

Aluminium : It was first prepared by Wohler, by [Wohler → father of organic chemistry]

The reaction of K and AlCl_3 . $3\text{K} + \text{AlCl}_3 \rightarrow 3\text{KCl} + \text{Al}$

Since, Al is reactive metal, it occurs only in the combined state

Minerals :

Corundum $\rightarrow \text{Al}_2\text{O}_3$

Diaspore $\rightarrow \text{Al}_2\text{O}_3\cdot\text{H}_2\text{O}$

Bauxite $\rightarrow \text{Al}_2\text{O}_3\cdot 2\text{H}_2\text{O}$

Gibbsite $\rightarrow \text{Al}_2\text{O}_3\cdot 3\text{H}_2\text{O}$

Cryolite $\rightarrow 3\text{NaF}\cdot\text{AlF}_3$ or Na_3AlF_6

Felspar $\rightarrow \text{KAlSi}_3\text{O}_8$ (or) $\text{K}_2\text{O}\cdot\text{Al}_2\text{O}_3\cdot 6\text{SiO}_2$

China or Kaolin Clay $\rightarrow \text{Al}_2\text{O}_3\cdot 2\text{SiO}_2\cdot 2\text{H}_2\text{O}$

Mica or potash $\rightarrow \text{K}_2\text{O}\cdot\text{Al}_2\text{O}_3\cdot 6\text{SiO}_2\cdot 2\text{H}_2\text{O}$

Alunite or Alum stone $\rightarrow \text{K}_2\text{SO}_4\cdot \text{Al}_2(\text{SO}_4)_3\cdot 4\text{Al}(\text{OH})_3$

Torquoise $\rightarrow \text{AlPO}_4\cdot \text{Al}(\text{OH})_3\cdot \text{H}_2\text{O}$

Extraction of Aluminum :

- Al is extracted from Bauxite by the electrolytic reduction. It involves three stages
 - 1) Purification of bauxite
 - 2) Electrolysis of alumina
 - 3) Refining of aluminium
 - Naturally occurring bauxite contains Fe_2O_3 or SiO_2 as impurities
 - If iron oxide impurity is present, it is called red bauxite
 - If silica impurity is present, it is called white bauxite
 - Red bauxite is purified by
 - 1) Baeyer's process
 - 2) Hall's process
- White bauxite is purified by Serpeck's process.

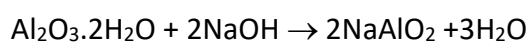
1. Baeyer's process: Reagent is caustic soda. (NaOH)

seeding agent (initiates) – $\text{Al}(\text{OH})_3$. It initiates precipitation of $\text{Al}(\text{OH})_3$.

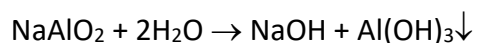
Bauxite is powdered & roasted to convert FeO into Fe_2O_3 , if present.

Bauxite is dissolved in NaOH to give sodium meta aluminate.

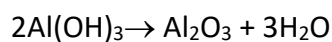
Only bauxite dissolves in NaOH and the insoluble Fe_2O_3 can be removed by filtration.



$\text{Al}(\text{OH})_3$ is precipitated by adding seeding agent.



Al(OH)_3 on ignition gives pure anhydrous alumina

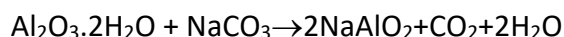


2. Hall's process: Reagent is Na_2CO_3

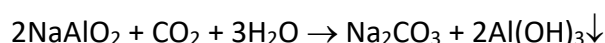
Red bauxite is powdered and roasted to convert FeO , (if any), into Fe_2O_3 .

Red bauxite is treated with Na_2CO_3 to convert into sodium meta – aluminate.

Only bauxite dissolves and impurity remains insoluble. The insoluble Fe_2O_3 is removed by filtration.



Al(OH)_3 is precipitated from NaAlO_2



On heating, Al(OH)_3 decomposes to give pure anhydrous alumina.

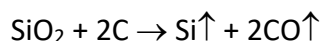
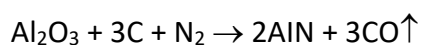
3. Serpeck's process: Reagent is coke + N_2 .

Impurity is SiO_2

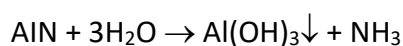
Impurity is removed as Si . Byproduct is NH_3 .

White bauxite is heated with coke powder and N_2 .

Bauxite is converted to AlN (Nitride)



The above AlN is hydrolysed to give Al(OH)_3 & NH_3 .



Al(OH)_3 on heating gives pure anhydrous alumina.

II stage : Electrolytic reduction of alumina : (Hall & Heroult's process)

Anhydrous. Al_2O_3 is bad conductor and its MP is very high.

Little amount of fluorspar (CaF_2) is added to reduce its melting point.

Little amount of cryolite (Na_3AlF_6) is added to increase conductivity.

