Handout -5/6

Class –X **Subject – Science**

CHAPTER – 3

METALS AND NON-METALS

OCCURENCE AND EXTRACTION OF METALS

Metals occur in nature in free as well as combined form.

Metals having low reactivity showlittle affinity for air, moisture, carbon dioxide or other non-metals present in nature. Suchmetals may remain in elemental or native (free) state in nature. Such metals are called "noblemetals" as they show the least chemical reactivity.

For example- gold, silver, mercury andplatinum occur in free state.

On the other hand, most of the metals are active and combine with air, moisture, carbon
dioxide and non-metals like oxygen, sulphur, halogens, etc. to form their compounds, like
oxides, sulphides, carbonates, halides and silicates. i.e., they occur in nature in a combined
state.

A naturally occurring material in which a metal or its compound occurs is called a***mineral.***
Amineral from which a metal can be extracted conveniently and economically is called an***ore***.

Types of ore–

Oxide ore-Haematite ($Fe_2O_3.xH_2O$)Magnetite (Fe_3O_4)Bauxite ($Al_2O_3.2H_2O$)
Sulphide ore-Zinc blende (ZnS), Galena (PbS),Iron pyrites (FeS_2),Cinnabar (HgS)
Carbonate ore- Calamine ($ZnCO_3$), Magnesite ($MgCO_3$)
Halide ore-Cryolite (Na_3AlF_6) ,Rock salt (NaCl) ,Fluorspar (CaF_2)

EXTRACTION OF METALS

Metallurgy

The various processes involved in the extraction of metals from their ores and their subsequent refining are known as metallurgy.

1) CONCENTRATION OF THE ORE-

Ores that are mined from the earth are usually contaminated with large amount of impurities
such as soil and sand etc.

Concentration means, simply getting rid of as much of the unwanted rocky material as possible before the ore is converted into the metal. The impurities like clay are
called *gangue.*

Enrichment of the ore:

It is a process of removing unwanted substances from the ore. This is also known as concentration of the ore or enrichment of ore. It is usually done by hydraulic washing, magnetic separation or froth-floatation process

Enriching the ore depends upondifference between physical properties of ore and gangue.

METHODS USED TO ENRICH THE ORE

Hydraulic Washing

Froth flotation

Magnetic separation

Chemical separation

2) CONVERSION OF ORE INTO METAL OXIDE-

After concentration of ore that obtained earth, we get a concentrated or enriched ore. To extract metal from this enriched ore it is converted into metallic oxide by Calcination or Roasting reaction.

The sulphide ores are converted into oxides by heatingstrongly in the presence of excess air. This process is known as roasting.

The carbonate ores are changed into oxides by heating strongly in limitedair. This process is known as calcination.

3) REDUCTION OF METAL OXIDE INTO METAL-

Metals can be categorized into three parts on the basis of their reactivity: most reactive, medium reactive and least reactive, extraction of the metal from its ores depends on the reactivity of the metal.

Arrange the metal in decreasing order of their reactivity is known as *activity series*. The
classification of the metals on the basis of their reactivity:

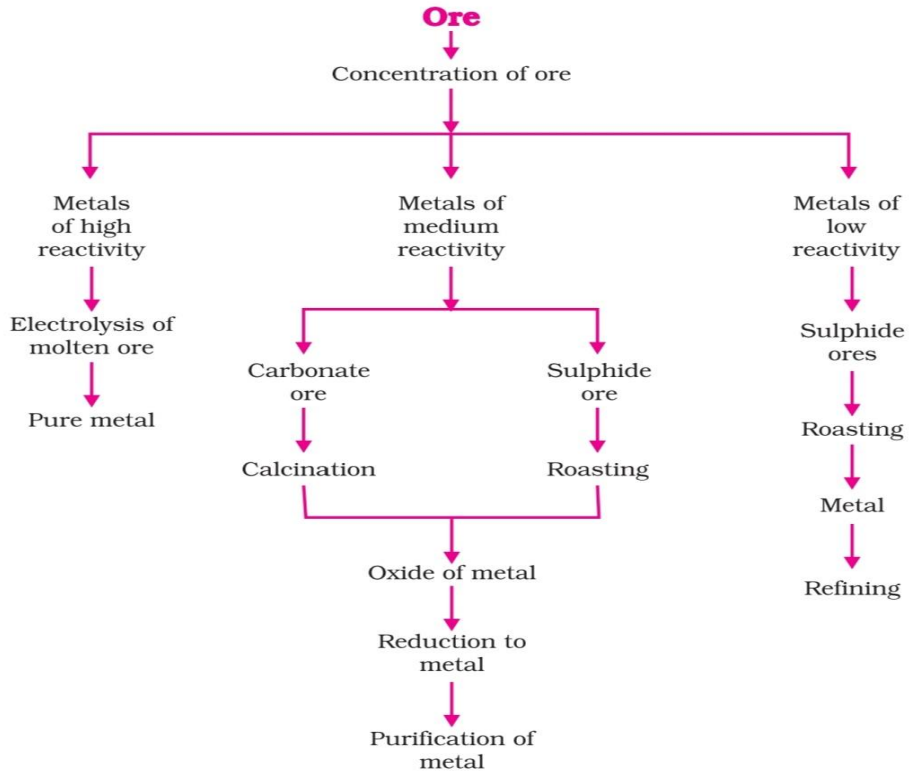

***Figure3.10** Steps involved in the extraction of metals from ores*

A) **Extraction of metals low in the activity series by heating compounds of metals in air**:

Less reactive metals can be obtained by heating their compounds in the presence of air for example mercury is produced by roasting the ore cinnabar in air.

