Chapter-7

AIR AND ATMOSPHERE

INTRODUCTION

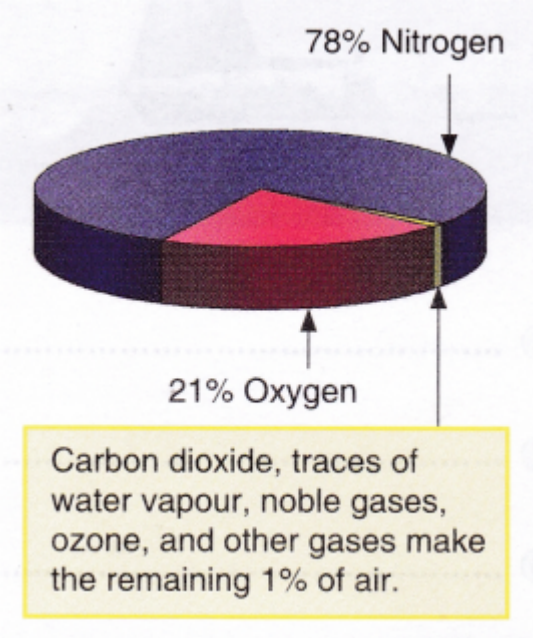
- Air is the most essential substance for the survival of life.
- It is used for respiration for all kinds of living beings.
- Air helps in burning and producing energy.
- It is invisible and transparent as it is a mixture of colourless gases.
- We cannot see air, but certainly feel it.

OCCURRENCE OF AIR

- Air occur in the atmosphere and surrounds the earth and extends about 300 Km above its surface.
- It occurs in the water bodies in the dissolved state and helps in the survival of aquatic animals.

CONSTITUENTS OF AIR

- The main constituents of air are nitrogen and oxygen.
- The composition of air can be shown by a pie chart as given below: -

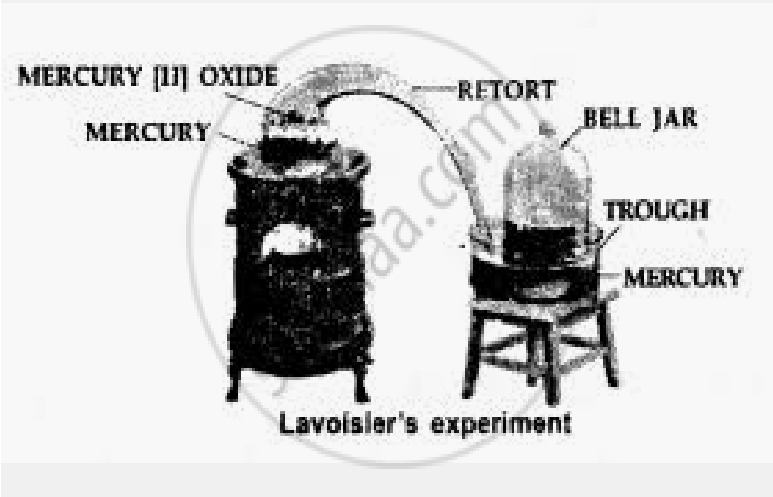


LAVOISIER'S EXPERIMENT

- Lavoisier took mercury in a retort and heated it. The other end of the retort is connected to a bell jar containing air. The jar was kept in an inverted position over mercury contained in a trough.
- Observation: -
  - A red layer of mercuric oxide was formed on the hot surface of mercury in the retort.
  - The level of mercury in the trough rose by 1/5 the of the total volume of the bell jar.

➤ Conclusion: -

- The $1/5^{th}$ portion of the air used up by mercury to form red oxide is the active air. Lavoisier named this part as "OXYGEN"
- The remaining $4/5^{th}$ part of the air does not support burning and was named as "azote" meaning unsuitable for life. Later on, Lavoisier named it "NITROGEN"
- It was concluded that nitrogen and oxygen are the two main constituents of air present in the ratio 4: 1.



