



CHAPTER

5

METALS AND NON-METALS

In unit 1, we have learnt that the earliest classification of elements on the basis of their common features was the grouping of the elements into two broad categories— **metals** and **non-metals**. In the periodic table, the metals are placed on the left hand side and in the centre of the periodic table. On the other hand, the non-metals are placed on the right hand side of the table (Table 5.1)

The periodic table is organized into groups based on the color of the element boxes:

- Metals (Dark Grey):** Includes elements like Li, Na, K, Rb, Cs, Mg, Ca, Sr, Ba, Sc, Y, La, Hf, Ta, W, Re, Os, Ir, Pt, Au, Hg, Zn, Cd, In, Sn, Pb, Bi, Po, At, Rn, Kr, Xe, and Ar.
- Non-metals (Light Grey):** Includes elements like C, N, O, F, S, Cl, Br, I, and At.
- Metalloids (Medium Grey):** Includes elements like B, Si, P, As, Se, Te, and Po.
- Noble gases (White):** Includes He, Ne, Ar, Kr, Xe, and Rn.

Arrows indicate specific classifications:

- An arrow labeled "Non-metal" points to Hydrogen (H).
- An arrow labeled "Metalloids" points to Boron (B).
- An arrow labeled "Metals" points to Manganese (Mn).

Table 5.1. Position of metals and non-metals in the Periodic Table

The metals and nonmetals are separated from each other in the periodic table by a zig-zag line. The elements close to zig-zag line show some properties of metals and some properties of non-metals. They are **metalloids**. The common examples of metalloids are germanium (Ge), arsenic (As), antimony (Sb), tellurium (Te) and polonium (Po). Although metals show a great diversity of properties, there are a few unifying characteristics, which set them apart from the non-metallic elements.

5.1. PHYSICAL PROPERTIES OF METALS AND NON-METALS

Some of the examples of metals are Iron, Aluminium, Copper, Silver, Gold, Tin, Lead, Mercury, Zinc, Sodium, Potassium, Calcium and Magnesium. All the metals are solids, except Mercury which is a liquid at room temperature.

Some of the examples of non-metals are Carbon, Sulphur, Phosphorus, Silicon, Hydrogen, Oxygen, Nitrogen, Chlorine, Bromine, Iodine, Helium, Neon and Argon.

Carbon occurs as diamond and graphite. Out of the non-metals, five are solids, one (bromine) is a liquid whereas remainings are gases.

Activity 5.1.

- ☞ Take samples of metals iron, copper, lead, silver, zinc and aluminium.
- ☞ Take samples of non-metals sulphur and graphite (carbon).
- ☞ Clean the surface of each sample of the metals by rubbing them with sand paper.
- ☞ Note their appearances.
- ☞ Carry out the same activities with the samples of non-metals.

Metals, in their pure state, have a shining surface. This property is called **metallic lustre**. **Non-metals, in general, do not have such property.**

Activity 5.2.

- ☞ Take pieces of iron, aluminium, copper and zinc.
- ☞ Try to cut these metals with a sharp knife.
- ☞ Note your observations.
- ☞ Hold a piece of sodium metal with a pair of tongs. Dry it by pressing between the folds of a filter paper.
- ☞ Put it on a watch-glass or filter paper and try to cut it with a knife.
- ☞ Note your observations.
- ☞ Repeat the activity with non-metals, sulphur and graphite.
- ☞ Note the differences.

We find that **metals are generally hard**. Only a few metals like sodium are soft i.e. the hardness varies from metal to metal. **Non-metals are generally soft.**

Activity 5.3.

- ☞ Take pieces of iron, zinc, lead, aluminium and copper.
- ☞ Place any one metal on a block of iron and strike it four or five times with a hammer. What do you observe?
- ☞ Repeat with other metals.
- ☞ Record the change in the shape of these metals.
- ☞ Repeat the activities with the samples of non-metals-sulphur and graphite
- ☞ Note the differences.

We find that **metals can be beaten into thin sheets**. This property is called **malleability**. Gold and silver are the most highly malleable metals.

Non-metals are not malleable.

Activity 5.4.

- ☞ Take wires of copper, iron and aluminium. How can these wires be formed?
- ☞ Can we draw out wires of sulphur and graphite ?

Metals can be drawn into thin wires. This property is called **ductility**. Gold is the most ductile metal. One gram of gold can be drawn into very thin wires.

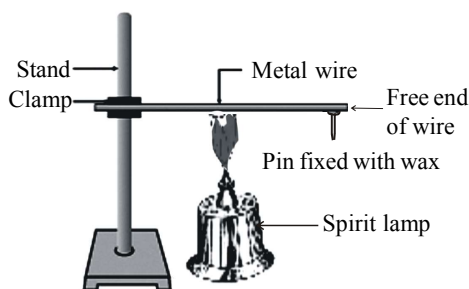


Fig. 5.1. Metals are good conductors of heat

Activity 5.5.

- ☞ Take a thick copper or aluminium wire. Clamp it horizontally as shown in Fig. 5.1
- ☞ Fix a pin with the help of wax (this can be done by keeping the pin over the wire and putting molten wax over it and allowing to cool).
- ☞ Heat the wire with a spirit lamp, candle or a burner near the place where it is clamped.
- ☞ What do you observe after some time?
- ☞ Does the metal wire melt ?

It will be observed that the wax melts and the pin falls. This shows that heat flows through the metal wire. Further, the wire does not melt even after long heating. The above activity shows that **metals are good conductors of heat and have high melting points**. Silver and copper are very good conductors of heat while lead and mercury are comparatively poor conductors. Non - metals do not have this property. *They are poor conductors of heat.*

You must have observed that if we connect a bulb to a battery through a metal wire, the bulb glows. We use copper or aluminium wires to carry electric current in our homes. This shows that **metals allow electric current to pass through them. Thus, metals are good conductors of electricity**. We have seen that wires which carry current in our homes have a Plastic coating of polyvinylchloride (PVC). This coating protects us from the current when we use the metal wires.

