## CHAPTER – 3

# METALS AND NON-METALS

About 118 elements are known today. There are more than **90 metals, 22 non metals** and a few metalloids.

Sodium (Na), potassium (K), magnesium(Mg), aluminium(Al), calcium(Ca), Iron(Fe), Barium(Ba) are some **metals.**

Oxygen(O), hydrogen(H), nitrogen(N), sulphur(S), phosphorus(P), fluorine(F), chlorine(Cl), bromine(Br), iodine(l) are some **non-metals**

***Physical properties of metals:**

Solid at room temperature **except mercury**

Ductile (drawn into wires)

Malleable (beaten into thin sheets)

Sonorous(produce sound)

Lustrous(natural shine)

Have **high melting point. Cesium** and **gallium** have very low melting point.

Generally **good conductor** of heat and electricity, except lead and mercury which are comparatively poor conductors. **Silver** and **copper** are best conductors.

Have high density. **Sodium** and **potassium** can be cut with knife, they have **low density**.

**Physical properties of non-metals:**

Occur as solid or **gas. Bromine** is **liquid**.

Generally **bad conductors** of heat and electricity. **Graphite** a natural form of carbon is a **good conductor**.

Non-sonorous.

Non-lustrous, only **iodine** has lustre.

Metals form **basic** oxides like Magnesium oxide(MgO), while non-metals form **acidic** oxides (as in acid rain).

***Chemical properties of metals:**

**1. Reaction with air**

Metals can burn in air, react or don't react with air.

**Metal + oxygen ⟶ Metal Oxide**

Some metals like Na and K are kept immersed in kerosene oil **as they react vigorously** with air and catch fire.

Some metals like **Mg, Al, Zn, Pb react slowly** with air and form a protective layer.

**Mg can also burn** in air with a white dazzling light to form its oxide

**Fe and Cu don't burn** in air but combine with oxygen to form oxide. When heated iron filings burn when sprinkled over flame.

Metals like silver, **platinum and gold don't burn or react** with air.

$2Na + O_2 \longrightarrow Na_2O$

$2Mg + O_2 \longrightarrow 2MgO$

$2Cu + O_2 \longrightarrow 2CuO$

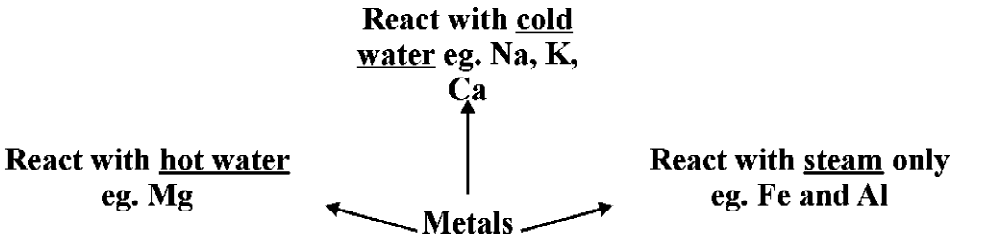
$4Al + 3O_2 \longrightarrow 2Al_2O_3$

**Amphoteric Oxides :** metal oxides which react with both acids as well as bases to form salt and water e.g. $Al_2O_3$, ZnO.

$Al_2O_3 + HCl \longrightarrow AlCl_3 + H_2O$

$Al_2O_3 + NaOH \longrightarrow NaAlO_2 + H_2O$

2. Reaction with water :



$Na + H_2O \longrightarrow NaOH + H_2$

$K + H_2O \longrightarrow KOH + H_2$

$Ca + H_2O \longrightarrow Ca(OH)_2 + H_2$

$Mg + H_2O \longrightarrow Mg(OH)_2 + H_2$

In case of Ca and Mg, the metal starts floating due to dubbles of hydrogen gas sticking to its surface.