Thus, fused electrolytic mixture of Al_2O_3 + fluorspar + Cryolite is to be electrolysed

Temperature is maintained at $900 - 950^\circ \text{C}$.

Electrolytic cell: Rectangular Fe tank lined inside with carbon.

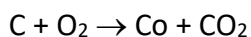
Cathode : Carbon lining of tank.

Anode : Bunch of C rods suspended from top.

Coke powder is sprayed over the electrolyte to prevent oxidation of Al. Product at cathode. Al.

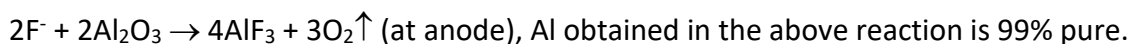
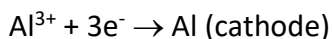
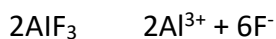
Product at anode : O_2 (first F_2 is formed)

Anodes are to be replaced from time to time because of evolution of O_2 at anode.



Al sinks to the bottom and can be tapped from there.

The following reactions occur during the electrolysis.



Refining of Aluminium : (Hoope's electrolytic refining)

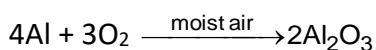
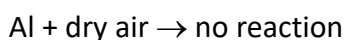
- The cell used is a rectangular Fe tank lined inside with gas carbon. It consists of three layers pure Al is taken in top layer impure Al is taken as bottom layer. Middle layer is electrolytic layer which consists of NaF, BaF_2 , AlF_3 , Al_2O_3 .
- These 3 layers differ in density. Bottom layer is densest & upper layer is lightest.
- C – lining of the bottom layer acts as anode and graphite rods in the upper layers act as cathode.
- The impurities in the impure Al are Cu, Mn, Si.
- Some more impurity is added to it to increase its density.
- On passing electric current, pure Al transfers from bottom to middle and from middle to upper layer.
- Thus, complete pure Al deposits in the upper layer and impurities are left behind in the bottom layer or middle layer.

Physical properties of aluminium :

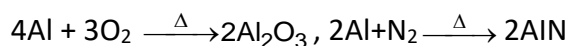
- It is light metal with bluish tinge
- It is malleable (sheet) and ductile
- It can be cast, weld but, difficult in soldering.
- It is a good conductor.
- It has greater tensile strength next to steel and copper.

Chemical reactions: Al is more reactive metal and good reducing agent because of more electro positive nature.

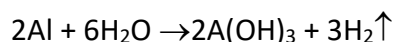
1. With air: Al is not affected by dry air but, reacts with moist air and forms a thin oxide layer.



Aluminium readily burns in air to give aluminium oxide and aluminium nitride .

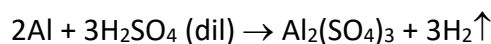
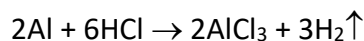


2. With water : Al will not react with pure water but reacts with sea water.

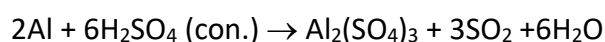


Though Al will not react with cold water, it reacts with boiling water or steam.

3. With acids: It liberates H_2 gas on reaction with dil.HCl or dil. H_2SO_4



with con. H_2SO_4 , it liberates SO_2



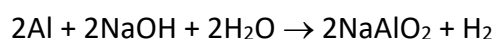
It reacts with dil. Nitric acid to give aluminium nitrate and ammonium nitrate but not H_2 gas.



Al will not react with con. HNO_3 due to the formation of protective Al_2O_3 layer on its surface by the oxidising action of HNO_3 . Thus, Al is rendered passive by con. HNO_3 .

Concentrated HNO_3 is transported or stored in Al containers

Reaction with alkalis : Al also reacts with alkalis to liberate H_2 gas



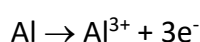
(sodium meta aluminate)

Meta aluminate ion (AlO_2) actually exists as $(\text{Al}(\text{OH})_4(\text{H}_2\text{O})_2)^-$

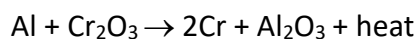
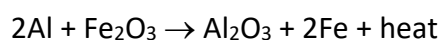
Reaction with non-metals :



Reducing nature : Al is good reducing agent because it is more electropositive



It reduces metal oxides such as Fe_2O_3 , Cr_2O_3 , Mn_3O_4 to their respective metals.



Gold schmidt's aluminothermic process: (Thermite process)

The reduction of iron oxide to iron by aluminium is called aluminothermic process. In this process, Al acts as reducing agent.

This reaction is highly exothermic. The heat liberated in the process is useful to get Fe in molten state. The mixture of Al and Fe_2O_3 in 1 :3 ratio is called thermit.

Ignition mixture consists of Al and BaO_2 .

Thermite is taken in a graphite crucible which is lined inside with magnesite. A Mg ribbon is inserted in the ignition mixture.

When Mg ribbon is ignited, the ribbon catches fire and Fe_2O_3 is reduced to Fe.