Most of the metals produce sound when they strike a hard surface or hard object. The **metals that produce a sound on striking a hard surface is said to be sonorous**. Strike a hard surface with a graphite rod. Can you get a ringing sound ?

Can you say why school bells are made up of metals ?

Non-metals are not sonorous.

Some exceptions to general trends

A comparison of the general physical properties of metals and non-metals shows that there are many exceptions in the general properties. For example –

- (i) **Physical state:** We have studied that metals are solids. But mercury is an exception as it is a liquid at room temperature.
- (ii) **Melting and Boiling Points:** In activity 5.5, we have observed that metals have high melting points. But sodium, potassium, gallium and cesium have low melting points. Gallium has such a low melting point (30-15°C) that it melts even when kept on our palm. We have also studied that non-metals have low melting and boiling points. But diamond which is a non-metal carbon has very high melting point.[Carbon, a non-metal, can exist in different forms. Each form is called an allotrope. Diamond and graphite are allotropes of carbon].

- (iii) **Lustre:** We have learnt that non-metals do not have a shining appearance or lustre. However, iodine is a non-metal but it is lustrous.
- (iv) **Hardness:** In activity 5.2, we have learnt that metals are generally hard, and hardness varies from metal to metal. We have found that sodium is a soft metal which can be easily cut with a knife. Similarly, lithium and potassium are soft. We have also studied that solid non-metals are soft. But carbon in the form of diamond is extremely hard.
- (v) **Electrical conductivity :** We have studied that non-metals are poor conductors of electricity. But graphite is a conductor of electricity .

From the above discussions, it is obvious that we cannot classify the elements as metals or non-metals on the basis of their physical properties alone because there are many exceptions. We have to see if elements can be more clearly classified as metals and non-metals on the basis of chemical properties.

5.2. CHEMICAL PROPERTIES OF METALS & NON-METALS

5.2.1. Formation of Oxides

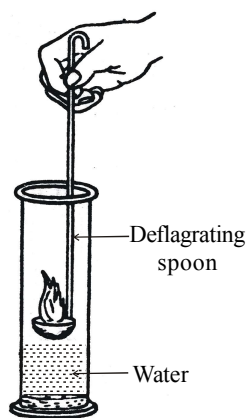


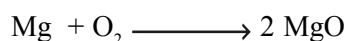
Fig. 5.2. Burning of sulphur powder

Activity 5.6.

- ☞ Take a magnesium ribbon and some sulphur powder.
- ☞ Recall activity 4.1. Burn the magnesium ribbon. Collect the ashes formed and dissolve them in water.
- ☞ Test the resultant solution with both blue and red litmus paper.
- ☞ Is the product formed on burning magnesium acidic or basic ?
- ☞ Take a little sulphur in a deflagrating spoon. Hold it over the flame of a spirit lamp till the sulphur melts and start burning.
- ☞ Now introduce the spoon into a jar containing some water at its bottom (Fig. 5.2)

- ☞ After the sulphur has burnt, take the deflagrating spoon out of the jar.
- ☞ Test the solution in the jar by dipping into it blue and red litmus paper.
- ☞ Is the product formed on burning sulphur acidic or basic ?
- ☞ Can we write the equations for these reactions ?

We can see that magnesium burns brilliantly with a dazzling white light. Magnesium combines with oxygen forming magnesium oxide.



Magnesium oxide reacts with water to form an alkali called magnesium hydroxide. It turns red litmus blue.



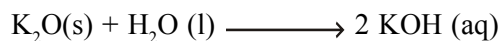
Almost all metals combine with oxygen to form metal oxides.



For example,



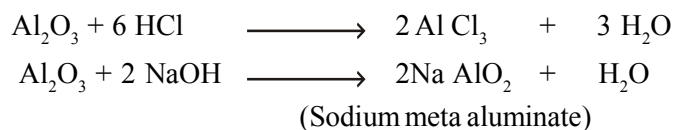
Many metal oxides are insoluble in water but some of these dissolve in water to form alkalis. Sodium oxide and potassium oxide dissolve in water to produce alkalis as follows :



Metal oxides react with acids to form salt and water. Thus metal oxides are basic in nature . For example,



But some metal oxides, such as aluminium oxide, zinc oxide, etc, show both acidic as well as basic behaviour. Such **metal oxides which react with both acids as well as bases to produce salts and water are known as amphoteric oxides**. Aluminium oxide reacts with acids and bases in the following manner.

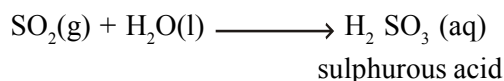


Non-metals react with oxygen to form acidic or neutral oxides:

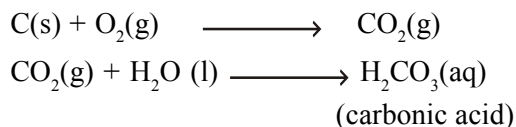
When sulphur burns in air, it combines with the oxygen of air to form an acidic oxide called sulphur dioxide



Sulphur dioxide dissolves in water to form an acid called sulphurous acid.



Similar behaviour is shown by carbon.



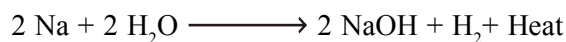
However, some oxides of non-metals are **neutral**. For example, carbon monoxide, nitric oxide (NO) and water are neutral oxides.

5.2.2 . Reaction with Water

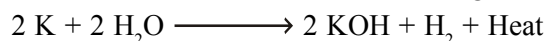
Activity 5.7.

