Air and Atmosphere

Composition of Air

Air

The space around us is not empty, it is filled with air. Air is colourless and transparent. It forms a layer around the earth known as atmosphere.

Wind

Have you seen kites flying in the sky? You may have also seen flags swirling in the sky, what makes these objects move?

They move because of the presence of air. The objects move along with the movement of air. Moving air is called **wind**. The direction of moving wind can be observed using a wind vane.

Composition of Air

We know that air exists in all places and that it is a gas. However, what is it composed of?

Air is a mixture of many components. Let us list and understand the features of its various components.

Water Vapour

Water from the ponds, lakes, rivers, etc. evaporates into the atmosphere as water vapour and is known as humidity. This water vapour condenses to form clouds. When the water droplets become too heavy for the clouds to hold them, it falls to the earth as rain. Thus, water vapour plays an important role in the water cycle.

The maximum amount of water vapour in the air will be 4-5%. The water vapour present in air depends upon the temperature and altitude of that place, therefore the amount of water vapour near sea and lakes is more than the water vapour present on land areas.

Oxygen

Let us perform a simple activity to prove that oxygen is present in the air. Place two burning candles in two different bowls containing some water. Invert two glasses of differing heights over the two burning candles. **Do the candles continue to burn? How long do they burn? Is there any change in the water levels inside the glasses?**

Oxygen is essential for burning. The candles continue to burn as the inverted glass contains oxygen. The candle that is covered by the longer glass burns longer than the candle covered with the shorter glass. This is because the longer glass contains more amount of air i.e., more amount of oxygen than the shorter glass. The water levels in the glasses increase with time. This is because the air present inside the glasses decrease as oxygen is being consumed by the burning candles. Water, therefore, moves in to fill these spaces.

Curiosity Corner

Deep sea divers carry oxygen cylinders. Humans cannot use dissolved oxygen unlike

fish and other aquatic animals, which can use the oxygen that is dissolved in water.

Carbon dioxide

Lime water changes its colour to milky white in the presence of carbon dioxide. This property can be used to test the presence of carbon dioxide as shown in the given animation.

The process of burning any material produces carbon dioxide. The black-coloured smoke that is released during burning contains carbon dioxide. Since we breathe in oxygen, we tend to feel suffocated when we try to breathe in air that contains carbon dioxide.

Carbon dioxide is a very important component of air as plants utilise it to synthesise their food in the presence of sunlight by the process of photosynthesis. It is also used in fir extinguishers to control fire.

Dust Particles

On a sunny day, observe the beam of light entering the room carefully. You will observe numerous small particles floating in the air. These are dust particles.

The ceiling fans become dirty even when cleaned regularly because of the presence of dust. When furniture and other objects are not regularly cleaned, we can observe a layer of dust on them.

The amount of dust particles present in the air varies from time to time and also from place to place. Dry regions that have fewer plants tend to have more dust.

Curiosity Corner

The air that we breathe contains dust particles. Fine hair that is present in the nose filters this dust before the air reaches the lungs.

Smoke

Have you seen smoke coming out from long chimneys that extend from factories? Do you know why these chimneys extend so high up in the air?

Burning produces smoke. Smoke contains harmful materials such as carbon dioxide. It also contains other harmful gases. Therefore, these chimneys are present away from the people.

Automobiles produce smoke. Since policemen spend most of their time in traffic, we often observe them wearing protective masks.

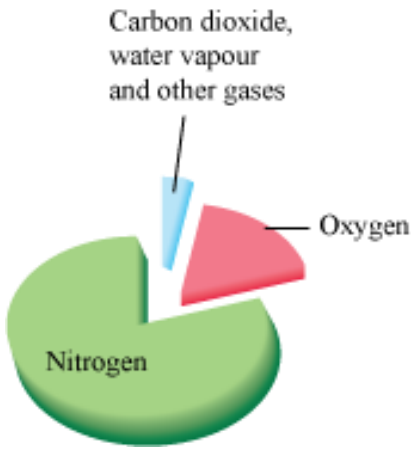
Argon

Argon is among the many unreactive gases present in the earth's atmosphere. It is present in very small amount in the atmosphere. It is used in industries for the manufacturing of high quality steels.

Nitrogen

Nitrogen is an important component of air. More than 78% of the air is composed of nitrogen. It is the largest constituent of air. It is used as fertilizer to increase the yield of crops. Also, in liquid form it is used as a coolent in industries.

