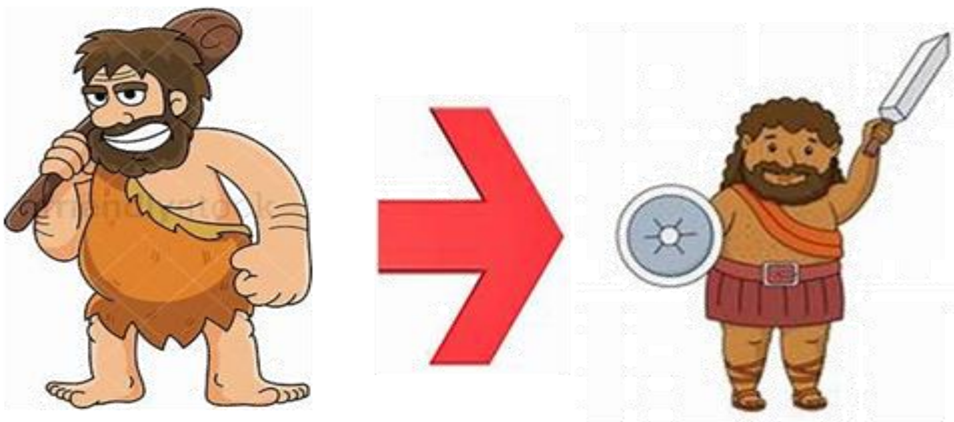
# METALS AND NON-METALS

## INTRODUCTION

Before the discovery of metals, man lived in a time period that is the **"Stone Age"** .The first discovery of **metal** probably happens during the period of 4000 BC. And the first metal that was used by man was **copper and gold.** In later periods, man discovered tin and learned to mix it with copper to form a bronze alloy. Between 3,500 B.C. and 1,200 B.C., bronze was the most important material for making tools and weapons of man. We now called this period as the **"Bronze Age"** Before man discovered iron from nature, he first discovered it from the meteorites he found. And by 1,200 B.C. he begins to use, developed and work with iron. This knowledge slowly spread all over the world and the use of bronze was slowly replaced by iron. This period is now what we call the **"Iron Age"**.



Stone age Iron age

Now a days man is all aware of the fact that all materials around him are made up of chemical elements, which are found in the earth crust. Earth is the source of coal, petroleum, graphite, diamond and many other minerals of metals and non-metals. We get various useful things like gasoline, kerosene, wax, coal gas and natural gas from the natural resources, which are made up of many non-metals. These elements occur as minerals and rocks in the earth's crust. Some of these elements like oxygen, nitrogen and carbon dioxide occur in atmospheric air. There are more than 115 elements known at present 80% of these elements are metals and rest are non-metals. On the basis of their properties, all the elements can be divided into two main groups: metals and non-metals.

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**On the basis of their properties, all the elements can be divided into two main groups: metals and non- metals**.

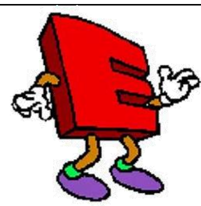
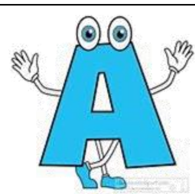
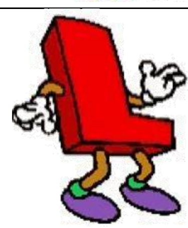
- ## METALS

Metals are the elements that conduct heat and electricity and are malleable and ductile. Some of the examples of metals are : Iron, Aluminum, Copper, Silver, Gold, Platinum, Zinc.

Metals are the elements which form positive ions by losing electrons (or donating electrons). Metals are known as electropositive elements because they can form positive ions by losing electrons.

**The most abundant metal in the earth’s crust is aluminium.**

**The word Metals itself provides enough information as:**

| | |
|---|---|
|   | Malleable |
|   | Electrical Conductor |
|   | Thermal conductors |
|   | Adaptable (ductile ) |
|   | Lustrous |
|   | Sonorous |

## • NON-METALS

Non-metals are the elements that does not conduct heat and electricity and are neither malleable nor ductile. They are brittle. Some of the examples of non-metals are: Carbon, Sulphur, Phosphorus, Silicon, Hydrogen, Oxygen, Nitrogen. The two allotropic forms of carbon element, diamond and graphite are also non - metal.

Non-metals are the elements which form negative ions by gaining electrons. Non-metals are known as electronegative elements because they can form negative ions by gaining electrons.

Carbon is one of the most important non-metals, as life on this earth is based on carbon compound because the carbon compounds like proteins, fats, carbohydrates, vitamins and enzymes etc. are essential for the growth and development of living organisms.

The most abundant non-metal in the earth's crust is oxygen.

## • POSITION OF METALS AND NON-METALS IN THE PERIODIC TABLE

(i) The elements which are placed on the left hand side (except hydrogen) and in the center of the periodic table are called metals. Such as sodium, potassium, magnesium, calcium, iron, copper zinc etc.

(ii) The elements which are placed on the right hand side of the periodic table are called non-metals such as oxygen, nitrogen, chlorine, fluorine etc. These metals and non-metals are separated from each other in the periodic table by a zig-zag line. The elements placed in the zigzag line show some properties of metals and some properties of non-metals are called metalloids. Such as boron(B), silicon(Si), germanium(Ge), arsenic(As), antimony(Sb), tellurium(Te) and polonium(Po).

(iii) The position of metals, non-metals and metalloids are shown in a simple form in figure.
Metals present at the extreme left are known as light metals, while those are present in the center of the periodic table are called heavy metals or transition metals.

(iv) The elements at the extreme left of the periodic table are most metallic and those on the right are least metallic ornon-metallic.

Thus, metallic character decreases on going from left to right side in the periodic table. For example, sodium is more metallic than aluminum because sodium is on the left hand side of aluminum.

(v) However on going down in a group the metallic character increases. For example, carbon is non-metal while lead is metal because metallic character increases down in a group.

## • ELECTRONIC VIEW OF METAL

An element is called metal, which forms positive ions (or cations) by losing electron.

**Example:** Sodium is a metal which forms sodium ion ($Na^+$) by losing one electron.

Similarly, magnesium metal forms $Mg^{2+}$ by losing two electrons, Al metal forms $Al^{3+}$ by losing three electrons.

Thus, metals are also known as electropositive elements.

The atoms of metals have 1 to 3 electrons in their outermost shell. For example, all the alkali metals have one electron in their outermost shell. (Lithium-2, 1, sodium 2, 8, 1, potassium-2, 8, 8, 1, ... etc.).

Sodium 11(2, 8, 1) magnesium 12 (2, 8, 2) and aluminum 13 (2, 8, 3) are metals having 1, 2 and 3 electrons respectively in their outermost shell, which lose these electron easily. The number of electrons lost by an atom of a metal is called its valency.

Thus metals have 1 to 3 electrons in their valence shell of their atoms.

**Exceptions:** Hydrogen and Helium. Hydrogen is a non-metal having 1 electron in its outermost shell of its atom. Helium having 2 electrons in its outermost shell of its atom.

## • PROPERTIES OF METALS

### • PHYSICAL PROPERTIES OFMETALS :

1. **Metals are malleable, i.e. metals can be beaten into thin sheets with hammer (without breaking)** Malleability is an important property of metals. Gold and Silver metals are some of the best malleable metals. Aluminum foils are used for packing food items like biscuits, chocolates, medicines, cigarettes, etc.

## ACTIVITY – 1

**Aim**: To test that metals are malleable, i.e. can be hammered into sheets.

**Method:**

(i) Take piece of iron, zinc, lead and copper.
(ii) Place anyone metal on the block of iron and strike it four or five times with a hammer.
(iii) Repeat with othermetals.
(iv) Record the change in shape of these metals.

### Discussion and conclusion

It is observed that metals can be beaten into thin sheets, Le., they are malleable.

2. **Metal are ductile, that is, metals can be drawn (or stretched) into thin wires.**

Ductility is another important property of metals. Gold is the most ductile metal. For example, 1 gram of gold can be drawn into a thin wire about 2 kilometer long. Copper and aluminium metals are also very ductile and can be drawn into thin copper wires and aluminium wires.

## ACTIVITY – 2

**Aim:** To justify that metals are ductile, i.e., can be drawn into wire.

**Method:**

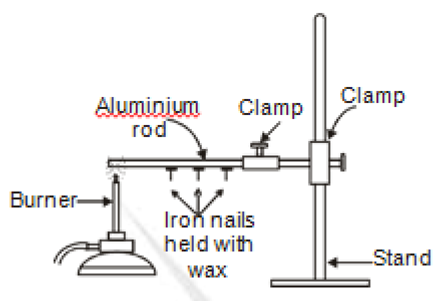
**(i)** Consider some metals such as iron, copper, aluminum, lead etc.

**(ii)** Check which of these metals are available in the form of wire?

### Discussion and conclusion

As wires of iron, copper and aluminium are easily available, this shows that metals can be drawn into wires i.e., they are ductile.

**3. Metals are good conductors of heat**




Metals allow heat to pass through them easily. Take a flat aluminium rod and stick some nails upon the rod with the help of wax. Start heating the free end of the aluminium rod by keeping a burner below it. We will see that the iron nails attached to aluminium rod with wax start falling one by one because heat travels from the left side to the right side along the aluminium rod. It melts the wax which holds the nails. Silver metal is the best conductor of heat. The cooking utensils and water boilers, etc., are usually made up of copper or aluminium metals because they are very good conductors of heat. Heat conductivity is an important property of metals.

## ACTIVITY - 3

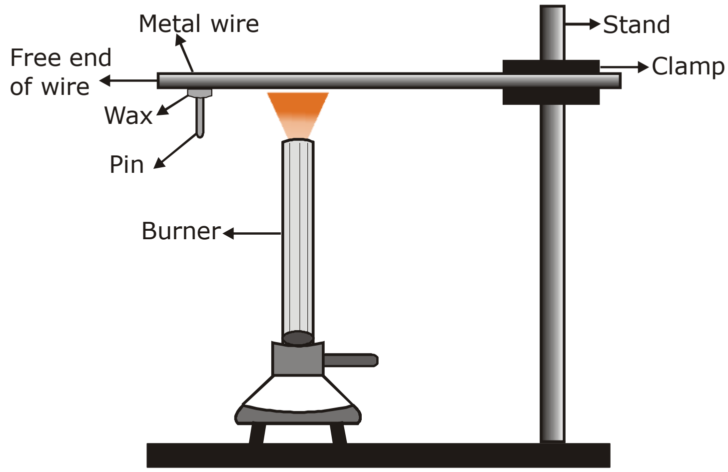
**Aim:** To test that metal are good conductors of heat and have high melting point.

**Method:**

(i) Take an aluminium or copper wire. Clamp the wire on a stand.

(ii) Fix a pin to the free end of the wire using wax.

(iii) Heat the wire with a spirit lamp, candle or a burner near the place where it is clamped.




**Metals conduct heat very easily**

**Now answer**

(i) What do you observe after sometime?

(ii) Does the metal wire melt?

**Discussion and conclusion**

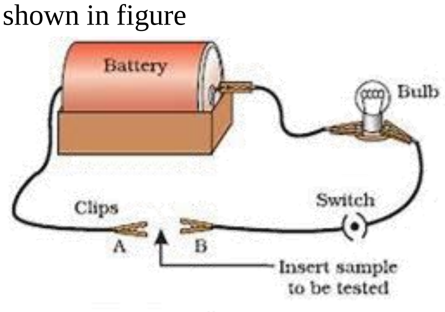
We observe that on heating the wire near the clamp, after some time the pin falls down. This shows that heat flows through the wire and melts the wax. Further, the wire does not melt even after heating for a long time. This shows that metals have high melting points

**4. Metals are good conductors of electricity**

Metals allow electricity (or electric current) to pass through them easily. Silver metal is the best conductor of electricity. The electric wires are made of copper and aluminium metals because they are very good conductors of electricity.

## ACTIVITY – 4

**Aim:** To test that metals are good conductor of electricity.
**Method:** Set up an electric circuit as shown in figure




Place the metal to be tested in the circuit between terminals A and B as shown in the figure.
**Now Answer**

Does the bulb glow? What does this indicate?

**Discussion**

**The bulb glows. This shows that electric current flows through the metal.**

**Conclusion**

Metals are good conductor of electricity.

**5. Metals are lustrous (or shiny) and can be polished**

Metals are lustrous, they have a shining surface. For example gold, silver and copper are shiny metals and they can be polished. The property of a metal having a shining surface is called 'metallic lustre'.

The metals lose their shine or brightness by keeping in air for a long time and acquire a dull appearance due to the formation of a thin layer of oxide, carbonate or sulphide on their surface (by the slow action of the various gases present inair).

## ACTIVITY – 5

**Aim :** To check that metals have lusture, i.e., a shining surface.

**Method:**

(i) Take samples of iron, copper, aluminium and magnesium. Note the appearance of each sample.

(ii) Clean the surface of each sample by rubbing them with sand paper and note their appearance again.

**Discussion:** The surface of the metals is dull because they are covered with a layer of oxide, hydroxide, carbonate etc. due to the attack of gases present in the air on their surface. On rubbing the surface with sand paper this layer is removed and a shining surface appears.

**Conclusion:** Metals in the pure state (or freshly prepared or cut) have shining surface.

**6. Metals are generally hard (except sodium and potassium which are soft metals).**

Most of the metals like iron, copper, aluminium, etc. are very hard. Some exceptions Sodium and potassium are soft metals which can be easily cut with a knife.

## ACTIVITY – 6

**Aim:** To test that metals are hard and hardness varies from metal to metal.

**Method:**

(i) Take small piece of iron, copper, aluminium and magnesium. Try to cut these metals with a sharp knife.

(ii) Hold a piece of sodium metal with a pair of tongs.

**Caution:** Always handle sodium metal with care. Dry it by pressing between the folds of a filter paper. Put it on a watch glass and try to cut it with a knife.

**Discussion and conclusion**

All the four metals (Fe, Cu, AI and Mg) are found to be cut with difficulty. This shows that metals are hard. The ease of cutting is found to be in the order Mg > Al > Cu > Fe. This shows that hardness varies from metal to metal. Sodium can be cut very easily. Hence sodium is soft, Le., it is an exception.

**7. Metals are strong (except sodium and potassium metals which are not strong).**

They can hold large weights without snapping (without breaking). **For example** iron metal (in the form of steel) is very strong. Due to this iron metal is used in the construction of bridges, buildings, railway lines, machines, vehicles and chains etc.