$Al + H_2O \longrightarrow Al_2O_3 + H_2$

$Fe + H_2O \longrightarrow Fe_3O_4 + H_2$

**Try Balancing these Chemical equations yourself**

3. Reaction with dilute acids:

Metal + dilute acid $\longrightarrow$ Salt + Hydrogen gas

Metals react with dilute hydrochloric acid and dilute sulphuric acid to form salt and hydrogen gas.

$Fe + 2HCl \longrightarrow FeCl_2 + H_2$

$Mg + 2HCl \longrightarrow MgCl_2 + H_2$

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

$2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$

Copper, mercury and silver don't react with dilute acids.

Hydrogen gas produced is oxidised to water when metals react with nitric acid. But Mg and Mn, react with very dilute nitric acid to evolve hydrogen gas.

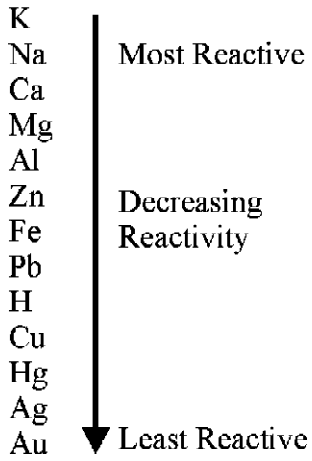
$Mg + 2HNO_3 \longrightarrow Mg(NO_3)_2 + H_2$

4. Reaction of metals with other metal salts :

Metal A + Salt solution of B $\longrightarrow$ Salt solution of A + Metal B

All metals are not equally reactive. Reactive metals can displace less reactive metals from their compounds in solution. This forms the basis of reactivity series of metals.

Reactivity series is a list of metals arranged in order of their decreasing activities.




A Metal can displace all the metals from their compounds which are below or after it in this series.

$$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$$

$$Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$$

**Reaction between Metals and Non-Metals :**

– Reactivity of elements can be understood as a tendency to attain a completely filled valence shell.

– Atom of metals can lose electrons from valence shells to form cations (+ve ions).

– Atom of non-metals gain electrons in valence shell to form anions (–ve ions).

– Oppositely charged ions attract each other and are held by strong electrostatic forces of attraction forming ionic compounds.

**Formation of $MgCl_2$**

$$Mg \longrightarrow Mg^{2+} + 2e^-$$

2,8,2 — 2,8 (Magnesium ion)

$$Cl_2 + 2e^- \longrightarrow 2Cl^-$$

2,8,7 — 2,8,8 (Chloride ion)



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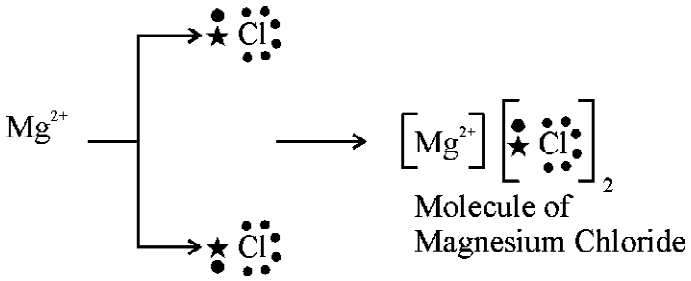



**Properties of Ionic Compounds :**

– Are solid and mostly brittle.

– Have high melting and boiling points. More energy is required to break the strong inter-ionic attraction.

– Generally soluble in water and insoluble in kerosene, petrol.

– Conduct electricity in solution and in molten state. In both cases, free ions are formed and conduct electricity.

**Occurance of Metals**

Minerals : elements of compounds occuring naturally are minerals.

ORES : mineral from which metal can be profitably extracted is an ore. For example, sulphide ore, oxide ore, carbonate ore.

– Metals at the bottom of activity series like gold, platinum, silver, copper generally occur in free state. But copper and silver also occur in sulphide and oxide ores.

– Metals of medium reactivity (Zn, Fe, Pb etc.) occur mainly as oxides, sulphides or carbonates.

– Metals of high reactivity (K, Na, Ca, Mg and Al) are very reactive and thus found in combined state.

GANGUE : ores are naturally found mixed impurities like soil, sand, etc. called gangue. The gangue is removed from the ore.