Thus, it can be concluded that air is a mixture of many gases, water vapour, dust particles, and smoke. After nitrogen, oxygen is the most abundant gas constituting around 21% of the air. The rest 1% of the air contains carbon dioxide, argon, water vapour, and dust particles.



After studying all the above components of air, the question arises that whether air is a mixture or a compound?

Air is a mixture and not a compound which can be elucidated by the following reasons:

- It can be separated into its constituents, such as oxygen, nitrogen etc. by fractional distillation of liquid air, while the components of compounds cannot be separated.
- It shows the properties of all the gases present in it, whereas in compounds the individual properties of the components are not evident.
- It has variable composition as at different places, different amount of gases are present in it, whereas the composition of a compound is always fixed, irrespective of time and place.
- It cannot be represented by a formula because the proportion of the constituents present in it is not fixed, whereas the compounds have a definite formula.

Do you know?

Matter can be changed from one state to the other by changing the temperature and pressure. Gases can also be changed into the liquid state by lowering the temperature and increasing the pressure of the gas. This process is known as "**liquefaction of gas**". Liquid gases like liquid oxygen and liquid hydrogen are used as a rocket fuel. LPG (**L**iquefied **P**etroleum **G**as) we use in our home is also a liquid gas which enables us to easy transportation and usage of it

Nitrogen Cycle

The Nitrogen Cycle

To understand the nitrogen cycle, we should know

- **where nitrogen is present in the environment**
- **which organisms utilize nitrogen and how they do so**
- **how the utilized nitrogen returns to the environment**

In the atmosphere, the concentration of nitrogen is about 78%. It is essential for plants. Nitrogen forms a structural component of many important molecules such as DNA, RNA, and other vitamins.

Plants cannot absorb nitrogen from the atmosphere. So, **how is atmospheric nitrogen utilized by plants?**

There are methods that change atmospheric nitrogen into usable forms through the process of **nitrogen fixation**. Two such methods are given below.

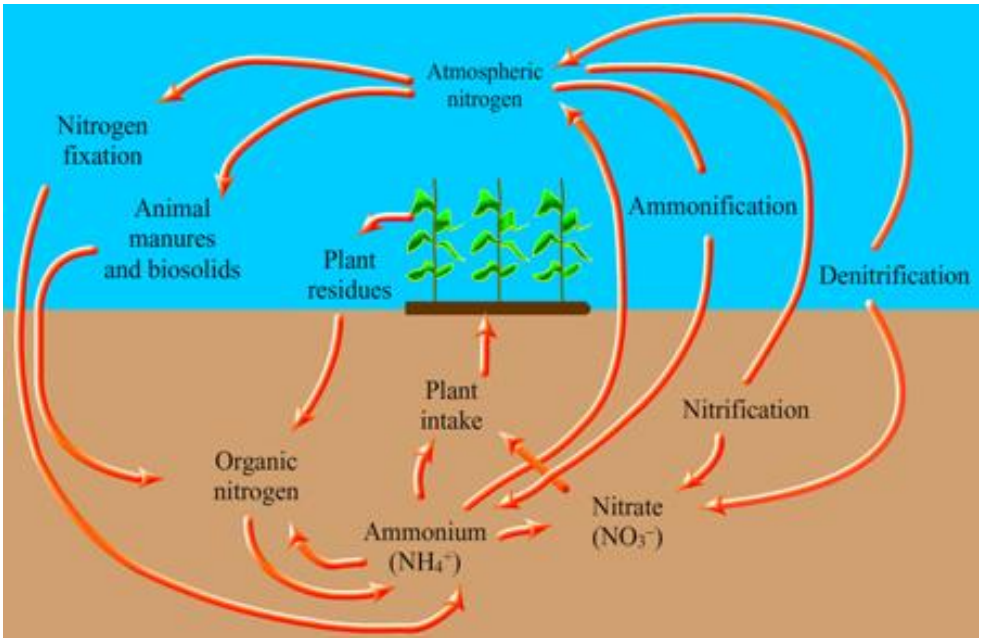
[1]. During lightning and thunder, the high temperature and pressure in the air convert atmospheric nitrogen into oxides of nitrogen that can dissolve in water to produce nitric and nitrous acids. These fall along with rain.