**8. Metals are solid at room temperature (except mercury which is a liquid metal).**

**9. Metals have high melting points and boiling points (except sodium and potassium metals which have low melting and boiling points)**

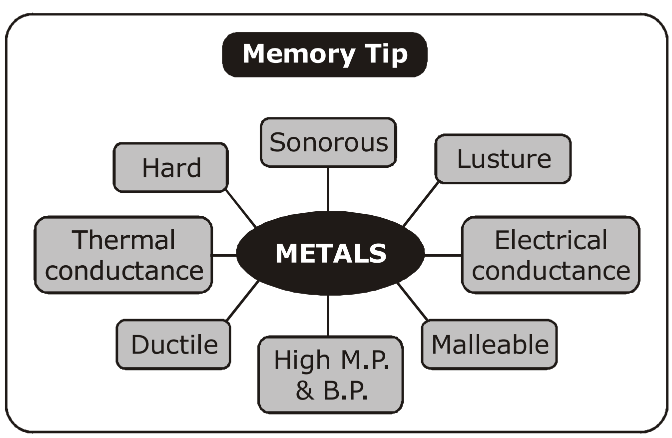
**Example,** iron metal has a high melting point of 1535°C. Copper metal has also a high melting point of 1083°C. Sodium and potassium metals have low melting points (of 98°C and 64°C respectively).

**10.** Metals have high densities (except sodium and potassium metals which have low densities). The density of iron is 7.8 g/cm$^3$ which is quite high. Sodium and potassium metals have low **densities (of 0.97 g/cm$^3$ and 0.86 g/cm$^3$ respectively)**

**11. Metals are sonorous. That is metals make sound when hit with an object.**

The property of metals of being sonorous is called sonorousness or sonority. It is due to the property of sonorousness (or sonority) that metals are used for making bells and strings (wires) of musical instruments like sitar and violin.

**12. Metals usually have a silver or grey colour (except copper and gold)**



**DO YOU KNOW ?**

**Anodising** is a process of forming a thick oxide layer of aluminium. Aluminium develops a thin oxide layer when it exposed to air. This oxide coat of aluminium (Al) make it's resistance to further corrosion. During anodising, the resistance can be improved further by making the oxide layer thicker. In this process, a clean Al article is made the anode and dilute sulphuric acid ($H_2SO_4$) is used for electrolyte. The oxygen gas evolved at the anode react with Al to make a thicker protective oxide layer. This oxide layer can be dyed easily to give Al articles an attractive finishing.

**USES OF SOME METALS**

**(i)** Many metals and their compounds are useful in our daily life. These are as follows : Aluminium is used to prepare utensils and house hold equipments like vacuum cleaner. Aluminium is extensively used in making bodies of rail, cars, automobiles, trucks and aircraft. Aluminium wires are widely used in electrical work. Aluminium foil is used to wrap chocolate cigarette and medicines and to seal milk bottles

**(ii)** Major use of copper is in making electrical wires & cables. Copper is also used in making utensils, steam pipes, coin and in electroplating.

**(iii)** Steel is an alloy of iron which is used for making parts of machines, as building material and in the construction of refrigerator. As a matter of fact steel is said to be the back bone of industry.

**(iv)** Gold and silver called noble metals (or coinage metals) are used in jewellery.

**(v)** Mercury is used in thermometers barometers and to prepare amalgams.

**(vi)** Platinum is used to make crucibles and electrodes.

**(vii)** Zinc is used to galvanize iron, to prepare roofing material, container of dry cells and to make brass when mixed with copper.

**(viii)** Metal like sodium, titanium and zirconium find their applications in atomic energy, research and medical industry.

**(ix)** Titanium (Ti) and its alloys are used in aerospace, marine equipments, aircraft frames, chemical industries and chemical reactors. The wide application of titanium is attributed to its resistance to corrosion, high melting points and high strength.

## • CHEMICAL PROPERTIES OF METALS:

**1. Reaction of Metals with oxygen (Air)**

When metals are burnt in air, they react with the oxygen of air to form metal oxides:

$$\underset{\text{From air}}{\text{Metal + Oxygen}} \longrightarrow \underset{\text{(Basic oxide)}}{\text{Metal oxide}}$$

**2.** Metals react with oxygen to form metal oxides. Metal oxides are basic in nature. The vigour of reaction with oxygen depends on the chemical reactivity of metal.

**(i)** Sodium metal reacts with the oxygen at room temperature to form a basic oxide called sodium oxide:

$$\underset{\substack{\text{Sodium}\\\text{(Metal)}}}{\mathbf{4Na(s)}} + \underset{\substack{\text{oxygen}\\\text{(from air)}}}{\mathbf{O_2(g)}} \longrightarrow \underset{\substack{\text{sodium oxide}\\\text{(Basic oxide)}}}{\mathbf{2Na_2O(s)}}$$

Potassium metal and sodium metal are stored under kerosene oil to prevent their reaction with the oxygen, moisture and carbon dioxide. Some of the metal oxides dissolve in water to form alkalies.

**Eg.** $Na_2O(s)$ + $H_2O(l) \longrightarrow 2NaOH(aq)$
sodium oxide water sodium hydroxide
(basic oxide) (An alkali)

**(ii)** Magnesium metal does not react with oxygen at room temperature. But on heating, magnesium metal burns in air giving instance heat and light to form a basic oxide called magnesium oxide (which is a white powder)

$$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$$
Magnesium Oxygen Magnesium oxide
(Metal) (From air) (Basic oxide)

Magnesium oxide dissolves in water partially to form magnesium hydroxide solution:

$$MgO(s) + H_2O(l) \longrightarrow Mg(OH)_2(aq)$$
Magnesium oxide water Magnesium hydroxide

**(iii)** Aluminium metal burns in air on heating to form aluminium oxide:

$$4Al + 3O_2 \longrightarrow 3Al_2O_3(s)$$
Aluminium Oxygen Aluminium oxide
(Metal) (From air) (Amphoteric oxide)

Those metal oxides which show basic as well as acidic behaviour are known as amphoteric oxides. Aluminium metal and zinc metal form amphoteric oxides. Amphoteric oxides react with both, acids as well as bases to form salts and water. **Example:**

(a) $Al_2O_3(s) + 6HCl \longrightarrow 2AlCl_3(aq) + 3H_2O(l)$
Aluminium oxide Hydrochloric acid Aluminium chloride Water
(Base) (Acid) (Salt)

(b) $Al_2O_3(s) + 2NaOH \longrightarrow 2NaAlO_2(aq) + H_2O(l)$
Aluminium oxide Sodium hydroxide Sodium aluminiate Water
(Acid) (Base) (Salt)

**(iv)** Zinc metal burns in air only on strong heating to form zinc oxide :

$$2\,Zn(s) + O_2(g) \longrightarrow 2\,ZnO(aq)$$
Zinc Oxygen Zinc oxide
(Acid) (Amphoteric oxide)

Zinc oxide reacts with hydrochloric acid to form zinc chloride (salt) and water.

$$ZnO(s) + 2HCl(aq) \longrightarrow ZnCl_2(aq) + H_2O(I)$$
Zinc oxide Hydrochloric acid Zinc chloride Water
(Base) (Acid) (Salt)

**(v)** Iron metal does notburn in air even on strong heating. Iron reacts with the oxygen on heating to form iron (II, III) oxide :

$$3Fe(s) + 2O_2(g) \longrightarrow Fe_3O_4(s)$$
Iron Oxygen Iron (II, III) oxide

**(vi)** Copper metal also does not burn in air even on strong heating. Copper reacts with the oxygen on prolonged heating to form a black substance copper (II) oxide :

$$2Cu(s) + O_2 \longrightarrow 2CuO(s)$$
Copper Oxygen Copper (II) oxide

- **NATURE OF METALLIC OXIDE**

Generally, metallic oxides are basic in nature except aluminium and zinc oxides which are amphoteric in nature. This means these oxides ($Al_2O_3$, ZnO) react with base as well as acid. The basic oxide of metals reacts with acid to give salt.

**For example:**

$$CuO + H_2SO_4 \longrightarrow CuSO_4 + H_2O$$

Copper(II)oxide  Sulphuric acid  Copper(II) sulphate  Water

Some oxide of metals dissolves in water and form alkalis.

Example for:

$$Na_2O(s) + H_2O(\ell) \longrightarrow 2NaOH(aq)$$

Sodium  hydroxide

$$K_2O(s) + H_2O(\ell) \longrightarrow 2KOH\ (aq)$$

Potassium  hydroxide

Reaction showing amphoteric in nature of $Al_2O_3$ and ZnO.

$$Al_2O_3(s) + 6HCl(aq) \longrightarrow 2AlCl_3(aq) + 3H_2O(\ell)$$

Hydrochloric acid  Aluminium chloride

$$Al_2O_3(s) + 2NaOH(aq) \longrightarrow 2NaAlO_2(aq) + H_2O(\ell)$$

Sodium hydroxide(base)  Sodium meta aluminate

**Similarly,**

$$ZnO(s) + 2HCl(aq) \longrightarrow 2ZnCl_2(aq) + H_2O(\ell)$$

Hydrochloric acid  Zinc-chloride

$$ZnO(s) + 2NaOH(aq) \longrightarrow Na_2ZnO_2(aq) + H_2O(\ell)$$

Sodium hydroxide  Sodium Zincate

## 1. Reaction of Metals with water

Metals react with water to form a metal hydroxide (or metal oxide) and hydrogen gas.

**(i)** Potassium react violently with cold water to form potassium hydroxide and hydrogen gas :

$$2K(s) + 2H_2O \longrightarrow 2KOH(aq) + H_2(g) + Heat$$

Potassium  Water  Potassium hydroxide  Hydrogen

**(ii)** Sodium reacts vigorously with cold water forming sodium hydroxide and hydrogen gas:

$$2Na(s) + 2H_2O(I) \longrightarrow 2NaOH(aq) + H_2(g) + Heat$$

sodium  water  sodium hydroxide  hydrogen

**(iii)** Calcium reacts with cold water to form calcium hydroxide and hydrogen gas :

$$Ca(s) + 2H_2O(I) \longrightarrow Ca(OH)_2(aq) + H_2(g)$$

Calcium  water(cold)  Calcium hydroxide  Hydrogen

The piece of calcium metal starts floating in water because the bubbles of hydrogen gas formed during the reaction stick to its surface.

**(iv)** Magnesium metal does not react with cold water. Magnesium reacts with hot water to form magnesium hydroxide and hydrogen:

$$\mathbf{Mg\ (s) + 2H_2O\ (l) \longrightarrow Mg(OH)_2(aq) + H_2(g)}$$

magnesium water(hot) Magnesium hydroxide Hydrogen

In this reaction the piece of magnesium metal starts floating in water due to the bubbles of hydrogen gas sticking to its surface.

Magnesium reacts very rapidly with steam to form magnesium oxide and hydrogen:

$$\mathbf{Mg\ (s) + H_2O(g) \longrightarrow MgO(s) + H_2(g)}$$

Magnesium Steam Magnesium oxide Hydrogen

(v) Aluminum reacts with steam to form aluminium oxide and hydrogen gas :

$$\mathbf{2Al\ (s) + 3H_2O(g) \longrightarrow AI_2O_3(s) + 3H_2(g)}$$

Aluminum Steam Aluminium oxide Hydrogen

Aluminium metal does not react with water under ordinary conditions because of the presence of a thin (but tough) layer of aluminium oxide on its surface.

(vi) Zinc reacts with steam to form zinc oxide and hydrogen :

$$\mathbf{Zn\ (s) + H_2O\ (g) \longrightarrow ZnO\ (s) + H_2\ (g)}$$

Zinc Steam Zinc oxide Hydrogen

(vii) Red - hot iron reacts with steam to form iron (II, III) oxide and hydrogen :

$$\mathbf{3Fe(s) + 4H_2O(g) \longrightarrow Fe_3O_4(s) + 4H_2(g)}$$

Iron Steam Iron (II, III) oxide Hydrogen

Metal like lead, copper, silver and gold does not react with water (or even steam).

## ACTIVITY – 7

**Aim:** To study the reactivity of metals with water.

**Caution:** This activity needs teacher’s assistance.

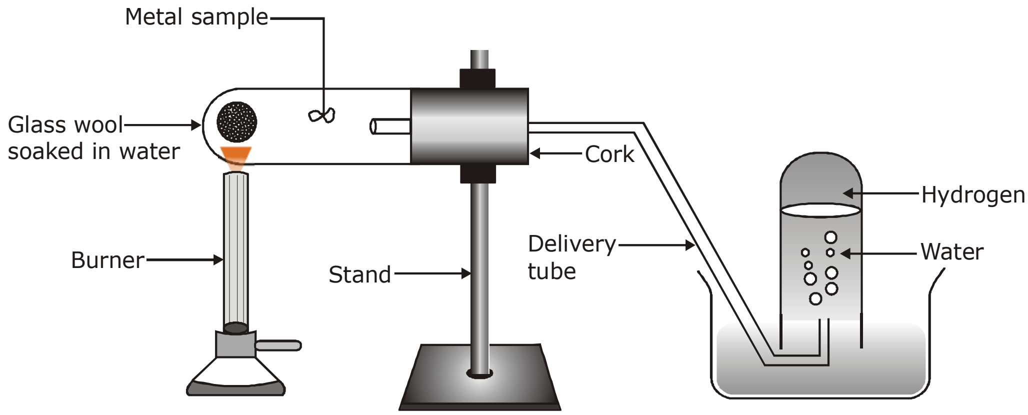
**Method:**

(i) Collect the samples of sodium, potassium, calcium, magnesium, zinc and copper.

(ii) Put small piece of the samples separately in beakers half-filled with cold water.

(iii) Put the metals that do not react with cold water in beaker half-filled with hot water.

(iv) For the metals that do not react with hot water, arrange the apparatus (to produce steam) and observe their reaction with steam.




**Action of steam on a metal**

**Now Answer**

(i) Which metals reacted with cold water? Arrange them in increasing order of their reactivity with cold water.

(ii) Does any metal produce fire on water?

(iii) Does any metal start floating after some time?

(iv) Which metals did not react even with steam?

## Discussion

(i) Na and K metals react vigorously with cold water to form NaOH and $H_2$ gas is liberated.

| | | | | | |
|---|---|---|---|---|---|
| **2Na(s)** | + | **$2H_2O(l)$** | $\longrightarrow$ **2NaOH(aq)** | + | **$H_2(g)$** |
| Sodium | | Cold water | Sodium hydroxide | | Hydrogen gas |
| **2K(s)** | + | **$2H_2O(l)$** | $\longrightarrow$ **2KOH(aq)** | + | **$H_2(g)$** |
| Potassium | | Cold water | Potassium hydroxide | | Hydrogen gas |

The reactions are so violent and exothermic that the $H_2$ gas evolved catches fire.

