General Principles and Processes of Isolation of Metals

Occurrence of Metals

Metal	**Name of the ore**	**Composition**
Pb	Galena	*PbS*
Zn	Zinc blende	*ZnS*
Hg	Cinnabar	*HgS*
Fe	Iron pyrites	FeS_2

***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	ZnO
Rutile	TiO_2
Ilmenite	$FeO.TiO_2$
Haematite	Fe_2O_3
Magnetite	Fe_3O_4
Limonite	$Fe_2O_3.3H_2O$
Bauxite	$Al_2O_3.2H_2O$

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	$Mg_2(Si_2O_5).Mg(OH)_2$
Asbestos	$CaMg_3.(SiO_3)_4$

***Halide ores*:** Metallic halides are very few in nautre. 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,

$Al_2O_3.2H_2O \rightarrow Al_2O_3 + 2H_2O$ $2Fe_2O_3.3H_2O \rightarrow 2Fe_2O_3 + 6H_2O$

$ZnCO_3 \rightarrow ZnO + CO_2$; $CaCO_3 \rightarrow CaO + CO_2$

$CuCO_3.Cu(OH)_2 \rightarrow 2CuO + CO_2 + H_2O$

(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.,

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

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

$Al_2O_3.\ 2H_2O + 2NaOH \rightarrow 2NaAlO_2 + 3H_2O$

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.

$SnO_2 + 2C \rightarrow Sn + 2CO$; $ZnO + C \rightarrow Zn + CO$

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

***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 $CaCl_2$
Magnesium	Carnallite, $KCl.MgCl_2.6H_2O$ Magnesite $MgCO_3$	Electrolysis of fused $MgCl_2$ with KCl
Calcium	• Lime stone, $CaCO_3$ Gypsum, $CaSO_4.2H_2O$	Electrolysis of fused $CaCl_2$ and CaF_2
Aluminium	• Bauxite, $Al_2O_3.2H_2O$	Electrolysis of Al_2O_3 in molten Na_3AlF_6 (cryolite)
Copper	• Copper pyrites, $CuFeS_2$ Cuprite, Cu_2O	Partial oxidation of sulphide ore $(2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2)$.
Silver	• Argentite, Ag_2S Native silver	Hydrometallurgy $Ag_2S + 4NaCN \longrightarrow 2NaAg\ (CN)_2 + Na_2S$ $2NaAg\ (CN)_2 + Zn \longrightarrow Na_2Zn\ (CN)_4 + 2Ag$
Zinc	• Zinc Blende, ZnS Calamine, $ZnCO_3$	Reduction of ZnO with carbon or electrolysis of $ZnSO_4$ $ZnO + C \longrightarrow Zn + CO$
Lead	• Galena, PbS	Reduction of PbO with carbon $PbO + C \longrightarrow Pb + CO$
Tin	• Cassiterite, SnO_2	Reduction of SnO_2 with carbon $SnO_2 + 2C \longrightarrow Sn + 2CO$
Iron	• Haematite, Fe_2O_3 Magnetite, Fe_3O_4	Reduction of oxide with carbon monoxide $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$
Chromium	• Chromite, $FeO.Cr_2O_3$.	Reduction of Cr_2O_3 with Al $Cr_2O_3 + 2Al- \rightarrow 2Cr + Al_2O_3$
Nickel	Millerite, NiS	duction of NiO with CO $NiO + 5CO \longrightarrow Ni(CO)_4 + CO_2;$ $Ni(CO)_4 \longrightarrow Ni + 4CO$
Mercury	Cinnabar, HgS	Direct reduction of *HgS* by heat alone $HgS + O_2 \longrightarrow Hg + SO_2$