EVIDENCES TO SHOW THAT AIR IS A MIXTURE

- The composition of air is not fixed.
- The components of the air retain their individual properties.
- Liquid air has no definite boiling point.
- No energy changes take place during the formation of mixture.
- Components of air can be separated by simple physical methods.

THE IMPORTANCE OF THE VARIOUS COMPONENTS OF AIR

NITROGEN

Physical properties of nitrogen

- It is a colourless, odourless and tasteless gas.
- It is slightly lighter than air.
- It is non-poisonous.

- It is not combustible
- It is slightly soluble in water.

Uses Of Nitrogen

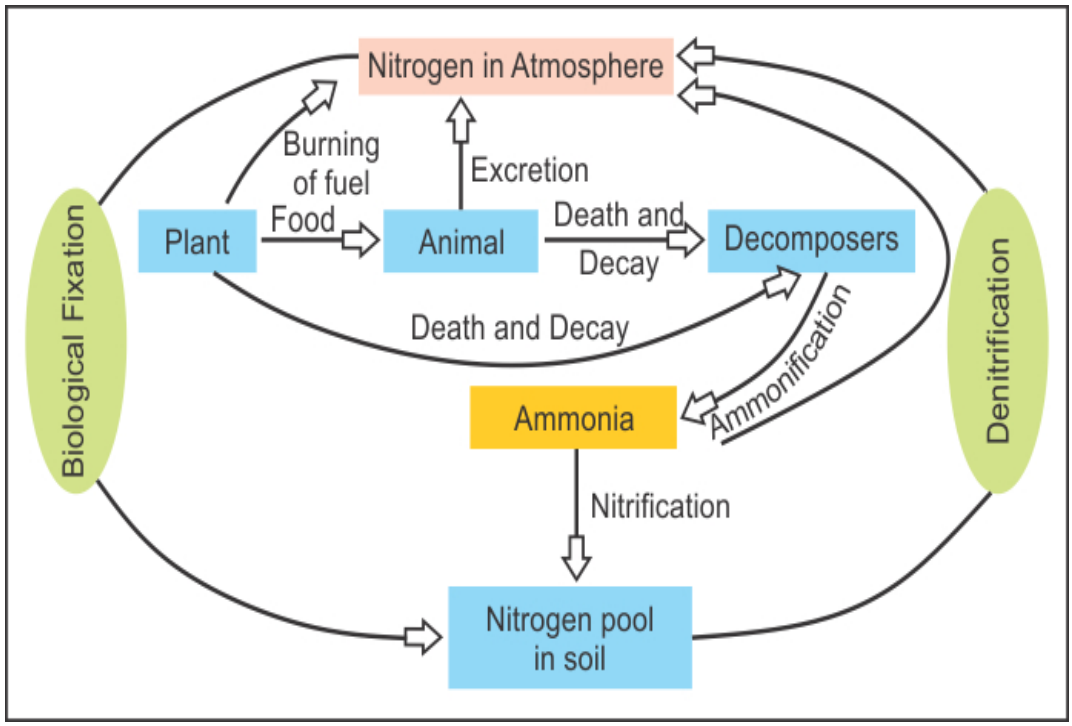
- It controls the rate of combustion
- It is used to make ammonia and nitric acid
- It is an important constituent of proteins that are necessary for the growth of plants animals and human beings
- It is used to make fertilizers like potassium nitrate ammonium sulphate urea
- It is used to prepare explosives like trinitrotoluene (T.N.T) and nitroglycerine
- For flushing food packages

IMPORTANCE OF NITROGEN FOR PLANTS ANIMALS AND HUMAN BEINGS

- Nitrogen is of vital importance to the plants and human beings as it provides proteins.
- Nitrogen gets returned to the soil when plants and animals die and decay. In this way the amount of nitrogen is balanced in the nature.

