Ozone is an allotropic form of oxygen. Its molecular formula is O$_3$ and molar mass is 48 g mol$^{-1}$.

**Occurrence of ozone**

Schonbein (1840) concluded that Van Marum's observations in 1785 of a peculiar smell, when an electric discharge was passed through oxygen (or air), was in fact a new gas. He named it Ozone, which is derived from a Greek word ozoaterr meaning smell. Soret in 1860, assigned the molecular formula O$_3$. The occurrence of ozone is in small amounts, in the upper layer of the atmosphere, where it is formed due to the action of ultraviolet rays on the oxygen of the air. It is also present in seawater where it is formed due to the reaction of fluorine with water.

In the structure of ozone, the bond length of 127.8 pm is intermediate between a single bond (bond length 148 pm) and a double bond (bond length 110 pm). Ozone is, therefore, considered to be a resonance hybrid of the following canonical forms:

![Ozone canonical forms](image)

**Uses of ozone**

- For air purification at the crowded places like cinema halls and tunnel railways. Due to its strong oxidizing power it also destroys the foul smell in slaughter houses.
- In sterilizing drinking water by oxidizing all germs and bacteria.
- For preservation of meat in cold storage.
- For bleaching delicate fabrics such as silk, ivory, oils, starch and wax.
- It helps to locate a double bond in any unsaturated organic compound by ozonolysis.

**Preparation of ozone**

When a silent electric discharge is passed through dry oxygen, ozone is formed. Oxygen is never converted into ozone completely and we always obtain a mixture of oxygen and ozone. This mixture is called ozonized oxygen.

\[
\ce{3O_2 \rightarrow [[electric][discharge]] 2O_3} \quad \Delta H = +284.5 \text{kJ/mol}
\]

The reaction is initiated by a sparkless or silent electric discharge, to produce less heat, as ozone is prone to decomposing back into oxygen with an increase in temperature (Le Chatelier's Principle). Hence, ozone is prepared in a specially designed apparatus called an ozonizer to facilitate the above conditions. An 'Ozoniler' is the apparatus used to prepare ozone by the passage of silent electrical discharge. Two types of ozonizers are commonly used: the Siemen's and the Brodie Ozonizers.
Siemen's Ozonizer

It consists of two co-axial glass tubes fused together. Tin foil is used to coat the inner-side of the inner tube and the outer-side of the outer tube. The inner and outer tin coatings are connected to the terminals of an induction coil, which produces current of high voltage. A slow current of pure and dry oxygen is passed through the annular space. On subjecting oxygen to silent electrical discharge, ozonized oxygen containing 10-15% ozone is formed. By taking the following precautions, the yield of ozone can be increased in the ozonized oxygen:

- Only pure and dry oxygen should be used.
- The ozonizer should be perfectly dry.
- A fairly low temperature (around 0°C) should be maintained.
- There should be no sparking.

![Siemen's ozonizer](image1)

Figure 1: Siemen's ozonizer

Brodie's ozonizer

In principle, this ozonizer is like the Siemen's ozonizer but dilute sulphuric acid replaces the tin foil. Two carbon electrodes are dipped in the acid and connected to an induction coil. A current of dry oxygen is passed through the space between the tubes. Ozonized oxygen containing about 5% \( O_3 \) comes out at the other end. If the apparatus is kept cool, the proportion of ozone may go up 20-25%.

![Brodie's ozonizer](image2)

Figure 2: Brodie's ozonizer
Problems

1. How is ozone formed in the upper atmosphere?

Solution

1. Ozone is formed in the upper atmosphere in two steps:

   i) Photodissociation of oxygen by ultraviolet radiations of wavelength less than 240 nm.

   \[
   \ce{O_2 ->[h\nu] O^\cdot + O^\cdot}
   \]

   Oxygen atoms are really diradicals with two unpaired p-orbital electrons, but are represented with a single electron here.

   ii) Combination of highly reactive oxygen atoms with oxygen molecules.

   \[
   \ce{O_2 + O^\cdot \rightarrow O_3}
   \]

12. What is the principle of preparation of ozone?

Contributors and Attributions

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