- ☞ Dry a piece of sodium metal by using a filter paper and cut a small piece of it.
- ☞ Place the piece of sodium metal in water taken in a trough.
- ☞ Observe what happens.
- ☞ Repeat the test with other samples of metals such as copper, iron, zinc etc, and also with non-metals, sulphur and graphite (carbon).
- ☞ Do they react with water in the same way as sodium ?

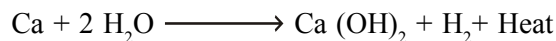
When sodium is placed in water, we find that the piece of sodium floats on water, starts moving on water making a hissing sound and then sodium catches fire with a little explosion. Sodium metal reacts vigorously with cold water forming sodium hydroxide and hydrogen gas. A lot of heat is also produced in the reaction. The heat burns hydrogen gas as well as the sodium metal. The reaction is highly exothermic.



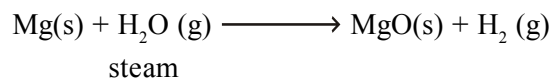
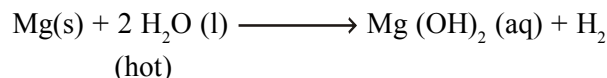
Potassium also reacts with cold water more vigorously.



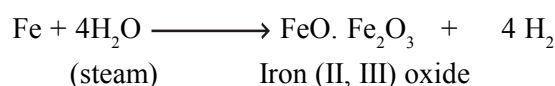
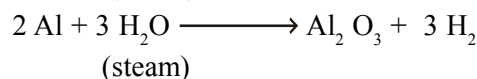
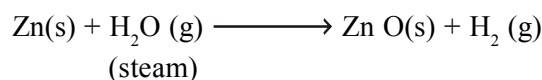
Calcium reacts with cold water to form calcium hydroxide and hydrogen gas. The reaction is less violent.



Magnesium does not react with cold water. It reacts slowly with hot water to form magnesium hydroxide and hydrogen but reacts very rapidly with steam to form magnesium oxide and hydrogen gas.



Aluminium, zinc and red hot iron also react with steam to form their respective oxides and hydrogen.



Non-metals do not react with water or steam to evolve hydrogen gas.

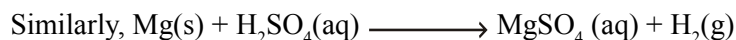
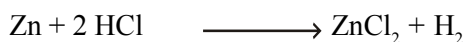
5.2.3. Reaction with Dilute Acids

Activity 5.8.

- ☞ Take small pieces of metals such as magnesium, zinc, iron, aluminium, copper etc except sodium and potassium. [sodium and potassium need not be taken as they react vigorously even with cold water]
- ☞ Put the samples separately in test tubes containing dilute hydrochloric acid.
- ☞ Observe the rate of formation of hydrogen gas bubbles carefully.
- ☞ Which metals react vigorously with dilute hydrochloric acid ?

Metals react with dilute acids to give salt and hydrogen gas

Metal + Dilute acid $\longrightarrow$ Salt + Hydrogen



The rate of formation of bubbles was very fast in the case of magnesium. The reactivity decreases in the order $\text{Mg} > \text{Al} > \text{Zn} > \text{Fe}$.

In the case of copper, no bubble is seen. This shows that copper does not react with dilute HCl. Silver and gold metals also do not react with dilute acids.

We also find that non-metals do not react with dilute acids.

Hydrogen gas is not evolved when a metal reacts with nitric acid. It is because HNO_3 is a strong oxidising agent. It oxidises the H_2 produced to water and itself gets reduced to one of the nitrogen oxides (nitrous oxide N_2O , nitric oxide, NO , nitrogen dioxide NO_2). But magnesium reacts with very dilute HNO_3 to evolve H_2 gas.

Let us answer these.

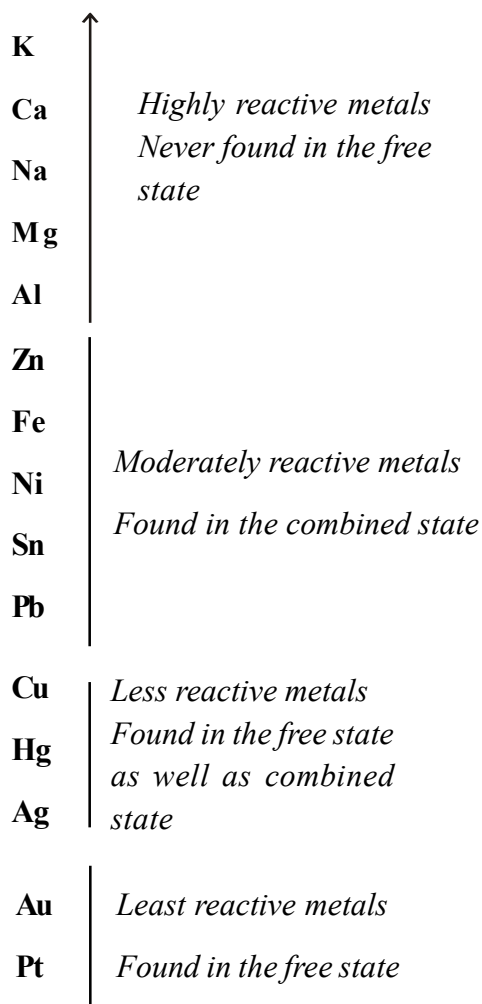
1. Name five metals and five non-metals
2. Name one metal and one non-metal which exist in liquid state at room temperature.
3. Give an example of a metal which
 - (i) can be easily cut with a knife,
 - (ii) is the best conductor of heat,
 - (iii) is a poor conductor of heat.
4. What is meant by saying that metals are malleable and ductile ?
5. Which property of copper and aluminium make them suitable for making electric wires.
6. Name a non-metal which conducts electric current.

