Metals and Non-metals - Class 10 Science Notes

1. Introduction to Metals and Non-metals

Classification of Elements

Elements in the periodic table are broadly classified into:

- **Metals** (left side of periodic table)
- **Non-metals** (right side of periodic table)
- **Metalloids** (elements with properties of both metals and non-metals)

Examples

Metals: Iron (Fe), Copper (Cu), Aluminum (Al), Gold (Au), Silver (Ag), Zinc (Zn), Sodium (Na), Magnesium (Mg)

Non-metals: Oxygen (O), Carbon (C), Sulfur (S), Nitrogen (N), Phosphorus (P), Chlorine (Cl), Bromine (Br)

Metalloids: Silicon (Si), Germanium (Ge), Arsenic (As), Boron (B)

2. Physical Properties of Metals

1. Metallic Lustre

- Metals have a shiny appearance when freshly cut
- This property is called metallic lustre
- Examples: Gold, silver, copper shine brightly

2. Malleability

- Ability to be beaten into thin sheets
- Metals can be hammered into different shapes
- Examples: Aluminum foils, gold sheets for decoration

3. Ductility

- Ability to be drawn into thin wires
- Metals can be stretched into wires
- Examples: Copper wires, aluminum wires

4. Thermal Conductivity

- Metals are good conductors of heat
- Heat passes through metals easily

- Examples: Iron, copper, aluminum cooking utensils

5. Electrical Conductivity

- Metals are good conductors of electricity
- Used in electrical wires and circuits
- Examples: Copper and aluminum wires

6. Sonorous Nature

- Metals produce sound when struck
- Property called sonority
- Examples: Bell metals, musical instruments

7. Other Physical Properties

- **High density:** Most metals are heavy
- **High melting and boiling points:** (Exception: Mercury is liquid at room temperature)
- **Metallic gray or silver color:** (Exceptions: Gold is golden, copper is reddish-brown)

3. Physical Properties of Non-metals

Contrasting Properties to Metals

1. **No metallic lustre:** Dull appearance (Exception: Iodine and graphite)
2. **Brittle:** Break easily, cannot be beaten into sheets
3. **Non-ductile:** Cannot be drawn into wires
4. **Poor thermal conductors:** Heat doesn't pass through easily (Exception: Graphite)
5. **Poor electrical conductors:** Don't conduct electricity (Exception: Graphite)
6. **Non-sonorous:** Don't produce sound when struck
7. **Low density:** Generally lighter than metals
8. **Low melting and boiling points:** (Exception: Carbon has very high melting point)
9. **Various colors:** Can be colored (sulfur is yellow, chlorine is greenish)

4. Chemical Properties of Metals

1. Reaction with Oxygen

Metal + Oxygen → Metal Oxide

- Metal oxides are generally basic in nature
- Examples:
  - $4Al + 3O_2 \rightarrow 2Al_2O_3$ (Aluminum oxide)

- $2Mg + O_2 \rightarrow 2MgO$ (Magnesium oxide)
- $2Cu + O_2 \rightarrow 2CuO$ (Copper oxide)

Amphoteric Oxides: Some metal oxides show both acidic and basic behavior

- Examples: Al_2O_3, ZnO
- $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$ (Basic behavior)
- $Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O$ (Acidic behavior)

2. Reaction with Water

Highly Reactive Metals (K, Na, Ca)

- React vigorously with water to form hydroxides
- $2Na + 2H_2O \rightarrow 2NaOH + H_2$ (Hydrogen gas evolved)
- $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

Moderately Reactive Metals (Mg, Al, Zn, Fe)

- React with steam to form oxides
- $Mg + H_2O$ (steam) $\rightarrow MgO + H_2$
- $3Fe + 4H_2O$ (steam) $\rightarrow Fe_3O_4 + 4H_2$

Less Reactive Metals (Cu, Ag, Au)

- Do not react with water or steam

3. Reaction with Acids

Metal + Acid → Salt + Hydrogen gas

- More reactive metals displace hydrogen from acids
- Examples:
  - $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
  - $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$
  - $Fe + 2HCl \rightarrow FeCl_2 + H_2$

Note: Copper does not react with dilute acids as it's less reactive than hydrogen

4. Reaction with Salt Solutions (Displacement Reactions)

More reactive metal + Salt of less reactive metal → Salt of more reactive metal + Less reactive metal

Examples:

- $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$
- $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$
- $Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$