NITROGEN CYCLE

- The circulation of nitrogen through the living and non-living compounds of the biosphere is called as nitrogen cycle.
- The diagrammatic representation of the nitrogen cycle is as follows: -



NITROGEN FIXATION

The phenomenon by which nitrogen is converted into nitrates and nitrites and get fixed in the soil is known as Nitrogen Fixation.

TYPES OF NITROGEN FIXATION

1- Biological fixation

2- Non-Biological fixation

BIOLOGICAL FIXATION

Leguminous Plants

1- Root nodules————convert———— 2- Free nitrogen--(in air and soil) ————————-–→ 3-Soluable Nitrates and Nitrites——(in soil) ————————(converted by plants) ———————4- Proteins

NON-BIOLOGICAL FIXATION

Nitrogen + O_2——electric spark--→ Nitric oxide + O_2—NO_2 + H_2O—HNO_3 (Nitric Acid) and Nitrous oxide——Minerals ———Soluble Nitrate.

Special Note: - ACID RAIN IS A BAD EFFECT OF THIS NATURAL PROCESS

OXYGEN

Oxygen constitutes about 21 % of air by volume. It is the active part of air.

Uses of Oxygen: -

- It supports life on the earth.
- It is essential for combustion.
- Oxygen dissolved in water supports aquatic life.

CARBON DIOXIDE

Carbon dioxide is present in the atmosphere in a very small quantity i.e 0.03 to 0.04 %.

Uses of Carbon dioxide: -

- It is essential for the process of Photosynthesis.
- It acts as a greenhouse gas and thus balances the temperature of the earth.
- Carbon dioxide is used in the fire extinguisher.

WATER VAPOUR

Water vapour in the air is also known as moisture. The amount of moisture present in the air is known as Humidity.

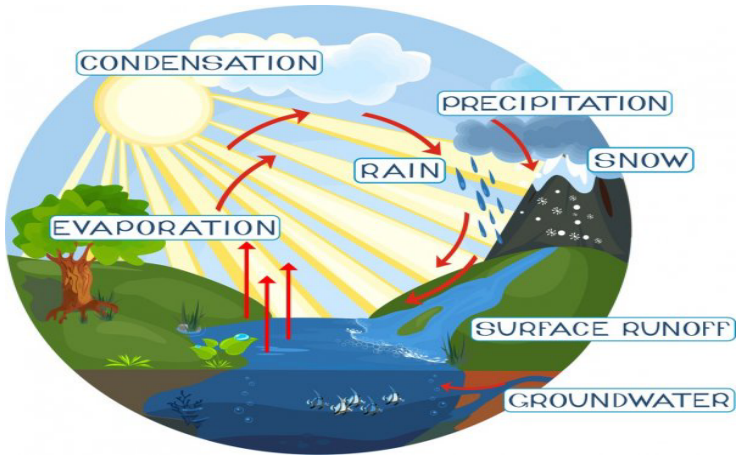
Uses of water vapour: -

- It determines the earth's climatic condition.
- It controls the rate of evaporation
- It is essential for the growth of plants.

WATER CYCLE

- The continuous circulation of water from the earth's surface to the atmosphere in the form of vapour and back to the earth's surface in the form of snow, mist, dew and fog etc in a cyclic manner is known as Water Cycle.

- The different form of precipitation are Fog, Mist, Dew, Frost, Hail, Sleet and Snow.
- The diagrammatic representation of the water cycle is given below : -



INERT GASES

About 0.96% of air, by volume is made up of inert gases. They are six in number. Helium, Neon, Argon, Radon, Krypton and Xenon. Argon is the most abundant inert gas.

DUST PARTICLES

- These are solid, minute soil particles present in the air.
- Water vapour condenses around the dust particles and form clouds.
- An excess of these particles causes serious respiratory problems.

AIR QUALITY

- Air is important for the survival of human beings.
- It should be free from the impurities.
- The various harmful substances present in the air is known as Air Pollutant.
- The following human activities are responsible for the pollution of air :-
    - Burning of fossils fuel and fibres.