[2]. Certain forms of bacteria are able to convert atmospheric nitrogen into usable forms such as nitrates and nitrites. Such nitrogen fixing bacteria are commonly found in the roots of **legumes** (plants of pulses) inside special structures called **root nodules**.

These usable forms of nitrogen are absorbed by plants to produce many compounds such as amino acids, which in turn form proteins.

When an animal feeds on plants, nitrogen enters its body.

How does nitrogen return to the environment?



When plants and animals die, they start decomposing after some time. During this process, proteins are converted into nitrates and nitrites by the action of decomposing

bacteria. Certain other forms of bacteria convert nitrates and nitrites into elemental nitrogen. Thus, nitrogen flows between the various components of the biosphere in a cyclical manner.

Sources of Air Pollution

Air is everywhere around us and we all need clean air for breathing. But did you know that as a result of the addition of some substances to air, it is increasingly becoming toxic for living organisms?

The contamination of air with unwanted substances, which have harmful effects on both plants and animals, is known as **air pollution**.

The substances that cause the contamination of air are called **air pollutants**. Let us explore these sources of air pollution in detail.

Sources of air pollution

There are two sources of air pollution:

- Natural sources
- Man-made sources

Natural sources

You may have seen on television that during the summer season some forests catch fire. These fires are caused when, as a result of high temperatures, dead plant materials such as barks, twigs, and leaves, which are lying on the forest floor, start burning. These fires emit large amounts of smoke into the atmosphere, thereby polluting the air.

The other natural source of air pollution is volcanoes. Volcanoes emit large amounts of harmful gases and dust particles into the atmosphere, thus contributing to air pollution.

Did you know that the Pacific Ring of Fire is an area of high volcanic activity encircling the basin of the Pacific Ocean?

Man-made sources

Although natural sources contribute to air pollution, did you know that human activities contribute the most towards air pollution? Human activities that cause air pollution include emissions from power plants, automobile exhausts, and factories; burning of fossil fuels and firewood, etc.

Let us now explore various air pollutants and their sources.

Carbon monoxide

Carbon monoxide is a toxic, colourless gas. It is produced by the incomplete burning of fossil fuels. It is mainly produced by vehicles.

Smog

Smog is formed by the combination of smoke and fog. It is a highly noxious mixture of pollutants that affects the health of living organisms. Smog is a common winter phenomenon in a large number of modern day cities such as Delhi.

Oxides of sulphur and nitrogen

Sulphur dioxide and nitrogen dioxide are major oxides of sulphur and nitrogen that act as pollutants. These are released from petroleum refineries and also from power plants that use coal as a fuel.

Chlorofluorocarbons

Chlorofluorocarbons are also known as CFCs. They are used in refrigerators, air conditioners, and aerosol sprays. They cause damage to the ozone layer in the atmosphere.

Do You Know:

Indian cities such as Delhi, Kolkata, and Kanpur top the list of cities in the world with the highest air pollution levels.

Effects of air pollution

- Increase in the amount of carbon dioxide level can cause increase in global temperature. This is known as "**Green House Effect".** This increase in temperature leads to the melting of polar ice caps and glaciers which increase the water level in seas and oceans.
- **Global warming -** The phenomena of rise in overall temperature of the Earth because of the rise in CO_2 is known as global warming. CO_2 has a tendency to absorb sun's heat and not let them escape. Thus, it increases the earth's temperature.
- Inhalation of certain gases like carbon monoxide (CO) can cause various respiratory diseases like Asthma and lung cancer.
- Sulphur dioxide causes irritation to the eyes and if combines with water vapour present in air, it forms an acid which comes on earth surface with the rain water. This type of rain is called acid rain. Acid rain affects the growth of the plants. It has also damaged "Taj Mahal"
- There is increase in the depletion of ozone layer due to the constant increase in the air pollution.

Do You Know?

Gases like Carbon dioxide, Methane, Chlorofluorocarbon and Nitrous oxide are known as Green House Gases.

Prevention of Air Pollution:

Air pollution can be prevented by adopting various methods like using non-conventional energy sources instead of conventional sources, increasing the efficiency of engines to control the smoke coming out of the vehicles, making factory chimneys at high altitude or using electrostatic precipitators. Air pollution can be reduced by recycling the plastic and rubber and by planting more and more trees.
Government has introduced **Euro/Bharat norm** (applicable to all vehicles) on the level of vehicular emission. Under this, strict controls are to be maintained in large cities, to cut down sulphur and nitrogen oxides from automobiles exhausts.