7. Write equations for the reactions of
 - (a) potassium with water
 - (b) red-hot iron with steam
 - (c) zinc with dilute sulphuric acid.
8. How do metals differ from non-metals in their reaction with oxygen and the product is dissolved in water ?

5.3. OCCURRENCE OF METALS

The major source of metals is the earth's crust. Sea water also contains some soluble salts of metals like sodium chloride, magnesium chloride, etc. The most abundant metal in the earth's crust is aluminium. The second most abundant metal is iron and third one is calcium.

Metals occur in nature in free (native state) or in combined state, i.e. in the form of their compounds. We have already studied the reactivity series of metals in Unit 4. The metals at the bottom of the activity series are the least reactive. They are often found in a free state. For example, gold, silver, platinum and copper are found in the free state. Copper and silver are also found in nature as their sulphides or oxides. The metals at the top of the activity series (K, Na, Ca, Mg and Al) are so reactive that they are never found in nature as free elements. They are found in the combined state as oxides, sulphides, halides or carbonates. The metals in the middle of the activity series i.e., Zn, Fe, Pb etc are moderately reactive. They are also found in the earth's crust mainly as oxides, or carbonates. It is found that many metals occur as oxides. This is because oxygen is a very reactive element and is very abundant on the earth. Thus we find that the occurrence of metals are closely related to their reactivity (Fig. 5.3).

A vertical activity series of metals. On the left, a vertical line has an upward-pointing arrow at the top. To the left of this line, the chemical symbols of metals are listed from top to bottom: K, Ca, Na, Mg, Al, Zn, Fe, Ni, Sn, Pb, Cu, Hg, Ag, Au, and Pt. To the right of the line, descriptive text is provided for different groups of metals.

K	
Ca	<i>Highly reactive metals</i> <i>Never found in the free state</i>
Na	
Mg	
Al	
Zn	
Fe	<i>Moderately reactive metals</i> <i>Found in the combined state</i>
Ni	
Sn	
Pb	
Cu	<i>Less reactive metals</i> <i>Found in the free state as well as combined state</i>
Hg	
Ag	
Au	<i>Least reactive metals</i> <i>Found in the free state</i>
Pt	

Fig. 5.3. Activity series and occurrences of metals.

The natural materials in which the metals or their compounds are found in earth are called minerals. Some minerals may contain a large percentage of metal whereas others may contain a small percentage of the metal. Thus, all the minerals cannot be used to extract metals. Those minerals from which metals can be extracted profitably are called **ores**. For example, aluminium occurs in the earth's crust in the form of two minerals, bauxite ($\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$) and clay ($\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$). Out of these two, aluminium can be profitably extracted from bauxite but not from clay. Therefore, the ore of aluminium is bauxite. Thus, all ores are minerals but all minerals are not ores.

The ores of some common metals are given below :

Metal	Name of the ore	Name of compound present in the ore	Formula of the ore
1. Sodium (Na)	Rock salt	Sodium chloride	NaCl
2. Aluminium (Al)	Bauxite	Aluminium oxide	$\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$
3. Copper (Cu)	(i) Cuprite	Copper (I) Oxide	Cu_2O
	(ii) Copper glance	Copper (I) sulphide	Cu_2S
	(iii) Copper pyrite	Copper iron sulphide	CuFeS_2
4. Iron (Fe)	Haematite	Iron (III) oxide	Fe_2O_3
5. Zinc (Zn)	(i) Zinc blende	Zinc sulphide	ZnS
	(ii) Calamine	Zinc carbonate	ZnCO_3
6. Mercury (Hg)	Cinnabar	Mercurry (II) sulphide	HgS
7. Lead (Pb)	Galena	Lead sulphide	PbS

5.4. EXTRACTION OF METALS (METALLURGY)

As we have learnt above, metals are obtained from their ores. An ore may contain the metal in the elementary state or in the form of its compounds along with earthy and sandy impurities. **The unwanted impurities such as the earthy, sandy and rocky materials associated with the ores are called gangue or matrix.** So, after mining of the ore from the ground, it is converted into pure metal. Several steps are involved in this process. **The various steps involved in the extraction of the metal from its ores followed by refining of the metal is called metallurgy.** The steps involved in the metallurgy varies from metal to metal. The actual process of metallurgy employed for a particular metal depend upon the nature of the ore, nature of the metal and the types of impurities present. However, metallurgy of most of the metals involves the following steps

- (i) Concentration or enrichment of the ore.
- (ii) Extraction of the metal from the concentrated ore.
- (iii) Refining or purification of the impure metal.

Step 1. Concentration or Enrichment of the ore

The first step in metallurgy is to remove the unwanted impurities or gangue from the ore. As the mined ore is in the form of big lumps, it is first broken into small pieces in mechanical crushers and then pulverised to a fine powder in special mills. The processes used for removing the gangue from the ore are based on the differences between the physical or chemical properties of the gangue and the ore. Different separation techniques are employed.

(a) Gravity Separation or Hydraulic Washing

The crushed and powdered ore is taken in large wooden tanks or spread on special types of tables having grooves on the top. It is then washed with a stream of water. The lighter gangue particles are washed away while the heavier ore particles are left behind. The method is used for the concentration of oxide ores of heavy metals like lead, tin and iron.

(b) Froth Floatation Process

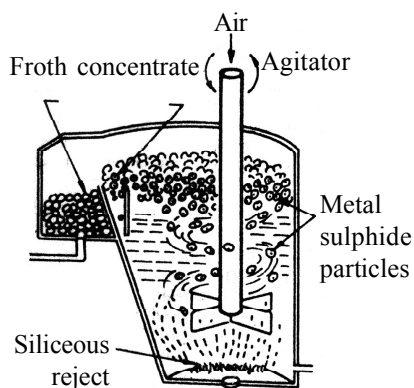


Fig. 5.4. Apparatus for froth floatation concentration

A convenient method widely used in the concentration of sulphide ores is the **froth floatation process**. Sulphides are more readily wetted by oil than by water, while those of gangue are preferentially wetted by water. The crushed and powdered ore is wetted with oil and then agitated in a tank of soapy water. Air is bubbled through the mixture (Fig. 5.4), bubbles stick to oil coated particles, and they float on the surface as **froth**. The gangue being wetted by water settles down to the bottom of the tank. The froth on the top of the tank is allowed to flow off, and the concentrated ore is recovered. Sulphide ores such as copper pyrites (CuFeS_2), galena (PbS), zinc blende (ZnS) etc are concentrated by this method.

