MIND MAP

Metallurgy

Metallurgy

The minerals from which metal can be economically and conveniently extracted are called ores.

Note : All minerals are not ores but all ores are minerals.

Ores may be classified mainly into following two classes.

ORES

- Native Ores
  Silver, gold, platinum etc, occur as native ores.
- Combined Ores
  They contain the metal in combined form.
  i)Oxidised ores
  ii)Sulphurised Ores
  iii)Halide Ores

By Chemical Separation Method

Leaching

It involves the treatment of the ore with a suitable reagent.
e.g, acids, bases and suitable chemical reagents.

Hall's Process Used for red bauxite

$$\text{Bauxite ore} + Na_2CO_3 \xrightarrow{\text{Fused}} NaAlO_2 \xrightarrow{\text{Hydrolysis}} Al(OH)_3 + NaOH$$

$$Al(OH)_3 + Na_2CO_3 \xrightarrow[\Delta]{1500^\circ C} Al_2O_3 + CO_2$$

Serpeck's Process

$$\text{Bauxite ore} + \text{coke} + N_2 \xrightarrow{1800^\circ C} AlN \xrightarrow{H_2O} Al(OH)_3 + NH_3$$

$$Al(OH)_3 \xrightarrow[\Delta]{1500^\circ C} Al_2O_3$$

$C + SiO_2$ (gangue) $\rightarrow CO_2 \uparrow + Si \uparrow$

By product or side product of serpec's process is silicon.

Cyanide Process

(a) Formation of cyanide complex (Ag/Au)

$Ag_2S + 4NaCN \rightleftharpoons 2Na[Ag(CN)_2] + Na_2S$

In absence of air reaction is reversible.

$4Na_2S + 5O_2 + 2H_2O \longrightarrow$

$2Na_2SO_4 + 2S + 4NaOH$

In presence of air reaction is irreversible.

Conversion of concentrated ore into oxide form

a) Calcination

Calcination is a process in which ore is heated, generally in the absence of air, to expel water from a hydrated or hydroxide ore and carbon dioxide from a carbonate ore at temperature below their melting points to form metal oxide.

All Carbonates, Hydrated Ore and Hydroxide Ore

$$MCO_3 \xrightarrow{\Delta} MO + CO_2$$

b) Roasting

Roasting is a process in which the concentrated sulphide ore is heated in reverberatory furnace, below its melting point or fusion temperature in the presence of an excess of air to form metal oxide.

$$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2$$

$$ZnS + 2O_2 \xrightarrow{\Delta} ZnSO_4 \xrightarrow{\Delta} ZnO + SO_2 \uparrow$$

$$CuS + 2O_2 \xrightarrow{\Delta} CuSO_4 \xrightarrow{\Delta} CuO + SO_2 \uparrow$$

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Reduction of ore to the metal

By Pyrometallurgy

Some Reactions of Reduction By Carbon

$PbO + C \longrightarrow Pb + CO$

$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

$ZnO + C \longrightarrow Zn + CO$

$SnO_2 + 2C \longrightarrow Sn + 2CO_2$

Gangue + Flux $\longrightarrow$ Slag

Flux

Two types of Flux are used.

a) Acidic Flux Substance used to remove basic impurities (metal oxide)

$CaO + SiO_2 \longrightarrow CaSiO_3$

(basic impurity) (acidic flux) (slag)

b) Basic Flux Substance used to remove acidic impurities (non metal oxide)

$CaO + SiO_2 \longrightarrow CaSiO_3$

(basic flux) (acidic impurities) (slag)

Self reduction (Auto reduction)

Compounds of certain metals are reduced to metal without using any additional reducing agent, ores of Cu, Pb, Hg etc.

Self Reduction of Cu_2S $2Cu_2S + 3O_2 \xrightarrow[\text{Roasting}]{\text{Partial}} 2Cu_2O + 2SO_2$

$2Cu_2O + Cu_2S \xrightarrow[\text{In absence of air}]{\text{High temperature}} 6\,Cu + SO_2$

(Blister Copper)

By Electometallurgy

i) Electrolytic Reduction

This process is mainly used for the extraction of highly electropositive metals.

Na, K, Mg, Ca, Al, etc.

e.g. Manufacture of metallic sodium (Down's process)

The various reactions that take place are

On Fusion

$NaCl \rightleftharpoons Na^+ + Cl^-$ (Ions become mobile)

On Electrolysis

At Cathode $Na^+ + e^- \longrightarrow Na$ (reduction)

(Metallic sodium)

At Anode $2Cl^- \longrightarrow Cl_2\,(g) + 2e^-$

Alumino Thermite Process

In this process those metal oxide will be reduced which require high temperature and at high temperature carbon reacts with metal to from metal carbide.

In this process we will use Aluminium as a reducing agent.

$Cr_2O_3 + Al \longrightarrow Al_2O_3 + 2Cr + Q$ cal

By Hydrometallurgy

$Ag_2S + 4NaCN \xrightarrow{air} 2Na\,[Ag(CN)_2] + Na_2SO_4$

(Powdered argentite)

$2Na\,[Ag(CN)_2] + Zn \longrightarrow Na_2\,[Zn(CN)_4]\,(aq) + 2Ag$

Black ppt.

MIND MAP

Metallurgy

i) Poling Process

This process is used for the purification of copper and tin.

Green wood $\longrightarrow$ Hydrocarbons $\longrightarrow$ CH_4

$4CuO + CH_4 \longrightarrow 4Cu$ (pure metal) $+ CO_2 + 2H_2O$

ii) Liquation

This method is used for the refining of metals having low melting point and are associated with high melting impurities.

Ex. Pb, Sn, Sb, Bi and Hg.

iii) Distillation

Metals having low boiling point are refined by this method, for example, zinc, cadmium and mercury.

Van-Arkel Process

In this method, the metal is converted into a volatile unstable compound (e.g.iodide), and impurities are not affected during compound formation.

$Ti(s) + 2I_2(g) \xrightarrow{523\ K} TiI_4(g)$

Impure

(i) Volatile in nature

(ii) Relatively thermally unstable

$TiI_4(g) \xrightarrow{1700\ K} Ti(s) + 2I_2(g)$

Amalgamation Process

For noble metal Au, Ag from the native ore.

Ore powder + Hg $\xrightarrow{\text{Distilled}}$ Amalgam $\xrightarrow[920°C]{\Delta}$ Hg (vapour) + Metal (s)

Refining of Metals

Mond's process

Nickel is purified by using CO gas. This involves the formation of nickel tetracarbonyl.

$Ni_{(Impure)} + 4CO \xrightarrow{\Delta} [Ni(CO)_4] \xrightarrow{\Delta} Ni_{(pure)} + 4CO$

(i) Volatile in nature

(ii) Relatively thermally unstable

Cupellation (removal of Lead from Silver or Gold)

In this process the molten impure metal is heated in a cupel, which is boat-shaped dish made of bone ash or cement, and a blast of air is passed over the molten metal.

Electro-refining of Metals

Metals such as Cu, Ag, Zn, Sn, Pb, Al, Ni, Au are refined by this method.

The impure metal is made the anode of a electrolytic cell, while cathode is thin plate of pure metal.

Electrorefining of Cu

Anode	Impure copper
Cathode	Pure copper
Electrolyte	An aqueous solution of $CuSO_4$ + 5% dil H_2SO_4

Thermodynamics of Reduction Processes (Ellingham Diagram)

Limitation of Ellingham Diagram

The graph simply indicates whether a reaction is possible or not i.e., the tendency of reduction with a reducing agent is indicated.

This is so because it is based only on the thermodynamic concepts.