- Cutting of forests.
- Emission from the vehicles.
- Increased number of industries.
- Use of chemical fertilizers and insecticides.
- Use of nuclear bombs and other chemical weapons.

TYPES OF POLLUTANTS IN THE AIR AND THEIR HARMFUL EFFECTS

1. Suspended Particulate Matter (SPM)

   - Particles of lead oxide present in the automobile exhaust can cause brain damage in children. It also obstructs the development of blood cells.
   - Particles of dust, cement, ash and soot in the smoke may causes bronchitis. Asbestos fibre can cause a serious diseases called as silicosis.
   - Pollen grains can cause allergic reactions in human beings.

2. Oxides of carbon

   - Carbon monoxide combines with the haemoglobin to form a stable compound carboxyhaemoglobin from which haemoglobin cannot be recovered back.
   - Breathing in carbon dioxide rich air causes headache, dizziness and might cause death.
   - Excess carbon dioxide in the air causes global warming.

3. Oxides of sulphur and nitrogen

   - SO_2 and SO_3 are highly poisonous gases and may causes serious respiratory problems.
   - H_2S (Hydrogen Sulphide) is highly obnoxious and causes headache.
   - Oxides of nitrogen in Smog affects our eyes.
   - Oxides of nitrogen causes acid rain, damages the buildings and crops etc.

4. Other pollutants (CFC)

- CFC (Chlorofluorocarbons) used in the refrigerators cause depletion of the ozone layer.
- The UV rays falling on the body of human beings causes skin cancer.

ACID RAIN

- A rain which is acidic in nature is called as ACID RAIN.
- The formation of acid rain can be shown by the following chemical equations: -

