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GENERAL PRINCIPLES OF METALLURGY

Occurrence and Properties of Metals

- Mostly, the **metals** occur in nature in a combined state but sometimes they can also occur in the free state.
- A native **metal** is a **metal** found in its metallic state naturally, either in pure form or in the form of an alloy.Examples :Less active metals like Cu,Ag,Au etc.
- Most **metals** can't resist natural processes like oxidation, corrosion etc.

ORES AND METALS

- **Ores** are those **minerals** from which metal are extracted conveniently and profitably.
  These **ores** contain good percentage of metal.
- Ores Of Al With Chemical Formula:

1. Bauxite , $Al_2O_3.2H2O$
2. Cryolite, Na3AlF6
3. Felspar, K AlSi3O8
4. Corundum, Al2O3

ORES AND METALS

- Ores Of Zn With Chemical Formula:

1. Zinc Blende, ZnS
2. Calamine, $ZnCO_3$
3. Zincite, ZnO

- Ores Of Cu With Chemical Formula:

1. Copper Glance, Cu_2S
2. Copper Pyrites, $CuFeS_2$
3. Cuprite,Cu_2O

ORES AND METALS

- Ores Of Fe With Chemical Formula

1.Haematite, Fe_2O_3

2. Magnetite, $MgCO_3$

3.Iron Pyrites, FeS_2

4.Siderite, $FeCO_3$

5.Lemonite, $2Fe_2O_3.3H_2O$

- Ore Of Sn With Chemical Formula:

Casseterite,SnO_2

ORES AND METALS

- Ore Of Pb With Chemical Formula:
  Gallena, PbS
- Ore Of Hg With Chemical Formula:
  Cinnabar, HgS
- Ore Of Ag With Chemical Formula:
  Horn Silver, AgCl
- Ore Of Au With Chemical Formula:
  Calaverite, $AuTe_2$

METHODS OF ORE DRESSING

- **Ore dressing** is a **process** of mechanically separating the grains of **ore** minerals from the gangue minerals..
- Gravity separation: Gravity separation is the separation of two or more ores of different specific gravity by their relative movement in response to the force of gravity and one or more other forces (such as centrifugal forces, magnetic forces, buoyant forces), one of which is resistance to motion by a viscous medium such as heavy media, water or, less commonly, air.
- Examples; ores of Gold and Silver.

METHODS OF ORE DRESSING

Froth-Flotation: **Froth-Flotation** is a **process** for selectively separating hydrophobic materials from hydrophobic. In some cases, for example, sulphides **ores** of copper, zinc and lead **concentration** is brought by this method.

- The principle of **froth floatation** is that sulphide ores are preferentially wetted by pine oil, whereas the gangue particles are wetted by water. ...
- **Example**: For an ore containing ZnS and PbS, the depressant used is NaCN. It selectively prevents ZnS from coming to **froth** but allows PbS to come with the **froth**.

METHODS OF ORE DRESSING

- **Magnetic Separation:** This involves the use of **magnetic** properties of either the **ore** or the gangue to separate them. The **ore** is first ground to fine pieces and then passed on a conveyor belt passing over a **magnetic** roller. The **magnetic ore** remains on the belt and the gangue falls off the belt.
- Example:Being magnetic, Iron Tungstate ($FeWO_4$) gangue can be separated from Casseterite(SnO_2).

METHODS OF ORE DRESSING

- Leaching or Chemical Separation: **Leaching** is a process where ore is treated with chemicals to convert the valuable metals within into soluble salts while impurity remain insoluble.
- There are four types of leaching:
- Cyanide leaching (e.g. gold ore)
- Ammonia leaching (e.g. Crushed ore)
- Alkali leaching (e.g. bauxite ore)
- Acid leaching (e.g. sulphide ore)

Extraction Of Crude Metal From Concentrated Ore

- **solation of metal** from the concentrated Ore involves the refining of metals from the compounds. The first step is to convert an ore into an oxide. Then the oxide is reduced using a suitable reducing agent.
- The first step consists Calcination and Roasting

1.Calcination: **Ores are heated below the melting point in absent of O2 to convert metal oxide by removing gangue. Examples:Oxide and carbonate ores.**

$Fe_2O_3.xH_2O(s) \rightarrow Fe_2O_3(s) + xH_2O(g)$; $MgCO_3 \rightarrow MgO + CO_2\uparrow$

2. **Roasting:** During this process, extraction is done by heating the ore in a regular supply of air to convert metal oxide. Sulphide ores of Zinc, Lead and Copper etc .

$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

Extraction Of Crude Metal From Concentrated Ore

- The Second step consists -

1. Carbon Reduction Process:

Roasting ores are heated with sufficient coke as reducing agent which reduces the oxides of metals (by losing oxygen) to produce metallic element like zinc ,iron,copper, lead etc.

Reaction: $2PbO+C \rightarrow 2Pb+CO$

2. Goldschmidt Thermite Process:

Metal Oxides are heated above the m.p with Al dust as reducing agent which reduces metal oxides to metals like V,Cr,Mn,Fe etc.

Reaction: $3\ V_2O_5 + 10\ Al \rightarrow 5\ Al_2O_3 + 6\ V$

Extraction Of Crude Metal From Concentrated Ore

3. Self Reduction Process: The sulphide ores of less electropositive metals like Hg, Pb, Cu etc., are heated in the air so as to convert part of the ore into oxide or sulphate which then reacts with the remaining sulphide ore to give the metal.

- Here Sulphide ore itself acts as a R.A and need not necessary any additional R.A.
- $Cu_2S + 3O2 \rightarrow 2Cu2O + 2SO2$
- $2Cu_2O + Cu2S \rightarrow SO_2 + 6CU$

PURIFICATION OF CRUDE METALS

- There are several methods of refining or **purifying metals.These methods include-**

1. Distillation: vapourizing the **metal** and then allowing it to solidify outside of the impurities.

Examples: Zn,Cd,Hg

2. Liquation: Metals that have particularly low melting points can use the liquation method

PURIFICATION OF CRUDE METALS

- **Liquation** is similar to distillation, except the impure metal is only melted instead of vapourized.

- When the other impurities have a much higher melting point, they will remain solid and can be removed from the pure liquid metal.

- Examples: Sn,Pb

PURIFICATION OF CRUDE METALS

- Electrolysis: Metal oxide is melted and a current is passed through it. The electric current separates the metal from the oxygen.
- A cathode adds electrons on the metal, making pure metal and an anode collects the extra electrons on the oxygen, combining it with carbon to form CO.
- Examples: Al,Zn,Sn etc.

PURIFICATION OF CRUDE METALS

- Zone Refining : A technique for the purification of a metal in which a molten region travels through the material to be **refined**, picks up impurities at its advancing edge, and then allows the purified part to recrystallize at its opposite edge. Examples:Ge,Si,Ga,In,B,Ta etc.

PURIFICATION OF CRUDE METALS

- Vapour Phase Refining: In this method, impure metal is first converted into its volatile compound by heating with a chemical reagent at lower temperature. After this, the volatile compound is decomposed by heating to give the pure metal.

1. Mond Process: Ni
2. Van Arkel Process: Ti, Zr

Thank You!