CHAPTER - 3

METALS AND NON-METALS

CLASS – X

SUBJECT - SCIENCE

MODULE -5/6

OCCURENCE OF METALS :-

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

For example- gold, silver, mercury and platinum 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.

Mineral and Ore

- **Minerals :- are elements or compounds which occur naturally inside**
- **the earth's crust.**
- **Ore :- is a mineral from which metals can be extracted profitably.**
- **Gangue :- is the impurities present in the ore like rock particles, sand particles, clay particles etc.**

Extraction of metals from their ores :-

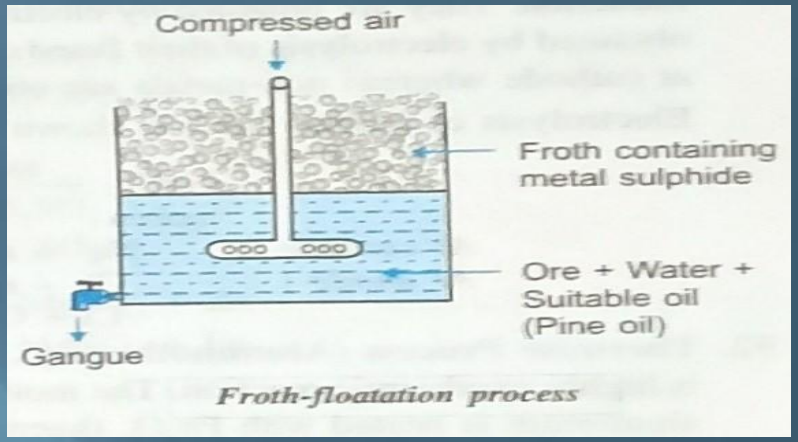
Metals are extracted from their ores in the following steps.

- i) Concentration of the ore (Enrichment of the ore).
- ii)Conversion of ore into metal oxide.
- iii) Reduction to the metal.
- iv) Refining (Purification of the metal).

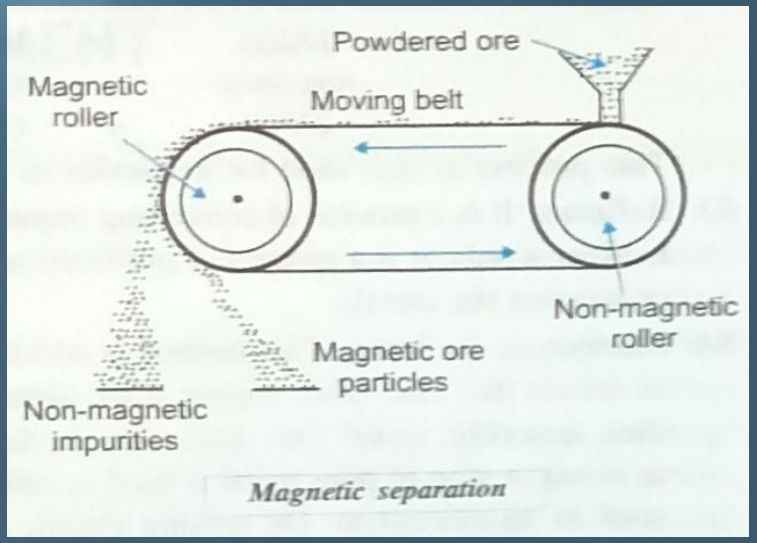
Concentration of the ore :-

- 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
- froth-floatation process
- Chemical separation

- Enriching the ore depends upon difference between physical properties of ore and gangue.



Froth-floatation process



Magnetic separation

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 Calcinations or Roasting reaction.
- This is also useful to remove volatile impurities.

