

Ganesh Institute of Engineering and Technology



SCTE &VT, BHUBANESWAR, ODISHA

By

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Unit - 3

classmate
Date
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Engineering Materials

- Earth crust is a great source of metals. These metals are found to occur in nature in two states either in free state or in combine state.
- A metal is said to be in free state when it is found in the earth's crust in elementary uncombined form.
- These are unreactive and have no tendency to react with oxygen and are not attacked by moisture, CO_2 or other non-metals for
Ex - Cu, Fe, Au
- Most metals are found in combine state due to their reaction with moisture, air and other substances present in the earth's crust.

Minerals and ores

- The naturally occurring chemical substances in which metals or their compounds occur either in free state or in combine state are called minerals.
- Those minerals from which metals are extracted easily and economically are called ores.
- Slightly reactive metals occur in sulphide form. (Copper sulphide, Lead sulphide)
- Moderately reactive metals occurs as oxides
Manganese oxide, Aluminium oxide
- While highly reactive metals can occur as carbonates, sulphates, halides etc

Fe ore

- 1) Haematite - Fe_2O_3
- 2) Magnetite - Fe_3O_4

Al ore

- 1) Bauxite $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$
- 2) Cryolite - Na_3AlF_6

Cu ore

- 1) Cu pyrite - CuFeS_2
- 2) Dolomite - $\text{CuCO}_3, \text{MgCO}_3$

General principle of Metallurgy

Extraction of metals from ore involves the following steps

- ① Crushing and grinding of ore
- ② Concentration of ore
- ③ Extraction of metal from concentrated ore
- ④ Purification of impure metal

→ Crushing and grinding of ore

Ores are found in nature in the form of big rocks. These rocks are crushed into small pieces with the help of a jaw crusher. The small pieces are then reduced into fine powder with the help of a ball mill or a stamp mill.

→ Concentration of Ore

It is the removal of unwanted impurity called gangue from the ore. It is carried out by both physical such as gravity separation, magnetic

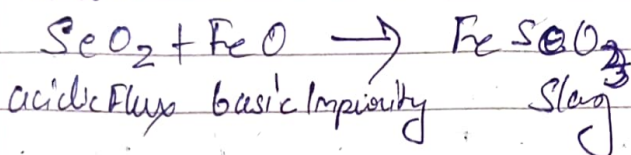
separation, Froth Flotation and chemical means such as calcination and roasting

↳ FLUX

Metal sometimes contains non fusible impurities they are fused easily with chemical substances called Flux gave rise to Flux Baring. Fusible substance called Slag which can be removed easily. It is of two types.

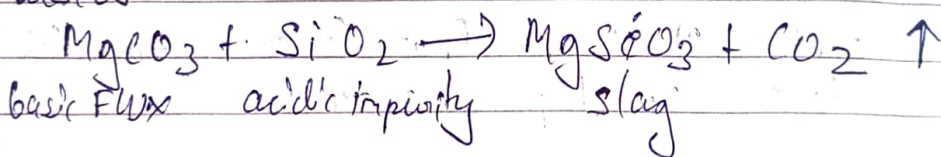
a) Acidic Flux

If impurities are basic then acidic Flux are used.



b) Basic Flux

If impurities are acidic then Basic Flux are used.



↳ Extraction of Metals

Extraction of Metal can be done in following steps

Step 1- Conversion of Metal ore into Metal oxide

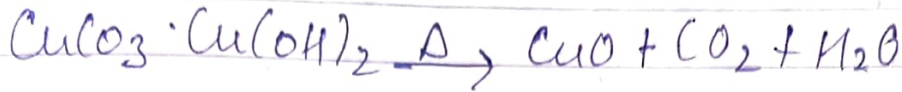
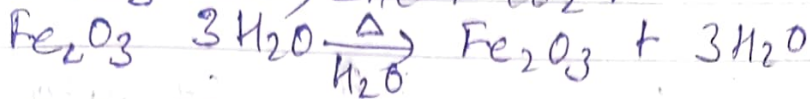
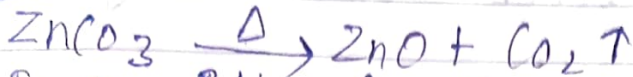
Step 2- Conversion of Metal oxide into Metal

Ores can be converted into metal oxides in following ways.

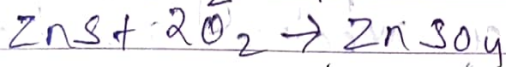
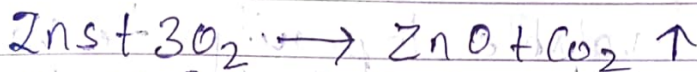
a) Calcination :-

It is the process of heating the concentrated ore in absence of air. This process is performed for hydrated and carbonated ores during this process moisture and volatile impurity is removed from the ore.

