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Metallurgy

Occurrence of Metals

Metals are found in the Earth's crust as minerals. Among these, those that can be profitably extracted are called ores.

Metal	Ore Name	Chemical Formula
Lead (Pb)	Galena	PbS
Zinc (Zn)	Zinc blende	ZnS
Mercury (Hg)	Cinnabar	HgS
Iron (Fe)	Iron pyrites	FeS ₂

Oxide Ores: Ores containing metals in the form of oxides or oxysalts (carbonates, sulphates, nitrates, silicates, etc.) are known as oxidized ores.

Key Oxide Ores:

Zincite	ZnO
Rutile	TiO ₂
Ilmenite	FeO · TiO ₂
Haematite	Fe ₂ O ₃
Magnetite	Fe ₃ O ₄
Limonite	Fe ₂ O ₃ ·3H ₂ O
Bauxite	Al ₂ O ₃ ·2H ₂ O
Corundum	Al ₂ O ₃
Diaspore	Al ₂ O ₃ ·H ₂ O
Chromite	Cr ₂ O ₃

Table 1: Some Common Carbonates

Name	Formula
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

Table 2: Common Nitrates

Name	Formula
Chile saltpetre	NaNO ₃
Salt petre	KNO ₃

Metallurgy

The entire sequence of operations involved in extracting metals from their ores is called metallurgy. It involves several stages:

Table 3: Common Sulphates

Name	Formula
Polyhalite	K ₂ SO ₄ · MgSO ₄ · CaSO ₄ · 2H ₂ O
Epsom salt	MgSO ₄ · 7H ₂ O
Barytes	BaSO ₄
Gypsum	CaSO ₄ · 2H ₂ O

Table 4: Phosphates and Silicates

Name	Formula
Fluor-apatite	3Ca ₃ (PO ₄) ₂ · CaF ₂
Felspar	KAlSi ₃ O ₈
Talc	Mg ₃ (Si ₄ O ₁₀)(OH) ₂
Asbestos	CaMg ₃ (SiO ₃) ₄

- Crushing and Grinding:** Conversion of ore into powdered form.
- Concentration or Dressing of Ore:** Removal of gangue (earthy impurities).

- **Gravity Separation:** Used for heavy oxide ores like tin stone.
- **Magnetic Separation:** Applied for magnetic ores like chromite and magnetite.
- **Froth Flotation:** Commonly used for sulphide ores using frothers and collectors.
- **Leaching:** Involves selective dissolving of the ore (e.g., for bauxite or gold).

3. Extraction of Crude Metal: Involves calcination, roasting, and reduction.

- **Calcination:** Heating in absence of air to remove volatile impurities.
- **Roasting:** Heating in presence of air to convert sulphides to oxides.
- **Reduction Methods:**
 - **Carbon Reduction:** Using coke or CO.
 - **Self-Reduction:** Sulphide ores reduce themselves (Pb, Cu, Hg).
 - **Aluminothermic Reduction:** Using aluminium powder (e.g., Cr, Mn).
 - **Electrolytic Reduction:** Electrolysis of molten salts (e.g., Na, Al).
 - **Hydrogen Reduction:** For oxides of noble metals like Ag, Au.

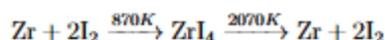
4. Refining of Metals: Final step to obtain pure metal.

- **Liquation:** Based on melting points (used for Sn, Pb).
- **Distillation:** Used for volatile metals (Zn, Cd).
- **Poling:** Removal of oxides by stirring with wooden poles (for Cu).
- **Electrolytic Refining:** Used for metals like Cu, Ag, Zn.
- **Zone Refining:** For semiconductors like Si, Ge.
- **Vapour Phase Refining:**

- **Mond's Process (Ni):**



- **Van Arkel Method (Zr, Ti):**



- **Chromatographic Methods:** Used for ultra-pure metals.

Summary Table: Metals and Their Extraction

Metal	Ore (with Composition)	Extraction Method
Sodium	Rock Salt (NaCl)	Electrolysis of molten NaCl
Magnesium	Magnesite (MgCO_3), Carnallite ($\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$)	Electrolysis of molten MgCl_2 with KCl
Calcium	Limestone (CaCO_3), Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)	Electrolysis of CaCl_2 with CaF_2
Aluminium	Bauxite ($\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$)	Electrolysis in molten cryolite (Na_3AlF_6)
Copper	Copper Pyrites (CuFeS_2), Cuprite (Cu_2O)	Partial oxidation and self-reduction
Silver	Argentite (Ag_2S), Native Silver	Cyanide leaching followed by displacement with Zn
Zinc	Zinc Blende (ZnS), Calamine (ZnCO_3)	Roasting and reduction or electrolysis
Lead	Galena (PbS)	Roasting to PbO and reduction with carbon
Tin	Cassiterite (SnO_2)	Carbon reduction ($\text{SnO}_2 + 2\text{C} \rightarrow \text{Sn} + 2\text{CO}$)