Sulphur dioxide + water———→ sulphurous acid

$SO_2 + H_2O$———→ H_2SO_3

Sulphur trioxide + water———→ sulphuric acid

$SO_3 + H_2O$———→ H_2SO_4

Sulphurous acid + oxygen———→ sulphuric acid

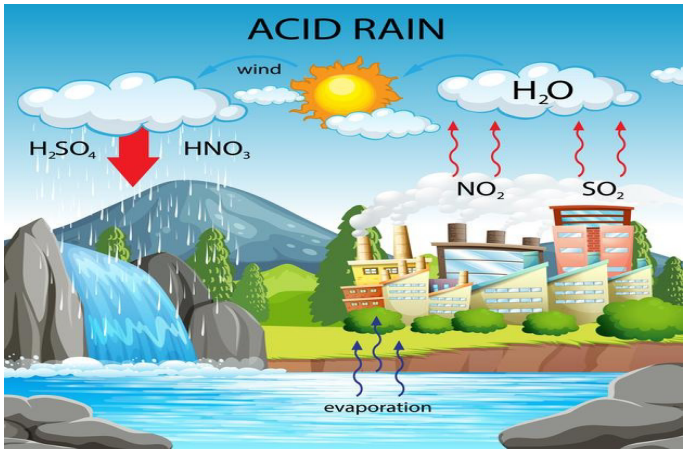
$2H_2SO_3 + O_2$———→ $2H_2SO_4$

Nitrogen dioxide + water———→ nitrous acid + nitric acid

$2NO_2 + H_2O$———→ $HNO_2 + HNO_3$

Nitrogen pentoxide + water———→ nitric acid

$N_2O_5 + H_2O$———→ $2HNO_3$

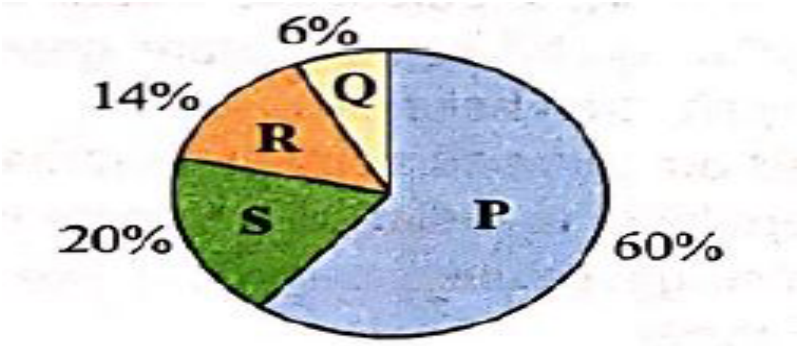


HARMFUL EFFECTS OF ACID RAIN

- It damages the wildlife in the ecosystem.
- It kills the aquatic animals and plants.
- It makes the soil lose its fertility
- It corrodes the metals and damages the buildings and monuments.
- It damages the railway tracks and bridges.
- It damages the nutrition levels of the leaves of the plants.

GLOBAL WARMING

- The increase in the temperature of the earth due to the increase in the percentage of the gases like methane, carbon dioxide etc. is known as GLOBAL WARMING



Q=Nitrous Oxide

R=CFC

S= Methane

P= Carbon dioxide

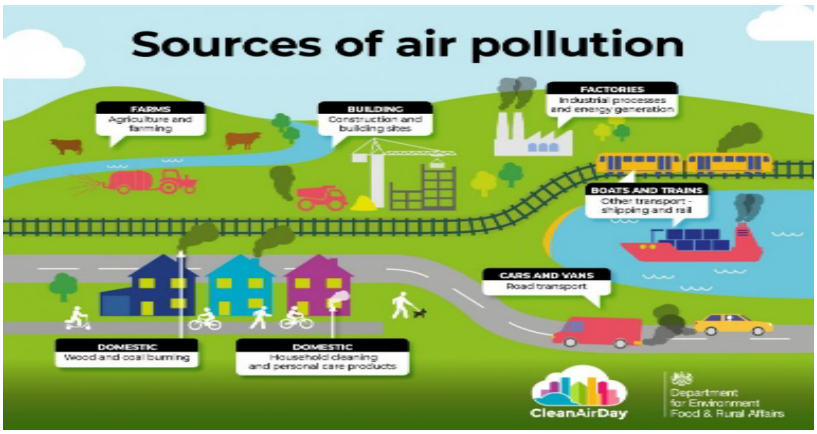
HOW TO PREVENT AIR POLLUTION

The contamination of the air by various harmful substances is known as Air Pollution.

Steps to prevent air pollution are as follows: -

- By growing more and more trees (afforestation)
- By installing tall chimneys with filters in the factories and power plants.
- By using internal combustion engines for efficient burning of the fuels.
- Using catalytic convertors in the vehicles.

The common agents can be seen in the given sketch: -



HOW CAN YOU CONTRIBUTE TO CONTROL AIR POLLLUTION?

- Do not burn paper, garbage, dry leaves and other waste materials rather pit them in a compost pit.
- Do not misuse electricity and try to save it.
- Do not use plastic bags.
- Try to plants as much trees as possible.
- Get your vehicles checked regularly.
- Keep your surroundings clean.
- Motivate others for the use of LPG

CASE STUDIES

OXYGEN

Symbol: O

Molecular formula: O2

Atomicity: 2

Valency: 2

DISCOVERY

Oxygen was first discovered by joseph Priestley in the year 1774. He obtained the gas by heating mercury (II) oxide. It was first named as "active air" due to its properties.

Later, in 1789, Antoine Lavoisier studied the properties of the gas and named it as "oxygen" which means "acid producer".

OCCURRENCE

- In the free state, it occurs in the atmosphere to the extent of 21% by volume.
- It is also present in the atmosphere in the form of Ozone (O_3)
- About 89 % of the mass of water is oxygen
- The human body has 65% of oxygen by mass.
- The plant body has 60% of oxygen by mass.
- About 50 % of the earth's crust contains oxygen in the form of oxides, carbonates and silicates etc.
- It is a component of carbohydrates, fats and proteins etc.

