Ostwald's Process

Ostwald method is the chief process of making nitric acid.

Principle

The ammonia gas is oxidised by the oxygen of air in the presence of platinum-rhodium gauze catalyst heated to above 1070K. Nitric oxide is formed in the process:

$$4NH_3 + 5O_2 \xrightarrow[Pt]{1070K} 4NO + 6H_2O \; ; \; \Delta H = -89.5 \text{ KJ/mole}$$

This is an exothermic reaction.

Nitric oxide is then cooled and it combines with more oxygen to form nitrogen dioxide.

$$2NO + O_2 \longrightarrow 2NO_2$$

Nitrogen dioxide is now converted to nitric acid by mixing it with water and air.

$$3NO_2 + H_2O \longrightarrow 2HNO_3(aq) + NO(g)$$

NO thus produced is recycled.

The oxidation of ammonia takes place at the surface of catalyst. Therefore, physical conditions of surfaces would affect the reaction.

The reaction is favoured by increasing

temperature until an optimum temperature 1023K is reached.

Procedure

1) Oxidation of Ammonia

A mixture of ammonia and dust free air in the ratio 1:10 by volume is passed through a converter made of steel and packed with platinum gauze or a catalyst containing 90% platinum and 10% rhodium.

The latter is preferred because platinum gauze gets rusted during the process and its efficiency is reduced.

The converter is heated electrically to about 1070K when nitric oxide is formed.

$$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O + 89.5\ KJ$$

As the reaction is exothermic, heating is required in the begining. As the reaction proceeds, the heat evolved in the reaction maintains the necessary temperature.

2) Oxidation of Nitric oxide

The gases coming out of the converter are a mixture of nitric oxide, nitrogen and oxygen.

These are cooled to about 325 K with the help of cooler and mixed with more air. The mixture is passed through an oxidation chamber where nitrogen dioxide is formed.

$$2NO + O_2 \longrightarrow 2NO_2$$

3) Absorption of Nitrogen dioxide

The vapours of nitrogen dioxide are then introduced into the absorption tower which is packed with acid proof stones.

Water sprayed from the top of this tower dissolve nitrogen dioxide to form dilute nitric acid (about 60%).

$$3NO_2 + H_2O \longrightarrow 2HNO_3 + NO$$

4) concentration of the Nitric acid

The dilute acid may be concentrated by distillation until it attains the composition of constant boiling point containing 68% HNO_3 (b.p 121°c) — this is the ordinary commercial acid of density 1.414.

It may be concentrated to 98% by distillation with conc. H_2SO_4.

Fuming Nitric acid

A yellow coloured fuming nitric acid contains dissolved NO_2 in conc. HNO_3.

It is obtained by distilling conc. HNO_3 with a little starch. Nitric acid is reduced to NO_2 by starch.

This NO_2 dissolves in remaining nitric acid to form fuming HNO_3 acid.

Identification Test (Analytical Test)

Ring Test

Nitric acid or nitrate is usually detected by the formation of brown ring.

To dilute nitric acid taken in a test tube, freshly prepared ferrous sulphate solution is added.

Now, conc. sulfuric acid is carefully poured down the sides of the test tube.

A dark brown ring at the junction of two

layers indicates the presence of nitric acid.

$$6FeSO_4 + 3H_2SO_4 + 2HNO_3 \longrightarrow 2Fe_2(SO_4)_3 + 4H_2O + 2NO$$

$$FeSO_4 + NO \longrightarrow \underset{\text{brown ring}}{FeSO_4 \cdot NO}$$

Brown ring is due to the formation of nitroso-ferrous sulphate ($FeSO_4 \cdot NO$).

The brown ring formed disappears on shaking the tube.

Uses of Nitric acid

Because of its diverse applications in industry, nitric acid is the most important compound of nitrogen.

1) Nitric acid is used in the manufacture of —
   i) Fertilizers such as ammonium nitrate, calcium ammonium nitrate etc.
   ii) Explosives such as TNT (trinitroglycerine) etc.
   iii) Sulfuric acid by lead chamber process.
   iv) Dyes, artificial silk, paints, perfumes and drugs.

v) Aqua regia for dissolving noble metals like gold and platinum.

vi) Celluloid products such as cellophane and photographic films.

2) Purification of Silver and Gold.

3) As a laboratory reagent.

4) For nitration of organic compounds.

5) Constituent of rocket fuel.

NOTE

Pure nitric acid is colourless. However, the nitric acid obtained in the laboratory is slightly yellow or brown.

This is due to the presence of some dissolved nitrogen dioxide formed by the partial decomposition of HNO_3.

$$4HNO_3 \longrightarrow 4NO_2 + 2H_2O + O_2$$