Ex



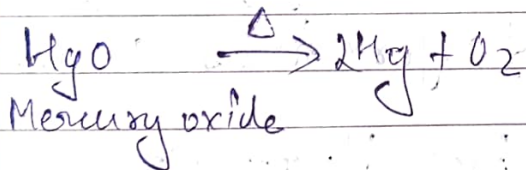
b) Roasting
 It is the process of heating the concentrated ore in excess of air. This process is performed for sulphides ores. During this process moisture and volatile impurities are removed.



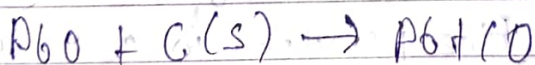
→ Conversion of Metal oxide into metal

It depends upon the reactivity of metal.

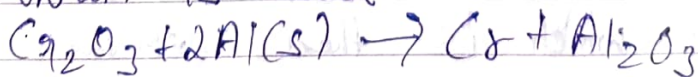
i) If the metal oxide shows low reactivity then it can be converted into metals by only heating.



If the metal is moderately reactive then it can be chemically reduced with carbon.



ii) If the oxide cannot be reduced by carbon then aluminium is used.



iii) IF it's highly reactive then electrolysis is performed



4) Purification of Impure metal

a) Liquation

When a fusible metal contains non fusible impurity then by heating the liquified metal can be separated from the impurity

b) Distillation

When a non-volatile impurity the volatile can be collected in a receiver and then separated from the impurity

c) Electric Refining

The impure metal when taken as anode of an electrolytic cell containing an electrolytic solution the impurity gets removed under the anode that is referred to as anode mud

Extraction of iron from hematite ore

1) Crushing and grinding of ore

The hematite ore is crushed in a jaw crusher and turned into fine powder in a ball mill.

2) Concentration: Extraction

Hematite ore is converted into iron oxide by calcination which is then chemically reduced

by carbon in a blast furnace.

3) Concentration
The hematite ore is concentrated through gravity separation process.

Wrought iron

It is the purest form of commercially used iron with 0.2 - 0.5% of carbon content. It can be prepared from cast iron by reducing its carbon content.

Steel

It can be prepared from cast and wrought iron. It has 0.2 - 2% carbon content.

Extraction of aluminium from bauxite ore

Aluminium is extracted from bauxite ore by reducing the ore. As electrode potential of aluminium is very high, the ore cannot be reduced chemically. Hence, electrolysis method is applied to reduce the ore. This is done in the following ways:

Purification of ore

Electrolysis of ore

Purification of ore Al

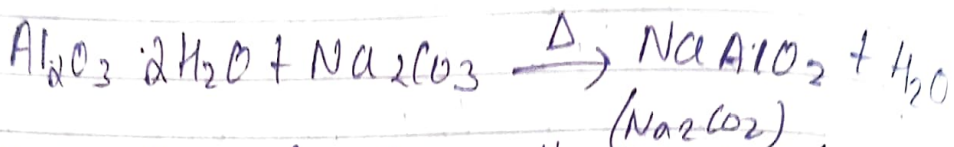
Purification of ore Bauxite

Bauxite ore contains 55% of aluminium oxide $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ along with impurities like silicon dioxide SiO_2 , ferric oxide Fe_2O_3 , titanium dioxide TiO_2 . These impurities can be

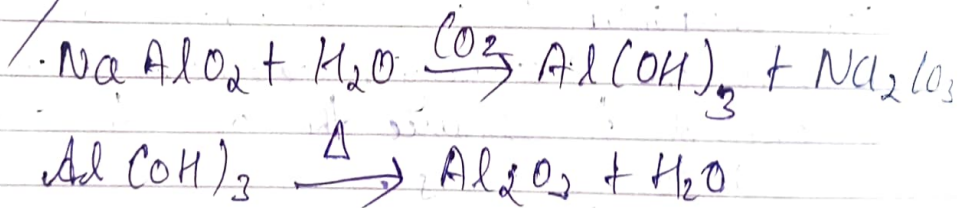
removed in the following three ways.

- Hall's process - SiO_2 / Fe_2O_3
- Bayer's process - FeO
- Sargol's process - SiO_2

Hall's process

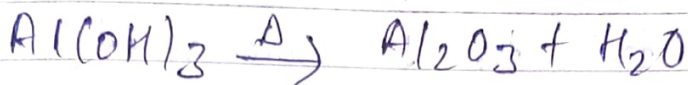
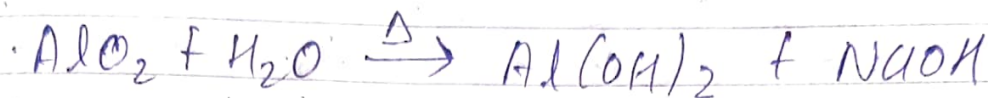


The ore is fused with sodium carbonate to form sodium aluminate (NaAlO_2). Silica and iron oxide do not react with sodium carbonate and hence are in the mixture. The sodium aluminate is then agitated with water in presence of carbon dioxide to form aluminium hydroxide. It is then heated to form aluminium oxide.