METALLURGY : step-wise process of obtaining metal from its ore.

*Enrichment of ore

*Obtaining metal from enriched ore.

*Refining of impure metal to obtain pure metal.

**Extracting Metals Low in the Activity Series :**

By heating the ores in air at high temperature.

*Mercury from cinnabar

$$2HgS + 3O_2 \xrightarrow{Heat} 2HgO + 2SO_2$$

$$2HgO \xrightarrow{Heat} 2Hg + O_2$$

* Copper from copper sulphide

$$Cu_2S + 3O_2 \xrightarrow{Heat} 2Cu_2O \_ 2SO_2$$

$$2Cu_2O + Cu_2S \xrightarrow{Heat} 6Cu + SO_2$$

**Extracting Metals in the Middle of Activity Series :**

*Metals are easier to obtain from oxide ores, thus, sulphide and carbonate ores are converted into oxides.

*Metal ore heated strongly in excess of air (Roasting)

$$2ZnS + 3O_2 \xrightarrow{Heat} 2ZnO + 2SO_2$$

Metal ore heated strongly in limited or no supply of air (Calcination)

$$ZnCO_3 \xrightarrow{Heat} ZnO + CO_2$$

**Reduction of Metal Oxide :**

1. USING COKE: Coke as a reducing agent.

$$ZnO + C \xrightarrow{Heat} Zn + CO$$

2. USING DISPLACEMENT REACTION : highly reactive metal like Na, Ca and Al are used to displace metals of lower reactivity from their compounds.

$$MnO_2 + 4Al \xrightarrow{Heat} 3Mn + 2Al_2O_3 + heat$$

$$Fe_2O_3 + 2Al \xrightarrow{Heat} 2Fe + Al_2O_3 + heat$$

– In the above reaction molten iron is formed and is used to join railway tracks. This is called thermit reaction.

**Extracting Metals at the Top of Activity Series :**

These metals

– have more affinity for oxygen than carbon.

– are obtained by electrolytic reduction. Sodium is obtained by electrolysis of its molten chloride $NaCl \longrightarrow Na^+ + Cl^-$

  As electricity is passed through the solution metal gets deposited at cathode and non-metal at anode.

– At cathode :
  $Na^+ + e^- \longrightarrow Na$

– At anode :
  $2Cl^- \longrightarrow Cl_2 + 2e^-$

**Refining of Metals :**

– Impurities present in the obtained metal can be removed by electrolytic refining.

**Copper is obtained using this method. Following are present inside the electrolytic tank.**

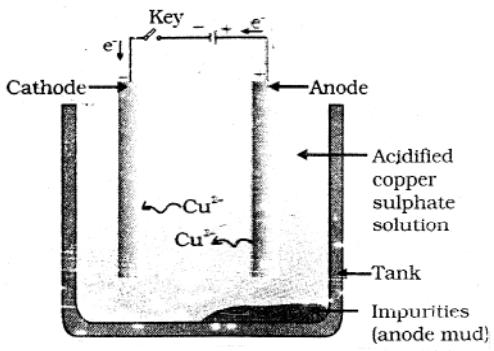
– Anode – slab of *impure* copper

– Cathode – slab of *pure* copper

– Solution – aqueous solution of copper sulphate with some dilute sulphuric acid

– From anode copper ions are released in the solution and equivalent amount of copper from solution is deposited at cathode.

– Impurities containing silver and gold gets deposited at the bottom of anode as anode mud.



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**Corrosion :**

– Metals are attacked by substances in surroundings like moisture and acids.

– Silver - it reacts with sulphur in air to form silver sulphide and articles become black.

– Copper - reacts with moist carbon dioxide in air and gains a green coat of copper carbonate.

– Iron-acquires a coating of a brown flaky substance called rust. Both air and moisture are necessary for rusting of iron.

**Prevention of corrosion:**

– Rusting of iron is prevented by painting, oiling, greasing, galvanizing, chrome plating, anodising and making alloys.