The molten Fe is taken out through tapping plug and is directly used in welding the broken ends of railway tracks.



Uses of Al : In electric cables.

Eventhough Cu is better conductor, Al is preferred over Cu because its atomic weight is less and conducts more amount of current [in case of equal weights of Al and Cu]

In making trays, picture frames etc.

As deoxidiser in metallurgy. It is used as reducing agent in thermit welding.

In the packing of chocolates, sweets, cigarettes, etc.

In painting iron surface to prevent rust in place of zinc or tin.

Its alloys are used in aircrafts, motor vehicle spare parts, coins, balances etc.

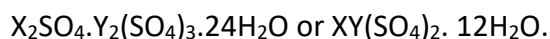
Alloys of Al :

Alloy	Composition	Uses
1) Magnalium	Mg (2-15%) Al (85- 98%)	Making cheap Balances, Laboratory utensils
2) Al Bronze	Al(10%) Cu(90%)	Utensils, Coins (French)
3) Duralumin	Cu(4%), Mg(0.5%), Mn(0.5%), Al(95%)	Air crafts ships
4) \square - Alloy	Al(92.5%), Cu(4%) Mg(1.5%) Ni(2%)	Air crafts submarines

Alloys of Al are light, tough and resist corrosion.

Alums : Alums are double sulphate salts with similar composition and similar crystalline structure i.e. isomorphous.

General formula of alum is



Where X is monovalent cation

$(\text{NH}_4^+, \text{Na}^+, \text{K}^+, \text{Rb}^+, \text{Cs}^+, \text{Tl}^+)$, Y is trivalent cation

(Al^{3+} , Fe^{3+} , Cr^{3+} , Mn^{3+}) Among alkali metal ions, Li^+ does not form alums because of its small size.

In alum, each cation is co-ordinated to 6 H_2O molecules.

Potash alum or common alum $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ (or) $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$

Chrome alum:

$\text{K}_2\text{SO}_4 \cdot \text{Cr}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ (or) $\text{KCr}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$

Ferric alum :

$(\text{NH}_4)_2\text{SO}_4 \cdot \text{Fe}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ (or) $\text{NH}_4\text{Fe}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$

Ammonia alum :

$(\text{NH}_4)_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ (or) $\text{NH}_4\text{Al}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$

Pseudoalums contain divalent and trivalent cations with 24 water molecules.

Eg : $\text{FeSO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$

$\text{MgSO}_4 \cdot \text{Fe}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$

Pseudoalums are not isomorphous as those of alums

Preparation of common alum :

1) By crystallisation : By taking K_2SO_4 & $\text{Al}_2(\text{SO}_4)_3$ in same number of moles and their aqueous solution is allowed to crystallize out.

2) From alunite or alum stone: $(\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 4\text{Al}(\text{OH})_3)$

Alunite is treated with dil. H_2SO_4 and required amount of potassium sulphate is added on cooling the solution, crystals of alum are separated out.

3) From alum shale: Aluminum silicate mixed with iron sulphide is alum shale.

$\text{Al}_2\text{O}_3 \cdot x\text{SiO}_2 + \text{FeS}_2$, FeSO_4 is crystallized out.

H_2SO_4 converts Al_2O_3 into $\text{Al}_2(\text{SO}_4)_3$ and then required amount of K_2SO_4 is added.

Properties : It is white crystalline substance

Soluble in water. Its aqueous solution is slightly acidic due to hydrolysis of Al^{3+} ion.

Uses : In purification of drinking water by coagulation of dust particles. As styptic to prevent bleeding. As mordant to fix the dye on the fabric. In the tanning of leather. In the sizing of paper.

Boron: It does not occur in free state but occurs only in the combined state.

Borax or tincal : $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$

Kernite or Razorie : $\text{Na}_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$

Colemanite : $\text{Ca}_2\text{B}_6\text{O}_{11} \cdot 5\text{H}_2\text{O}$

Boric acid : H_3BO_3 or $\text{B}(\text{OH})_3$

Borax : Chemical name is sodium tetraborate deca hydrate

Boron has two allotropes

- 1) Amorphous : It is reactive
- 2) Crystalline : It is less reactive

Amorphous B burns in air and readily combines with elements like F, Cl. B forms only covalent compounds. In all the compounds, it contains sextet configuration.

∴ almost all B compounds are electron deficient and act as Lewis acids.

Hydrides of boron : The compounds of B & H₂ are called boranes.

Based on the ratio of B to Hydrogen two types of borons are possible.

B_nH_{n+4}	:	B_nH_{n+6}
B_2H_6	:	B_4H_{10}
B_5H_9	:	B_5H_{11}
B_6H_{10}	:	B_6H_{12}
B_8H_{12}	:	$B_{10}H_{16}$
$B_{10}H_{14}$:	$B_{10}H_{16}$

The boranes are electron deficient

The simplest and more important is B_2H_6