is passed through lime water, it turns milky due to the formation of insoluble calcium carbonate.

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$$

Calcium carbonate

When an excess amount of CO_2 is passed through lime water, it first turns milky and the milkyness disappears due to the formation of soluble calcium hydrogen carbonate, $Ca(HCO_3)_2$.

Venus' atmosphere consists of roughly 96-97% carbon dioxide. Because of the amount of carbon dioxide present, the surface of Venus continually retains heat and as such, the surface temperature of Venus is roughly 462°C, making it the hottest planet in our solar system.

11.3.4 Uses of Carbon dioxide

- CO_2 is used to prepare soft drinks or aerated drinks.
- It is used in fire extinguishers
- It is used in the manufacturing of sodium carbonate by Solvay process.

- Solid carbon dioxide, called as dry ice is used as a refrigerant. The gas is so cold that moisture in the air condenses on it, creating a dense fog which is used in stage shows and movie effects.
- It is used along with ammonia in the manufacture of fertilizers like urea.
- CO_2 can be used in the preservation of food grains, fruits etc.

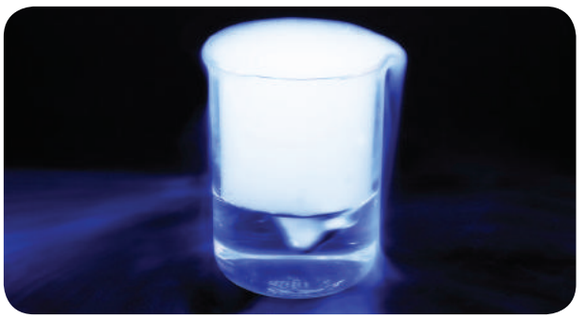

Figure 11.5 Solid carbon dioxide

DO YOU KNOW?

Aerated water is nothing but carbon dioxide dissolved in water under pressure. This is also called 'soda water'.

11.4 Green House Effect and Global Warming

The solar radiation is absorbed by the surface of land and ocean. In turn, they release infra red radiation or heat into the atmosphere. Certain gaseous molecules present in the atmosphere absorb the infra red rays and reradiate the heat in all directions. Hence, these gases maintain the temperature of earth's surface. The gases which absorb these radiations are called **green house gases** and this effect is called **green house effect**.

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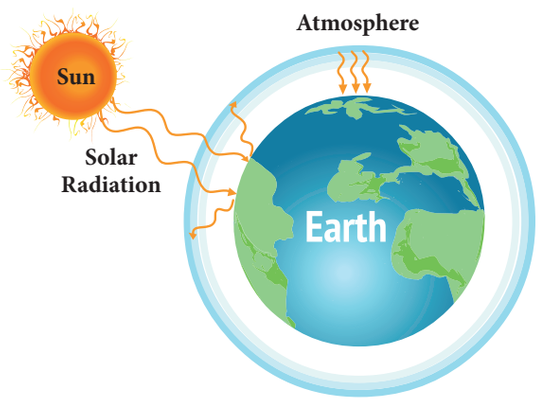


Figure 11.6 Greenhouse effect

The green house gases are CO_2, N_2O, CH_4, CFC (Chlorofluoro carbon) etc. The increase in the levels of these gases results in the gradual increase of temperature of the earth's surface. This green house effect is caused due to increase in the air pollutants and it results in the average increase of temperature of the atmosphere. This is called as **Global warming**.

11.4.1 Effects of Global warming

The following are the effects of global warming.

- Melting of ice cap and glaciers.
- Increase in frequency of floods, soil erosion and unseasonal rains.
- Loss of biodiversity due to the extinction of coral reefs and other key species.
- Spreading of waterborne and insectborne diseases.

11.4.2 Preventive measures

In order to save the earth and its resources we need to take certain measures. Some of the measures are given below.

- Reducing in the use of fossil fuels.
- Controlling deforestation.
- Restricting the use of CFCs.
- Planting more trees.
- Reducing, reusing and recycling resources.
- Using renewable energy resources.

11.5 Acid rain

Rain water is actually the purest form of water. However, pollutants such as oxides of nitrogen (N_2O, NO_2) and sulphur (SO_2, SO_3) in the air released by factories, burning fossil fuels, eruption of volcanoes etc., dissolve in rain water and form nitric acid and sulphuric acid which adds up to the acidity of rain water. Hence, it results in acid rain.