Effects of Air Pollution on Living Organisms

Do you know that air pollution has significant health effects on all living organisms including human beings? Let us explore further.

Various air pollutants cause diseases that range from skin cancers to respiratory disorders. Let us examine in detail the effect that each pollutant has on living organisms.

Carbon monoxide

Carbon monoxide is a pollutant that is released as a result of the incomplete burning of fuels such as diesel and petrol. **What effect does carbon monoxide have on the health of humans**?

Carbon monoxide combines with haemoglobin, which is present in the red blood cells, and decreases the oxygen-carrying capacity of blood.

Sulphur dioxide

Sulphur dioxide is a pollutant that is produced during the combustion of fuels such as coal. It causes many respiratory problems such as cough and throat irritation when inhaled in small amounts. Continuous exposure to sulphur dioxide may cause permanent damage to the lungs.

Nitrogen dioxide

Exposure to nitrogen dioxide causes damage to the lungs apart from other respiratory disorders.

Smog

Do you know what smog is? Some of you may have seen a thick fog-like layer in the atmosphere during the winter months. This is smog. **Do you know how it is formed?** Smog is formed when smoke mixes with fog. **But how does smog affect the health of living organisms?**

Smog is made up of many air pollutants such as the oxides of nitrogen. It causes breathing difficulties such as asthma, cough, and wheezing among children.

Do You Know:

The great smog of 1952 in London caused the darkening of streets and killed approximately 4,000 people in just four days.

Chlorofluorocarbons (CFCs)

Chlorofluorocarbons are responsible for damaging the ozone layer and have led to the formation of the ozone hole in the atmosphere. A rapidly depleting ozone layer allows the harmful UV radiations of the Sun to reach the Earth, which is responsible for an increase in the cases of skin cancers.

Suspended particles

Suspended particles are tiny particles that are produced because of the burning of fossil fuels. They trigger many respiratory diseases such as asthma and sneezing when inhaled.

The hair present in the nostrils prevent the suspended dust particles from entering our lungs. However, some dust particles are so small that they cannot be trapped in the nostrils and they enter the respiratory system.

Do you know that pollution has an equal damaging effects on plants?
Yes, pollution causes various klinds of changes in plants like unrequired closure of stomata, slower rates of photosynthesis and retarded growth of plants.

Oxygen

Oxygen forms 21% of the air by volume and is vital for the existence of life.

Discovery: Oxygen was discovered in 1774 by the British chemist Joseph Priestly. He heated mercury (II) oxide with concentrating rays of the sun. He found that a gas evolves, which is colourless and odourless but chemically active.

Occurrence: Oxygen occurs in free as well as in combined state.

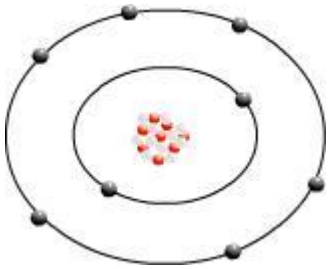
Forms of Oxygen	Percentage (%)
Earth's crust	50
Water	89
Minerals	45−50
Atmosphere	21
Vegetation	60−70
Animals	60−70

When in free state, it is represented as O.

Oxygen has an atomic number 8 and an atomic mass of 16 u. It contains 2

and 6 electrons in K and L shell respectively.

In molecular form, it is a diatomic molecule, i.e. O_2.

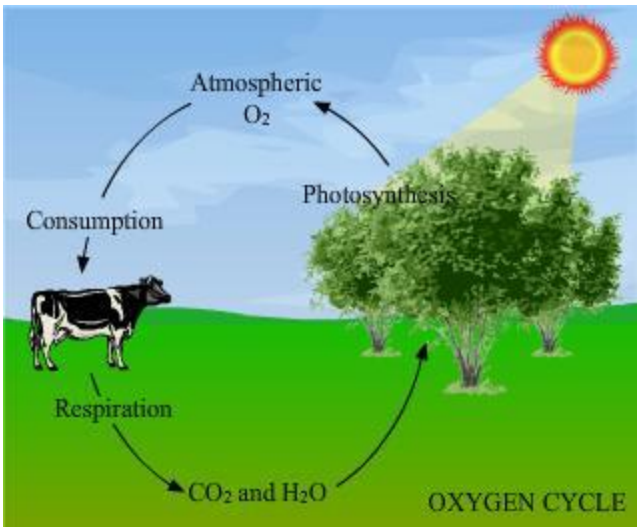


Do You Know?