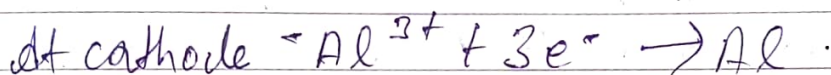
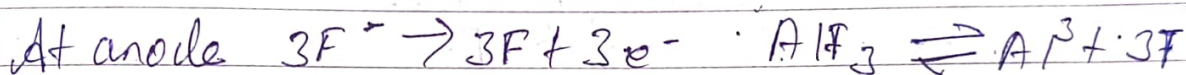
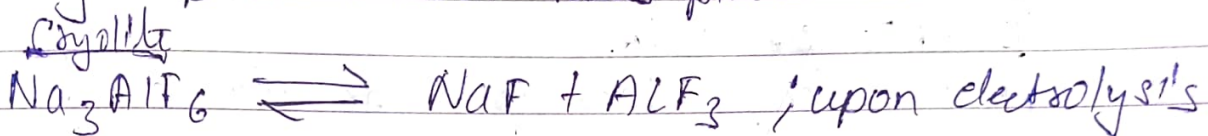
Bayer's Process

The ore is roasted to convert ferrous oxide into ferric oxide Fe_2O_3 . Then it is treated with sodium hydroxide to get sodium aluminate. NaAlO_2 The sodium aluminate is then agitated to form aluminium hydroxide $\text{Al}(\text{OH})_3$ which is then heated to form aluminium oxide Al_2O_3 .



Electrolysis of Bauxite

In this process Bauxite is mixed with a small amount of Cryolite. Cryolite dissociates into fluorides of Sodium and aluminium in next step. Step of reaction takes place as follows.



The fluoride liberated at anode reacts with bauxite as follows :-



Purification of aluminium

The metal obtained from the above process contains impurities like Iron and silicon. This aluminium can be purified by using Hoopes' method.

In an iron tank three layers of liquid is of different density is taken the bottom of the tank

is lined with carbon that acts as anode the middle layer consists of a fused mixture of fluorides of sodium, aluminium, beryllium the top layer contains pure molten aluminium in which a carbon rod is dipped that acts as cathode. when electricity is passed through the tank aluminium ion migrates to the top to cathode where it gets reduced to form pure aluminium.

Alloy Homogeneous

It is a mixture of metals or metals or non-metals.

Benefits of alloy

Alloys have increased resistance to corrosion, increased hardness, increased tensile strength, lower melting point. They produce good cast. The chemical reactivity of a metal can be altered by alloying with other metals.

Classification of alloys

Alloys are classified into two components

① Ferrous alloy - These type of alloys have iron as their main component

Ex - Stainless steel

It is prepared by combining steel with chromium and nickel.

② Non-Ferrous alloy

In these type of alloys iron is not the main component. Ex - Brass

It is prepared by alloying of copper and zinc.

Cement

Cement is a finely ground mixture of various metals and non-metal oxides of different composition with adhesive and cohesive properties.

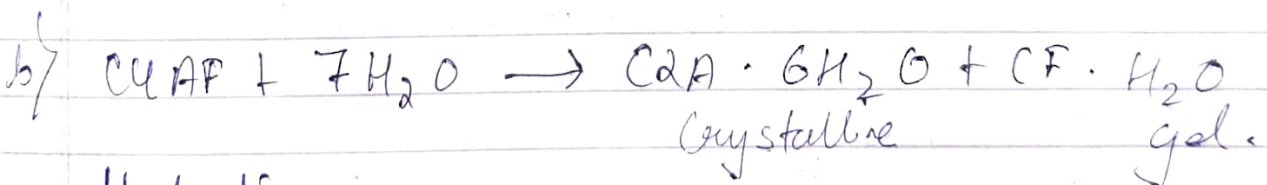
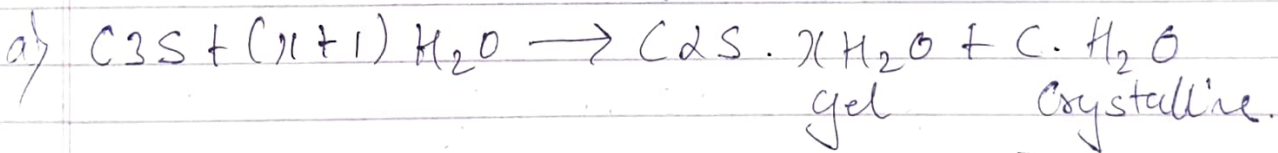
Portland Cement

Cement manufactured from chalk and clay which hardens in contact with water & resembling portland stone is called portland cement.