5. Chemical Properties of Non-metals

1. Reaction with Oxygen

Non-metal + Oxygen → Non-metallic oxide

- Non-metallic oxides are generally acidic in nature
- Examples:
  - $C + O_2 \rightarrow CO_2$ (Carbon dioxide - acidic)
  - $S + O_2 \rightarrow SO_2$ (Sulfur dioxide - acidic)
  - $4P + 5O_2 \rightarrow 2P_2O_5$ (Phosphorus pentoxide - acidic)

2. Reaction with Water

- Most non-metallic oxides dissolve in water to form acids
- $CO_2 + H_2O \rightarrow H_2CO_3$ (Carbonic acid)
- $SO_2 + H_2O \rightarrow H_2SO_3$ (Sulfurous acid)

3. Reaction with Hydrogen

- Non-metals react with hydrogen to form hydrides
- $H_2 + Cl_2 \rightarrow 2HCl$ (Hydrogen chloride)
- $H_2 + S \rightarrow H_2S$ (Hydrogen sulfide)

4. Reaction with Metals

- Non-metals react with metals to form salts
- $2Na + Cl_2 \rightarrow 2NaCl$ (Sodium chloride)
- $Mg + S \rightarrow MgS$ (Magnesium sulfide)

6. Activity Series of Metals

Reactivity Series (Most reactive to least reactive)

1. **Potassium (K)** - Most reactive
2. **Sodium (Na)**
3. **Calcium (Ca)**
4. **Magnesium (Mg)**

5. **Aluminum (Al)**
6. **Zinc (Zn)**
7. **Iron (Fe)**
8. **Lead (Pb)**
9. **Hydrogen (H)**
10. **Copper (Cu)**
11. **Silver (Ag)**
12. **Gold (Au)** - Least reactive

Key Points about Activity Series

- Metals above hydrogen can displace hydrogen from acids
- Metals higher in series can displace metals lower in series from their salt solutions
- Metals at the top are most reactive, at bottom are least reactive
- Metals below hydrogen cannot displace hydrogen from acids

7. Extraction of Metals

Occurrence of Metals in Nature

Free State (Native State)

- **Least reactive metals** found as free elements
- Examples: Gold (Au), Silver (Ag), Platinum (Pt)

Combined State

- **Most metals** found as compounds (ores)
- Examples: Iron ore (Fe_2O_3), Bauxite (Al_2O_3), Zinc blende (ZnS)

Steps in Metal Extraction

1. Enrichment/Concentration of Ores

- **Gravity separation:** Based on density differences
- **Magnetic separation:** For magnetic ores
- **Froth flotation:** For sulfide ores

2. Extraction of Metal from Concentrated Ore

Method depends on reactivity of metal:

For Highly Reactive Metals (K, Na, Ca, Mg, Al):

- **Electrolytic reduction**
- $2Al_2O_3 \rightarrow 4Al + 3O_2$ (Electrolysis)

For Moderately Reactive Metals (Zn, Fe, Pb):

- **Reduction with carbon or carbon monoxide**
- $ZnO + C \rightarrow Zn + CO$
- $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

For Less Reactive Metals (Cu, Ag, Au):

- **Simple heating or reduction**
- $2HgS + 3O_2 \rightarrow 2HgO + 2SO_2$
- $HgO \rightarrow Hg + O_2$

3. Refining of Metals

- **Electrolytic refining:** Most common method
- **Distillation:** For metals like mercury and zinc
- **Zone refining:** For very pure metals

8. Corrosion

Definition

Corrosion is the process of slow eating up of metals due to attack by atmospheric gases, moisture, acids, etc.

Examples of Corrosion

- **Rusting of iron:** Most common example
- **Black coating on silver:** Due to H_2S in air
- **Green coating on copper:** Due to moist CO_2

Rusting of Iron

Chemical Process:

- Iron + Oxygen + Water → Rust ($Fe_2O_3.xH_2O$)
- $4Fe + 3O_2 + 6H_2O \rightarrow 2Fe_2O_3.3H_2O$

Conditions Required for Rusting:

- Presence of oxygen
- Presence of moisture/water

- Both conditions must be present

Prevention of Corrosion

1. Barrier Methods

- **Painting:** Creates barrier between metal and air
- **Oiling and greasing:** Prevents contact with oxygen and moisture
- **Galvanization:** Coating iron with zinc

2. Alloying

- Mixing metal with other metals or non-metals
- Examples: Stainless steel (iron + chromium + nickel)

3. Sacrificial Protection

- More reactive metal is used to protect less reactive metal
- Example: Zinc blocks attached to ship hulls

9. Alloys

Definition

An alloy is a homogeneous mixture of two or more metals, or a metal and a non-metal.