Oxygen element is also present in triatomic form in atmosphere, which is known as ozone. Ozone is represented as O_3.

Oxygen is used by all living beings for respiration. This oxygen comes from the process of photosynthesis. Thus, oxygen is maintained in the atmosphere by photosynthesis and respiration.

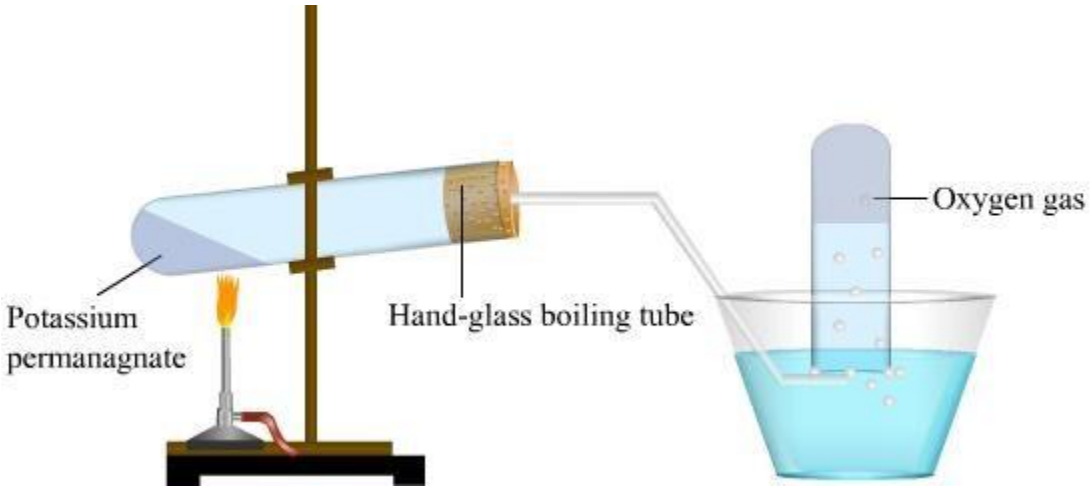
Respiration ⇿ Photosynthesis



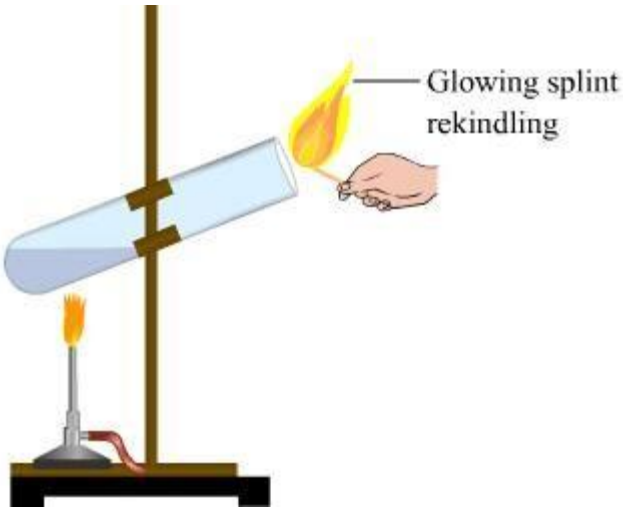
Hence, green vegetation plays an important role in maintaining the constant percentage of oxygen in the atmosphere.

Laboratory preparation of Oxygen: When potassium permanganate is heated in a test tube at 240ºC, it gets decomposed into potassium manganate, manganese dioxide and oxygen.

$$2\ KMnO_4 + \text{heat} \rightarrow K_2MnO_4 + MnO_2 + O_2$$



If a burning matchstick is taken near the test tube, it will start burning sharply. This proves that oxygen is essential for the process of burning.



Oxygen can also be prepared from air:
To obtain oxygen from air, the air is first treated to remove carbon dioxide, water vapours and dust particles. Now the air contains only nitrogen and oxygen. This air is then subjected to high pressure and then cooled and expanded so that it gets liquified.

The liquid air is then distilled. Nitrogen boils and turns into gas again at -195.5°C. This leaves behind bluish liquid oxygen which turns into a gas at -183°C.

