

Class 12 Chemistry – General Principles & Processes of Isolation of Elements | Study Guide

1. Theory in Simple Words with Visuals

1.1 What is Metallurgy?

- **Definition:** Metallurgy is the science of extracting metals from their ores and refining them.
 - **Analogy:** Think of ores as “treasure chests” and metallurgy as the “process to unlock and purify the treasure.”
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1.2 Steps in Extraction of Metals

Step	Description	Visual / Analogy
1. Concentration of Ore	Removing impurities (gangue)	Sorting stones from rice
2. Conversion to Oxide	Preparing ore for reduction	Baking raw clay into bricks
3. Reduction of Oxide	Removing oxygen to get metal	Stripping paint off metal
4. Refining	Purifying crude metal	Polishing gold to shine

Flowchart:

Ore → Concentration → Metal Oxide → Reduction → Crude Metal → Refining → Pure Metal

1.3 Methods of Concentration

1. **Gravity Separation:** Heavy minerals sink, light gangue floats
 - Example: Tin (Sn) ore
 2. **Froth Flotation:** Useful for sulphide ores
 - Example: Zinc (ZnS), Lead (PbS)
 3. **Magnetic Separation:** Magnetic ores separated by magnets
 - Example: Fe_3O_4
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1.4 Extraction Techniques

Type	Method	Example
Chemical Reduction	Using C or CO	$\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$
Electrolytic Reduction	Electrolysis of molten salt	$\text{NaCl} \rightarrow \text{Na} + \text{Cl}_2$
Thermite Process	Al reduces metal oxides	$\text{Fe}_2\text{O}_3 + 2\text{Al} \rightarrow 2\text{Fe} + \text{Al}_2\text{O}_3$

Tip: Electrolysis is used for **highly reactive metals** (Na, K, Al).

1.5 Refining Methods

- **Distillation:** For metals with low boiling points → Example: Zn
 - **Electrolytic Refining:** Impure metal as anode → Example: Cu
 - **Zone Refining:** For extremely pure metals → Example: Si, Ge
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1.6 Important Concepts

- **Ellingham Diagram:** Helps decide which metal oxide can be reduced by C
 - **Passivation:** Some metals form protective oxide layer → Example: Al
 - **Alloys:** Mixtures of metals to improve properties → Example: Brass (Cu + Zn)
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2. Key Concepts & Formulas

Concept	Formula / Fact	Tip / Mnemonic
Gibbs Free Energy ΔG	$\Delta G = \Delta H - T\Delta S$	Use Ellingham diagram for oxide stability
Reduction by C	$\text{MO} + \text{C} \rightarrow \text{M} + \text{CO}$	"Carbon steals oxygen"
Electrolysis	$\text{M}^{n+} + n\text{e}^- \rightarrow \text{M}$	For highly reactive metals
Froth Flotation	Ore + collector + froth	"Float the ore like soap bubbles"
Zone Refining	Impurities move with molten zone	"Impurities travel like little trains"

Mnemonic for steps of metallurgy:

"Cool Cats Really Run Fast" → Concentration, Conversion, Reduction, Refining, Final Metal

3. Solved Numerical Problems

Example 1: Amount of Metal Extracted

Problem: 160 g Fe_2O_3 is reduced with CO. Find mass of Fe obtained.

Solution:

- Molar mass $\text{Fe}_2\text{O}_3 = 160 \text{ g/mol}$
- Reaction: $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$
- 1 mol $\text{Fe}_2\text{O}_3 \rightarrow 2 \text{ mol Fe} \rightarrow 112 \text{ g}$
- $160 \text{ g} \rightarrow 112 \text{ g} \times (160/160) = 112 \text{ g Fe}$

Tip: Always balance the chemical equation before calculations.

Example 2: Electrolysis

Problem: How much Cu is deposited by passing 2 Faraday through CuSO_4 solution?

Solution:

- $2 \text{ F} \rightarrow 2 \times 1 \text{ mol e}^- \rightarrow 2/2 = 1 \text{ mol Cu}$
 - Mass Cu = 63.5 g
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4. Previous Years' Board Questions (Solved)

- Steps of metallurgy (2016, 2018, 2020)
 - Extraction of Al, Cu, Fe numericals
 - Refining techniques (electrolytic, distillation)
 - Ellingham diagram questions
 - High-weightage: **Electrolysis of molten salts & Cu refining**
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5. Quick Revision Notes / Important Points

- **Steps of metallurgy:** Concentration → Conversion → Reduction → Refining
- **Extraction by C:** Fe, Zn, Sn
- **Extraction by Electrolysis:** Na, K, Al
- **Alloys:** Brass, Bronze, Stainless steel
- **Refining methods:** Electrolytic (Cu), Distillation (Zn), Zone refining (Si, Ge)

Visual:

Ore → Concentration → Oxide → Reduction → Crude Metal → Refining → Pure Metal

6. Predicted / Likely Questions

1. Stepwise metallurgy of Cu, Al, Fe
 2. Numerical: Mass of metal from ore or electrolysis
 3. Differences between methods (chemical vs electrolytic)
 4. Properties & uses of alloys
 5. Ellingham diagram interpretation
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7. Exam Tips & Tricks

- Draw stepwise flowchart for metallurgy
 - Remember which metals are extracted by which method
 - Use mnemonics for steps & methods
 - For numericals, always check stoichiometry & units
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8. Visual & Kid-Friendly Learning Style

- Ore: Treasure chest → "dig and extract"
- Reduction: Removing oxygen → "stripping paint"
- Electrolysis: "Electric river flows, metals deposit"
- Color-code steps of metallurgy & methods of extraction for quick recall