1. LABORATORY PREPARATION OF OXYGEN

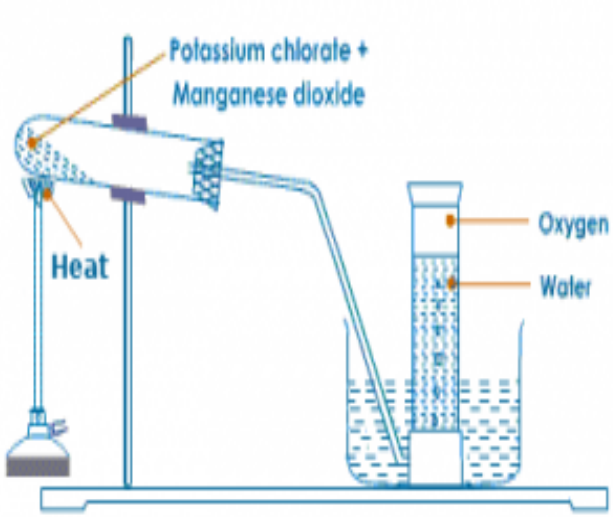
➤ In the Laboratory, oxygen is prepared by the action of heat on potassium chlorate.

➤ The chemical reaction involved in this reaction ais as follows : -

Potassium Chlorate——heating——→ potassium chloride + Oxygen

$2KClO_3$ ——-Heat————→ $2KCl + 3O_2$

- The rate of reaction can be increased by using Manganese dioxide as a Catalyst.
- Catalyst are substances that either increases or decreases the rate of chemical reaction without any change by itself.



2. From Hydrogen Peroxide

- Oxygen can be prepared by reaction of Hydrogen peroxide and Manganese dioxide, that acts like a catalyst.
- The chemical equation for this reaction can be given as follows: -

  Hydrogen Peroxide——-MnO_2————-→ Water + Oxygen

  $2H_2O_2$———MnO_2-——-→ $2H_2O + O2$

- Oxygen is collected in the jar by the downward displacement of water because oxygen is slightly soluble in water and slightly heavier than air.
- The diagrammatic representation of this process is as given: -