(c) Electromagnetic Separation

This method is used for the concentration of the ore when either the ore or the impurities (gangue) is magnetic in nature.

The arrangement consists of two rollers over which a leather belt moves. One of the rollers is an electromagnet. The powdered ore is dropped over the belt on the side of non-magnetic roller. As the ore particles move

along over the belt and reach the magnetic roller, the magnetic particles are attracted by the magnetic roller and fall into a heap on the inner side. The non

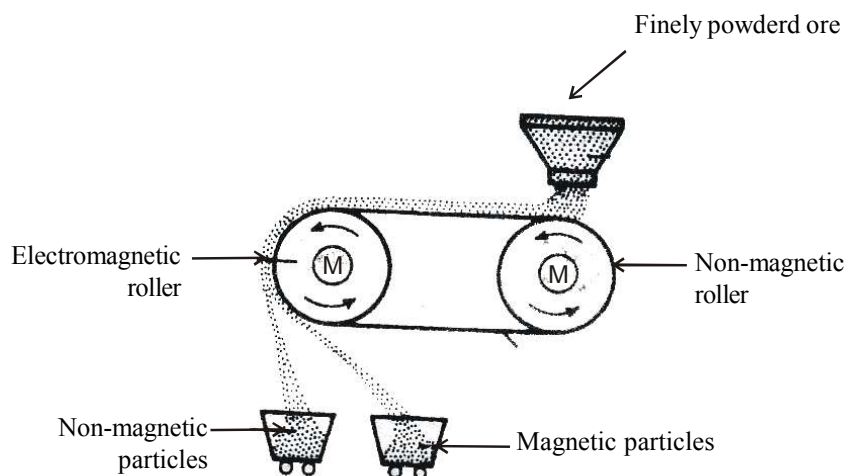


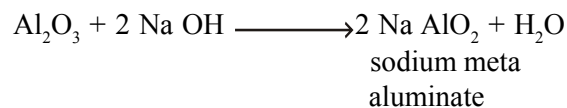
Fig. 5.5. Electromagnetic methods of concentration

magnetic particles simply falls down from the edge of the magnetic roller (Fig 5.5). Some ores like tinstone, magnetite etc. are separated by this method.

(d) Leaching

This is a chemical method for the concentration of the ore. In this process, a particular mineral in the ore is dissolved selectively by employing certain acids, bases or other reagents, separating it from the gangue.

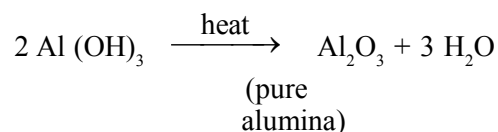
For example, bauxite, (Al_2O_3) an aluminium ore is concentrated by leaching with hot sodium hydroxide solution. The aluminium oxide dissolves in the excess base forming soluble sodium meta-aluminate



The solution is filtered to remove insoluble gangue particles. The filtrate when diluted with water and agitated gives precipitate of aluminium hydroxide.



The precipitate is dried and then heated strongly to get pure aluminium oxide (alumina).

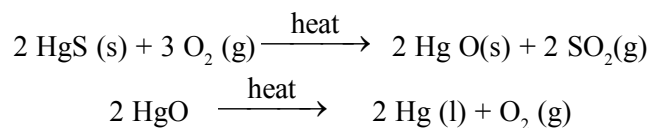


Step II Extraction of the Metal from the Concentrated Ore (Reduction)

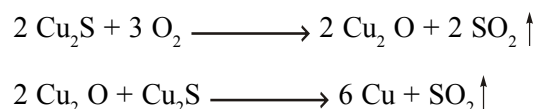
On the basis of reactivity, we have classified the metals into three categories. They are (i) highly reactive metals (ii) moderately reactive metals and (iii) metals of low reactivity (Fig.5.3) Different techniques are used for obtaining the metals in each category. You are familiar with the process of oxidation and reduction explained in previous chapter. Obtaining metals from their compounds is also reduction process.

(a) Extraction of Metals which are low in the Activity series

Metals in this group are unreactive. The sulphides and oxides of these metals can be reduced to metals by heating alone. For example, cinnabar (HgS) is an ore of mercury. When it is heated in air, it is first converted into mercuric oxide (HgO). Mercuric oxide is then reduced to mercury on further heating.



Similarly, when copper glance (Cu_2S), an ore of copper, is heated strongly in air, it gives copper according to the following reactions :

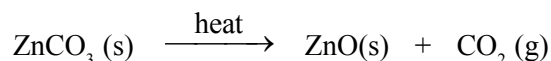


(b) Extraction of Metals in the Middle of the Activity Series. (Fe, Zn, Pb, etc.)

These metals are found in nature in the form of their oxide, sulphide or carbonate ores. Further, it is easier to obtain the metal from its oxide than sulphides or carbonates. Therefore, prior to reduction, the sulphide and carbonate ores are first converted into the corresponding metal oxides. This is done by either of the following two methods.

