

Chapter 17

Introduction

The Earth's crust is made up of various **elements**, including **metals** and **non-metals**, each with distinct properties and uses in our daily life.

What are Metals?

Metals are elements that:

- Are generally **solid at room temperature** (except mercury)
- **Shiny** (lustrous)
- Good **conductors** of heat and electricity
- **Malleable** and **ductile**
- Form **positive ions (cations)**

Main Properties of Metals:

Property	Description
Malleability	Can be hammered into thin sheets
Ductility	Can be drawn into wires
Conductivity	Good conductors of heat and electricity
Lustrous	Have shiny appearance
Sonorous	Produce sound when struck
High melting/boiling points	Generally high

What are Non-Metals?

Non-metals are elements that:

- Are usually **gases or brittle solids**
- Are **poor conductors** of heat and electricity
- Tend to **gain electrons** to form negative ions (**anions**)

Main Properties of Non-Metals:

Property	Description
Brittle	Break easily; not malleable or ductile
Poor conductors	Except graphite, they don't conduct electricity
Non-lustrous	Usually dull in appearance
Low density	Often lighter than metals
Low melting points	Usually lower than metals

Minerals and Ores

What are Minerals?

- Naturally occurring **inorganic substances** found in Earth's crust.
- May or may not contain metals in **extractable form**.

What are Ores?

- Minerals that contain **metal in a profitable or economical form**.
- Example: **Bauxite** is an ore of **aluminium**.

Ores of Some Important Metals

Iron Ores:

Ore Name	Molecular Formula	Description
Hematite	Fe_2O_3	Main ore of iron, reddish in color
Magnetite	Fe_3O_4	Magnetic ore, black
Limonite	$\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$	Brown iron ore, hydrated oxide
Siderite	FeCO_3	Carbonate ore of iron

Aluminium Ores:

Ore Name	Molecular Formula	Description
Bauxite	$\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$	Main ore of aluminium
Cryolite	Na_3AlF_6	Used in aluminium extraction (not main ore)
Corundum	Al_2O_3	Used as abrasive, gemstone form exists

Copper Ores:

Ore Name	Molecular Formula	Description
Chalcopyrite	CuFeS_2	Major copper ore
Cuprite	Cu_2O	Red oxide of copper
Malachite	$\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$	Green carbonate ore

Silver Ores:

Ore Name	Molecular Formula	Description
Argentite	Ag_2S	Primary ore of silver
Horn Silver	AgCl	Occurs in dry regions

Gold Ores:

Ore Name	Molecular Formula	Description
Native Gold	Au	Found as pure metal in rocks
Sylvanite	$(\text{Ag}, \text{Au})\text{Te}_2$	Gold telluride
Calaverite	AuTe_2	Gold telluride ore

Metallurgy

Metallurgy is the science of extracting metals from their ores and refining them for use.

Mining

Mining is the process of extracting ores from [Earth's crust](#).

General Steps of Metallurgical Process

a. Crushing and Grinding

- Ores are crushed into **fine particles** to liberate the metal content.

b. Concentration of Ore (Enrichment)

To remove unwanted materials (gangue) using methods like:

i. Gravity Separation

- Based on **difference in density** (used for heavy oxide ores).

ii. Froth Flotation

- Used for **sulphide ores**.
- Ore is mixed with water and chemicals; **froth traps the ore particles**.

iii. Magnetic Separation

- Used when one of the components is **magnetic** (e.g. magnetite).

iv. Leaching

- Ore is dissolved in a chemical solution; the metal is later recovered from the solution.

c. Oxidation (Conversion to Oxide)

i. Roasting

- Heating ore in air** (used for sulphide ores).
- Example: $\text{ZnS} \rightarrow \text{ZnO} + \text{SO}_2$

ii. Calcination

- Heating in absence of air** (used for carbonate ores).
- Example: $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$

d. Reduction

Reduction involves converting metal oxides to pure metal.

Smelting:

- Melting the ore and reducing it with a **reducing agent** like carbon.

e. Refining of Metals

Purification of extracted metal. Common methods include:

i. Distillation

- Used for **low boiling point metals** like zinc and mercury.

ii. Electro-refining

- Impure metal acts as anode**, pure metal gets deposited on cathode.

Interesting Facts:

- **Gold is the most ductile metal**—1 gram can be drawn into a 2 km wire.
- **Aluminium is the most abundant metal** in Earth's crust.
- **Silver** is the **best conductor of electricity** among all metals.
- **Bauxite** is so important that aluminium is often called the “metal of the future.”
- **Froth flotation** was first developed in the early 20th century and revolutionized metal mining.

Quick Revision Table:

Topic	Key Points
Metal properties	Malleable, ductile, lustrous, conductors
Non-metal properties	Brittle, dull, poor conductors
Ore vs Mineral	Ore is profitable, mineral is natural substance
Main iron ores	Hematite (Fe_2O_3), Magnetite (Fe_3O_4)
Concentration methods	Gravity, flotation, magnetic, leaching
Roasting vs Calcination	Roasting = air, Calcination = no air
Refining methods	Distillation, electro-refining