(ii) Calcium reacts with cold water to form $Ca(OH)_2$ and $H_2$ gas. It is less violent.

| | | | | | |
|---|---|---|---|---|---|
| **Ca(s)** | + | **$2H_2O(l)$** | $\longrightarrow$ **$Ca(OH)_2(aq)$** | + | **$H_2(g)$** |
| | | Cold water | Calcium hydroxide | | Hydrogen gas |

(iii) Magnesium react with hot boiling water to form MgO and $H_2$ gas.

| | | | | | |
|---|---|---|---|---|---|
| **Mg(s)** | + | **$H_2O(l)$** | $\longrightarrow$ **MgO(s)** | + | **$H_2(g)$** |
| | | Boiling water | Magnesium oxide | | Hydrogen gas |

(iv) Aluminium does not react either with cold or hot water. But it react only with steam to form aluminium oxide and hydrogen gas.

| | | | | | |
|---|---|---|---|---|---|
| **2Al(s)** | + | **$3H_2O(g)$** | $\longrightarrow$ **$Al_2O_3(s)$** | + | **$3H_2(g)$** |
| | | Steam | Aluminium oxide | | Hydrogen gas |

(v) Similarly, zinc react with steam to form zinc oxide and $H_2$ gas.

| | | | | | |
|---|---|---|---|---|---|
| **Zn(s)** | + | **$H_2O(g)$** | $\longrightarrow$ **ZnO(s)** | + | **$H_2(g)$** |
| | | Steam | Zinc oxide | | Hydrogen gas |

(vi) Copper do not react with water even under strong conditions. The above reactions indicate that sodium and potassium are the most reactive metals while copper is less reactive.

### Conclusion

The reactivity order of these metals with water are

K > Na > Ca > Mg > Al > Zn > Fe > Cu

## 2. Reaction of metals with Dilute Acids:

Metals usually displace hydrogen from dilute acids. When a metal reacts with a dilute acid, then a metal salt and hydrogen gas are formed

Metal + Dilute acid $\longrightarrow$ Metal salt + Hydrogen

**(i)** Sodium metal reacts violently with dilute hydrochloric acid to form sodium chloride and hydrogen:

$$\underset{\text{Sodium}}{\mathbf{2Na(s)}} + \underset{\text{Hydrochloric}}{\mathbf{2HCl(aq)}} \longrightarrow \underset{\text{Sodium chloride}}{\mathbf{2NaCl(aq)}} + \underset{\text{Hydrogen}}{\mathbf{H_2(g)}}$$

**(ii)** Magnesium reacts quite rapidly with dilute hydrochloric acid forming magnesium chloride and hydrogen gas:

$$\underset{\text{Magnesium}}{\mathbf{Mg(s)}} + \underset{\text{Hydrochloric acid}}{\mathbf{2HCl(aq)}} \longrightarrow \underset{\text{Magnesium chloride}}{\mathbf{MgCl_2(aq)}} + \underset{\text{Hydrogen}}{\mathbf{H_2(g)}}$$

**(iii)** Aluminium metal at first reacts slowly with dilute hydrochloric acid due to the presence of a tough protective layer of aluminium oxide on its surface.But when the thin, outer oxide layer gets dissolved in acid.

Aluminium metal reacts rapidly with dilute hydrochloric acid to form aluminium chloride and hydrogen gas :

$$\underset{\text{Aluminium}}{\mathbf{2AI(s)}} + \underset{\text{Hydrochloric acid}}{\mathbf{6HCI(aq)}} \longrightarrow \underset{\text{Aluminium chloride}}{\mathbf{2AlCl_3(aq)}} + \underset{\text{Hydrogen}}{\mathbf{3H_2(g)}}$$

The reaction of aluminium with dilute hydrochloric acid is less rapid than that of magnesium, so aluminium is less reactive than magnesium.

**(iv)** Zinc reacts with dilute hydrochloric acid to give zinc chloride and hydrogen gas(but the reaction is less rapid than that of aluminium)

$$\underset{\text{Zinc}}{\mathbf{Zn(s)}} + \underset{\text{Hydrochloric acid}}{\mathbf{2HCl(aq)}} \longrightarrow \underset{\text{Zinc chloride}}{\mathbf{ZnCl_2(aq)}} + \underset{\text{Hydrogen}}{\mathbf{H_2(g)}}$$

This reaction shows that zinc is less reactive than aluminum.

**(v)** Iron reacts slowly with cold dilute hydrochloric acid to give iron (II) chloride and hydrogen gas:

$$\underset{\text{Iron}}{\mathbf{Fe(s)}} + \underset{\text{Hydrochloric acid}}{\mathbf{2HCl(aq)}} \longrightarrow \underset{\text{Iron (II) chloride}}{\mathbf{FeCl_2}} + \underset{\text{Hydrogen}}{\mathbf{H_2(g)}}$$

**(vi)** Copper does not react with dilute hydrochloric acid (or dilute sulphric acid) at all. This shows that copper is even less reactive than iron :

**Cu (s)** + **HCl (aq)** $\longrightarrow$ **No reaction**
Copper Hydrochloric acid

Metals like copper and silver which are less reactive than hydrogen, does not displace hydrogen from dilute acids.

## • REACTION OF METALS WITH SOLUTIONS OF OTHER METAL SALTS

When a more reactive metal is placed in a salt solution of less reactive metal, then the more reactive metal displaces the less reactive metal from its salt solution. This reaction is also known as displacement reaction. Let us learn it with the help of following activity.

## ACTIVITY - 8

**Aim:** To compare the reactivity of the metals.

**Procedure:** Take a clean wire of copper and an iron nail and two test tube. Now dissolve copper sulphate in water in one test tube and ferrous sulphate in another test tube. Place iron nail in the blue coloured copper sulphate solution with the help of a thread and copper wire in the greenish colour ferrous sulphate solution as shown in figure as below.

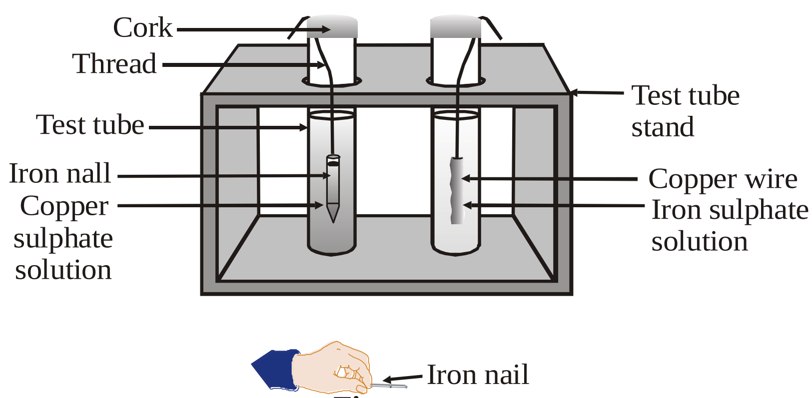



**Figure :**
**Reaction of metals with salt solutions**

**Observation:** The blue colour of copper sulphate has faded and becomes greenish. The green colour of the solution is due to the formation of iron (II) sulphate and copper is displaced. A reddish-brown coating is formed on the surface of iron nail. The reaction is represented by the chemical equation.

**$Fe(s)$** + **$CuSO_4(aq)$** $\longrightarrow$ **$FeSO_4(aq)$** + **$Cu(s)$**
Iron Copper sulphate solution Ferrous sulphate

But the greenish colour of $FeSO_4$ does notchange. That means no reaction take place.

**Conclusion:** These activities shows that iron metal is more reactive than copper.

Similarly,

## • REACTION OF COPPER WITH SILVER NITRATE SOLUTION :

When a strip of copper metal is placed in a solution of $AgNO_3$. The solution becomes gradually blue and a shining coating of silver metal gets deposited on the copper strip. The reaction may be written as:

| | | | | | | |
|---|---|---|---|---|---|---|
| **$2AgNO_3(aq)$** | + | **Cu(s)** | $\longrightarrow$ | **$Cu(NO_3)_2$** | + | **2Ag** |
| Silver nitrate (colourless solution) | | | | Copper nitrate (blue colour) | | Silver |

However, if we place silver wire in a copper sulphate solution no reaction occurs. This means copper can displace silver from its salt solution but silver cannot displace copper from its solution. i.e. copper is more reactive metal than silver.

## • PROPERTIES OF NON-METALS

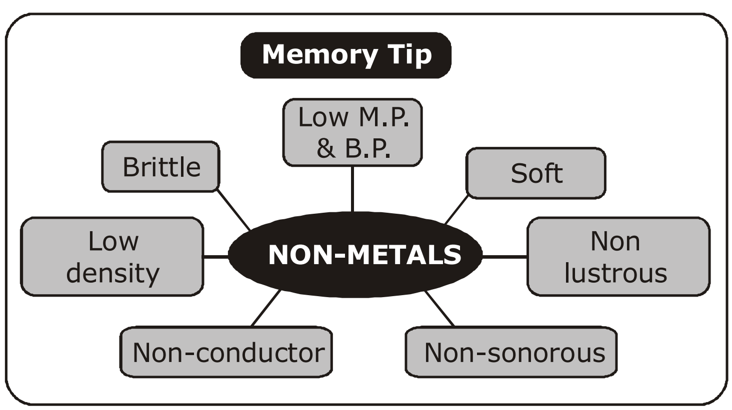
## • NON-METALS AND THEIR GENERAL PROPERTIES

Non-metals are present on the right hand side of the periodic table (exception : Hydrogen). Among the total known elements, there are only 22 non-metals, out of which 11 are gases like oxygen, nitrogen, hydrogen one is a liquid (Bromine) and the rest 10 are solids such as sulphur, phosphorus and the allotrops of carbon (Diamond and graphite).

## • ELECTRONIC VIEW OF NON-METALS

An elements is called non-metal which form ions by gaining electrons. For example, oxygen is a non-metal which forms $O^{2-}$ ions by gaining two electrons. Similarly, nitrogen form $N^{3-}$ ions by gaining three electrons. Thus, non-metals also known as electronegative elements.

The atoms of non-metals have usually 4 to 8 electrons in their outer most shell. For example, Carbon (At No. 6), Nitrogen (At. No. 7), Oxygen (At. No. 8), Fluorine (At. No. 9) and Neon (At. No. 10), have respectively 4, 5, 6, 7 and 8 electrons in their outermost shell. However, there are two exceptions namely hydrogen and helium which have one and two electrons in their valence shell or outer most shell, but they are non-metals.




## • PHYSICAL PROPERTIES OF NON-METALS

**(1) Non-metals are neither malleable nor ductile. Non-metals are brittle (break easily).**

Solid non-metals can neither be hammered into thin sheets nor drawn into thin wires. For example, sulphur and phosphorus are solid non-metals which are non-malleable and non-ductile. The property of being brittle (breaking easily) is called **brittleness**. Brittleness is an important property of non-metals.

**(2) Non-metals does not conduct heat and electricity.**

Non-metals does not conduct heat and electricity because unlike metals, they have no free electrons (which are necessary to conduct heat and electricity). For example, sulphur and phosphorus are non-metals which does not conduct heat and electricity. There is, however one exception, carbon (in the form of graphite) is the only non-metal which is a good conductor of electricity because of it's structure.

**(3) Non-metals are not lustrous (not shiny). They are dull.**

Non-metals does not have a shining surface. For example, sulphur and phosphorus are non-metals which have non lustre. Iodine is a non-metal having lustrous appearance.

**(4) Non-metals are generally soft (except diamond which is extremely hard non-metal)**

**(5) Non-metals are not strong. They are easily broken.**

**(6) Non-metals may be solid, liquid or gases at the room temperature.**

**(7) Non-metals have comparatively low melting points and boiling points (except diamond which is a non-metal having a high melting point and boiling point).**

The melting point of sulphur is 115°C which is quite low. The melting point of diamond is, however more than 3500°C which is very high.

**(8) Non-metals have low densities, that is, non-metals are light substances.** The density of sulphur of $2g/cm^3$.

**(9) Non-metals are non-sonorous. They does not produce sound when hit with an object.**

**(10) Non-metals have many different colours.**

On the basis of the above discussion of the physical properties of metals and non-metals, we have concluded that elements can not be grouped according to the physical properties alone, as there are many exceptions.

### For example,

(i) All metals except mercury are solids at room temperature. We know that metals have very high melting points but gallium (Ga) and caesium (Cs) have very low melting points. These two metals will melt if we keep them at our palm.

(ii) Iodine is a non-metal but it is lustrous.

(iii) Alkali metals such as Lithium, Sodium and Potassium are soft and they can be easily cut with a knife. i.e. they have very low densities and low melting points.

(iv) Carbon is a non-metal that can exist in different forms. Each form is called an allotrope of Diamond; an allotrope of carbon is the hardest natural substance. Which has very high melting and boiling point? Graphite is another allotrope of carbon which is good conductor of electricity.

The elements can be more clearly classified as metals and non-metals on the basis of their chemical properties.

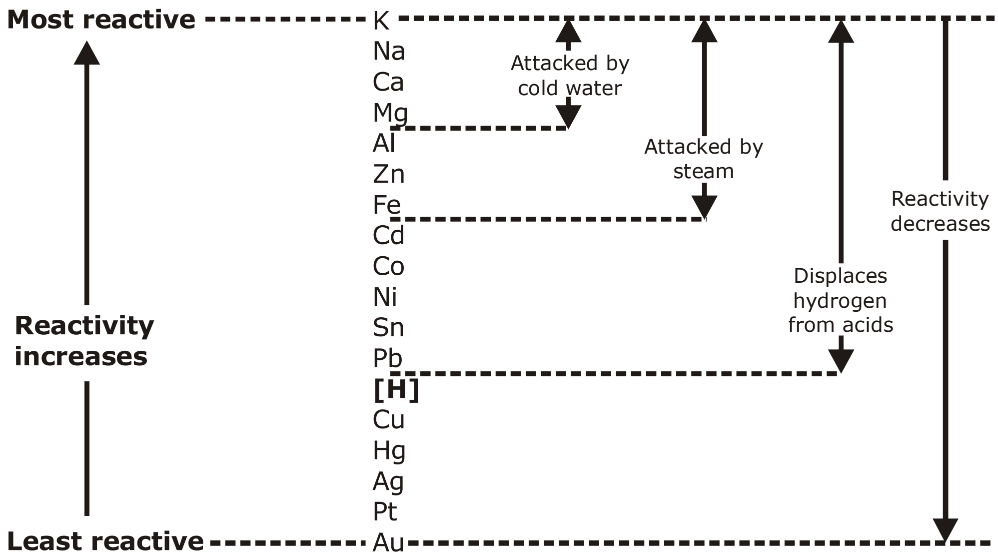
| Distinction between Metals and Non-metals | | |
|---|---|---|
| **Properties** | **Metals** | **Non-metals** |
| **Physical properties** | | |
| State | Metals are solids at ordinary temerature. Exception. Mercury is a liquid. | Non-metals exist in all the three states, that is, solid, liquid and gas. |
| Lustre | They possess lustre or shine. | They possess no lustre. Exceptions: Iodine and graphite. |
| Malleability and Ductility | Metals are generally malleable and ductile. | Non-metal are neither malleable nor ductile. |
| Hardness | Metals are generally hard. Alkali metals are exceptions. | Non-metal possess varying hardness. Diamond is an exception. It is the hardest substance known to occur in nature. |
| Density | They have high densities. | They generally possess low densities. |
| Conductivity | Metals are good conductors of heat and electricity. | Non-metals are poor conductors of heat and electricity. The only exception is graphite which is a good conductor of electricity. |
| Melting and boiling points | They usually have high melting and boiling points. | Their melting and boiling points are usually low. The only exceptions are boron, carbon and silicon. |

| Distinction between Metals and Non-metals | | |
|---|---|---|
| **Properties** | **Metals** | **Non-metals** |
| **Chemical properties** | | |
| Action with mineral acids | Metals generally react with dilute mineral acids to liberate $H_2$ gas. | Non-metals do not displace hydrogen on reaction with dilute minerals acids. |
| Nature of oxides | They form basic oxides. For example, $Na_2O$, MgO, etc. These oxides are ionic in nature. | Non-metals form acidic or neutral oxides. For example, $SO_2$, $CO_2$, $P_2O_5$, etc. are acidic whereas CO, $N_2O$, etc. are neutral. These oxides are covalent in nature. |
| Combination with hydrogen | Metals generally do not combine with hydrogen. However, Li, Na, Ca, etc. form unstable hydrides. For example, LiH, NaH, $CaH_2$ etc. These hydrides are ionic in character. | Non-metals combine with hydrogen to form stable hydrides. For example, KCl, $H_2S$, $CH_4$, $NH_3$, $PH_3$, etc. These hydrides are covalent. |
| Combination with halogens | They combine with halogens to form well defined and stable crystalline solids. For example, NaCl, KBr, etc. | Non-metals form halides which are unstable and undergo hydrolysis readily. For example $PCl_5$, $PCl_3$, etc. |
| Electrochemical behaviour | Metals are electropositive in character. They form cations in solution and are deposited on the cathode when electricity is passed through their solution. | Non-metals are electronegative in character. They form anions in solution and are liberated at the anode when their salt solutions are subjected to electrolysis. Hydrogen is an exception. It usually forms positive ions and is liberated at cathode. |
| Oxidising or reducing behaviour | Metals behave as reducing agents. This is because of their tendency to lose electorns. $Na \longrightarrow Na^+ + e^-$ | Non-metals generally behave as oxidising agents since they have the tendency to gain electrons. $1/2\ Cl_2 + e^- \longrightarrow Cl^-$ |

