

USES OF BORON, ALUMINIUM AND THEIR COMPOUNDS

Compounds of Aluminium

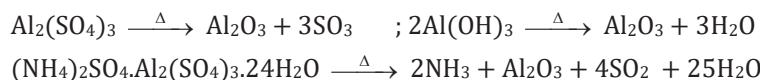
Aluminum Oxide (Al_2O_3)

It is also called alumina. It occurs in nature in the form of bauxite and corundum. It is also found in the form of gems. Some important aluminum oxide gems are:

- (A) Oriental Topaz-yellow (Fe^{3+})
- (B) Sapphire-blue ($\text{Fe}^{2+} / 3+ / \text{Ti}^{4+}$)
- (C) Ruby-red (Cr^{3+})
- (D) Oriental Emerald-green ($\text{Cr}^{3+} / \text{V}^{3+}$)

Preparation

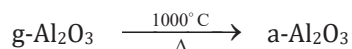
Pure Al_2O_3 is obtained by igniting $\text{Al}_2(\text{SO}_4)_3$, $\text{Al}(\text{OH})_3$ or ammonium alum.



Properties

It is a white amorphous powder insoluble in water but soluble in acids (forming e.g., AlCl_3) as well as alkali's (forming e.g., NaAlO_2), Thus amphoteric in nature. It is a polar covalent compound. Exists in two forms a- Al_2O_3 or corundum and g- Al_2O_3 .

Addition of Cr_2O_3 or Fe_2O_3 makes alumina coloured.



Uses

- (i) It is used for the extraction of aluminum.
- (ii) It is used for making artificial gems.
- (iii) It is used for the preparation of compounds of aluminum.
- (iv) a- Al_2O_3 is used in making furnace linings. It is a refractory material.
- (v) It is used as a catalyst in organic reactions.
- (vi) Corundum is extremely hard and is used as 'Jewelers rouge' to polish glass.
- (vii) g- Al_2O_3 dissolves in acids absorbs moisture and is used in chromatography.

Aluminum Chloride ($\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$)

It is a colourless crystalline solid, soluble in water. It is covalent. Anhydrous AlCl_3 is a deliquescent white solid.

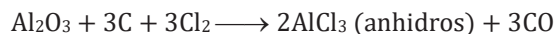
Preparation:

- (i) By dissolving aluminum, Al_2O_3 , or $\text{Al}(\text{OH})_3$ in dilute HCl:

$$2\text{Al} + 6\text{HCl} \longrightarrow 2\text{AlCl}_3 + 3\text{H}_2; \quad \text{Al}_2\text{O}_3 + 6\text{HCl} \longrightarrow 2\text{AlCl}_3 + 3\text{H}_2\text{O}; \quad \text{Al}(\text{OH})_3 + 3\text{HCl} \longrightarrow \text{AlCl}_3 + 3\text{H}_2\text{O}$$

The solution obtained is filtered and crystallized when the crystals of $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$ are obtained.

- (ii) Anhydrous AlCl_3 is obtained by the action of Cl_2 on heated aluminum.
- (iii) By heating a mixture of Al_2O_3 and coke and passing chlorine over it.

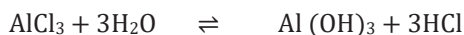


Properties:

- (i) Action of heat: Hydrated salt when heated strongly is converted to Al_2O_3 .



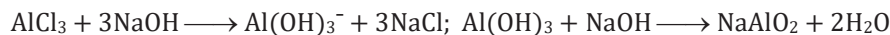
- (ii) Action of moisture on anhydrous AlCl_3 : When exposed to air, anhydrous AlCl_3 produces white fumes of HCl.



- (iii) Action of NH_3 : Anhydrous AlCl_3 absorbs NH_3 since the former is a Lewis acid.

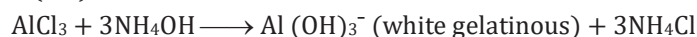


- (iv) Action of NaOH solution: When NaOH solution is added dropwise to an aqueous AlCl_3 solution, a gelatinous precipitate of $\text{Al}(\text{OH})_3$ is first formed which dissolves in excess of NaOH solution to give a colourless solution of sodium meta-aluminate.