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

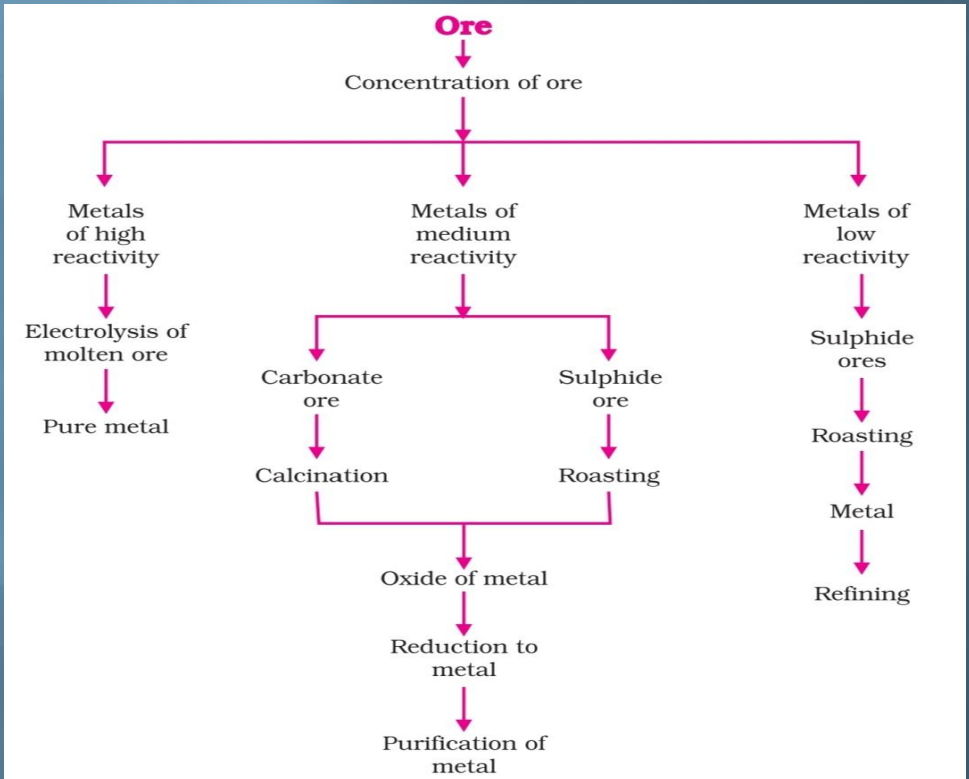


Figure3.10 *Steps involved in the extraction of metals from ores*

A) Extraction of metals low in the activity series

- **Metals which are low in the activity series can be reduced to the metals by heating in the presence of oxygen (Roasting).**
- **Ex :- Mercury is obtained from its ore Cinnabar (HgS) by heating in the presence of oxygen. When it is heated in the presence of oxygen it is first converted into mercuric oxide (HgO) and on further heating it is reduced to mercury.**

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

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

- **Auto (self) reduction of sulphide ores on heating -**

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

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

B) EXTRACTION OF METALS IN THE MIDDLE OF THE ACTIVITY SERIES :-

Metals in the middle of the activity series like Zn, Fe, Pb, are found as oxide, sulphide or carbonate ores.

It is easier to obtain metals from their oxides than from their sulphides or carbonates. So non oxide ores are converted into oxide form before reduction. Non oxide ores can be converted into oxide form by roasting or calcination.

Roasting :- is heating of an ore in the presence of oxygen. It is used to convert suphide ores into oxide form.

$$2ZnS(s) + 3O2\ (g) \xrightarrow{Heat} 2ZnO(s) + 2SO2\ (g)$$

Calcination :- is heating of an ore in the absence of oxygen. It is used to convert sulphide ores into oxide form.

$$ZnCO3\ (s) \xrightarrow{Heat} ZnO(s) + CO2\ (g)$$

The oxide ore is then reduced to the metal by heating with a reducing agent. The most common reducing agent is coke (carbon).

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

THERMIT REACTIONS :-

Sometimes reactive metals like Na, Ca, Al etc. are used as reducing agents to obtain metals from their oxides.

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

(Manganese dioxide) **(Manganese)**

The reaction between metal oxides and aluminium is highly exothermic and the metals are obtained in molten state. Such reactions are called thermit reactions.

The reaction between iron oxide and aluminium produces molten iron. This reaction is used to join rail tracks, broken machine parts etc.

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

Thermite Welds

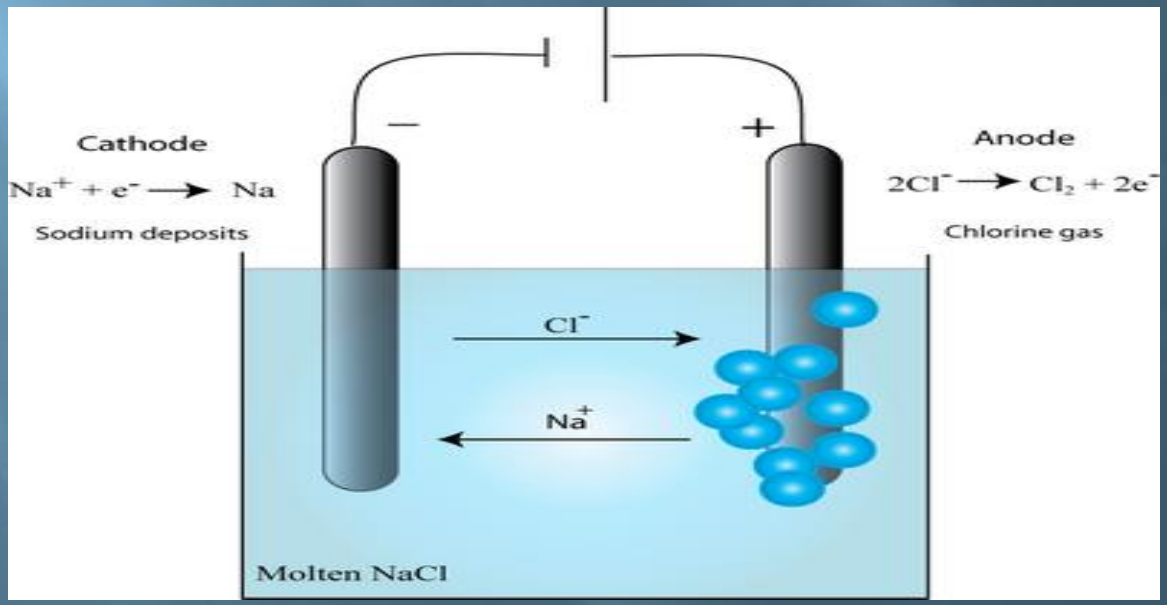
C) EXTRACTION OF METALS AT THE TOP OF THE ACTIVITY SERIES :-