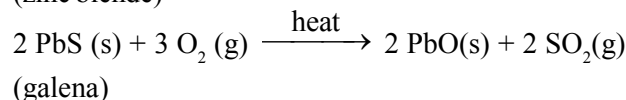
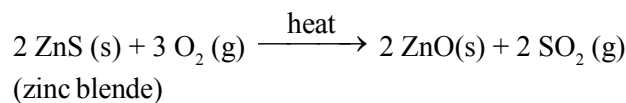
(i) Calcination (for carbonate ores)

The carbonate ores are changed into oxides by heating strongly in limited air. The process is known as calcination. For example, calamine, a carbonate ore of zinc can be converted to zinc oxide by calcination.

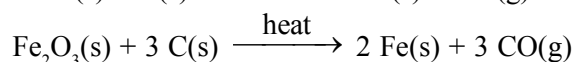
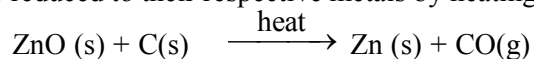
**(ii) Roasting (for sulphide ores)**

It is the process of heating the ores strongly in the presence of excess air. As a result, the sulphide ores are converted into oxides

For example,

**Reduction to the Metal**

To reduce the metal oxide to the metal, the roasted or calcined ore is mixed with suitable quantity of coke (carbon), or another element which has greater affinity for oxygen. They act as reducing agents. Oxides of zinc, iron and lead are reduced to their respective metals by heating with coke.



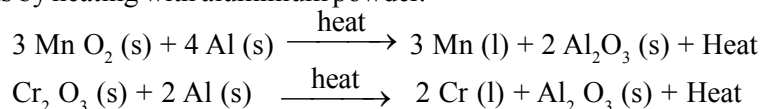
Carbon monoxide formed also acts as reducing agent. It further reduces the metal oxide to metal.



The process by which the metal oxides in the fused state are reduced by carbon to the free metal involving melting is also called **smelting**.

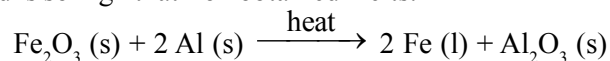
Certain metallic oxides cannot be reduced by carbon because the affinity of oxygen for the metal is greater than its affinity for carbon. Such metallic

oxides can be reduced with the help of highly reactive metals such as sodium, magnesium, aluminium, etc. Such metals can act as reducing agents. For example, oxides of manganese and chromium are reduced to their corresponding metals by heating with aluminium powder.



The reaction is **highly exothermic**. The heat evolved is so high that the metal is obtained in the molten state. As the reaction using aluminium liberates a large amount of heat, the process is known as **aluminothermic process**.

Similarly, when iron (iii) oxide (Fe_2O_3) is heated with aluminium powder, the heat evolved is so high that iron obtained melts.

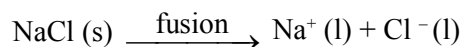


The reaction is, therefore, used for welding the broken parts of iron machinery, join railway tracks or cracked machine parts.

(c) Extraction of Metals of High Reactivity (K, Na, Ca, Mg, Al)

These highly reactive metals cannot be obtained by reduction of their oxides by heating with carbon or aluminium. This is because these highly reactive metals have greater affinity for oxygen than for carbon or aluminium. These metals are obtained by the electrolysis of their fused salts. The method is called **electrolytic reduction**. As an example, we may consider the manufacture of sodium metal by the electrolysis of fused sodium chloride (NaCl). Various reactions taking place during electrolysis may be represented as given below.

When sodium chloride melts, it splits into sodium ion (Na^+) and chloride ion (Cl^-).



When electricity is passed through the melt, Na^+ ions go to the negatively charged electrode (cathode) and reduced to sodium atoms. Chloride (Cl^-) ions move towards the positively charged electrode (anode) and are oxidised to chlorine gas.



Similarly, calcium and magnesium are also obtained by the electrolysis of their fused chlorides. Aluminium is obtained by the electrolytic reduction of the molten alumina (Al_2O_3).

Step III . Refining of Impure Metals

The metals obtained by various reduction processes are not very pure. They are called crude metals. They contain impurities, which must be removed to obtain pure metals. The method used for refining depends upon the nature of the metals and the nature of the impurities present.

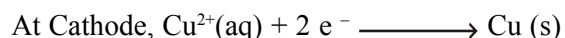
The most widely used method for refining impure metals is **electrolytic refining**. The procedure generally followed in this method is as follows .

- (i) The impure metal, taken in the form of a thick block is made the anode in the electrolytic cell.
- (ii) A thin sheet of pure metal is made the cathode.
- (iii) A solution of the salt of the metal is taken as the electrolyte (electrolytic bath).

When an electric current is passed through the solution, the pure metal from the anode passes into the solution in the form of metal ions. An equivalent amount of metal ions from the solution is deposited as pure metal on the cathode. Thus, as the electrolysis proceeds the size of anode keeps on decreasing while that of the cathode keeps on growing. The soluble impurities go into the solution, whereas, the insoluble impurities settle down below the anode as **anode mud**.

As an example, we may consider the electrolytic **refining of copper** (Fig. 5.6)

The block of impure copper is made the anode. A thin sheet of pure copper is made the cathode . The electrolyte is a solution of copper sulphate acidified with dilute sulphuric acid. On passing electric current, pure copper from the anode passes into solution as copper (II), Cu^{2+} ions. Equivalent amounts of Cu^{2+} ions from the solution are deposited on the cathode as pure copper.



Thus, as the electrolysis proceeds, anode becomes thinner whereas cathode becomes thicker. The impurities present in the crude copper either go

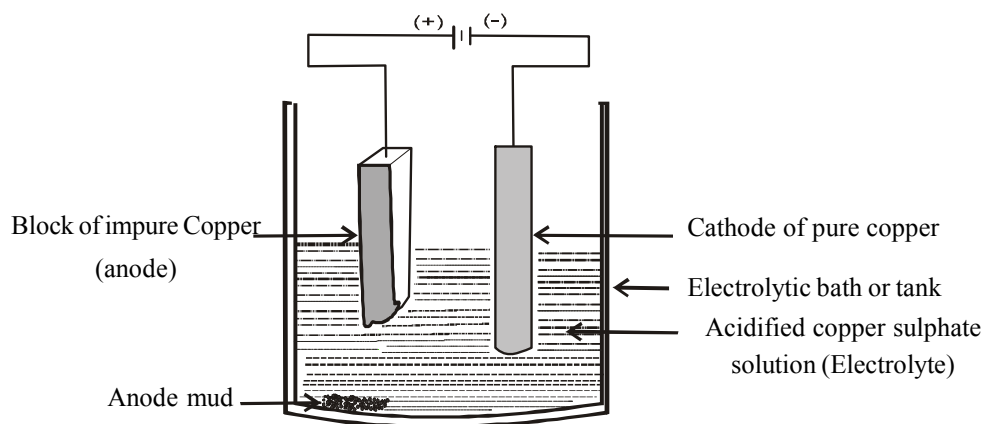
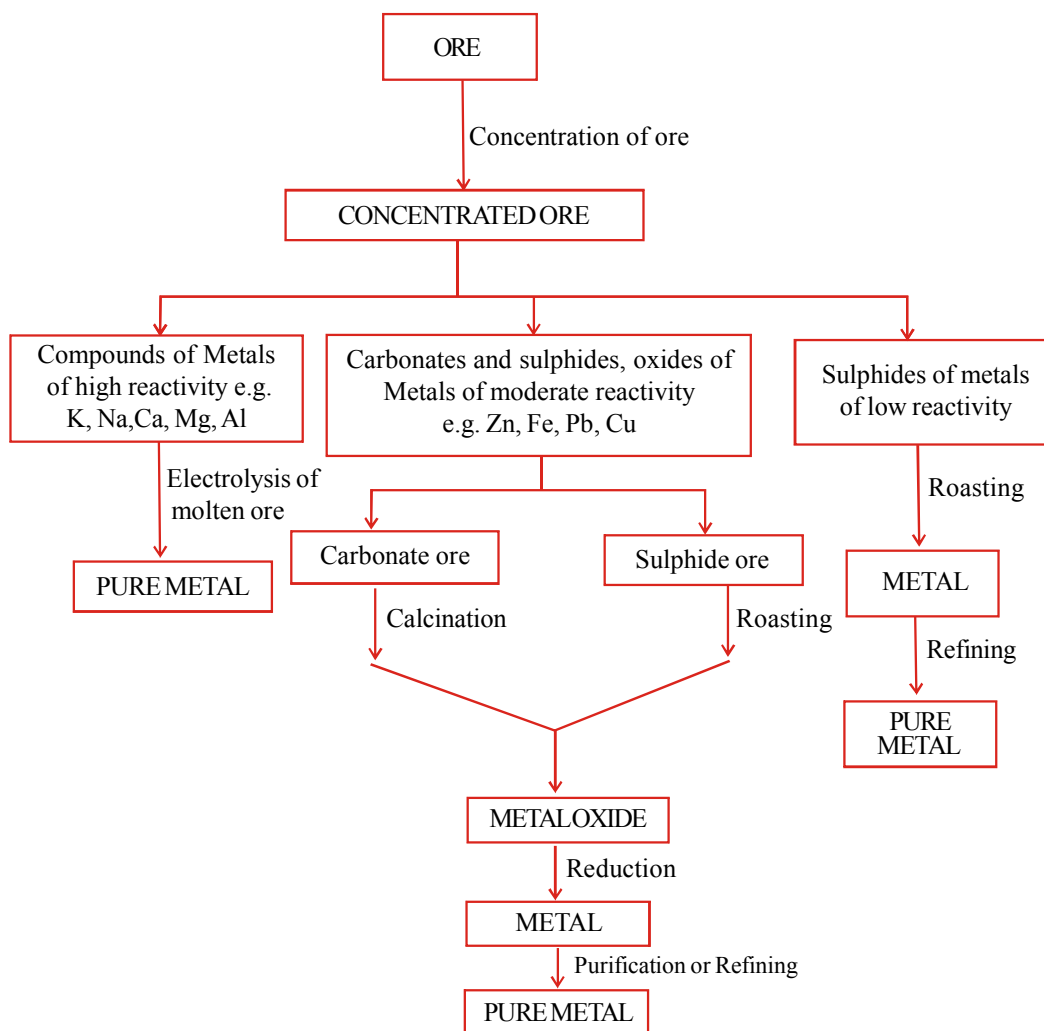


Fig.5.6. Electrolytic refining of Copper

into the solution or fall down below the anode. The less reactive metals like gold, silver etc present in the impure coppers falls below the anode as such in the form of **“anode mud”**.

Many metals, such as zinc, tin, nickel, silver, gold, etc. are refined electrolytically in this manner.

The different steps involved in the extraction of pure metal from ores may be summarised as follows.



5.5. ALLOYS AND AMALGAM

We are familiar with many household implements like knife, dagger, spades, springs, saws etc. made of steel. We are also familiar with various kitchen utensils like dishes, bowls, spoons, nuts, screws etc. made of stainless steel or brass. Statues are made of bronze. They are made of materials called **alloys**.

A homogenous mixture of two or more metals or metal and non-metal is called an alloy. An alloy containing mercury as one of the constituent metals is known as **amalgam**. For example, sodium amalgam, zinc amalgam etc. Although there are only about 75 naturally occurring metal elements, there are thousands of different combinations of them, each of which has its own

special properties. This shows that metals have the ability to mix with and combine with one another to form practically a large number of alloys. In general, an alloy is the solid which result when two or more metals, or metal and non-metal are melted together to form a homogenous mixture and then allowed to cool.

Alloys have properties of their own that often differ markedly from those of the elements of which they are made. For example, solder is a low melting alloy of tin and lead. Its melting point is lower than that of any of its constituents. There are also alloys which have higher melting points than any of their constituents.

Alloys are usually harder than the parent metals. Pure iron is quite soft and ductile in comparison with steel alloys which are composed mainly of iron and small percentage of carbon. The tensile strength of duralumin (an alloy of Al with Cu, Mg & Mn) is five times that of pure aluminium. Gold is too soft even for jewelery. It must be hardened by alloying with copper or some other metal.

One of the chief differences between pure metals and alloys is corrosion resistance. Alloys are usually more resistant to corrosion, hence they are more useful for materials that are exposed to the action of corrosive agents. However, alloys are generally poorer conductors of heat and electricity than pure metals. Very pure copper is needed for electrical wires, because even traces of certain impurities decrease the conductivity a great deal.

In spite of the important differences between the elemental metals and alloys, there are some important similarities. Alloys usually, have to some degree the metallic properties of heat and electrical conductivity, ductility and malleability, and they show metallic lustre.

Table 5.4. gives some of the commonly used alloys, their composition and uses.

Table 5.4. Some common alloys

Name	Composition	Properties	Uses
1. Steel	Iron (98.4 – 99.2%) Carbon (0.2 – 1.6 %)	Hard, tough and strong	Fabrication, cutting blades, saws, springs, ships, bridges, vehicles etc
2. Stainless Steel	Iron (74%) Chromium (18%) Nickel (8%)	Corrosion-resistant, hard	Kitchenware, stainless cutlery, ornamental pieces, surgical instruments
3. Brass	Copper (60–80%) Zinc (20–40%)	Malleable, strong, corrosion resistant, can be easily cast	Utensils, hardware, radiator cores, screws, nuts, bolts, musical instruments
4. Bronze	Copper (75–90%) Tin (10–25%)	Light, strong, highly resistant to corrosion	Statues, coins, medals, cooking utensils, valves, rods
5. Duralumin	Aluminium (95%) Copper (4%) Manganese (0.5%) Magnesium (0.5%)	Light, strong, corrosion resistant, great tensile strength	Aeroplanes, automobile parts, pressure cookers
6. Solder	Lead (40 – 60 %) Tin (40– 60 %)	Lower melting point than either Pb or Sn	Soldering, joining electrical wires.

A great deal of scientific research is going on at present to the study of alloys for use in high-temperature jet and rocket engines and nuclear energy power plants. When the methods for the production of rarer metals are perfected, these researches will undoubtedly lead to the formation of more valuable alloys than we have today.

Let us Answer these.

1. Name two metals which are found in nature in the free state.
2. Define the following terms.
(i) Mineral (ii) Ore (iii) Gangue
3. Differentiate between roasting and calcination used in metallurgy.
4. Name two sulphide and two oxide ores.
5. Name the systematic steps involved in metallurgy.

6. Write the chemical process used for obtaining a metal from its oxide.
7. Give an example of a sulphide ore which is reduced to metal by heating alone. Give the relevant equations involved.
8. Why aluminium cannot be obtained by reduction of its oxide with coke ?
9. Explain how the following metals can be obtained from their compounds by reduction process.
 - (a) Metal “X” which is low in activity series
 - (b) Metal “Y” which is moderately reactive
 - (c) Metal “Z” which is high up in the reactivity seriesGive one example of each type.
10. An alloy “solder” is used in electronic industry to join different electronic components. What are the constituents of this alloy ?
11. Which alloy is used for making bodies of aircrafts ? What is its approximate composition?

SUMMARY

- ✱ Elements can be classified as metals and non-metals.
- ✱ Metals have metallic lustre, malleability ductility and are good conductors of heat and electricity. They are solids at room temperature except mercury which is a liquid.
- ✱ Non-metals have properties different from those of metals. They are neither malleable nor ductile. They are bad conductors of heat and electricity, except graphite which conducts electric current.
- ✱ Metals combine with oxygen to form basic oxides. Aluminium oxide and zinc oxide show the properties of both basic and acidic oxides. These oxides are known as amphoteric oxides.
- ✱ Non-metals combine with oxygen to form acidic or neutral oxides.
- ✱ Different metals have different reactivities with water and dilute acids.
- ✱ Metals occur in nature as free elements or in the form of their compounds.
- ✱ The extraction of metals from their ores and then refining them for use is known as metallurgy.
- ✱ Several steps are involved in the extraction of pure metal from ores. Different techniques are to be used for obtaining the metals from their ores.

- ✱ Metallurgy of most of the metals involve three steps—
(i) Concentration or enrichment of the ore (ii) Extraction of the metal from the concentrated ore and (iii) Refining or purification of the impure metal.
- ✱ A homogenous mixture of two or more metals, or metal and non-metal is called an alloy.

EXERCISES

1. Give five points to distinguish metals from non-metals.
2. You are given a hammer, a battery, a bulb, wires and a switch.
 - (a) How would you use them to distinguish between samples of metals and non-metals.
 - (b) Assess the usefulness of these tests.
3. Frying pans and boilers are generally made from aluminium but not from steel. Why? Give two reasons.
4. Distinguish between metals and non-metals on the basis of their chemical properties. (Give three points).
5. What are amphoteric oxides ? Give examples of two amphoteric oxides.
6. Name two metals which will displace hydrogen from dilute acids, and two metals which will not.
7. Differentiate between :
 - (i) Mineral and ore
 - (ii) Alloy and amalgam
 - (iii) Calcination and roasting.
8. What are the common methods of ore concentration ?
9. Name the process that is used to concentrate sulphide ores. Describe the stages that are involved in the conversion of concentrated sulphide ore into the corresponding metal.
10. How is impure metal refined electrolytically ?
11. What is an alloy ? Write the composition and two uses of brass and bronze.

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