Oxygen can also be prepared from water:
Oxygen can be prepared from water by using electrolysis. Electrolysis is a process in which electricity is passed through water containing small amount of acid.

As a result, water breaks into hydrogen and oxygen gases. Using this method, oxygen can be obtained on a large scale along with hydrogen.

$$\text{Water} \xrightarrow{\textit{Electric current}} \text{Hydrogen} + \text{Oxygen}$$

Let us perform an activity to understand the importance of oxygen gas in burning.

Activity Time!

Take two lighted candles and place an inverted glass chamber over one of them.

What do you observe?

You will see that the candle is blown off.

Why does this happen?

When inverted glass chamber is placed over the burning candle, it inhibits the supply of oxygen gas, which causes the blowing off of the candle flame.

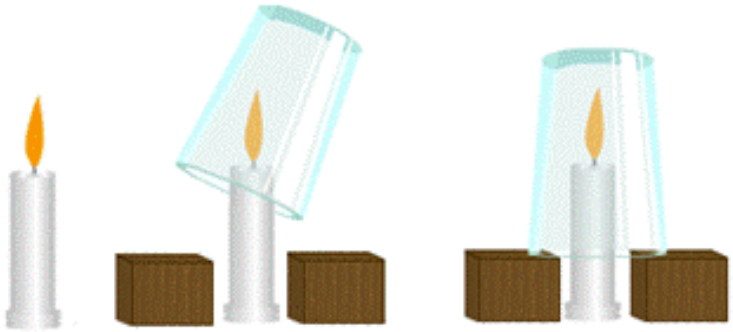
Now take another candle. On two wooden blocks, place an inverted glass chamber over the candle.

What do you observe?

You will see that candle is still burning.

Why does this happen?

This happens because now oxygen gas is available to the candle for the burning process.



Do You Know?

Combustion: Combustion is a chemical reaction in which fuel is burnt in the presence of oxygen or an oxidizing agent. It is a type of exothermic reaction which involves the release of energy in the form of heat or release of light.

The best example of combustion is the combustion of hydrogen and oxygen, which produces water vapour. This reaction is commonly used in rocket engines.

$$2H_2 + O_2 \rightarrow 2H_2O(g) + \text{Heat}$$

Chemical properties of oxygen:

• Reaction with carbon: Carbon reacts with oxygen to form carbon dioxide with the release of heat.

$$C\,(s) + O_2\,(g) \xrightarrow{\Delta} CO_2\,(g) + \Delta T$$

• Reaction with sulphur: Oxygen reacts with burning sulphur to form sulphur dioxide and sulphur trioxide.

$$2S\,(s) + 3O_2\,(g) \xrightarrow{\Delta} 2SO_3\,(g) + \Delta T$$

• $S\,(s) + O_2\,(g) \xrightarrow{\Delta} SO_2\,(g) + \Delta T$

• Reaction with phosphorus: Oxygen reacts with burning phosphorus to form phosphorus pentoxide.

$$4P\,(s) + 5O_2\,(g) \xrightarrow{\Delta} 2P_2O_5\,(s) + \Delta T$$

• Reaction with sodium: Oxygen reacts with warm sodium to produce a golden yellow flame to form sodium peroxide.

$$4Na\,(s) + O_2\,(g) \xrightarrow{\Delta} 2Na_2O\,(s) + \Delta T$$

• Reaction with calcium: Oxygen reacts with burning calcium with a brick red flame to form calcium oxide.

$$2Ca\,(s) + O_2\,(g) \xrightarrow{\Delta} 2CaO\,(s) + \Delta T$$

• Reaction with iron: Oxygen reacts with iron with white sparks and crackling sound to form a reddish brown powder of triferric tetraoxide.

$$3Fe\ (s) + 2O_2\ (g) \xrightarrow{\Delta} Fe_3O_4\ (s) + \Delta T$$

In the last three reactions, the metals lose their lustre due to the formation of an oxide layer on their surface, this is termed as corrosion of metals.

Rusting of iron

You must have observed that when articles of iron are kept out in the open for some time, they get covered by a brownish substance. This brownish substance is called **rust**. Rust is the new substance obtained from the combination of iron and atmospheric oxygen.

The characteristic properties of rust are different from that of iron as well as oxygen. Hence, rusting of iron is a chemical change, which affects the articles made of iron and slowly destroys them.

