OXYGEN

Oxygen was discovered independently by Scheele in 1772 and Priestley in 1774. However, it was Lavoisier who first described the major properties of this newly discovered gas and arrived at the conclusion that the gas was essential for the combustion of substances. He erroneously thought that this gas was a major constituent of all acids and named it oxygen, which meant acid-producer.

Occurrence

Oxygen is the most abundant element on earth. It occurs in nature in both the free and combined states. Free oxygen constitutes about 21% by volume of the atmospheric air and about 33% by volume of dissolved air. In the combined form, oxygen accounts for nearly 50% by mass of the earth's crust, the oceans and the air. It is present in the trioxosilicates (IV), trioxocarbonates (IV) and oxides of both metals and non-metals which make up the rocks and clays. Water, one of the most

abundant compounds on earth, is made up of about two-thirds by mass of oxygen in the combined state.

Physical Properties

1. Oxygen is a colourless, odourless, and tasteless gas.
2. It is neutral to moist litmus paper.
3. It is slightly soluble in water, i.e. only about 2% by volume of it will dissolve in water at room temperature and standard pressure.
4. Gaseous oxygen is approximately 1.1 times denser than air.
5. Gaseous oxygen liquefies at -183^{o}C and solidifies at -225^{o}C.

Chemical Properties

Oxygen combines readily with other elements (except the rare gases, some halogens and some unreactive metals) to form oxides.

$$4K_{(s)} + O_{2\,(g)} \rightarrow 2K_2O + H_2 \rightarrow 4KOH$$

$$S_{(s)} + O_{2\,(g)} \rightarrow H_2SO_3$$

Many hydrocarbons and organic compounds burn in oxygen to form carbon (IV) oxide and water. Sulphides burn in oxygen to give sulphur (IV) oxide and another oxide. Ammonia forms nitrogen and water when it burns in oxygen. In the presence of a catalyst, ammonia is oxidized to nitrogen (II) oxide and water at room temperature.

The reactions of oxygen with elements and compounds are examples of oxidation reactions. Rusting of iron is a typical example of this kind of oxidation reaction. An oxidation process in which heat and light are produced is called combustion. Examples are the burning of fuels, like wood, coal and petrol.

Laboratory Preparation

1. Oxygen can be prepared from potassium trioxochlorate (V) by heating it above its melting

point (368^{o}C). Manganese (IV) oxide could be used as catalyst to increase the rate of reaction.

$$2KClO_{3\,(s)} \rightarrow 2KCl_{\,(s)} + 3O_{2\,(g)}$$

2. Oxygen can also be prepared from hydrogen peroxide. Hydrogen peroxide decomposes readily to liberate oxygen in the presence of manganese (IV) oxide as catalyst.

$$2H_2O_{2\,(aq)} \rightarrow 2H_2O_{\,(l)} + O_{2\,(g)}$$

3. Hydrogen peroxide also reacts with acidified potassium tetraoxomanganate (VII) solution in the cold to produce oxygen.

$$5H_2O_{2\,(aq)} + 2KMnO_{4\,(aq)} + 3H_2SO_{4\,(aq)} \rightarrow K_2SO_{4\,(aq)} + 2MnSO_{4\,(aq)} + 8H_2O_{\,(l)} + 5O_{2\,(g)}$$

Industrial Preparation

In places where a cheap source of electricity is available, oxygen may be prepared industrially by the "electrolysis of water." However, in most places, it is prepared by the "fractional distillation of liquid air." This preparation involves two main

processes: the liquefaction of air, and the fractional distillation of the resultant liquid air.

Air, in the gaseous form, is first passed through caustic soda to remove carbon (IV) oxide. It is then compressed to a pressure of about 200atm, cooled and allowed to escape rapidly through a minute aperture. The sudden expansion of the air into a region of lower pressure causes it to cool even further (since heat energy is used up in separating the molecules). The cooled air will cool the incoming stream of air. This process is repeated until the gaseous air becomes a liquid at -200^{o}C.

The liquid air is then led to a fractional column. On distillation, nitrogen, which has a lower boiling point of -196^{o}C, is evolved first, leaving behind a liquid very rich in oxygen. Further heating converts the liquid oxygen to a gas at -183^{o}C. The oxygen gas is dried, compressed and stored in steel cylinders under a pressure of about 100atm.

Uses of Oxygen

1. Oxygen is required for respiration. It is used in breathing apparatus of people who have to be in surroundings which do not contain any air or contain little air. People who have breathing difficulties are placed in oxygen tents. During surgical operations, patients are given a mixture of anaesthetic and oxygen.
2. Liquid oxygen and fuels are used as propellants for space rockets.
3. Oxygen is used in the steel industry for the removal of carbon, sulphur and phosphorus impurities from pig iron. It is sometimes called tonnage oxygen because it is produced on a large scale by a special plant in the steel works.
4. Oxygen is also used in the manufacture of important chemical compounds like tetraoxosulphate (VI) acid, trioxonitrate (V) acid and ethanoic acid.
5. Oxygen combines with ethyne to produce oxy-ethyne flame whhich has a temperature of over 2000^{o}C. The flame is used to cut through metals

like steel. Oxygen is also used in oxy-hydrogen flame. This flame is not as hot as the oxy-ethyne flame. It is frequently used in welding pieces of metal together.