This reaction is important as a test to distinguish between an aluminum salt from salts of Mg , Ca , Sr , and Ba . (When NaOH solution is added to their salt solutions, a white precipitate of hydroxide forms which does not dissolve in excess of NaOH).

- (v) Action of NH_4OH solution: When NH_4OH solution is added to a solution of AlCl_3 , a white precipitate of $\text{Al}(\text{OH})_3$ is formed which does not dissolve in excess of NH_4OH .

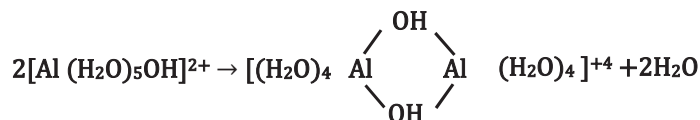


This reaction is important as a test to distinguish an Al salt from a Zn salt. (With a Zn salt a white precipitate of $\text{Zn}(\text{OH})_2$ is formed which dissolves in excess of NH_4OH solution).

- (vi) Hydrolysis with water: When AlCl_3 is dissolved in water, it undergoes hydrolysis rapidly to produce $\text{Al}(\text{OH})_3$ which is a weak base and HCl which is a strong acid. Hence the solution is acidic to litmus.



The complex cation has a high tendency to get dimerized.



- (vii) $4\text{LiH} + \text{AlCl}_3 \longrightarrow \text{LiAlH}_4 + 3\text{LiCl}$

Uses:

- (i) As catalyst for cracking of petroleum.
- (ii) As catalyst in Friedel-Crafts reactions.
- (iii) For preparing aluminum compounds.

Alums; $\text{M}_2\text{SO}_4 \cdot \text{M}'_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ or $\text{MM}'(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$

Alums are transparent crystalline solids having the above general formula where M is almost any univalent positive cation (except Li^+ because this ion is too small to meet the structural requirements of the crystal) and M' is a trivalent positive cation (Al^{3+} , Ti^{3+} , V^{3+} , Cr^{3+} , Fe^{3+} , Mn^{3+} , Co^{3+} , Ga^{3+} etc.). Alums contain the ions $[\text{M}(\text{H}_2\text{O})_6]^+$, $[\text{M}'(\text{H}_2\text{O})_6]^{3+}$ and SO_4^{2-} in the ratio 1: 1: 2. Some important alums are:

- (i) Potash alum $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$
- (ii) Chrome alum $\text{K}_2\text{SO}_4 \cdot \text{Cr}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$
- (iii) Ferric alum $\text{K}_2\text{SO}_4 \cdot \text{Fe}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$
- (iv) Ammonium alum $(\text{NH}_4)_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$

Alums are double salts which when dissolved in water produce metal ions (or ammonium ions) and the sulphate ions.

Preparation:

A mixture containing solutions of M_2SO_4 and $\text{M}'_2(\text{SO}_4)_3$ in 1 : 1 molar ratio is fused & then the resulting mass is dissolved into water. From the solution thus obtained, alums are crystallized.

Uses:

- (i) As a mordant in dye industry. The fabric which is to be dyed is dipped in a solution of the alum and heated with steam. $\text{Al}(\text{OH})_3$ obtained as hydrolysis product of $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$ deposits into the fibres and then the dye is absorbed on $\text{Al}(\text{OH})_3$.
- (ii) As a germicide for water purification
- (iii) As a coagulating agent for precipitating colloidal impurities from water.

Uses of Boron Compounds

- (i) Boron finds application in the fabrication of high-strength steel designed to withstand high-impact forces, and its neutron-absorbing properties make it valuable in reactor rods for regulating nuclear reactions.
- (ii) Boron carbide serves as an abrasive material in various applications.

Uses of Aluminium Compounds

It is extensively used

- (i) In the production of cooking and domestic utensils.
- (ii) As a coating of aluminum on tanks, pipes, iron bars, and various steel items to protect against corrosion.
- (iii) In the fabrication of aluminum cables.
- (iv) For crafting precision instruments, surgical equipment, aircraft structures, railcar bodies, motorboats, and automobiles.
- (v) Aluminates play a vital role as components of Portland cement.