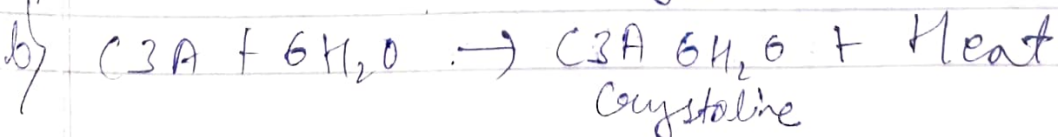
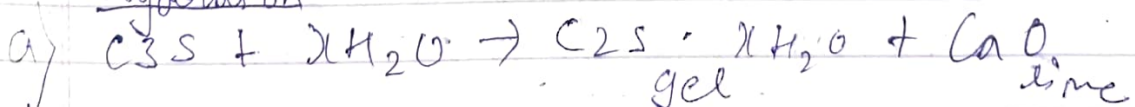
Hardening of Portland Cement

The setting and hardening of cement are mainly due to hydration and hydrolysis reaction. Unhydrated compounds react with water and undergo hydration resulting in the formation of insoluble gels and crystalline products.

Hydrolysis



Hydration



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Here gel acts as the binding material & holds the crystalline components together.

Application of Portland cement

- It is used for the production of concrete.
- It is applied for laying floors, roof, stair pillars etc.
- Construction of bridges, dams, tunnels etc.
- Making joints for drains and pipes.
- Preparation of foundation, water tight floors, footpath etc.

→ Glass

Glass is an amorphous, hard, brittle, transparent or translucent or super cooled liquid of infinite viscosity having no definite melting point. It is obtained by fusing a mixture of several metallic silicates or borates of Na, K, Ca, Pb.

→ Properties of Glass

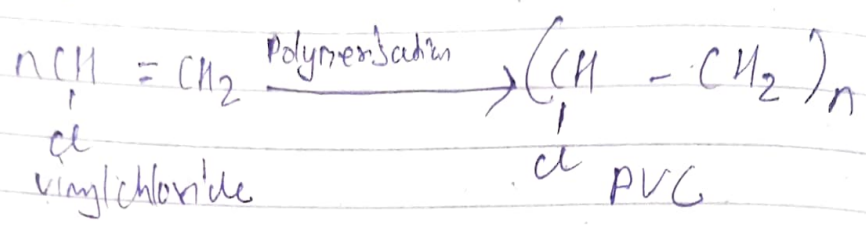
- Glass is hard, brittle, weather and fire resistance.
- It can provide insulation against heat, electricity and radiation.
- It can withstand chemical reaction.

* Refractory

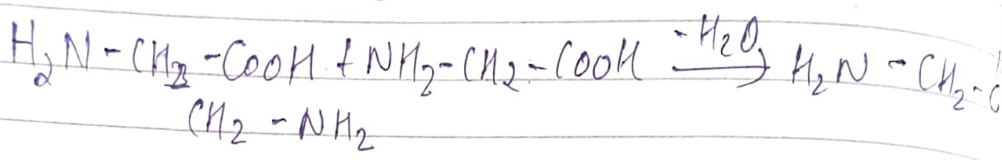
It is an inorganic non-metallic material which can withstand high temperature without undergoing physicochemical changes.
Ex - Hot Blast stove

Classification of Polymers

a) According to the source of its formation polymers are classified into natural and synthetic polymers.

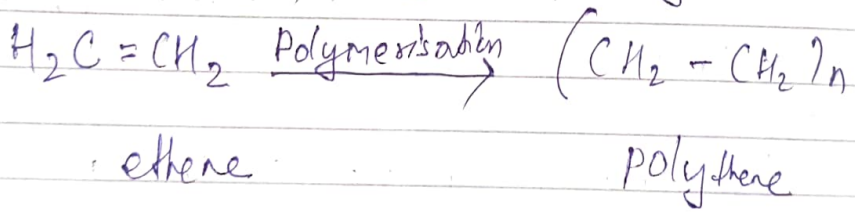


Ex of natural polymer - protein



b) Based upon the chemical reaction involved in the formation polymers are classified into addition and condensation polymer.

Ex of addition polymer - polyethene



Ex of Condensation reaction - Nylon 6,6

c) Polymers are also classified into thermosetting and thermo plastic polymers.

Thermosetting polymers can't be reshaped upon heating while thermo plastic polymer can be reshaped upon heating.

Ex of Thermosetting polymer - Bakelite

Ex of thermoplastic polymer - PVC

Serpain's process :-

Excess silica (SiO_2) crushed are heated with C & N, one converts to AlN, silica converted to silica which is volatile, so escapes the mixture.

