



## General Principles and Processes of Isolation of Metals

### Occurrence of Metals

<i>Metal</i>	<b>Name of the ore</b>	<b>Composition</b>
<i>Pb</i>	Galena	<i>PbS</i>
<i>Zn</i>	Zinc blende	<i>ZnS</i>
<i>Hg</i>	Cinnabar	<i>HgS</i>
<i>Fe</i>	Iron pyrites	<i>FeS<sub>2</sub></i>

**Oxidised ores:** In these ores, metals are present as their oxides or oxysalts such as carbonates, nitrates, sulphates, phosphates, silicates, etc.

**Important ores of this group are listed below,**  
**Oxides**

Zincite	<i>ZnO</i>
Rutile	<i>TiO<sub>2</sub></i>
Ilmenite	<i>FeO.TiO<sub>2</sub></i>
Haematite	<i>Fe<sub>2</sub>O<sub>3</sub></i>
Magnetite	<i>Fe<sub>3</sub>O<sub>4</sub></i>
Limonite	<i>Fe<sub>2</sub>O<sub>3</sub>.3H<sub>2</sub>O</i>
Bauxite	<i>Al<sub>2</sub>O<sub>3</sub>.2H<sub>2</sub>O</i>



Corundum	$Al_2O_3$
Diaspore	$Al_2O_3.H_2O$
Chromite	$FeO.Cr_2O_3$
Chromeochre	$Cr_2O_3$

## Carbonates

Malachite	$CuCO_3.Cu(OH)_2$
Azurite	$Cu(OH)_2.2CuCO_3$
Cerussite	$PbCO_3$
Siderite	$FeCO_3$
Magnesite	$MgCO_3$
Lime stone	$CaCO_3$
Dolomite	$CaCO_3.MgCO_3$
Calamine	$ZnCO_3$

## Nitrates

Chile saltpetre	$NaNO_3$
Salt petre	$KNO_3$



## Sulphates

Polyhalite	$K_2SO_4.MgSO_4.CaSO_4.2H_2O$
Epsom salt	$MgSO_4.7H_2O$
Barytes	$BaSO_4$
Gypsum	$CaSO_4.2H_2O$

## Phosphates and Silicates

Fluor-apatite	$3Ca_3(PO_4)_2.CaF_2$
Felspar	$KAlSi_3O_8$
Talc	$Mg_3(Si_2O_5)_2.Mg(OH)_2$
Asbestos	$CaMg_3.(SiO_3)_4$

**Halide ores:** Metallic halides are very few in nature. Chlorides are most common. For example.

Common salt  $NaCl$ ; Horn silver  $AgCl$

Carnallite  $KCl.MgCl_2.6H_2O$

The important fluoride ores are

Fluorspar  $CaF_2$ ; Cryolite  $Na_3AlF_6$



## Extraction of Metals: Metallurgy

The extraction of a pure metal from its ore is called *metallurgy*.

**Physical Methods** (i) **Gravity Separation or levigation:** This process of concentration is based on the difference in the specific gravity of the ore and gangue. The sieved ore is either subjected to dry centrifugal

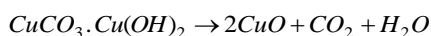
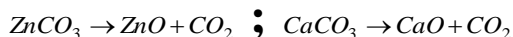
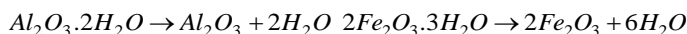
**Froth floatation process:** In some cases for example, sulphides ores of copper, zinc and lead concentration is brought by this method.

**Electromagnetic separation:** If the mineral and not gangue is attracted by a magnet, it can be concentrated by magnetic separation.

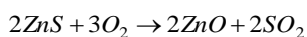
### Chemical methods

(i) **Calcination:** In this process the concentrated ore is heated in a suitable furnace generally in reveratory furnace much below its **melting point** in absence of air.

For example,



(ii) **Roasting:** The process of heating the ores strongly in presence of air with or without certain substances, below its melting point is termed as roasting.,



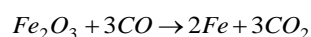
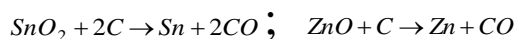


(iii) **Leaching:** It involves the treatment of the ore with a suitable reagent as to make it soluble while impurities remain insoluble.