- **THE REACTIVITY SERIES**

The arrangement of metals in order of decreasing reactivities is called reactivity series or activity series of metals. After performing displacement experiments the following series has been developed.

**Reactivity Series of Metals**




- **CHARACTERISTICS OF REACTIVITY SERIES:**

(i) The most reactive metal is placed at the top and the least reactive metal is placed at the bottom of the table.

(ii) Metals present above the hydrogen in reactivity series can displace hydrogen from dilute acids.

(iii) A metal can displace the metals placed below it in the reactivity series.

(iv) Metals present at the top are more electro-positive, so they will occur in combined or compound form only in nature.

(v) Metals at the bottom are less reactive and do not react easily so they may be present in free state in nature.

**Example 1.** A, B and C are three elements which undergo chmical change according to the following equations

$$A_2O_3 + 2B \longrightarrow B_2O_3 + 2A$$

$$3CSO_4 + 2B \longrightarrow B_2(SO_4)_3 + 3C$$

$$3CO + 2A \longrightarrow A_2O_3 + 3C$$

Write the anme of the most reactive and the least reactive elements.

**Sol.**

(i) In the first reaction, B displaces A, so B is more reactive than A.

(ii) In second reaction, B displaces C, so B is more reactive than C.

(iii) In third reaction, A displaces C, so A is more reactive than C.

So, B is more reactive than A and C and A is more reactive than C, So the order of their reactivities is as follows:

$$B > A > C$$

**Example 2.** Explain why zinc metal can displace copper from copper sulphate solution but copper cannot displace zinc from zinc sulphate solution.

Or

When a piece of copper metal is added to a solution of zinc sulphate, no change takes place, but the blue colour of copper sulphate fades away when a piece of zinc is placed in its solution.

**Sol.** When a piece of zinc is placed in a solution of copper sulphate, zinc being more reactive than copper, can displace copper from its salt solution and forms zinc sulphate and blue colour of copper sulphate fades away slowly, but when a piece of copper sulphate fades away slowly, but when a piece of copper metal is added to a solution of zinc sulphate, no change takes place as copper being less reactive than zinc, cannot displace zinc from zinc sulphate.

**ELECTRONIC CONFIGURATION OF SOME ELEMENTS :**

| **Types of element** | **Element** | **Atomic number** | **Number of electrons is shells** | | | |
|---|---|---|---|---|---|---|
| | | | **K** | **L** | **M** | **N** |
| Noble gases | Helium (He) | 2 | 2 | | | |
| | Neon (Ne) | 10 | 2 | 8 | | |
| | Argon (Ar) | 18 | 2 | 8 | 8 | |
| Metals | Sodium (Na) | 11 | 2 | 8 | 1 | |
| | Magnesium (Mg) | 12 | 2 | 8 | 3 | |
| | Aluminium (AI) | 13 | | 2 | 8 | 3 |
| | Potassium (K) | 19 | 2 | 8 | 8 | 1 |
| | Calcium (Ca) | 20 | 2 | 8 | 8 | 2 |
| Non-Metals | Nitrogen (N) | 7 | 2 | 5 | | |
| | Oxygen (O) | 8 | 2 | 6 | | |
| | Fluorine (F) | 9 | 2 | 7 | | |
| | Phosphorus (P) | 15 | 2 | 8 | 5 | |
| | Sulphur (S) | 16 | 2 | 8 | 6 | |
| | Chlorine (CI) | 17 | 2 | 9 | 7 | |

## • CHEMISTRY OF METAL AND NON METAL REACTION?

It is clear from the above table that except helium, all other noble gases have 8 electrons (octet) in their outermost shell. Which represent a highly stable electronic configuration? Due to this stable configuration, the noble gases have no any tendency to lose or gain electrons. So they exist monoatomic, sodium atom has one electron in its outermost shell. If it loses the electron from its M shell the its L shell becomes the outermost shell. Which has stable octet like noble gases. The nucleus of this atom still has 11 protons but the number of electrons has 10. Therefore, if becomes positively charged sodium ion or cation ($Na^+$).

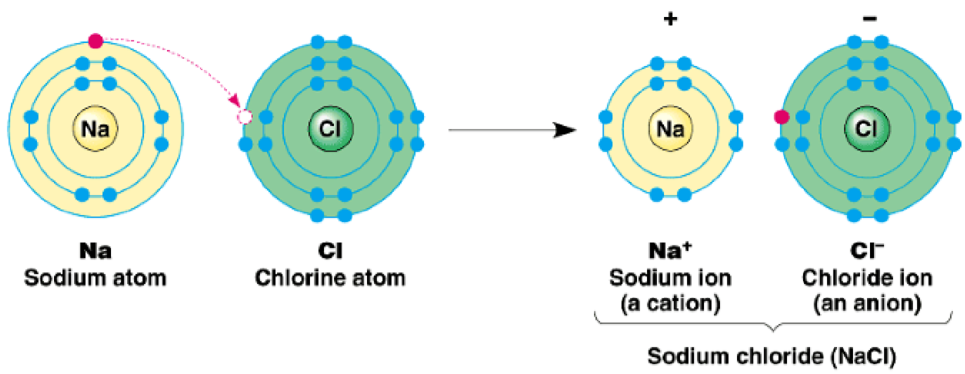
$$\underset{2,\,8,\,1}{\mathbf{Na}} \xrightarrow{\textit{lose}\ 1.\ \text{electron}} \underset{\substack{2,\,8 \\ \text{Sodium cation}}}{\mathbf{Na^+ + e^-}}$$

On the other hand chlorine has seven electrons in its outer most shell and it require one more electron to complete its octet. The nucleus of chlorine atom has 17 protons and the number of electrons become 18. This makes chloride ion, $Cl^-$ as negatively charged

$$\mathbf{Cl} \xrightarrow{\textit{gain}\ 1.\ \text{electron}} \mathbf{Cl^-}$$

2, 8, 7 → 2, 8, 8
Chloride ion

So, $Na^+$ and $Cl^-$ ions being oppositely charged atoms which attract each other and are held by strong electrostatic forces of attraction to exist as NaCl. In other words, $Na^+$ and $Cl^-$ ions are held together by electrovalent or ionic bond.

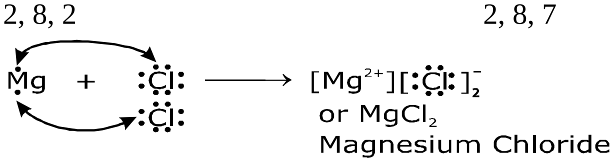



The formation of one more ionic compound magnesium chloride:
The electronic configuration of magnesium (Mg) and chlorine atoms are:

| | | |
|---|---|---|
| $\mathbf{Mg_{12}}$ | : | **2, 8, 7** |
| $\mathbf{Cl_{17}}$ | : | **2, 8, 7** |

Magnesium atom has two electrons in its valence shell. It has a tendency to lose both of its electrons to attain the nearest noble gas configuration (i.e. Ne). $Mg \longrightarrow Mg^{2+}$.
On the other hand, chlorine has only one electron less than the nearest noble gas (i.e. Ar) configuration. The magnesium loses its both the valence electrons to two chlorine atoms, each of which is need of one electron to form $Cl^-$ ion.

$\mathbf{Mg} \longrightarrow \mathbf{Mg^{2+}}$ , $\mathbf{Cl} \longrightarrow \mathbf{2Cl^-}$
2, 8, 2 2, 8, 7 2, 8, 8




The compounds formed by the transfer of electrons from a metal to a non-metal are known as ionic compound or electrovalent compounds. The structure of some common ionic compounds is given below:
Structure of some common ionic compounds:

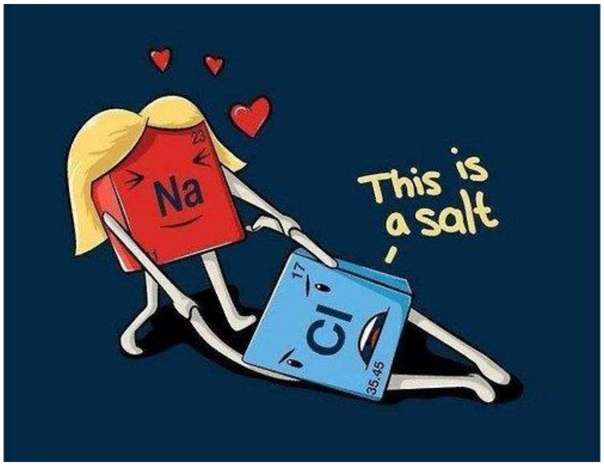
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (1) | Magnesium oxide | Mg<br>2, 8, 2 | + | O<br>2, 6 | $\longrightarrow$ | $Mg^{2+}[O]^{2-}$ | or | MgO |
| (2) | Magnesium fluoride | Mg<br>2, 8, 2 | + | 2F<br>2, 7 | $\longrightarrow$ | $Mg^{2+}2[F]^-$ | or | $MgF_2$ |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (3) | Calcium oxide | Ca<br>2, 8, 8, 2 | + | O<br>2, 6 | $\longrightarrow$ | $Ca^{2+}[O]^{2-}$ | or | CaO |
| (4) | Aluminium oxide | Al<br>2, 8, 3 | + | O<br>2, 6 | $\longrightarrow$ | $2A^{3+}3[O]^{2-}$ | or | $Al_2O_3$ |
| (5) | Magnesium Chloride | Mg<br>2, 8, 2 | + | 2Cl<br>2, 8, 7 | $\longrightarrow$ | $Mg^{2+}2[Cl]^{-}$ | or | $MgCl_2$ |
| (6) | Aluminium nitride | Al<br>2, 8, 3 | + | N<br>2, 5 | $\longrightarrow$ | $Al^{3+}N^{3-}$ | or | AlN |

## ACTIVITY – 9

**Aim:** To study the properties of ionic compounds.

**Method:**




(i) Take samples of sodium chloride, potassium iodide, barium chloride or any other salt from the science laboratory.
(ii) Take a small amount of sample on a metal spatula and heat directly on the flame. Repeat with other samples.
(iii) Try to dissolve the compound in water and kerosene.
(iv) Make a circuit as shown in figure and insert the electrons into a solution of one salt. Test the other salt samples too in this manner.

## Now Answer

(i) What is the physical state of the salt taken?
(ii) Did the samples impart any colour to the flame on heating?
(iii) Did the compounds melt on heating?
(iv) Are the compounds soluble in water or kerosene?
(v) Did the electric bulb glows on passing electric current?
(vi) What is your inference about the nature of these compounds?

## Discussion

(i) All the salts taken are solids. Each salt imparted a particular colour to the flame.

(ii) The compounds did not melt on heating.
(iii) The compounds were soluble in water but not in kerosene.
(iv) The electric bulb glows on passing electric current. All these properties show that the compounds are ionic in nature.

## Conclusion

(i) Ionic compounds are generally solids.
(ii) They impart a characteristic colour to the flame.
(iii) They are soluble in a polar solvent like water and insoluble in non-polar solvent like kerosene, petrol, etc.
(iv) Their molten or aqueous solution conducts electricity.

- ## Following are the general properties of ionic compounds.

**(a) Physical state**
Ionic compounds are solids and relatively hard because of the strong force of attraction between the positive and negative ions. This force of attraction is also known as strong electrostatic force of attraction. These compounds are generally brittle and break into pieces when pressure is applied.

**(b) Solubility**
Electrovalent compounds are generally soluble in water (because of their polar nature) and insoluble in solvents such as kerosene, petrol, etc.

**(c) Melting and boiling points**
Ionic compounds have high melting and boiling points, due to the strong electrostatic force of attraction between the oppositely charged ions. Therefore, large amount of energy is needed to break these bonds.

**(d) Conduction of electricity**
Ionic compounds in the solid state do not conduct electricity because movement of ions in the solid state is not possible due to their rigid structure. But they can conduct electricity in molten or aqueous state.

**(e) Colour to the flame**
Most of the salts when brought into the flame, impart characteristic colour to the flame.

| Ionic Compound | Melting Point (K) | Boiling Point (K) |
|---|---|---|
| NaCl | 1074 | 1738 |
| LiCl | 878 | > 1570 |
| KBr | 1007 | 1708 |
| KI | 953 | 1600 |
| $CaCl_2$ | 1055 | 1870 |
| CaO | 2845 | 3123 |
| $MgCl_2$ | 987 | 1685 |

- ## IMPORTANT INFORMATION

Hydrogen gas is not evolved when metals such as Zn, Fe, Cu and Al reacts with nitric acid. Because $HNO_3$ is strong oxidising agent. It oxidises $H_2$ gas to water and itself gets reduced to form oxides of (NO, $N_2O$ and $NO_2$) nitrogen.

$$3Fe(s) + 8HNO_3(aq) \longrightarrow 3Fe(NO_3)_2(aq) + 4H_2O(l) + 2NO(g)$$

Iron   Nitric acid (dil)   Iron(II) nitrate   Water   Nitric oxide

$$3Cu(s) + 8HNO_3(aq) \longrightarrow 3Cu(NO_3)_2(aq) + 4H_2O(l) + 2NO(g)$$

Copper   Nitric acid   Copper nitrate   Water   Nitric oxide

But copper reacts with hot concentrated sulphuric acid ($H_2SO_4$) to produce copper sulphate, sulphur dioxide and water.

$$Cu(s) + 2H_2SO_4 \longrightarrow CuSO_4 + 2SO_2 + 2H_2O$$

Mg reacts with very dilute $HNO_3$ to evolve $H_2$ gas.

$$Mg(s) + 2HNO_3(aq) \longrightarrow Mg(NO_3)_2(aq) + H_2O(g)$$

Magnesium   Nitric acid (dil)   Magnesium nitrate

Fe react with dil $H_2SO_4$ to evolve $H_2$

$$Fe(s) + \text{dil } H_2SO_4(aq) \longrightarrow FeSO_4(s) + H_2(g)$$

Iron   Sulphuric acid   Ferrous sulphate

## • AQUA REGIA (ROYAL WATER)

Aqua regia is a Latin word it means " royal water". It is a freshly prepared mixture of concentrated hydrochloric acid and concentrated nitric acid in the ratio of 3 : 1. It is a highly corrosive, fuming liquid and it is used to dissolve gold and platinum.

## • OCCURENCE OF METALS

The main source of metal is earth's crust. Some metals also occur in sea water. The metals are found in nature in :

**(1)** **Native state (or free state) :** Only a few less reactive metals like silver, gold platinum etc., are found in the free state in which they are called "native metals".

**(2)** **Combine state:** i.e., in the form of their compounds admixed invariably with various useless impurities such as clay, sand, rocky material, etc. Usually, metals are found in the form of oxides, sulphides, carbonates, phosphates, halides silicates, etc.

(i) The naturally occurring form of metal in combined state, is known as "mineral".

(ii) Those naturally occurring minerals, which are economically suitable for commercial extraction of metals, are known as 'ores'. Thus, every ore is a mineral, but every mineral is not an ore.

(iii) The rocky and earthy impurities (like clay, sand) generally associated with ore, are called gangue (or matrix).

## TYPES OF ORES

| Nature of ore | Metal | | Composition |
|---|---|---|---|
| Oxide Ores | Aluminium | Bauxite | $Al_2O_3 . 2H_2O$ |
| | Copper | Cuprite | $Cu_2O$ |
| | Iron | Magnetite | $Fe_3O_4$ |
| Sulphide Ores | Copper | Copper pyrities | $CuFeS_2$ |
| | | Copper glance | $Cu_2S$ |
| | Zinc | Zinc blende | $ZnS$ |
| | Lead | Galena | $PbS$ |
| | Mercury | Cinnabar | $HgS$ |
| Carbonate Ores | Calcium | Limestone | $CaCO_3$ |
| | Zinc | Calamine | $ZnCO_3$ |
| Halide Ores | Sodium | Rock salt | $NaCl$ |
| | Magnesium | Carnallite | $KCl\ MgCl_2 . 6H_2O$ |
| | Calcium | Fluorspar | $CaF_2$ |
| | Silver | Horn silver | $AgCl$ |
| Sulphate Ores | Calcium | Gypsum | $CaSO_4 . 2H_2O$ |
| | Magnesium | Epsom Salt | $MgSO_4 . 7H_2O$ |
| | Barium | Barytes | $BaSO_4$ |
| | Lead | Anglesite | $PbSO_4$ |

**Note:**

(1) Sodium a very reactive metal, and reacts readily with moisture, oxygen and carbon dioxide of air. So sodium cannot exit ‘free’ in nature. Hence, it is not found ‘native’ in nature.

(2) Sodium is highly reactive metal, and has affinity for oxygen. If it is exposed to air, a coating of the oxide is formed and sometimes, it may even catch fire. Consequently, sodium metal should not be exposed to air. Hence, sodium is stored under kerosene.

(3) Aluminium is a reactive metal, so it is not found in free state in nature. It occurs in the form of its compounds, chief of which is bauxite ($Al_2O_3\ 2H_2O$).

(4) Gold and silver occupr low position in the activity series. Consequently, they are least reactive elements and are not affected by most chemicals, atmospheric oxygen, moisture, carbon dioxide etc. Hence, they often occur in free or native state in nature.

**Extraction of metals:** We have learnt about the reactivity series of metals, according to which, the metals at the “bottom” of the reactivity series are the “least reactive” and these are often found in a free-state, e.g., Au, Ag, Pb and Cu. However Cu and Ag are also found in combined state as their oxides and sulphides. On the other hand, metals at the “top” of the reactivity series are so reactive, they are never found in nature as free elements, e.g., Li, K, Na, Ca, Mg etc. The metals in the “middle” of the reactivity series (e.g., Al, Zn, Fe, Pb etc.) are moderately reactive and they are found in the earth’s crust mainly as oxides, sulphides or carbonates [e.g., $Al_2O_3 . 2H_2O$ (bauxite), HgS (cinnabar), $ZnCO_3$ (calamine)]

***On the basis of reactivity seires, we can have following three groups of elements :***

**(i) Metals of low reactivity.**

**(ii) Metals of medium reactivity.**

**(iii) Metals of high reactivity**

**Metallurgy:** is the process of extracting a metal in the free form from its ore and then refining it for use. Various steps involved in the extraction of metals from their ores are generally as follows:

(a) Concentration (or enrichment) of ore

(b) Conversion of concentrated ore into oxide

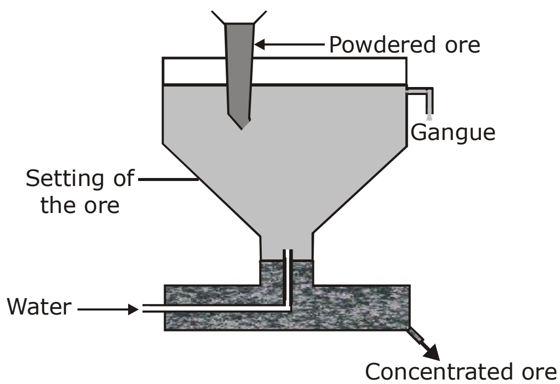
(c) Reduction of oxide ore into impure metal

(d) Refining of impure metal.

**(a) Con centration (or enrichment) of ore :** The ore is, generally, associated with useless rocky and earthy impurities (like clay, sand etc.), called ‘gangue’ or matrix. The ‘concentration’ (or enrichments) of ore means removal of gangue from the powdered ore. Thus, the percentage of the metal in the concentrated ore is higher than that in the original ore. The concentration of ore can be brought about in the following ways. depending upon the type of ore such as hydraulic washing, froth floatation method, magnetic separation etc.

**(i) Levigation or gravity separation or hydraulic washing**

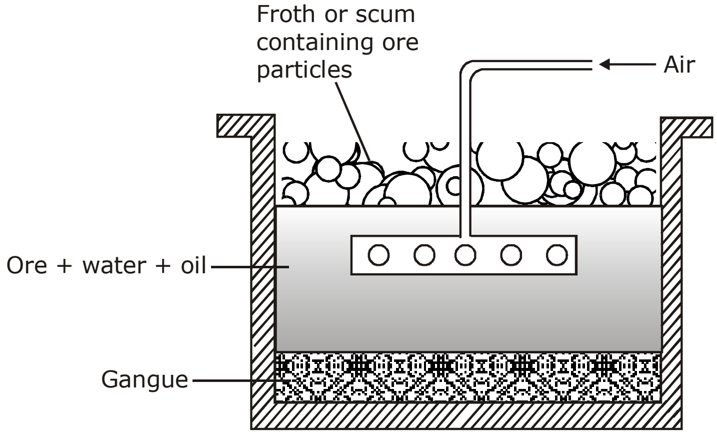
This method is based upon the difference in the densities of the ore particles and impurities (gangue). Example: Haemetite ore of iron.




**Gravity Separation**

**(ii) Froth floatation**

This method is based on the difference in the wetting properties of the ore and gangue particles with water and oil. It is used for enrichment of sulphide ores. Example: ZnS, HgS.



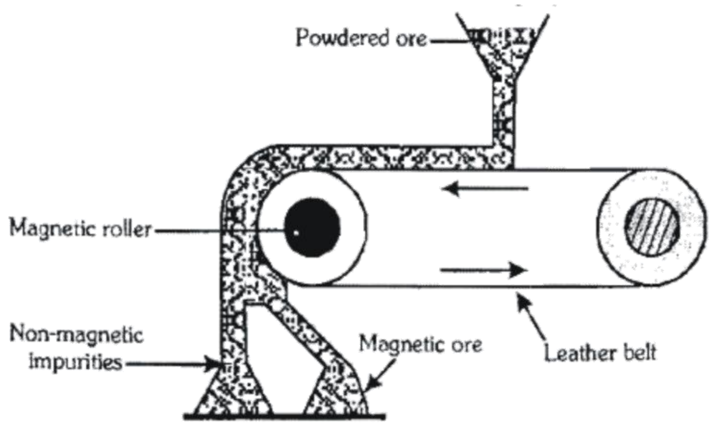

**Froth Floatation**

**(iii) Liquation**

This method is based on difference in melting point of ore and gangue particles. Example: ore of tin and zinc.

**(iv) Magnetic separation**

This method is based on difference in the magnetic properties of the ore and gangue. Example: magnetite ($Fe_3O_4$) ore of iron.




**Magnetic Separation**

**(v) Chemical separation**

When none of the physical property makes the difference, then we use chemical properties as the basis for enrichment. e.g. Bayer's process for alumina enrichment.

**Next steps of metallurgy depend on the type of metal to be extracted:**

**(a) Extracting metals low in reactivity series:** Since these metals are unreactive, so the oxides of these metals can be "reduced" by heating alone. For example, cinnabar (HgS) an ore of mercury changes to mercury on heating

**(b) Extracting metals in the middle of the reactivity series:** Since these metals (e.g. Fe, Zn, Pb, Cu, etc.) are moderately reactive, so they are usually found in earth's crust as sulphides or carbonates.
Consequently are converted into metal oxides.

$$\underset{\text{Cinnabar}}{2HgS(s)} + 3O_2(g) \xrightarrow{\Delta} 2HgO(s) + 2SO_2(g) \xrightarrow{\Delta} 2Hg(l) + O_2(g)$$

(i) The process of conversion of metal sulphide to oxide by strongly heating in the presence of excess air, is called roasting. For example :

$$\underset{\text{Zinc blende}}{2ZnS(g) + 3O_2\,(g)} \xrightarrow[\text{Excess air}]{\Delta} 2ZnO(s) + 2SO_2(g)$$

(ii) The process of conversion of metal carbonate to oxide by heating strongly in limited air, is called calcination. For example :

$$\underset{\text{Calamine}}{2ZnCO_3(s)} \xrightarrow[\text{Limited air}]{\Delta} 2ZnO(s) + 2SO_2(g)$$

**Reduction of oxide to metal :** The metal oxides obtained above are reduced by hearting with suitable reducing agents like carbon. For example:

$$\underset{}{ZnO(s)} + \underset{\text{(Reducing agent)}}{C(s)} \xrightarrow{\Delta} Zn(s) + CO(g)$$

It may be pointed out here that besides using carbon (coke), to reduce metal oxides to metals, sometimes, displacement reactions are also employed. The highly reactive metals (e.g., Na, Ca, Al, etc.) are employed as reducing agents, since they displace metals of lower reactivity from their compounds, For example :

$$\mathbf{2MnO_2(s) + 4Al(s) \longrightarrow 3Mn(l) + 2Al_2O_3(s) + Heat}$$

Such a displacement reaction is highly exothermic (i.e., lot of heat is evolved), so the metal produced is in molten state [e.g., Mn(l)] Al is also used to reduce iron (III) oxide ($Fe_2O_3$) and this reaction is called thermite reaction and used to join railway trackes or machine parts.

$$\mathbf{Fe_2O_3(s) + 2Al(s) \longrightarrow 2Fe(s) + Al_2O_3(s) + Heat}$$

| Do You Know? |
|---|
| The reaction in which one of the reactant ($Cu_2S$) carries the reduction of the product ($Cu_2O$) is known as auto reduction. |

**Difference between Roasting and Calcination**

| Roasting | Calcination |
|---|---|
| 1. The ore is heated in the presence of air (oxygen). | 1. The ore is heated in the absencef of air (oxygen). |
| 2. It is used to convert sulphide ores into oxides ores. Sulphide ore $\xrightarrow{\text{Roasting}}$ Oxide ore | 2. It is used to convert carbonate ores into oxides ores. Carbonate ore $\xrightarrow{\text{Calcination}}$ Oxide ore |

| Do You Know? |
|---|
| It is easy to extract a metal from its oxide, as compared to its sulphide or carbonate. |

**(c) Extracting metals near the top of the reactivity series:** Since these metals are highly reactive, so their oxides cannot be reduced by heating with carbon. For example, $Na_2O(s)$, $MgO(s)$, $CaO(s)$, $Al_2O_3(s)$, etc. cannot be reduced by heating with carbon. This is because these metals possess more affinity for oxygen than carbon. Consequently, these metals are extracted by electrolytic reduction process. For example, when molten sodium chloride is electrolyed sodium is obtained at the cathode (the negatively charged electrode): while chlorine is liberated at the anode (the positively charged electrode).

Thus: At cathode: $Na^+ + e^- \longrightarrow Na(s)$

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

Likewise, Al is obtained by the electrolytic reduction of $Al_2O_3$.

**(d) Refining of metals:** the process of purifying the crude metal to get pure metal, is called refining. The method of metal refining depends on :

(i) the nature of the metal to be purified and (ii) the type of impurities present.

**Electrolytic refining:** Most of the metals are refined by this method. In this process, a large block of impure metal is made the anode in an electrolytic cell, and a thin sheet of pure metal is made the cathode. Suitable metal salt solution is made as an electrolyte. On passing electric current, pure metal deposits on the cathode sheet; while some of impurities are left in solution, and other noble metal impurities settle below the anode as 'anode mud'.

For example, during the electrolytic refining of a copper, a thick block of impure copper is made anode, and thin plate of pure copper is made cathode. Copper sulphate solution. is used as an electrolyte.

On passing electric current, following reactions take place:

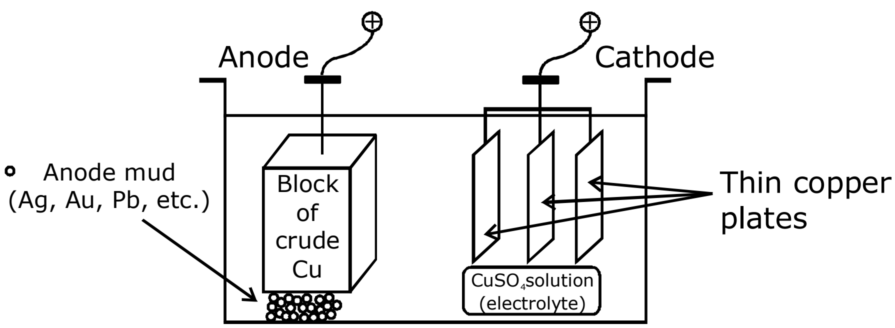
(1) $Cu^{2+}$ ions (from copper sulphate solution) go to the cathode (negative electrode), where they are reduced to copper, which gets deposited on the cathode.

$$\underset{\text{(From solution)}}{Cu^{2+}(aq) + 2e^-} \longrightarrow \underset{\substack{\text{(Deposits on cathode)} \\ \text{(At cathode)}}}{Cu(s)}$$

(2) Copper (of impure anode) forms copper ions and these go into solution of electrolyte.

$$\underset{\text{(From anode)}}{Cu(s)} \longrightarrow \underset{\substack{\text{(Goes into solution)} \\ \text{(At anode)}}}{Cu^{2+}(aq)}$$

Thus, the net result is transfer of pure copper from anode to the cathode. Impurities like zinc, iron etc., go into solution; while noble impurities like silver, gold etc., are left behind as anode mud.




- ## CORROSION

Any process of deterioration (or destruction) and consequent loss of a solid metallic material, through an unwanted (or unintentional) attack by its environment, starting at its surface, is called corrosion. Thus, corrosion is a proces "reverse of extraction of metals".


The most familiar example of corrosion is rusting of iron, when exposed to the atmospheric conditions. During this, a layer of reddish scale and powder of oxide ($Fe_2O_3$ . x $H_3O$) is formed and the iron becomes weak. Another common example is formation of green films of basic copper, when exposed to moist-air containing carbon dioxide. Similarly, silver article turns black after some time, when exposed to air. This is due to the reaction of Ag with $H_2S$ present in air to form black coloured $Ag_2S$.

**Note:**

(i) It may be pointed out that noble metals such as gold and platinum do not corrode easily.

(ii) The process of corrosion is continuous and causes decrease in strength of the metal

## Prevention of rusting:

**(i)** **By painting:** The corrosion of a metal can be prevented simply by painting the metal surface by grease or varnish that forms a protective layer on the surface of the metal which protect the metal from moisture and air.

**(ii)** **Self-prevention:** Some metals form protective layers.

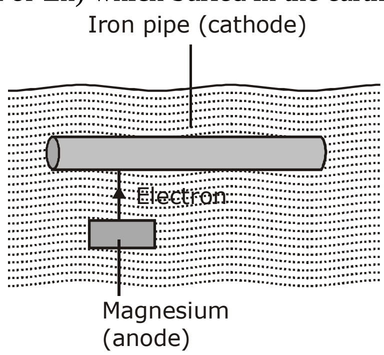
***For example:*** When zinc is left exposed to the atmosphere, it combines with the oxygen of air to form a layer of zinc oxide over its surface. The oxides layer does not allow air to go inside the metal. Thus, zinc is protected from corrosion by its own protective layer.

Similarly, aluminium combines with oxygen to form a dull layer of aluminium oxide on its surface which protects the aluminium from further corrosion.

**(iii)** **Cathodic protection:** In this method the more reactive metal which is more corrosion-prone is connected to a bar of another metal which is less reactive and to be protected. In this process electron flow from the more reactive metal to the less reactive metal. The metal to be protected becomes the cathode and the more reactive metal becomes the anode.

In this way, the two metals form an electrochemical cell and oxidation of the metal is prevented.

**Example:** The pipelines (iron) under the surface of the earth are protected from corrosion by connecting them to a more reactive metal (magnesium or Zn) which buried in the earth and connected to the pipelines by a wire.




**Cathodic Protection**

**(v)** **Oiling and greasing:** Both protect the surface of metal against moisture and chemicals etc. In addition the oil and grease prevent the surface from getting scratched.

**(vi)** **Electroplating:** It is a very common and effective method to check corrosion. The surface of metal is coated with chromium, nickel or aluminium etc. by electrolysis also called **electroplating**. They are quite resistant to the attack by both air and water and check corrosion. If the surface of metal is electroplated by zinc, it is known as **galvanisation** and in case tin metal is used, then the process is called **tinning**.

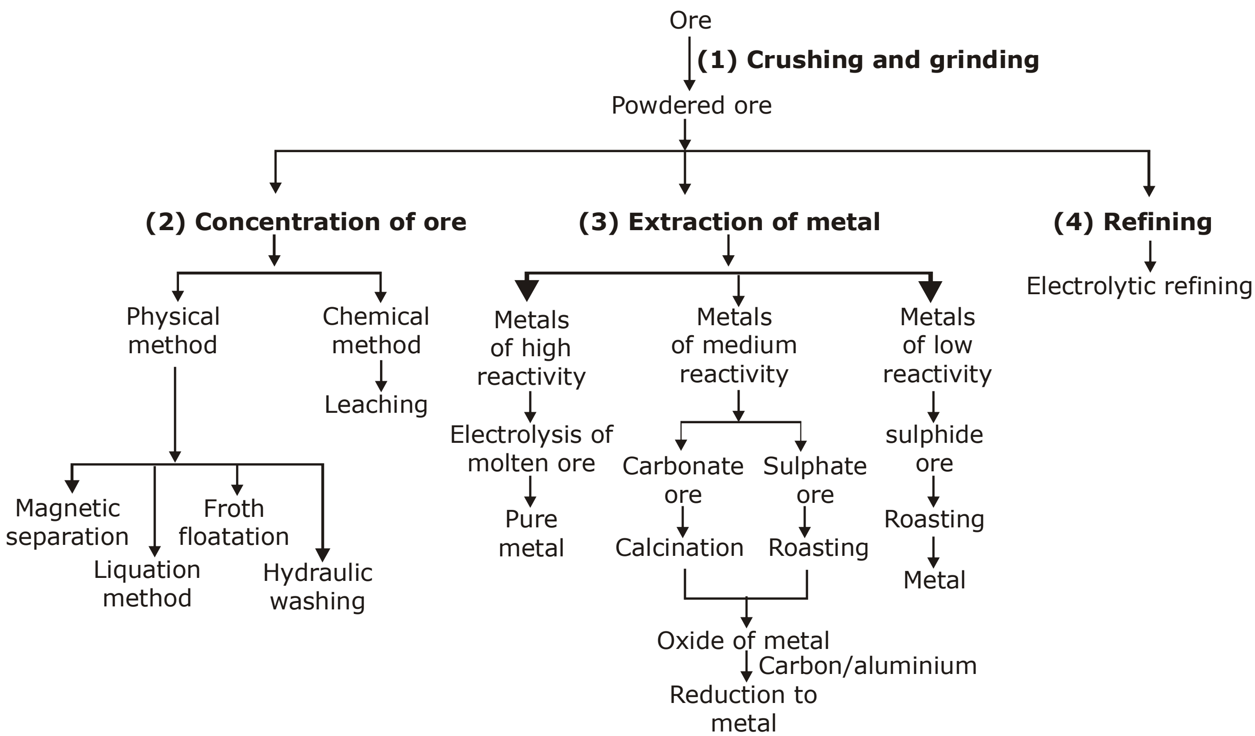
**(vii)** **By alloying:** It is a very good method of improving the properties of a metal.

***For example:*** Iron is the most widely used metal. But it is never used in its pure state. This is because pure iron is very soft and stretched easily when hot. But, it it is mixed with a small amount of carbon (about 0.05%) it becomes hard and strong.

When iron is mixed with nickel and chromium to form stainless steel which is hard and does not rust, i.e. its properties change. In fact, the properties of any metal can be changed, if it is mixed with some other substances.

**(viii)** **Importance of corrosion :** Sometimes corrosion of a metal prevents further corrosion of the underlying metal : For example, when Al is exposed to air a thin coating of $Al_2O_3$ on the metal article is formed. This film, quite adhering and non-porous, thereby it protect the Al metal underneath from further corrosion and damage. This is the reason why Al, being a very reactive metal, is used for making uternsils.

**PROCESS OF METALLURGY**




## • ALLOYING

"An alloy is a homogeneous solid solution of one metal with one or more metals or non-metals." such as brass, bronze, steel etc.

**Purposes of alloy making:** Alloys are generally, made to serve one or more of the following purposes:

(i) To modify chemical activity such as increased resistance to corrosion.

(ii) To harden a metal e.g., copper in gold ornaments.

(iii) To increase the strength and toughness.

(iv) To lower the melting point.

(v) To produce good castings.

For instance, pure iron is very soft and stretches easily, but it is mixed with some metals and non-metals, the alloys formed show considerable improvement in the qualities.

**(i)** **Steel:** When iron has carbon (0.05 to 0.5%) it is called steel. It is hard and strong. It is used for making ships, vehicles and building.

**(ii)** **Stainless Steel:** When steel is mixed with nicked and chromium, it is called stainless steel. It is hard and rust-proof. It is used for making utensils, equipments for feed and dairy industry.

### Some common Alloys

**(i)** **Brass:** It is an alloy of copper and zinc (Cu-60 to 90%; Zn-10 to 40%). It is a yellow coloured alloy and used for making utensils, coins and decorative pieces.

**(ii)** **Bronze:** It is an alloy of copper and tin (Cu-88 to 96%; tin-4 to 12%). It is shining light, yellowish coloured alloy. It is used for making statures, ships and medals.

**(iii)** **Solder:** It is an alloy of lead and tin (lead 33%; tin 67%). Its melting point is low. It is used for soldering electrical wires.

**(iv)** **Alloying of gold:** The purity of gold is expressed in 'carat' and 24 carat gold is supposed to be 100% pure. Pure gold or 24 carat gold tis very soft and cannot be sued for making ornaments. To make is hard, it is alloyed with silver, copper or both. Mosdy 22 carat or 20 carat gold is used for making ornaments. 22 carat gold means 22 parts of pure gold mixed with 2 parts of silver or copper or both.

**(v)** **Duralumin:** It is an alloy of aluminium. It contains 95% of aluminium, 4% of copper, magnesium is 0.5% and 0.5% of manganese. It is stronger and lighter than aluminium. Duralumin is used for making bodies of air crafts, helicopters, jets, kitchen ware like pressure cooker. It is also used for making bodies of ships (due to its resistance to sea water corrosion). It is also known as duralium.

**(vi)** **Amalgam:** It is an alloy of mercury and one or more other metals is known as an amalagam. It may be solid or liquid. A solution of sodium metal in liquid mercury metal is called sodium amalgam, which is used as a reducing agent. Amalgam of silver, tin and zinc is used by dentists for filling in teeth.

**(vii)** What is activity series of metals, Arrange the given metals in activity series: Fe, Au, Zn, Al, Cu.

# EXERCISE – 1

- **PROPERTIES OF METALS AND NON METALS**

1. Explain the meanings of malleable and ductile.
2. You are given a hammer, a battery, a bulb, wires and a switch.
   i. How could you use them to distinguish between samples of metals and non-metals?
   ii. Assess the usefulness of these tests in distinguishing between metals and non-metals.
3. Explain the meaning of malleable and ductile.
4. Give three difference between metals and non- metalsbased on physical properties.
5. Give an example of a metal which
   (a) is a liquid at room temperature. (b) can be easily cut with a knife.
   (c) is the best conductor of heat. (d) is a poor conductor of heat.

- **REACTION OF METALS**

6. Name two metals which does not react with oxygen. What type of oxides are formed when metals combine with oxygen
7. Why sodium is kept immersed in kerosene oil ?
8. Name two metals which are found in nature in the free state.
9. What determines the reactivity of metals ?
10. How would you show that silver is chemically less reactive than copper ?
11. What would you observe when zinc is added to a solution of iron (II) sulphate? Write the chemical reaction that takes place.
12. What are amphoteric oxides? Give two examples of amphoteric oxides.
13. Name two metals which will displace hydrogen from dilute acids, and two metals which will not.
14. **What is activity series of metals, Arrange the given metals in activity series: Fe, Au, Zn, Al, Cu.**
15. Samples of four metals A, B, C and D were taken and added to the following solutions one by one. The results obtained have been tabulated as follows

| Metal | $FeSO_4$ | $CuSO_4$ | $ZnSO_4$ | $AgNO_3$ |
|---|---|---|---|---|
| A. | N.R. | Dis. | – | – |
| B. | Dis. | – | N.R. | – |
| C. | N.R. | N.R. | N.R. | Dis. |
| D. | N.R. | N.R. | N.R. | N.R. |

Here N.R. = No reaction, Dis. = Displacement Use the above table to answer the following questions about metals A, B, C and D.

i. Which is the most reactive metal?

ii. What would you observe if B is added to a solution of copper (II) sulphate?

iii. Arrange the metals A, B, C and D in the order of decreasing reactivity.

16. You must have seen tarnished copper vessels being cleaned with lemon or tamarind juice. Explain why these sour substances are effective in cleaning the vessels
17. What happen when :
    (a) Lead is heated to 400ºC–500°C in air.
    (b) Steam is passed over heated iron.
    (c) Copper oxide is heated with magnesium.
    (d) Aluminium wire is dipped in heating water.
18. Metallic oxides of zinc, magnesium and copper were heated with the following metals.

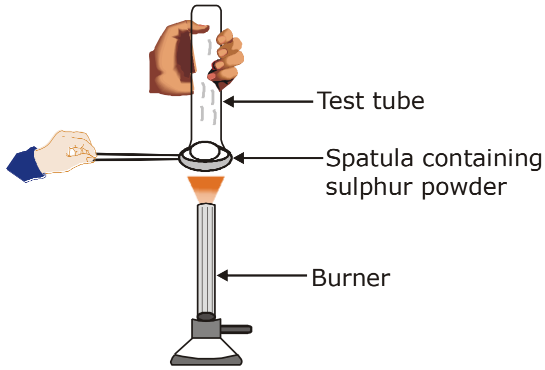
| Metal | Zinc | Magnesium | Copper |
|---|---|---|---|
| Zinx oxide | – | – | – |
| magnesium oxide | – | – | – |
| Copper oxide | – | – | – |

19. In which cases will you find displacement reactions taking place?

## • REACTIONS OF NON METALS

20. What type of oxides is formed when non-metals combine with oxygen?
21. An element reacts with oxygen to form an oxide which dissolves in dilute hydrochloric acid. The oxide also turns a solution of red litmus blue. Is the element a metal or a non-metal ? Explain with the help of a suitable example.

22. Pratyush took sulphur powder on a spatula and heated it. He collected the gas evolved by inverting a test tube over it, as shown in figure below.




**Collection of Gas**

(a) What will be the action of gas on

(i) dry litmus paper?

(ii) moist litmus paper?

(b) Write a balanced chemical equation for the reaction taking place.

23. Differentiate between metal and non-metal on the basis of their chemical properties.

- ## Properties of ionic compounds

24. Write the electron-dot structures for sodium, oxygen and magnesium.

(i) Show the formation of $Na_2O$ and MgO by the transfer of electrons.

(ii) What are the ions present in these compounds

25. Why do ionic compounds have high melting points

26. Give electron dot structure of chlorine and oxygen.

27. Ionic compounds are good conductors of electricity. Comment

28. Name a metal which occurs as fluoride.

## Metallurgy

29. Define the following terms

(i) Mineral (ii) Ore (iii) Gangue

30. What chemical process is used for obtaining a metal from its oxide ?
31. Name two metals which may occur as sulphides. Which gas is produced when dilute hydrochloric acid is added to a reactive metal? Write the chemical reaction when iron reacts with dilute $H_2SO_4$.
32. An oxide ore has been found to contain some impurities which are magnetic. State the process to concentrate this ore.
33. Name the process in relation to metallurgy whereby an ore is heated strongly in absence of air.
34. What types of ores are treated in ‘calcination’
35. Name the process in relation to metallurgy whereby an ore is heated in excess of air or oxygen.
36. Name an ore of zinc other than zinc oxide. By what process can this ore be converted to zinc oxide ?
37. A man went door to door posing as a goldsmith, He promised to bring back the glitter of old and dull gold ornaments. An unsuspecting lady gave a se: of gold bangles to him which he dipped in a particular solution,

The bangles sparkled like new but their weight was reduced drastically. The lady was upset but after a futile argument the man beat a hasty retreat. Can you play the detective to find out the nature of the solution he had used?

38. Give reasons.

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

    (b) Sodium, potassium and lithium are stored under oil.

    (c) Aluminium is a highly reactive metal, yet it is used to make utensils for cooking.

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

39. Are all pure liquids bad conductors of electricity?

    (a) Name a liquid which is a good conductor of electricity but does not undergo electrolysis on passing electric current.

    (b) If pure water is used, no electrolysis takes place. Why?

40. Name one practical application based on the phenomenon of electrolysis.

# EXERCISE – 2

- **Metals**

1. What is the equation of reaction of iron with steam?
2. What is the reason for high melting point of ionic compounds?
3. State two properties of sodium in which it shows behaviour which is not expected from its classification as a metal.
4. An element E combines with $O_2$ to form an oxide $E_2O$, which is a good conductor of electricity? Answer the following.
   (i) How many electrons will be present in the outer most shell of E?
   (ii) Write the formula of the compound formed when it combines with chlorine.
5. What happens to the electrical conductivity of a metal when it is heated?

- **Non – Metals**

6. An element X on reacting with $O_2$ forms $X_2O$. This oxide dissolves in water and turns blue litmus paper red. Predict the nature of element whether it is a metal or a non metal.

- **Reaction of Metals and Non – metals**

7. What is the reason for high melting point of ionic compounds?
8. Ionic compounds are bad conductors of electricity but conduct electricity in the fused sate. Explain.
9. A yellow coloured powder 'X' is soluble in carbon disulfide. It burns with a blue flame forming suffocating smelling gas which turns moist blue litmus red. Identify 'X' and gives chemical reaction. Identify it as a metal or a non – metal.

- **Metallurgy**

10. What is "gangue"?
11. What is the purpose of coke in metallurgical processes? Name a metal extracted by this process.
12. A metal acts as a good reducing agent. It reduces $Fe_2 O_3$ and $MnO_2$. The reaction with $Fe_2 O_3$ is used for welding broken railway tracks. Identify the metal and write all the chemical reaction.

- **Corrosion & Alloys**

13. What is amalgam?
14. What is the purpose a adding C to molten Iron?

# EXERCISE – 3

1. Which of the following pairs will give displacement reactions?
   (a) NaCl solution and copper metal
   (b) $MgCl_2$ solution and aluminium metal
   (c) $FeSO_4$ solution and silver metal
   (d) $AgNO_3$ solution and copper metal
2. 55Metal have ............no. of electrons in their outer most shell –
   (a) 1 to 8 (b) 7 to 9 (c) 1 to 3 (d) 10 to 12
3. 56Which oxide is neutral?
   (a) $NO_2$ (b) MgO (c) $H_2O$ (d) None of these
4. The constituent of haemoglobin is –
   (a) Iron (b) Sodium (c) Copper (d) Magnesium
5. The most abundant metal in the earth crust is –
   (a) Al (b) Fe (c) O (d) Cu
6. Because of high electro positively, the atom of metals can easily form –
   (a) Positive ions (b) Negatively ions (c) Neutral ions (d) Covalent bonds
7. A purple-coloured solid halogen is:
   (a) CI (b) Br (c) I (d) F
8. Element M is a metal and its chloride has the formula $MCl_2$. The element most likelybelongs to which group of the period IC table'?
   (a) 1 (b) 2 (c) 15 (d) 17
9. An element A is soft and can be cut with a knife. This is very reactive to air and cannot be kept open in air. It reacts vigorously with water. Identify the element from the following.
   (a) Mg (b) Na (c) P (d) Ca
10. An element reacts with oxygen to give a compound with a high melting point. This compound is also soluble in water. The element is likely to be
    (a) Calcium (b) Carbon (c) Silicon (d) Iron
11. Which of the following property is generally not shown by metals?
    (a) Electrical conduction (b) Sonorous in nature
    (c) Dullness (d) Ductility
12. The ability of metals to be drawn into thin wire is known as:
    (a) Ductility (b) malleability (c) sonorousity (d) conductivity
13. Which of the following metals exist in their native state in nature?
    (i) Cu (ii) Au (iii) Zn (iv) Ag
    (a) (i) and (ii) (b) (ii) and (iii) (c) (ii) and (iv) (d) (iii) and (iv)
14. Generally metals are solid in nature. Which one of the following metals is found in liquid state at room temperature?
    (a) Na (b) Fe (c) Cr (d) Hg
15. Generally non-metals are non-conductors of electricity. Which of the following is a good conductor of electricity?
    (a) Diamond (b) Graphite (c) Sulphur (d) Fullerene
16. Electrical wires have a coating of an insulating material. The material, generally used is

(a) Sulphur (b) Graphite (c) PVC (d) All can be used

17. Food cans are coated with tin and not with zinc because
    (a) zinc is costlier than tin.
    (b) zinc has a higher melting point than tin.
    (c) zinc is more reactive than tin.
    (d) zinc is less reactive than tin.
18. Which one of the following four metals would be displaced from the solution of its salts by other three metals?
    (a) Mg (b) Ag (c) Zn (d) Cu
19. The electronic configurations of three elements X, Y and Z are X — 2, 8: Y — 2, 8, 7 and Z — 2, 8, 2. Which of the following is correct?
    (a) X is a metal (b) Y is a metal
    (c) Z is a non-metal (d) Y is a non-metal and Z is a metal
20. Which one of the following metals do not react with cold as well as hot water?
    (a) Na (b) Ca (c) Mg (d) Fe
21. Which of the following metals are obtained by electrolysis of their chlorides in molten state?
    (i) Na (ii) Ca (iii) Fe (iv) Cu
    (a) (i) and (iv) (b) (iii) and (iv) (c) (i) and (iii) (d) (i) and (ii)
22. What happens when calcium is treated with water?
    (i) It does not react with water.
    (ii) It reacts violently with water.
    (iii) It reacts less violently with water.
    (iv) Bubbles of hydrogen gas formed stick to the surface of calcium.
    (a) (i) and (iv) (b) (ii) and (iii) (c) (i) and (ii) (d) (iii) and (iv)
23. Generally metals react with acids to give salt and hydrogen gas. Which of the following acids does not give hydrogen gas on reacting with metals (except Mn and Mg)?
    (a) $H_2SO_4$ (b) HCI (c) $HNO_3$ (d) All of these
24. The composition of aqua-regia is
    (a) Dil.HCI : Conc. $HNO_3 \leftrightarrow 3 : 1$ (b) Conc. HCI: Dil. $HNO_3 \leftrightarrow 3 : 1$
    (c) Conc. HCl: Conc. $HNO_3 \leftrightarrow 3 : 1$ (d) Dil. HCl: Dil. $HNO_3 \leftrightarrow 3 : 1$
25. Which of the following are not ionic compounds?
    (i) KCl (ii) HCl (iii) $CCl_4$ (iv) NaCl
    (a) (i) and (ii) (b) (ii) and (iii) (c) (iii) and (iv) (d) (i) and (iii)
26. Which one of the following properties is not generally exhibited by ionic compounds?
    (a) Solubility in water
    (b) Electrical conductivity in solid state
    (c) High melting and boiling points
    (d) Electrical conductivity in molten state
27. If copper is kept open in air, it slowly loses its shining brown surface and gains a green coating. It is due to the formation of
    (a) $CuSO_4$ (b) $CuCO_3$ (c) $Cu(NO_3)_2$ (d) CuO

28. Which of the following is used for making magnets?
(a) duralumin (b) magnalium (c) bronze (d) alnico
29. $Al_2.O_3\ 2SiO_2.2H_2O$ is the chemical formula of–
(a) Bauxite (b) Haemetite (c) China Clay (d) Monazite
30. Which compound is used in photography –
(a) $AgNO_3$ (b) AgO (c) AgBr (d) AgCl
31. Carnallite is the mineral of –
(a) Na (b) Ca (c) Mg (d) All of these
32. Volatile metals are purified by –
(a) Oxidation (b) Distillation (c) Liquation (d) Electrolytic refining
33. Amalgam is the homogeneous mixture of –
(a) Metal and metal (b) Metal and mercury
(c) Metal and non-metal (d) All of these
34. Which of the following is a ferrous alloy–
(a) Solder (b) Brass (c) Magnalium (d) Steel
35. Cinnabar is an ore of –
(a) Mercury (b) Copper (c) Calcium (d) Lead
36. Which of the following statements is correct–
(a) All minerals are ores (b) All ores are minerals
(c) Some ores are minerals (d) None is correct
37. Stainless steel is very useful material, for our life. In stainless steel, iron is mixed with
(a) Ni and Cr (b) Cu and Cr (c) Ni and Cu (d) Cu and Au
38. Alloys are homogeneous mixtures of a metal with a metal or non-metal. Which among the following alloys contain non-metal as one of its constituents?
(a) Brass (b) Bronze (c) Amalgam (d) Steel
39. Which among the following alloys contain mercury as one of its constituents?
(a) Stainless steel (b) Alnico (c) Solder (d) Zinc amalgam
40. Although metals form basic oxides, which of the following metals form an amphoteric oxide?
(a) Na (b) Ca (c) Al (d) Cu
41. Which of the following methods is suitable for preventing an iron frying pan from rusting?
(a) Applying grease (b) Applying paint
(c) Applying a coating of zinc (d) all of the above.
42. Which of the following oxide(s) of iron would be obtained on prolonged reaction of iron with steam?
(a) FeO (b) $Fe_2O_3$ (c) $Fe_3O_4$ (d) $Fe_2O_3$ and $Fe_3O$

# EXERCISE – 4

1. Which among the following is a rigid non-metal:
(a) Copper. (b) Carbon (c) Iron. (d) Wood.
2. Which among the following is a metal used in electric bulb ?
(a) Ar. (b) W. (c) Un. (d) Na.
3. Which among the following is the alotrop of carbon is conductor of electricity?
(a) Fullurenes (b) Coal. (c) diamond (d) graphite .

4. All ___________ are good conductors of heat and electricity.
   (a) Metals. (b) Non-metals. (c) Metalloids. (d) Gases.
5. Which metal can be easily cut with a knife?
   (a) Iron. (b) Aluminum. (c) Sodium. (d) Zinc.
6. Which among the following shows the correct meaning of malleable for metals?
   (a) They are sonorous (b) They can be drawn into sheets.
   (c) They can be drawn into wires. (d) None of these.
7. Which among the following shows the correct meaning of ductility for metals?
   (a) They can be drawn into wires. (b) They can be drawn into.
   (c) They are shiny. (d) None of these.
8. White phsphorus is stored in
   (a) ether (b) water (c) alcohol (d) kerosene oil
9. Which of the following is a solid at STP?
   (a) fluorine (b) chlorine (c) bromine (d) iodine
10. Generally non-metals are not lustrous. Which of the following non-metals is lustrous?
    (a) Sulphur (b) Oxygen (c) Nitrogen (d) Iodine
11. Which of the following non-metals is a liquid?
    (a) Carbon (b) Bromine (c) Phosphorus (d) Sulphur
12. Arrange the following metal in the increasing order of their reactivity towards water: Zinc, Iron, Magnesium, Sodium
    (a) iron < Magnesium < sodium < zinc (b) iron < zinc < magnesium < sodium
    (c) magnesium < iron < sodium < zinc (d) sodium < iron < magnesium < zinc
13. The formula of Oleum is
    (a) $H_2SO_4$ (b) $H_2S_2O_7$ (c) $H_2S_2O_3$ (d) $H_2S_2O_6$
14. Which among the following statements is incorrect for magnesium metal?
    (a) It burns in oxygen with a dazzling white flame.
    (b) It reacts with cold water to form magnesium oxide and evolves hydrogen gas.
    (c) It reacts with hot water to form magnesium hydroxide and evolves hydrogen gas.
    (d) It reacts with steam to form magnesium hydroxide and evolves hydrogen gas.
15. Reaction between X and Y forms compound Z. X loses electron and y gains electron. Which of the following properties is not shown by Z?
    (a) Has high melting point
    (b) Has low melting point
    (c) Conducts electricity in molten state
    (d) Occurs as solid
16. Which of the following can undergo a chemical reaction?
    (a) $MgSO_4$ + Fe (b) Zn $SO_4$ + Fe (c) $MgSO_4$ + Pb (d) Cu $SO_4$ + F
17. Metals are refined by using different methods. Which of the following metals are refined by electrolytic refining?

(i) Au (ii) Cu (iii) Na (iv) K

(a) (i) and (ii) (b) (i) and (iii) (c) (ii) and (iii) (d) (ii) and (iv)

18. An alloy is

(a) An element (b) A compound

(c) A homogeneous mixture (d) A heterogeneous mixture

19. An electrolytic cell consists of

(i) Positively charged cathode (ii) Negatively charged anode

(iii) Positively charged anode (iv) Negatively charged cathode

(a) (i) and (ii) (b) (iii) and (iv) (c) (i) and (iii) (d) (ii) and (iv)

20. During electrolytic refining of zinc, it gets

(a) Deposited on cathode (b) Deposited on anode

(c) Deposited on cathode as well as anode (d) Remains in the solution

21. Silver articles become black on prolonged exposure to air. This is due to the formation of

(a) $Ag_3N$ (b) $Ag_3O$ (c) $Ag_2S$ (d) $Ag_2S$ and $Ag_3N$

22. Galvanisation is a method of protecting iron from rusting by coating it with a thin layer of

(a) Gallium (b) Aluminium (c) Zinc (d) Silver

23. Aluminium is used for making cooking utensils. Which of the following properties of aluminium are responsible for the same?