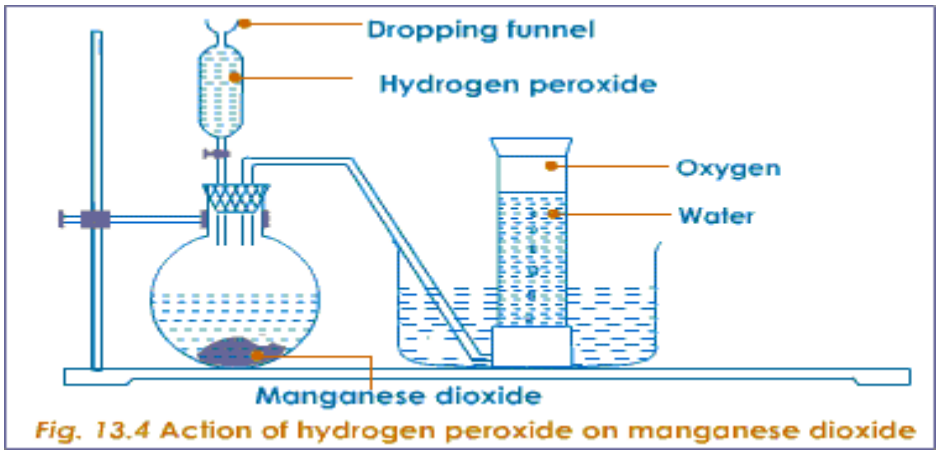


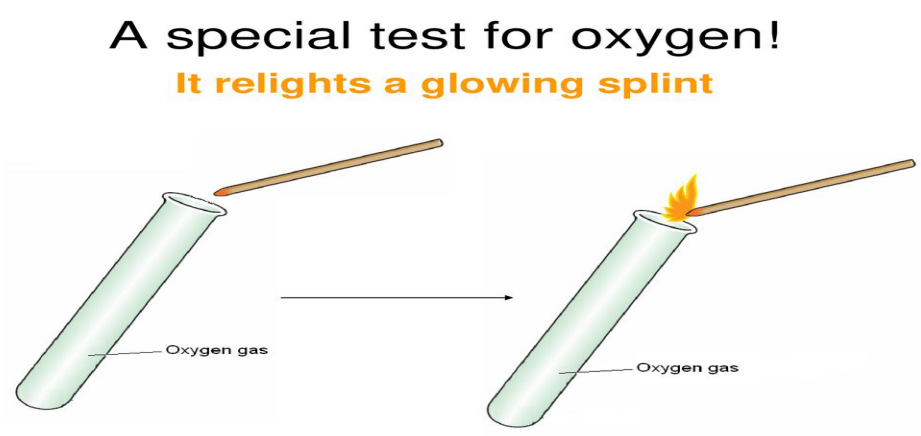
Fig. 13.4 Action of hydrogen peroxide on manganese dioxide

Q. Why hydrogen peroxide is preferred to potassium chlorate for the preparation of oxygen in the Laboratory?

- No heating is required
- The rate of evolution of oxygen can be controlled.
- Hydrogen Peroxide is a safe chemical.
- If prepared from potassium chlorate, the glass apparatus may crack.
- Accidents may be caused if potassium chlorate is used.

TEST FOR OXYGEN

On bringing a glowing splinter near the mouth of the gas jar containing oxygen, it rekindles, but the gas does not catch fire



PHYSICAL PROPERTIES OF OXYGEN

- Oxygen is colourless, odourless and tasteless gas.
- It is non-poisonous gas.
- It is slightly heavier than air.
- It is slightly soluble in water.
- It has a boiling point of -183 degree Celsius and freezing point of -218 degree Celsius.

CHEMICAL PROPERTIES OF OXYGEN

1. Action of oxygen with non-metals:

- Oxygen reacts with non-metals like carbon, sulphur and phosphorous to form their respective oxides which are acidic in nature.
- For example, the reaction of carbon and sulphur with oxygen can be given as follows:

Carbon + Oxygen ———→ Carbon dioxide + Heat

Sulphur + Oxygen ———→ Sulphur dioxide + Heat.

Special Note *

When oxygen supply is insufficient, the carbon reacts with oxygen to produce Carbon Monoxide gas.

$2C + O_2$——Heat——→ 2CO

2. Action of oxygen with metals:

- Metals reacts with oxygen to produce metallic oxides which are basic in nature.
- For examples, the reaction of oxygen with metals like Sodium, calcium and magnesium are given below:

Sodium + Oxygen ————————→ Sodium Oxide + Heat

Calcium + Oxygen ————————→ calcium Oxide + Heat

Magnesium + Oxygen————→ Magnesium Oxide + Heat.

Burning Of Elements with Oxygen

- The burning of elements with oxygen to form some new compounds or oxides is known as Oxidation.
- Combustion or burning of any substances is *FAST OXIDATION.*
- Respiration and Rusting is *SLOW OXIDATION.*
- The minimum temperature at which substances catches fire or burns is known as IGNITION TEMPERATURE

RUSTING

- Rusting of iron is a special corrosion in which iron slowly reacts with moist air to produce a reddish-brown substance called as Rust.
- Rust has the formula of $Fe_2O_3.xH_2O$ (Hydrated Ferric Oxide)
- Rusting can be expressed in the form of chemical reaction as follows: -
- Iron + Oxygen————Moisture————-→ Hydrated Ferric Oxide
- $4Fe + 3O_2$——-$x.H_2O$————→ $2Fe2O_3.XH_2O$

(Slow Process)

DIFFERENCE BETWEEN RUSTING AND BURNING(COMBUSTION)

Rusting	Burning
Slow Oxidation	Fast Oxidation
Small amount of heat is released without light.	large amount of heat is released with light.
Air and moisture are necessary	Only air is necessary
Ignition is not required	Ignition is required

SIMILARITIES OF RUSTING AND COMBUSTION

Rusting	Burning
Needs Oxygen	Needs Oxygen
Forms Oxides	Forms Oxides

TESTS FOR OXYGEN

- Oxygen rekindles a glowing splinter indicating that it is a supporter of burning.
- When colourless oxygen is bought into the contact of colourless nitric oxide, brown coloured nitrogen dioxide is formed.
- Alkaline pyrogallol solution turns brown when oxygen is passed through it.

