

Chapter 3: Oxygen and Sulfur

1- Oxygen

Oxygen is found in the group 16 elements and is considered a **chalcogen**. Named from the Greek *oxys* + *genes*, "acid-former", oxygen was discovered in 1772 by Scheele and independently by Priestly in 1774. Oxygen was given its name by the French scientist, Antoine Lavoisier.

2- Occurrence In Nature

- 1- Oxygen is an essential element for life on Earth: water, respiration, photosynthesis, etc.
1. After hydrogen and helium, it is the third most plentiful element in the universe.
2. It is the most prevalent element in the Earth's crust in terms of mass. To make minerals like quartz and sand, oxygen forms compounds with silicon and other atoms. (e.g. Fe_2O_3), silicates (e.g. SiO_2) or carbonates (e.g. CaCO_3).
3. It is the atmosphere's second most abundant gas. Oxygen makes up about 21% of the air we breathe. Oxygen, on the other hand, is a highly reactive gas.
4. Oxygen also makes up the majority of the Earth's oceans in terms of mass. Nearly 90% of water's bulk is made up of oxygen.
5. Because our bodies are 70% water, it is the most abundant element in the human body (by mass)

2) Preparation:

a- In industry:

Dioxygen is obtained mainly by **fractional distillation of liquid air**:

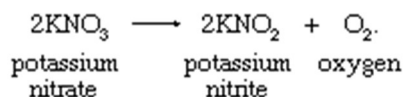
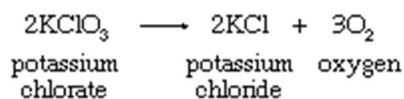
1st step: Liquefaction of air (at $-200\text{ }^\circ\text{C}$) (Such a low temperature is obtained in three steps that are repeated several times: compression of the air - cooling of the compressed air - expansion of the compressed air.

2nd step: Distillation of the air.

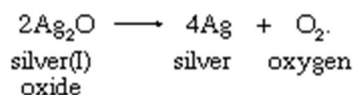
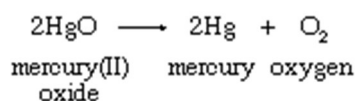
A: Dioxygen is delivered in steel bottles, in compressed form. Under the effect of high pressure, the dioxygen is in the liquid state.

b- In the laboratory:

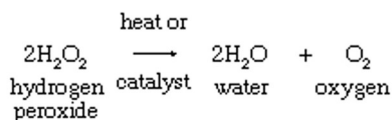
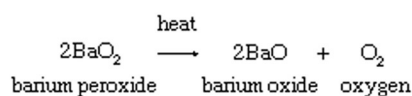
1. Thermal decomposition of certain salts, such as potassium chlorate or potassium nitrate:



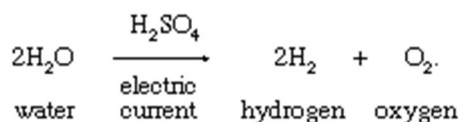
2. Thermal decomposition of oxides of heavy metals:



3. Thermal decomposition of metal peroxides or of hydrogen peroxide:



4. Electrolysis of water containing small proportions of salts or acids to allow conduction of the electric current:

**Properties of Oxygen****a- Physical Properties of Oxygen**

1. The gas oxygen is colourless, odourless, and tasteless.
2. At a temperature of -182.96°C (-297.33°F), it transforms from a gas to a liquid.
3. The resulting liquid is slightly bluish in colour.

4. At a temperature of -218.4°C (-361.2°F), liquid oxygen can be solidified or frozen.
5. Oxygen has a density of 1.429 gms per litre.
6. Air, by comparison, has a density of 1.29 grams per litre.
7. There are two allotropes of oxygen; dioxygen (O_2) and trioxygen (O_3) which is called ozone.

b- Chemical Properties of Oxygen

8. dioxygen is an oxidizing gas; it supports combustion, but it is not flammable.
9. oxygen ranks second in the Pauling electronegativity scale after fluorine.
10. oxygen is particularly reactive (oxidizing) at high temperatures. It combines with all elements except rare gases.

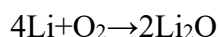
General Chemistry of Oxygen

Oxygen normally has an oxidation state of -2, but is capable of having oxidation states of -2, -1, -1/2, 0, +1, and +2. The oxidation states of oxides, peroxides and superoxides are as follows:

- Oxides: O^{-2} ,
- peroxides: O_2^{-2} ,
- superoxide: O_2^{-1} .

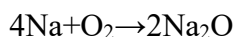
Oxygen does not react with itself, nitrogen, or water under normal conditions. Oxygen does, however, dissolve in water at 20 degrees Celsius and 1 atmosphere. Oxygen also does not normally react with bases or acids. Group 1 metals (alkaline metals) are very reactive with oxygen and must be stored away from oxygen in order to prevent them from becoming oxidized. The metals at the bottom of the group are more reactive than those at the top. The reactions of a few of these metals are explored in more detail below.

Lithium: Reacts with oxygen to form white lithium oxide in the reaction below.

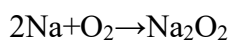


Sodium: Reacts with oxygen to form a white mixture of sodium oxide and sodium peroxide.

- Sodium oxide:

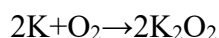


- Sodium peroxide:

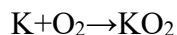


Potassium: Reacts with oxygen to form a mixture of potassium peroxide and potassium superoxide.

- Potassium peroxide:

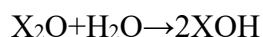


- Potassium superoxide:

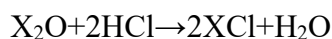


Reaction of Oxides

- **Reaction with water:** The oxides react with water to form a metal hydroxide.

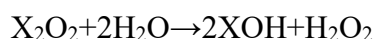


- **Reaction with dilute acids:** The oxides react with dilute acids to form a salt and water.

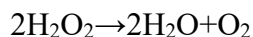
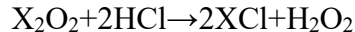


Reactions of Peroxides

Reaction with water

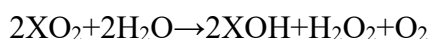


Reaction with dilute acid: This reaction is more exothermic than that with water.



Reaction of Superoxides

Reaction with water: The superoxide and water react in a very exothermic reaction.



Reaction with dilute acids:

