General Principles of Isolation of Elements Class 12 Key Points

CBSE Class 12 Chemistry · NCERT · for boards, NEET and JEE revision

ChapterNotes

The Metallurgy Pipeline

Concentration → Conversion to oxide → Reduction → Refining

The more reactive the metal, the more energy-intensive (usually electrical) its extraction.

- Unreactive metals (Au, Pt) occur native; reactive ones stay trapped as compounds
- Oxides are the easiest form to reduce, so ores are turned into oxides first
- Memorising this sequence organises the whole chapter

Minerals, Ores, Gangue, Flux, Slag

flux + gangue → slag

Every ore is a mineral (TRUE); every mineral is an ore (FALSE).

- Mineral = any natural form of a metal; Ore = mineral extractable profitably & conveniently
- Gangue = earthy impurity; Flux added on purpose to form fusible slag
- Acidic gangue (SiO_2) needs basic flux (CaO); $CaO + SiO_2 \rightarrow CaSiO_3$ (slag)

Important Ores

Bauxite $Al_2O_3 \cdot xH_2O$ · Haematite Fe_2O_3 · Chalcopyrite $CuFeS_2$ · Zinc blende ZnS

Cryolite Na_3AlF_6 is a flux/solvent, NOT the ore of Al.

- Iron: Haematite Fe_2O_3, Magnetite Fe_3O_4
- Zinc: Zinc blende ZnS, Calamine $ZnCO_3$; Silver: Argentite Ag_2S
- Watch lookalikes: Cu_2S (copper glance) vs $CuFeS_2$ (chalcopyrite)

Concentration of Ores

$4Au + 8CN^- + 2H_2O + O_2 \rightarrow 4[Au(CN)_2]^- + 4OH^-$ (cyanide leaching)

Froth flotation is for sulphide ores ONLY; leaching is the chemical method.

- Hydraulic washing = density; Magnetic separation = magnetism (Fe_3O_4, $FeWO_4$)
- Froth flotation: pine oil + air; sulphides go hydrophobic and rise as froth
- Depressant NaCN holds ZnS down to separate it from PbS

Calcination vs Roasting

$ZnCO_3 \rightarrow ZnO + CO_2$ (calcination) · $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$ (roasting)

Calcination = limited/no air; Roasting = excess air, below melting point.

- Carbonate/hydrated ore → calcination (drives off CO_2 / H_2O, no O_2 added)
- Sulphide ore → roasting (excess O_2 burns S off as SO_2)
- Both steps end at an oxide, the easiest form to reduce

Reduction of the Oxide

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ · $Cr_2O_3 + 2Al \rightarrow 2Cr + Al_2O_3$ (thermite)

Reduction is feasible only when net ΔG° is negative.

- Common reducing agents: carbon, carbon monoxide, aluminium (thermite)
- ZnO + C → Zn + CO is a standard carbon reduction
- Very reactive metals (Na, Mg, Ca, Al) need electrolysis instead

Ellingham Diagram

$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

Gives only thermodynamic feasibility, NOT the rate (kinetics).

- Metal-oxide lines slope UP (O_2 consumed, ΔS negative)
- C → CO line slopes DOWN, so hot carbon can reduce almost any oxide
- Lower line (more negative ΔG°) reduces the oxide of the higher line

Electrolytic Reduction & Self-Reduction

$Al^{3+} + 3e^- \rightarrow Al$ · $2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$

Reactive metals are reduced from MOLTEN salts, never aqueous (water reduces first).

- Hall–Héroult: Al_2O_3 in molten cryolite (Na_3AlF_6) lowers m.p. & raises conductivity
- Carbon anode burns away as CO/CO_2; Al collects at the cathode
- Self-reduction is special to Cu, Pb, Hg sulphides (no external reductant)

Refining the Crude Metal

Mond: $Ni + 4CO \rightarrow Ni(CO)_4 \rightarrow Ni + 4CO$ · van Arkel: $Ti + 2I_2 \rightarrow TiI_4 \rightarrow Ti + 2I_2$

Electrolytic refining: impure metal = ANODE, pure metal = CATHODE.

- Distillation: low-boiling Zn, Hg; Liquation: low-melting Sn, Pb
- Zone refining gives ultra-pure Si, Ge, Ga (impurities prefer the molten zone)
- Anode mud collects valuable Ag, Au, Pt during electrolytic refining

Quick revision

- Concentration methods: gravity, magnetic, froth flotation (sulphides), leaching (bauxite/gold)
- Froth flotation: sulphide ore + water + pine oil + air; collectors enhance, depressants separate
- Bayer's process: bauxite + NaOH → aluminate → $Al(OH)_3 \rightarrow Al_2O_3$
- Ellingham diagram: lower line reduces upper; C becomes better reducer at high T
- Highly reactive metals → electrolysis; moderate → carbon reduction; low → self-reduction
- Iron: blast furnace, CO is the main reducing agent
- Al: Hall-Héroult, electrolysis of Al_2O_3 in cryolite
- Cu: roasting → smelting → self-reduction → blister copper → electrolytic refining
- Refining: electrolytic (Cu), zone (Si/Ge), Mond (Ni), Van Arkel (Zr/Ti)
- Thermite: $Fe_2O_3 + 2Al \rightarrow 2Fe + Al_2O_3$ (welding railway tracks)

Full chapter notes with solved examples and practice questions: https://chapternotes.in/cbse/class-12-chemistry/general-principles-of-isolation-of-elements-class-12-notes/