Gold and silver are also extracted from their native ores by Leaching (Mac-Arthur forest cyanide process).

(iv) **Smelting:** The process of extracting a metal in the state of fusion is called *smelting*.



**Flux and slag:** Flux is a substance that is added during smelting to convert infusible silicons or earthy impurities into fusible material known as slag.

**Impurities + Flux = Slag.**

## Summary of the Extraction of Metals

Metal	Main Occurrence	Main method of Extraction
Sodium	Common Salt, NaCl	Electrolysis of fused NaCl with CaCl <sub>2</sub>
Magnesium	Carnallite, KCl.MgCl <sub>2</sub> .6H <sub>2</sub> O Magnesite MgCO <sub>3</sub>	Electrolysis of fused MgCl <sub>2</sub> with KCl
Calcium	<ul style="list-style-type: none"> <li>Lime stone, CaCO<sub>3</sub> Gypsum, CaSO<sub>4</sub>.2H<sub>2</sub>O</li> </ul>	Electrolysis of fused CaCl <sub>2</sub> and CaF <sub>2</sub>
Aluminium	<ul style="list-style-type: none"> <li>Bauxite, Al<sub>2</sub>O<sub>3</sub>.2H<sub>2</sub>O</li> </ul>	Electrolysis of Al <sub>2</sub> O <sub>3</sub> in molten Na <sub>3</sub> AlF <sub>6</sub> (cryolite)
Copper	<ul style="list-style-type: none"> <li>Copper pyrites, CuFeS<sub>2</sub> Cuprite, Cu<sub>2</sub>O</li> </ul>	Partial oxidation of sulphide ore (2Cu <sub>2</sub> O + Cu <sub>2</sub> S → 6Cu + SO <sub>2</sub> ).
Silver	<ul style="list-style-type: none"> <li>Argentite, Ag<sub>2</sub>S Native silver</li> </ul>	Hydrometallurgy Ag <sub>2</sub> S + 4NaCN → 2NaAg (CN) <sub>2</sub> + Na <sub>2</sub> S 2NaAg (CN) <sub>2</sub> + Zn → Na <sub>2</sub> Zn (CN) <sub>4</sub> + 2Ag
Zinc	<ul style="list-style-type: none"> <li>Zinc Blende, ZnS Calamine, ZnCO<sub>3</sub></li> </ul>	Reduction of ZnO with carbon or electrolysis of ZnSO <sub>4</sub> ZnO + C → Zn + CO
Lead	<ul style="list-style-type: none"> <li>Galena, PbS</li> </ul>	Reduction of PbO with carbon PbO + C → Pb + CO
Tin	<ul style="list-style-type: none"> <li>Cassiterite, SnO<sub>2</sub></li> </ul>	Reduction of SnO <sub>2</sub> with carbon SnO <sub>2</sub> + 2C → Sn + 2CO
Iron	<ul style="list-style-type: none"> <li>Haematite, Fe<sub>2</sub>O<sub>3</sub> Magnetite, Fe<sub>3</sub>O<sub>4</sub></li> </ul>	Reduction of oxide with carbon monoxide Fe <sub>2</sub> O <sub>3</sub> + 3CO → 2Fe + 3CO <sub>2</sub>
Chromium	<ul style="list-style-type: none"> <li>Chromite, FeO.Cr<sub>2</sub>O<sub>3</sub>.</li> </ul>	Reduction of Cr <sub>2</sub> O <sub>3</sub> with Al Cr <sub>2</sub> O <sub>3</sub> + 2Al → 2Cr + Al <sub>2</sub> O <sub>3</sub>
Nickel	Millerite, NiS	duction of NiO with CO NiO + 5CO → Ni(CO) <sub>4</sub> + CO <sub>2</sub> ; Ni(CO) <sub>4</sub> → Ni + 4CO
Mercury	Cinnabar, HgS	Direct reduction of HgS by heat alone HgS + O <sub>2</sub> → Hg + SO <sub>2</sub>