(i) Good thermal conductivity (ii) Good electrical conductivity

(iii) Ductility (iv) High melting point

(a) (i) and (ii) (b) (i) and (iii) (c) (ii) and (iii) (d) (i) and (iv)



## Matrix Match Type

1. Match the column

| Column I | Column II |
|---|---|
| (A) Galena | (p) $Fe_2O_3$ |
| (B) Cinnabar | (q) $AI_2O_3.\ 2H_2O$ |
| (C) Haematite | (r) HgS |
| (D) Bauxite | (s) PbS. |

2. Match the column

| Column I | Column II |
|---|---|
| (A) Leaching | (p) Dolomite |

| | |
|---|---|
| (B) Magnetic separation | (q) Zinc blende |
| (C) Froth floatation | (r) Chromite |
| (D) Calcination | (s) Bauxite |

3. Match the column

| Column I | Column II |
|---|---|
| (A) Aircrafts | (p) Stainless steel |
| (B) Utensils | (q) Bronze |
| (C) Medals | (r) Duralumin |
| (D) Balace beam | (s) Magnalium |

4. Match the column

| Column I | Column II |
|---|---|
| (A) Brass | (p) Cu, Sn |
| (B) Bronze | (q) Pb, Sn |
| (C) Solder | (r) Cu, Zn |
| (D) Magnalium | (s) AI, Mg |

5. Match the column

| Column I | Column II |
|---|---|
| (A) Iron | (p) Electrolysis |
| (B) Aluminium | (q) Roasting |
| (C) Copper | (r) Heating with carbon |
| (D) Sodium | (s) Leaching |

6. Match the column

| Column I | Column II |
|---|---|
| (A) Amphoteric oxide | (p) Solder |
| (B) Oxide reduced by carbon | (q) Roasting |
| (C) Conversion of sulphide ore into its oxide | (r) Zinc oxide |
| (D) Alloy used in joining electrical wires | (s) Aluminum oxide |

7. Match the column

| Column I | Column II |
|---|---|
| (A) A metal unreactive towards dilute acids and oxygen | (p) zinc |
| (B) A metal stored in kerosene | (q) aluminium |

| | |
|---|---|
| (C) A metal used for galvanisation | (r) gold |
| (D) A metal used for making foils for warpping food | (s) sodium |

8. Match the column

| Column I | Column II |
|---|---|
| (A) An acid oxide | (p) Oxygen |
| (B) Acid rain | (q) Bromine |
| (C) Electronegative element | (r) phosphorus pentoxide |
| (D) Liquid non-metal | (s) Oxides of sulphur |

9. Match the column

| Column I | Column II |
|---|---|
| (A) 2, 8, 1 | (p) Neon |
| (B) 2, 8, 7 | (q) Sulphur |
| (C) 2, 8, 6 | (r) Chlorine |
| (D) 2, 8 | (s) Sodium |

10. Match the column

| Column I | Column II |
|---|---|
| (A) Good conductor of heat and electricity | (p) NaCI |
| (B) Soluble in water | (q) S |
| (C) Poor conductor of electricity | (r) Cu |
| (D) Yellow flame | (s) Na |

## Assertion and Reason Type

Directions: In each of the following questions, a statement of Assertion (A) is given followed by a corresponding statement of Reason (R) just below it. Of the statements, mark the correct answer as

(a) If both assertion and reasons are true and reason is the correct explanation of assertion
(b) If both assertion and reason are true but reason is not the correct explanation of assertion
(c) If assertion is true but reason is false
(d) If assertion is false but reason is true

1. Assertion: Leaching is a process of reduction of oxide to metal.

Reason: Leaching involves treatment of the ore with a suitable reagent so as to make it soluble while impurities remain insoluble.

2. Assertion: Zinc is used in the galvanisation of iron.
   Reason: its coating on iron articles increases their life by protecting iron from rusting.
3. Assertion: Forth floatation process is based on the different melting nature of ore and gangue particles.
   Reason: Mustard oil is used as frothing agent in the process
4. Assertion: Different metals have different reactivities with water and dilute acids.
   Reason: Reactivity of a metal depends on its position in the reactivity series.
5. Assertion: In smelting, the roasted ore is heated with powdered coke in presence of flux.
   Reason: Oxides are reduced to metals by carbon or carbon monoxide and impurities are removed as slag.
6. Assertion: Elements Cu, Ag Au, Pt noble gases etc. occur in native state in nature.
   Reason: Elements which are not attacked by moisture, oxygen and $CO_2$ of air occur in native stat.
7. Assertion: Aluminum occurs in nature as bauxite ($AI_2O_3.2H_2O$) and clay ($AI_2O_3.2SiO_2.2H_2O$). However AI is conveniently and economically isolated from the bauxite.
   Reason: Bauxite is an ore of aluminium. The process of extracting metals from their ores is called metallurgy.
8. Assertion: Aluminum is used as a reducing agent in the extraction of chromium from its oxide ($Cr_2O_3$)
   Reason: Reduction by aluminum is known as Gold Schmidt thermite process or aluminothermite process.
9. Assertion: Iron can be obtained from $Fe_2O_3$ by reduction with aluminium.
   Reason: The process is known as thermite process.
10. Assertion: Sulphide ores such as zinc blende (ZnS), copper pyrites ($CuFeS_2$), galena (PbS) etc. are generally concentrated by froth floatation method.
    Reason: The mathod is based on the fact that the surface of the sulphide ore is preferentially wetted by oils while that of gangue is preferably wetted by water.
11. Assertion: zinc is obtained from the roasted or calcined ore (ZnO) by heating with calculated quantity of coal or coke in a reverberatory furnace, when C reduces the metal oxide to free metal.
    Reason: The process of extracting the metal by reduction of its oxide ore with carbon is called smelting.
12. Assertion: For acidic impurities like $SiO_2$ present in an ore, basic fluxes are used.
    Reason: Silica is a basic flux
13. Assertion: Sulphide ores are usually concentrated by froth floatation process.
    Reason: In this process, pine oil is used as frothing agent.
14. Assertion: In calcination, the ore is heated with calcium.
    Reason: Calcination is carried out in reverberatory furnace.
15. Assertion: The ores are unusually associated with impurities called gangue or matrix. These impurities have to be removed from the ore before extraction of metal.
    Reason: The removal of unwanted earthy impurities from the ore is called ore dressing or concentration of ores and the process used to concentrate the ore is called to concentrate the ore is called the benefaction process.
16. Assertion: gold occurs in native state.
    Reason: Gold is a noble metal.
17. Assertion: The composition of rust is $Fe_3O_7$.
    Reason: Iron gets rusted in moist air.

18. Assertion: Bronze contains Sn (90%), Cu (10%) and Zn (10%).
    Reason: Bronze does not get corroded in presence of air and water.
19. Assertion: Impure copper is purified by electro-refining.
    Reason: Copper is a good conductor of electricity.
20. Assertion: Potassium is not obtained by electrolysis of fused KCI.
    Reason: Fused KCI does not conduct electricity.

## Passage comprehension

**PASSAGE – 1:** Metals occur in nature in the free as well as in the combined state. The less reactive metals are generally found in the free state. Most of the metals, however are found in the combined form as minerals. The minerals from which metals can be obtained on a commercial scale are called ores. In other words, the minerals from which metals can be obtained on a commerical scale are called ores. In other words, the minerals from which metals can be extracted profitably are called ores. Thus, bauxite ($AI_2O_3$. $2H_2O$) and clay ($AI_2O_3$. $2SiO_2$. $2H_2O$) are minerals of aluminium. However, it is a bauxite that is chiefly used to obtain aluminium commercially. So, bauxite, and not clay, is an ore of aluminium.

1. Metal which occurs in native state is
   (a) Na (b) Ca (c) Mn (d) Ag
2. Which of the following is a sulphide ore?
   (a) Galena (b) Cryolite (c) Cuprite (d) Bauxite
3. Halide ore is
   (a) Cinnabar (b) galena (c) calamine (d) horn silver
4. Which of the folowing is a strategic metal?
   (a) Scandium (b) Rubidium (c) Gallium (d) Zirconium

**PASSAGE – 2:** The ore mined from the earth contains some unwanted subtances called gangue. Enrichment of ore is done by various methods depending upon the nature of the impurities. Hydraullic washing is the process based on the difference indensities of ore and gangue particles, i.e., if ore particles are heavy and gangue particles are light, then lighter matrix can be removed by stream of water on large wooden table having obstacles. Forth floatation method is used for ores with different wetting properties of ore and gangue particles. On adding sulphide ore in a mixture of oil and water, the sulphide particles are wetted by water. On passing air in this mixture, sulphide ore particles form light oily froth and reach the surface whereas gangue particles settle down at the bottom. Few ores are enriched by chemical processess.

1. Which method is used for the purification of bauxite ore?
   (a) Levigation (b) Leaching (c) Electrolysis (d) Magnetic separation
2. In the froth floatation process for the purification of minerals, the ore particles float because
   (a) They are light
   (b) They are insoluble
   (c) Their surface is preferentially wetted by oil
   (d) They bear an electrostatic charge
3. The process in which lighter earthy particles are removed by jet of water is called
   (a) Leaching
   (b) Levigation
   (c) Froth floation
   (d) None of these
4. The rocky and silicons matter associated with an ore is called

(a) Slag (b) mineral (c) gangue (d) flux

**PASSAGE – 3:** The arrangment of metals in a vertical column in the decreasing order of their reactivites is called the reactivity series or activity series of metals.

The most reactive metal is at the top position of the reactivity series. The least reactive metal is at the bottom of the reactivity series.

By careful and repreated experiments, the reactivity series of metals has been eestablished.

The study was made mainly for the reactions between metals and water and metals and acids in which hydrogen was one product in many cases. Hydrogen, though a nonmetal, has been included in the activity series of metals only for cmparison Apart from it, the hydrogen atom also has tendency to lose it valence elecron the form cation like the behaviour shown by metals. Thus, $H \rightarrow H^{+} + e^{-}$

1. What metal can be displaced by copper from its salt solution?
   (a) Zinc (b) silver (c) Iron (d) Lead
2. An element 'X' after reacting with acids liberate hydrogen gas and can displace lead and tin from their salt solution. The metal 'X' is
   (a) Copper (b) gold (c) nickel (d) hydrogen
3. The most reactive metal is
   (a) Potassium (b) barium (c) sodium (d) calcium
4. The metal which does not liberate hydrogen gas after reacting with acid is
   (a) Zinc (b) lead (c) tin (d) gold
5. The only non-metal involved in activity series of metal is
   (a) Sulphur (b) chlorine (c) hydrogen (d) magnesium

**PASSAGE – 4:** Corrosion may be defined as : The process of slow eating up of a metal by the gases and water vapours present in air due to formation of certain chemical componds.

Corrosion is favoued by the following factors:

(i) Position of metal in the reactivity series: Active metals placed above hydrogen in the reactivity series are easily corroded as compared to the metals which are placed below hdrogen.

(ii) Air and moisture: The presence of water vapours and gases like $CO_2$, $SO_2$ etc. in air helps the process of corrosion.

(iii) Uneven metal surface: If the surface of metal is uneven, it will have certain depressions. Water drops will stick in these and take part in the chemical process leading to corrosion.

(iv) Presence of salts: Presence of salts or electrolytes in water promotes corrosion. For example, rusting of iron is faster in sea water (also called saline water) than in ordinary water or distilled water.

1. Chemically rust is
   (a) Hydrated ferrous oxide
   (b) Hydrated ferric oxide
   (c) Only ferric oxide
   (d) None of these
2. Following, processes are very common for checking rusting of iron
   (a) Galvanization
   (b) Tinning
   (c) Electroplating

(d) All of these

3. Copper and silver get corroded in air by developing a coloured layer. The colour of the layers respectively is
(a) Green and black
(b) Brown and black
(c) Green and blue
(d) Black and green

# ANSWER KEY

## EXERCISE – 3

| **Ques.** | **1.** | **2.** | **3.** | **4.** | **5.** | **6.** | **7.** | **8.** | **9.** | **10.** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Ans.** | d | c | a, c | a | a | a | c | b | b | a |
| **Ques.** | **11.** | **12.** | **13.** | **14.** | **15.** | **16.** | **17.** | **18.** | **19.** | **20.** |
| **Ans.** | c | a | c | d | b | c | c | b | d | d |
| **Ques.** | **21.** | **22.** | **23.** | **24.** | **25.** | **26.** | **27.** | **28.** | **29.** | **30.** |
| **Ans.** | d | d | c | c | b | b | b | d | c | c |
| **Ques.** | **31.** | **32.** | **33.** | **34.** | **35.** | **36.** | **37.** | **38.** | **39.** | **40.** |
| **Ans.** | c | b | b | d | a | b | a | d | d | c |
| **Ques.** | **41.** | **42.** | | | | | | | | |
| **Ans.** | c | c | | | | | | | | |



## EXERCISE – 4

| **Ques.** | **1.** | **2.** | **3.** | **4.** | **5.** | **6.** | **7.** | **8.** | **9.** | **10.** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Ans.** | b | b | d | a | c | b | a | b | d | d |
| **Ques.** | **11.** | **12.** | **13.** | **14.** | **15.** | **16.** | **17.** | **18.** | **19.** | **20.** |
| **Ans.** | b | b | b | b | b | d | a | c | b | a |
| **Ques.** | **21.** | **22.** | **23.** | **24.** | **25.** | **26.** | **27.** | **28.** | **29.** | **30.** |
| **Ans.** | c | c | d | | | | | | | |
| **Ques.** | **31.** | **32.** | **33.** | **34.** | **35.** | **36.** | **37.** | **38.** | **39.** | **40.** |
| **Ans.** | | | | | | | | | | |

## MATCH THE FOLLOWING TYPE

1. A-(q) B-(s) C-(p) D-(r)

2. A-(q) B-(r) C-(p) D-(s)

3. A-(q) B-(r) C-(p) D-(s)

4. A-(q) B-(p) C-(s) D-(r)

5. A-(q) B-(r) C-(s) D-(p)

## ASSERTION REASON TYPE

| Ques. | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. |
|---|---|---|---|---|---|---|---|---|---|---|
| Ans. | c | c | a | d | d | b | b | c | d | b |
| Ques. | 11. | 12. | 13. | 14. | 15. | 16. | | | | |
| Ans. | a | c | a | b | a | d | | | | |

## COMPREHENSION TYPE

| Ques. | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. |
|---|---|---|---|---|---|---|---|---|---|---|
| Ans. | c | b,c | b | c | b | a | b | a | c | d |
| Ques. | 11. | 12. | 13. | 14. | | | | | | |
| Ans. | a | c | d | a | | | | | | |

## INTEGER TYPE QUESTIONS

| Ques. | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|
| Ans. | 5 | 0 | 2 | 6 | 3 |