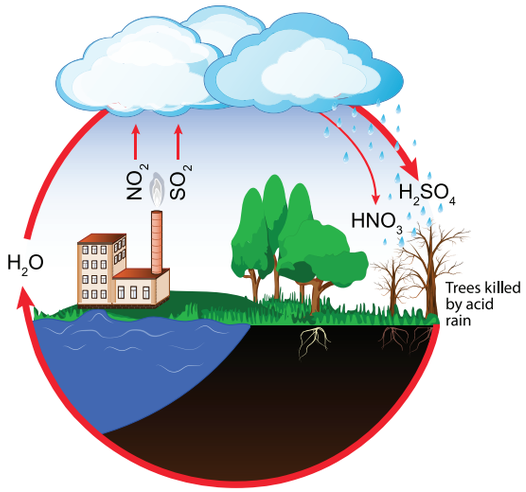


Figure 11.7 Acid rain

DO YOU KNOW?

Acid rain has pH less than 5.6 whereas pH of pure rain water is around 5.6 due to dissolution of atmospheric CO_2 in it.

11.5.1 Effects of Acid rain

Acid rain affects us in many ways. Some of the consequences are given below.

- It irritates eyes and skin of human beings.
- It inhibits germination and growth of seedlings.
- It changes the fertility of the soil, destroys plants and aquatic life.
- It causes corrosion of many buildings, bridges etc.

11.5.2 Preventive measures

Acid rain and its effects can be controlled by the following ways.

- Minimizing the usage of fossil fuel such as petrol, diesel etc.,
- Using CNG (**C**ompressed **N**atural **G**as).
- Using non-conventional source of energy.
- Proper disposal of the industrial wastes.

Points to Remember

- Oxygen exists in nature as silicates, carbonates, oxides and water. It also exists in free state as part of air in the atmosphere.
- Oxygen is a colourless and odourless gas. It dissolves sparingly in water. It is denser than air.
- Metals like magnesium, iron and sodium burn in oxygen and give basic oxides.
- Bacteria convert atmospheric nitrogen directly into soluble nitrogen compounds.
- Though nitrogen is inactive at ordinary condition, it combines with many elements at high temperature and pressure or in the presence of catalyst.
- Carbon dioxide cannot exist as a liquid at atmospheric pressure. It occurs as carbonates in nature.
- Carbon dioxide is acidic in nature and turns lime water milky. It is used in fire extinguisher.
- Global warming refers to an average increase in the temperature of the atmosphere or simply it is the warming of the earth.
- The green house gases are carbon dioxide, methane, nitrous oxide, chlorofluoro carbons, etc.

A-Z GLOSSARY

Atmosphere	Gaseous jacket that surrounds the earth.
Fixation of nitrogen	Process that converts nitrogen in the air into a nitrogen compounds.
Global warming	An average increase in the temperature of the atmosphere.
Green house effect	Trapping of radiation from the sun by green house gases in the atmosphere that leads to rise in the earth's atmospheric temperature.
Haber's process	Synthesis of ammonia from nitrogen and hydrogen with the help of catalyst under 500 atm pressure and 550°C temperature.

Oxygenes	A Greek word meaning 'acid producers' from which the name 'Oxygen' is derived.
Soda water	A form of water produced when carbon dioxide is dissolved in water under pressure.
Sublimation	Process of conversion of solid directly to vapour without reaching liquid state.

TEXTBOOK EXERCISES

Z3N6F8

I. Choose the best answer.

1. Which of the following is true about oxygen?
   a) Completely burning gas
   b) Partially burning gas
   c) Doesn't support burning
   d) Supports burning
2. Aerated water contains
   a) air b) oxygen
   c) carbon dioxide d) nitrogen
3. Solvay process is a method to manufacture
   a) lime water b) aerated water
   c) distilled water d) sodium carbonate
4. Carbon dioxide with water changes
   a) blue litmus to red
   b) red litmus to blue
   c) blue litmus to yellow
   d) doesn't react with litmus
5. Which of the following is known as azote?
   a) Oxygen b) Nitrogen
   c) Sulpher d) Carbon dioxide

II. Fill in the blanks.

1. _____ is called as vital life.
2. Nitrogen is _____ than air.
3. _____ is used as a fertilizer.
4. Dry ice is used as a _____.
5. The process of conversion of iron into hydrated form of oxides is called _____.