– In galvanization, iron or steel is coated with a layer of zinc because zinc is preferably oxidized than iron.

**Alloys** : These are mixture of metals with metals or non-metals

– Adding small amount of carbon makes iron hard and strong.

– Stainless steel is obtained by mixing iron with nickel and chromium. It is hard and doesn't rust.

– Mercury is added to other metals to make amalgam.

***Brass*** : alloy of copper and zinc.

***Bronze*** : alloy of copper and tin.

– In brass and bronze, melting point and electrical conductivity is lower than that of pure metal.

***Solder*** : alloy of lead and tin has low melting point and is used for welding electrical wires.

## Question Bank

**1 MARK**

1 Name a metal which is the best conductor of electricity and one which is poor conductor of electricity.

2 Why food cans are coated with tin and not with zinc?

3. Name any two alloys whose electrical conductivity is less than that of pure metals.

4. Name the non-metal with lustre.

5. Define amphoteric oxide.

6. An aqueous solution of $Al_2O_3$ is electrolysed. Name the element collected at anode.
7. An oxide of an element was dissolved in water. The final solution turned red litmus blue. Is the element metal, non-metal or a metalloid?
8. What happens when cinnabar is heated?
9. Ionic compounds have high melting point. Why?
10. Name two metals which are found in nature in free state.

**2 MARKS**

1. Why Magnesium and calcium float when they react with water?
2. Write the chemical equations of heating of Cu and Fe.
3. Write two chemical equations to show that $Al_2O_3$ is an amphoteric oxide.
4. What is galvanization? Why it is done?
5. Hydrogen gas is not evolved generally when metals react with nitric acid. Explain.
6. Explain the thermit process. Write the chemical equation involved.
7. Distinguish between roasting and calcination.
8. Every ore is a mineral but not every mineral is an ore. Explain.
9. Why highly reactive metals can't be obtained from their oxides using coke as a reducing agent?

**3 MARKS**

1. Diagrammatically show the formation of MgO.
2. Ionic compounds are good conductors of electricity under specific conditions. Name the two conditions and give reasons.

**5 MARKS**

1. i) What is reactivity series of metals? Arrange the metals zinc, magnesium, aluminium, copper and iron in a decreasing order of reactivity.

   ii) What is observed when you put

   a) Some zinc pieces into blue copper sulphate solution.

   b) Some copper pieces into green ferrous sulphate solution.

   iii) Name a metal which combines with hydrogen gas. Name the compound formed.

2. Give reasons:

   i) Platinum, gold and silver are used to make jewellery.

   ii) Sodium and potassium are stored under oil.

   iii) Aluminium is a highly reactive metal, still it is used to make utensils for cooking.

   iv) Carbonate and sulphide ores are usually converted into oxides during the process of extraction.

**METALS AND NON-METALS**

**IN BRIEF**

– Metals are generally solid, sonorous, lustrous, good conductor of heat and electricity, malleable, ductile, high melting point, high densities, form basic oxides, form +vely charged ion.

– Non-metals are generally solid or gas, non-lustrous, non-sonorous, bad conductor of heat and electricity, have low melting point, form acidic oxides and form -vely charged ions.

– Metals like Na, K and Ca are highly reactive, while others like Magnesium, Aluminium, Zinc and Lead are less reactive and some others are least reactive like silver, gold and platinum.

– Metals generally displace hydrogen from acids.

– Reactivity series is based on displacement capability of metals and is a series of metals in the order of their decreasing reactivity.

– Metals and non-metals react to form ionic compounds which are soluble in water, have high melting point and are good conductor of electricity in their aqueous solution or molten state.

– Ores are minerals from which a metal can be profitably extracted.

– Metals are extracted from their ores according to their reactivity.

– Sulphide and chloride ores are roasted while carbonate ores are roasted.

– Pure metals can be obtained using electrolytic refining process.

– Metals are generally attacked by air and corrode. To alter the properties of metals alloys are made.

– Steel, stainless steel, amalgams, brass, bronze and solder are some alloys.