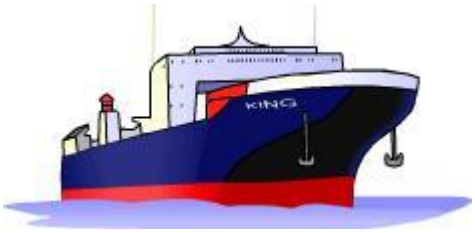
The chemical process that occurs during rusting can be represented as follows:

Iron (Fe) + Oxygen (O_2) + Water (H_2O) → Rust (Fe_2O_3)

The process of rusting becomes faster with an increase in moisture content in the air. That is why water pipes made of iron tend to get rusted easily.

Do You Know?

Salt makes the process of rusting faster. Rusting is a complex process that involves many steps. The presence of salt speeds up the first step, which in turn speeds up the whole process.

Do you know?	
Ships are made of iron, a part of which remains under water. Seawater has many salts dissolved in it and salty water hastens the process of rusting. Therefore, ships suffer a lot of damage and a fraction of a ship's iron has to be replaced every year. A large amount of money is spent to replace the damaged iron and steel.	

Physical properties of Oxygen

- Oxygen is a colourless, odourless and tasteless gas.
- It supports life and is non-poisonous.
- It is slightly heavier than air.
- It is only slightly soluble in water.
- It can be liquefied into a bluish liquid by applying high pressure at -183°C.
- The boiling point and freezing point of liquid nitrogen is -183°C and -218.4°C.

Uses of Oxygen Gas:

Respiration: Oxygen is essential for life. It is also used for artificial respiration in deep sea diving, submarines, high altitude climbing and spaceships.

Aquatic life: Oxygen is sparingly soluble in water but the small quantity of oxygen dissolved in water is essential for aquatic life.

Cutting and welding: Oxygen gas is used with hydrogen or coal gas in blowpipes. It is used with acetylene in the oxy-acetylene torch for welding and cutting metals.

Industries: Oxygen gas is also used in a number of industrial processes and chemical laboratories.

Medical: Oxygen gas is used in the treatment of asthma, heart attack, pneumonia and gas poisoning. It can be used as an anesthetic when mixed with nitrous oxide, ether vapour, etc.

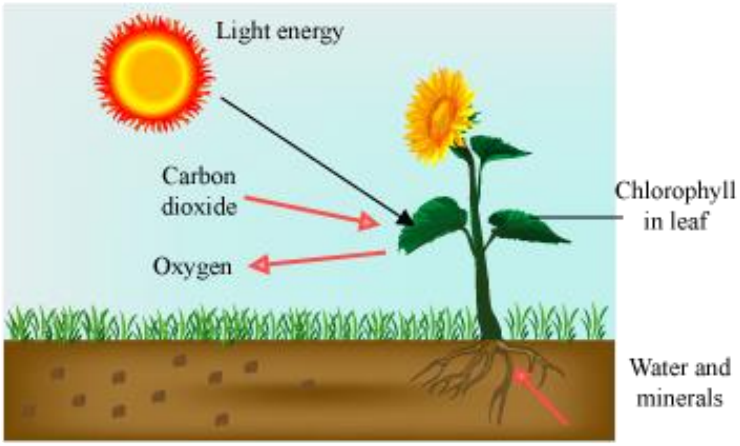
Carbon dioxide is often mixed with oxygen as this stimulates breathing and this mixture is also used in case of carbon monoxide poisoning.

Explosives: Liquid oxygen mixed with powdered charcoal and coal dust is used for blasting rocks.

Oxygen-Carbon Dioxide Cycle

Oxygen is consumed during the process of respiration. If all the organisms consume oxygen, then the amount of oxygen in the atmosphere would continuously decrease. Over a period of time, there will be no oxygen left in the atmosphere. However, this does not occur.

Therefore, there must be some process that is constantly producing oxygen in the environment in order to maintain a balance.



The process illustrated in the figure is photosynthesis. Plants produce food by the process of photosynthesis. During photosynthesis, plants consume carbon dioxide and water to produce food and release oxygen into the environment.

$$6\,CO_2 + 12H_2O \xrightarrow[\text{chlorophyll}]{\text{light}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

Animals and humans, on the other hand, breathe in oxygen and produce carbon dioxide that is released during the process of respiration. Thus, both plants and animals are important to maintain a balance of the respiratory gases in the environment.