When cinnabar (HgS) which is an ore of mercury, heated in air, it is first converted into
(HgO) then reduced to mercury on further heating.

Eg: $2HgS + 3O_2 \rightarrow 2HgO + 2SO_2$

$2HgO \rightarrow 2Hg + O_2$ on heating

Auto (self) reduction of sulphide ores: In the extraction of Cu from its sulphide ore,

the ore is subjected partial roasting in air to give its oxide.

$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$

When the supply of air is stopped and the temperature is raised. The rest of the sulphide reacts with oxide and forms the metal and SO2.

$2Cu_2O + Cu_2S \rightarrow 6Cu + 2SO_2$

B) Extraction of metals in the middle of the activity series:

i. Roasting: it is a process in which over is heated in the presence of air so as to obtain metal oxides, which can be reduced easily to get free metal. Sulphide ores are converted into oxides by roasting example.

ii. Calcination: it is a process of heating ore in the absence of air so as to remove moisture and volatile impurities to convert carbonate into oxides example.

iii. By heating metal oxides with reducing agent: some metals are obtained by heating their oxide with suitable reducing agent when metal oxide is heated with reducing agent like carbon (coke) or aluminium thus free metal is obtained.

Roasting -

$2ZnS(s) + 3O_2\ (g) \text{ –Heat}\longrightarrow 2ZnO(s) + 2SO_2\ (g)$

Calcination -

$ZnCO_3\ (s) \text{ –Heat}\longrightarrow ZnO(s) + CO_2\ (g)$

Reduction by using Carbon (coke)

$ZnO(s) + C(s) \rightarrow Zn(s) + CO(g)$

Reduction by using aluminium -

$3MnO_2(s) + 4Al(s) \rightarrow 3Mn(l) + 2Al_2O_3(s) + Heat$

Thermite process: When highly reactive metals such as sodium, calcium, aluminium etc., are used as reducing agents, they displace metals of lower reactivity from the compound. These displacement reactions are highly exothermic. The amount of heat evolved is so large that the metals produced in molten state. This type of reaction is used in thermite process. The reactionof Iron (III) oxide (Fe2O3), with aluminium is used to join railings of railway tracks or crackedmachine parts. This reaction is known as the **thermite reaction**.

$Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(l) + Al_2O_3(s) + Heat$

C) Extraction of metals towards the top of the activity series :

Electrolytic Reduction. Most reactive metals like sodium, potassium, calcium, aluminium cannot be obtained by chemical reduction. They are obtained by electrolysis of fused (molten) compounds Sodium, potassium, calcium and magnesium are obtained by electrolysis of their fused chlorides. Aluminium is obtained by electrolysis of molten bauxite Metals are obtained at cathode whereas non-metals are obtained at anode.

Electrolysis of molten Na is shown as follows with the help of chemical reactions.

At cathode $Na+ + e– \rightarrow Na$

At anode $2Cl^{-} \rightarrow Cl_2 + 2e–$

4) <u>Refining of Metals</u>

The metals produced by various reduction processesdescribed above are not very pure. They containimpurities, which must be removed to obtain pure metals.The most widely used method for refining impure metalsis electrolytic refining.

In this method, the impure metal is made to act as anode. A strip of
the same metal in pure form is used as cathode. They are put in a suitable electrolytic bath containing soluble salt of the same metal. The required metal gets deposited on the cathode in the pure form. The metal, constituting the impurity, goes as the anode mud.

We use this electrolytic method to refine copper.

For this an impure copper is taken as anode and pure copper strips are taken as cathode. The electrolyte is a acidified solution of copper sulphate. As a result of electrolysis copper in pure
form is transferred from the anode to the cathode.

Anode: $Cu \rightarrow Cu^{2+} + 2e-$

Cathode: $Cu^{2+} + 2e- \rightarrow Cu$

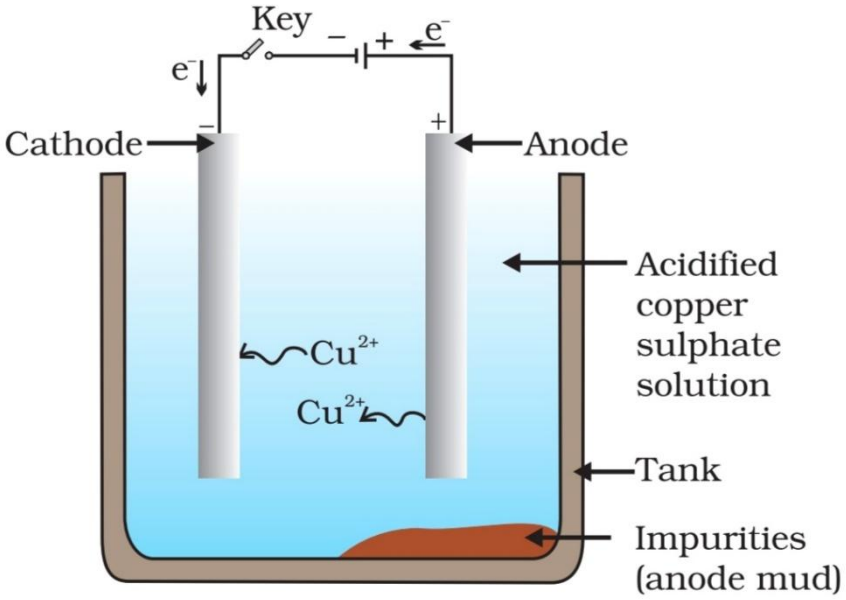

Figure 3.12

Electrolytic refining of copper. The electrolyte is a solution of acidified copper sulphate. The anode is impure copper, whereas, the cathode is a strip of pure copper. On passing electric current, pure copper is deposited on the cathode.