

The main directions of ammonia use: production of nitric acid, mineral fertilizers (urea, ammophos), nitrates, sulfates, ammonium carbonates, herbicides, hydrazine, polyamides, polyurethanes, polyacrylonitriles, urea-aldehyde polymers, urotropin, etc.

Nitric acid production. General scheme of nitric acid production. Physico-chemical basis of the synthesis of nitric acid from ammonia. Oxidation of ammonia and nitrogen oxides. Chemisorption of nitrogen oxides. Production of dilute nitric acid. Production of concentrated nitric acid. Methods of nitric acid concentration

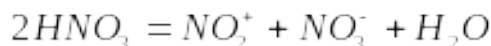
Nitric acid is one of the most important mineral acids. In terms of production, it ranks second after sulfuric acid. It is used for the production of nitrogen and complex mineral fertilizers (up to 40%), synthetic dyes, explosives, nitro-varnishes, plastics, medicinal substances; for passivation and protection of iron from corrosion, etc. In laboratory practice, nitric acid with a concentration of 65% is usually used.

Two types of  $HNO_3$  are used in industry: diluted (50–60%) and concentrated (96–98%). It has  $T_{\text{melting}} = -41.6\text{ }^\circ\text{C}$ ,  $T_{\text{boiling point}} = -82.6\text{ }^\circ\text{C}$ . Its density is  $1.552\text{ g/cm}^3$ . It mixes with water in any proportions, forming an azeotrope (68.4% by weight of  $HNO_3$   $T_{\text{boil}} = 121.9\text{ }^\circ\text{C}$ ).

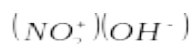
The following equilibrium processes occur in anhydrous nitric acid:



Pure nitric acid is self-ionized, and the molar concentration of each type of particle is 0.51 mol/L at  $-10^\circ\text{C}$ :

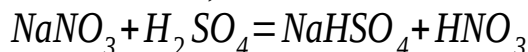


In the solid state, the acid molecule is nitronium hydroxide:



### History of nitric acid production

The method of obtaining nitric acid by heating a mixture of saltpetre with iron vitriol or alum was first described in the eighth century. Later it was found that nitric acid is also formed by the action of concentrated sulfuric acid on nitrate, this method was used until the early 20th century:



In 1839, the French scientist *Kulman* obtained nitrogen oxides by the contact oxidation of ammonia on sponge platinum. Upon cooling the formed nitrogen oxides, nitrous and nitric acids were obtained from them. In modern industries, the method of synthesis of nitric acid from nitrogen oxides obtained by the oxidation of ammonia on platinum is used.

In 1913, the industrial synthesis of ammonia from elementary substances was mastered, it quickly became widespread. Soon, a method was developed for the production of nitric acid from ammonia.

The priority in the development of a method for the production of nitric acid from nitrogen oxides obtained by the oxidation of ammonia on platinum belongs to *V. Ostwald* and *II. Andreev*, who solved this problem independently of each other. The first plant for the production of nitric acid, according to a scheme operating at atmospheric pressure with a capacity of 8,000 t/year, was built in 1916 in the city of *Yuzovka*. The method was based on the oxidation of ammonia obtained from coke oven gas, proposed by Russian scientist *I.I. Andreev*. Platinum nets were used as process catalysts.