NITROGEN

Nitrogen occurs chiefly as a free element in the air, making up about 78% by volume of the atmosphere. Free nitrogen in the air is important because it dilutes the oxygen to the point where combustion, respiration, and oxidation of metals are reasonably slow. In the combined form, nitrogen occurs abundantly in the earth's crust as trioxonitrates (V) of sodium and calcium, as well as ammonium salts. Combined nitrogen is also found in organic matter such as proteins, urea, and the vitamin B compounds.

Laboratory Preparation

Nitrogen can also be produced by the following chemical methods.

From ammonium dioxonitrate (III). Pure nitrogen is usually obtained by the thermal decomposition of ammonium dioxonitrate (III), NH_4NO_2. The dioxonitrate (III), however, is not heated directly as the reaction may get out of

control and an explosion may occur. This is because ammonium dioxonitrate (III) is unstable decomposes exothermally.

A mixture of sodium dioxonitrate (III) and ammonium chloride in a ratio of 7:5 is heated to yield ammonium dioxonitrate (III), which in turn decomposes to produce nitrogen and steam. This procedure is safer than heating the dioxonitrate (III) directly because the ammonium dioxonitrate (III) is decomposed as fast as it is formed.

$$NaNO_{2\,(aq)} + NH_4Cl_{\,(aq)} \rightarrow NH_4NO_{2\,(aq)} + NaCl_{\,(aq)}$$

$$NH_4NO_{2\,(aq)} \rightarrow N_{2\,(g)} + 2H_2O_{\,(l)}$$

From ammonia. Nitrogen is liberated when ammonia is oxidized by hot copper (II) oxide.

$$2NH_{3\,(g)} + 3CuO_{\,(s)} \rightarrow 3Cu_{\,(s)} + 3H_2O_{\,(g)} + N_{2\,(g)}$$

From dinitrogen (I) oxide. When dinitrogen (I) oxide is passed over red-hot copper, the gas is reduced to nitrogen.

$$N_2O_{\,(g)} + Cu_{\,(s)} \rightarrow CuO_{\,(s)} + N_{2\,(g)}$$

Industrial Preparation

Nitrogen is prepared by the fractional distillation of liquid air. Air from which carbon (IV) oxide has been removed is liquefied by subjecting it to successive compression and cooling processes. Upon distillation, nitrogen gas is evolved first at -196^{o}C (at standard pressure) and is separated from oxygen which boils at -183^{o}C (at standard pressure). Nitrogen is stored in steel cylinders and sold as liquid nitrogen or as the compressed gas.

Physical Properties

1. Nitrogen is a colourless, odourless and tasteless gas.
2. Pure nitrogen is slightly lighter than air.
3. It is only slightly soluble in water. Two volumes of the gas dissolve in 100 volumes of water at room temperature.
4. The melting point of nitrogen is -210^{o}C and its boiling point is -196^{o}C. These low temperatures are due to the weak Van der Waals forces that

exist between the nitrogen molecules in the solid and liquid states.

Chemical Properties

Nitrogen combines directly with very electropositive metals, e.g. magnesium, calcium, aluminium and iron, to form nitrides. For example, red-hot magnesium combines directly with nitrogen to produce magnesium nitride.

$$3Mg_{(s)} + N_{2\,(g)} \rightarrow Mg_3N_{2\,(s)}$$

The nitride is readily hydrolyzed when warmed with water to give ammonia gas.

$$Mg_3N_{2\,(s)} + 6H_2O_{(l)} \rightarrow 3Mg(OH)_{2(s)} + 2NH_{3\,(g)}$$

Nitrogen combines reversibly with hydrogen to produce ammonia. It combines directly with oxygen at very high temperatures (about 2000^{o}C) or in the presence of a high voltage electric spark to form small amounts of nitrogen (II) oxide. In nature, this reaction occurs in the atmosphere when lightning flashes.

$$Na_{(g)} + O_{2(g)} \rightarrow 2NO_{(g)}$$

Uses of Nitrogen

1. Nitrogen is used in the industrial manufacture of ammonia, cyanide, cyanamide, and carbamide (an important fertilizer).
2. Liquid nitrogen is used as a cooling agent.
3. Due to its inert nature, nitrogen is used
   a. as a carrier gas in gas chromatography
   b. in providing an inert atmosphere for certain industrial processes involving easily oxidable chemicals, e.g. in making electronic components such as transistors, and in the annealing of metals.
   c. as a preservative to prevent rancidity (due to the oxidation of fats) in packaged foods.