USES OF OXYGEN

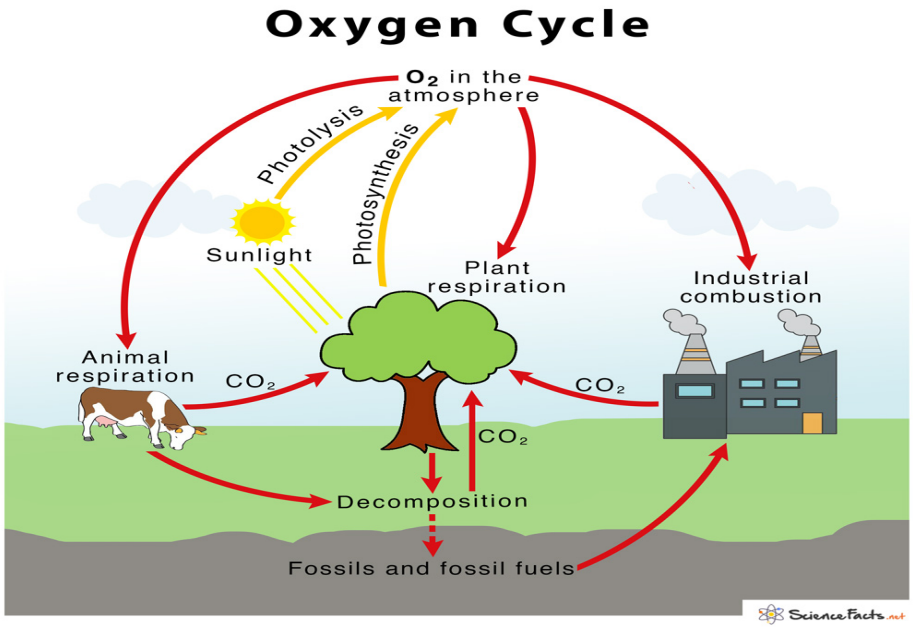
1. RESPIRATION
2. BURNING
3. USE IN MEDICINES
    - Oxygen cylinders are provided to the patients.
    - Oxygen is a major constituent of carbogen (95% O2 and 5% CO2) that is given to the patients to stimulate natural breathing.
    - A mixture of oxygen and nitrous oxide is used in dentistry as local anaesthesia
4. INDUSTRIAL USE.
    - For welding and cutting of metals.
    - For removing impurities.
    - In chemical industries as an oxidising agent.
    - As a propellant fuel in Space crafts (LOX-Liquid Oxygen)

DIFFERENCES BETWEEN BURNING AND RESPIRATION

Burning	Respiration
Fast oxidation process	slow oxidation process
It occurs at high temperature	It occurs at body temperature
Large amount of heat is released in the form of heat and light	Small amount of heat is released in the form of heat and light
Artificial process and needs initiation	Natural process and do not need initiation

RENEWAL OF OXYGEN IN AIR (OXYGEN CYCLE)

- The circulation of oxygen in a cyclic manner in the atmosphere is known as Oxygen Cycle.
- Oxygen is released during photosynthesis and photolysis and is being used up during respiration and industrial combustion.
- The rate of oxygen is much faster than respiration , hence we say that "oxygen is a gift from plants to all living beings"



RELAESE OF OXYGEN DURING PHOTOSYNTHESIS

$6CO_2 + 6H_2O \xrightarrow{Chlorophyll/Sunlight} C_6H_{12}O_6 + 6O_2$

(glucose)