III. Match the following.

Nitrogen	Respiration in living animals
Oxygen	Fertilizer
Carbon dioxide	Refrigerator
Dry ice	Fire extinguisher

IV. Answer briefly.

1. Mention the physical properties of oxygen.
2. List out the uses of nitrogen.
3. Write about the reaction of nitrogen with non metals.
4. What is global warming?
5. What is dry ice? What are its uses?

V. Answer in detail.

1. What happens when carbon dioxide is passed through lime water? Write the equation for this reaction.
2. Name the compounds produced when the following substances burn in oxygen.
   a) Carbon b) Sulphur
   c) Phosphorous d) Magnesium
   e) Iron f) Sodium
3. How does carbon dioxide react with the following?
   a) Potassium b) Lime water
   c) Sodium hydroxide
4. What are the effects of acid rain? How can we prevent them?

VI. Higher Order Thinking Questions.

1. Soda bottle bursts sometimes when it is opened during summer. Why?
2. It is said that sleeping beneath the tree during night is not good for health. What is the reason?
3. Why does the fish die when it is taken out of water?
4. How do astronauts breathe when they go beyond earth's atmosphere?

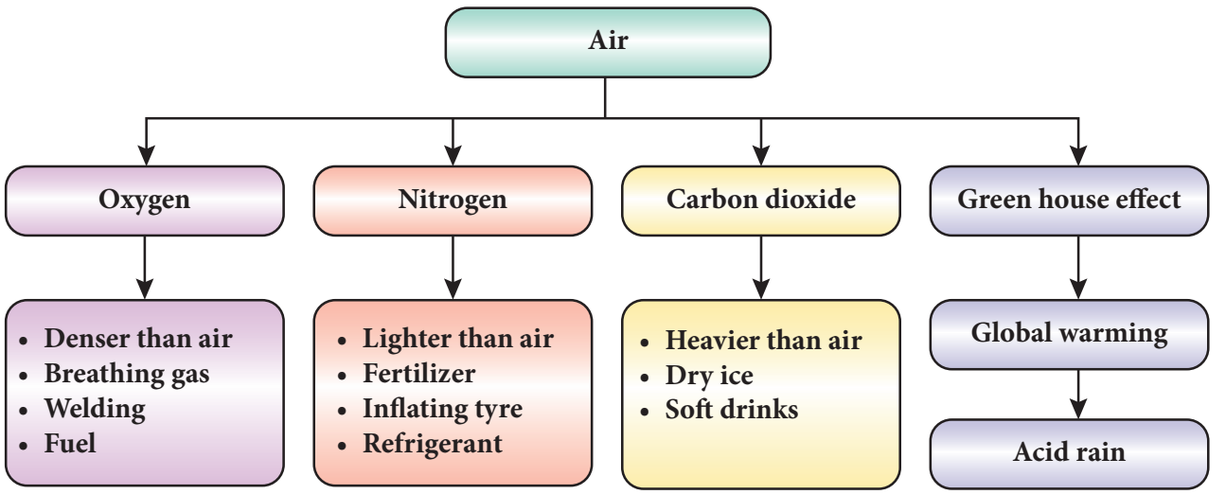
REFERENCE BOOKS

1. Environmental Science - Timothy O Riordan Second edition
2. Basic of atmospheric science - A. chandrasekar
3. Text book of Air pollution and its control - S.C. Bhatia

INTERNET RESOURCES

1. www.chemicool.com
2. www.nationgeographic.com
3. www.environmentalpollutioncenters.org

Concept Map



ICT CORNER

AIR

Through this activity you will know about carbon emission, climate change, global average temperature etc.

Step 1

- Open the Browser and type the URL given below.
- Click onany one of the items to know about carbon emission, climate change, global average temperature, sea level etc.
- For example, click on the "**Climate Time Machine**" a popup screen will open. In that you can able to see carbon emission global average sea level, temperature, sea ice etc.
- When you click global average sea level, you will find year wise sea level.

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Browse in the link: https://climatekids.nasa.gov/menu/play/