Why Make Alloys?

- **Increase strength:** Pure metals are often soft
- **Increase hardness:** Alloys are generally harder
- **Increase corrosion resistance:** Better than pure metals
- **Modify properties:** Get desired properties

Important Alloys

1. Steel

- **Composition:** Iron + Carbon (0.1% to 2%)
- **Properties:** Hard, strong, malleable
- **Uses:** Construction, tools, machinery

2. Stainless Steel

- **Composition:** Iron + Chromium + Nickel
- **Properties:** Corrosion resistant, hard, strong

- **Uses:** Cutlery, kitchen utensils, surgical instruments

3. Brass

- **Composition:** Copper + Zinc
- **Properties:** Hard, malleable, doesn't rust
- **Uses:** Musical instruments, decorative items

4. Bronze

- **Composition:** Copper + Tin
- **Properties:** Hard, strong, corrosion resistant
- **Uses:** Statues, medals, ship propellers

5. Solder

- **Composition:** Lead + Tin
- **Properties:** Low melting point
- **Uses:** Welding electrical wires

6. Amalgam

- **Composition:** Mercury + Other metals
- **Properties:** Liquid alloy at room temperature
- **Uses:** Dental fillings, thermometers

10. Important Chemical Equations

Metal-Oxygen Reactions

- $4Al + 3O_2 \rightarrow 2Al_2O_3$
- $2Mg + O_2 \rightarrow 2MgO$
- $2Cu + O_2 \rightarrow 2CuO$

Metal-Water Reactions

- $2Na + 2H_2O \rightarrow 2NaOH + H_2$
- $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$
- $Mg + H_2O(steam) \rightarrow MgO + H_2$

Metal-Acid Reactions

- $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
- $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$

- $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$

Displacement Reactions

- $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$
- $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$
- $Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$

Non-metal Reactions

- $C + O_2 \rightarrow CO_2$
- $S + O_2 \rightarrow SO_2$
- $H_2 + Cl_2 \rightarrow 2HCl$

Metal Extraction Reactions

- $2Al_2O_3 \rightarrow 4Al + 3O_2$ (Electrolysis)
- $ZnO + C \rightarrow Zn + CO$
- $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

11. Minerals and Ores

Definitions

- **Mineral:** Naturally occurring substance with definite chemical composition
- **Ore:** Mineral from which metal can be extracted economically
- **Gangue:** Unwanted impurities in ore

Important Ores

- **Bauxite:** $Al_2O_3.2H_2O$ (Aluminum ore)
- **Hematite:** Fe_2O_3 (Iron ore)
- **Magnetite:** Fe_3O_4 (Iron ore)
- **Zinc blende:** ZnS (Zinc ore)
- **Copper pyrites:** $CuFeS_2$ (Copper ore)
- **Galena:** PbS (Lead ore)

12. Key Points to Remember

1. **Metals** are generally malleable, ductile, and good conductors
2. **Non-metals** are generally brittle and poor conductors (except graphite)
3. **Activity series** determines reactivity of metals

4. **Metal oxides** are basic, **non-metal oxides** are acidic
5. **Displacement reactions** follow activity series
6. **Corrosion** can be prevented by various methods
7. **Alloys** have better properties than pure metals
8. **Method of extraction** depends on metal's reactivity
9. **Hydrogen** acts as reference in activity series
10. **Both oxygen and water** are needed for rusting

13. Practical Applications

Uses of Metals

- **Iron:** Construction, tools, machinery
- **Aluminum:** Aircraft, utensils, foils
- **Copper:** Electrical wires, plumbing
- **Gold:** Jewelry, electronics
- **Silver:** Jewelry, mirrors, photography
- **Zinc:** Galvanization, batteries

Uses of Non-metals

- **Oxygen:** Respiration, combustion, steel making
- **Carbon:** Steel making, pencils, diamonds
- **Sulfur:** Vulcanizing rubber, medicines
- **Nitrogen:** Fertilizers, preservation
- **Chlorine:** Water purification, bleaching

14. Environmental Impact

Metal Extraction

- **Mining:** Environmental degradation
- **Smelting:** Air pollution, greenhouse gases
- **Solution:** Recycling metals, cleaner technologies

Corrosion Prevention

- Use of eco-friendly coatings
- Development of better alloys
- Proper disposal of corroded materials

These comprehensive notes cover all major concepts in Metals and Non-metals for Class 10 Science. Focus on understanding the activity series, chemical reactions, and practical applications for better exam preparation.