Metals at the top of the activity series like K, Na, Ca, Al etc. cannot be obtained from their ores by simple heating or by heating with reducing agents. They are obtained by electrolytic reduction of their molten chlorides.

Eg :- When electric current is passed through molten sodium chloride, sodium metal is deposited at the cathode and chlorine gas is deposited at the anode.

At cathode $Na^+ + e^- \rightarrow Na$

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

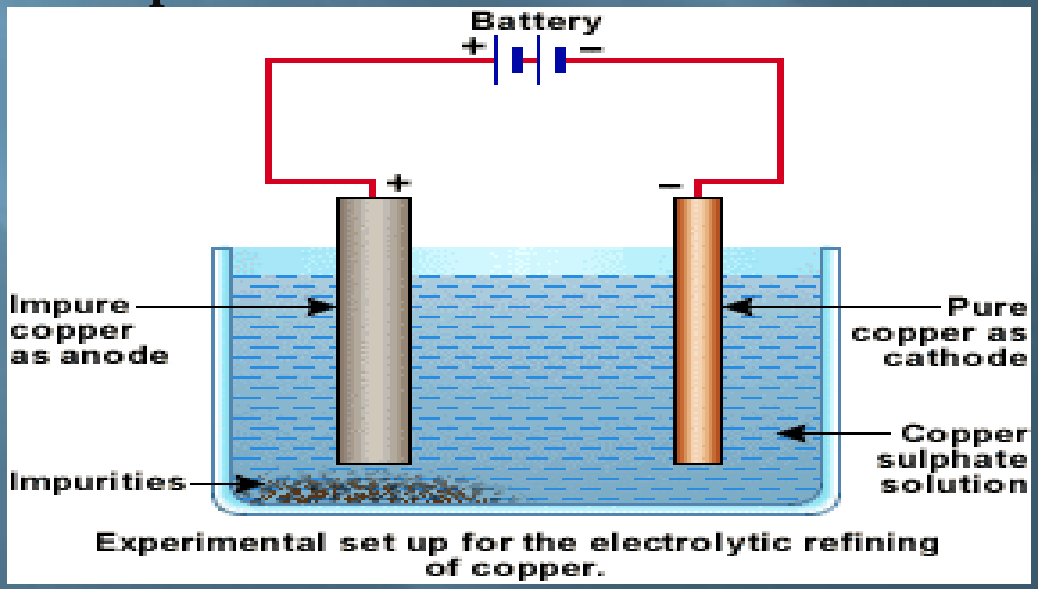


REFINING OF METALS :-

The removal of impurities from the metal to obtain the pure metal is called refining of metals. The most common method for refining of metals is electrolytic refining.

In this method a block of the impure metal is made the anode and a thin sheet of the pure metal is made the cathode. The electrolyte is a salt solution of the metal to be purified.

Eg :- In the electrolytic refining of copper, a block of impure copper is made the anode and a thin sheet of pure copper is made the cathode. The electrolyte is acidified copper sulphate solution. When electric current is passed through the electrolyte, pure copper from the anode is deposited at the cathode and the impurities settle down as anode mud.



Experimental set up for the electrolytic refining of copper.

Questions

1) Concentration of an ore is done by froth-floatation process. What is the nature of an ore?
2) Write Differences between Calcination and Roasting.
3) What do you mean by enrichment of an ore?
4) What is metallurgy?
5) Name one ore for each – Iron and Aluminium
6) What is cinnabar?
7) What is thermite reaction? What is its use?
8) Give example of self-reduction to obtain metal from its ore.
9) Explain electrolytic refining of copper with suitable diagram.