Coinage metals

- The elements of group IB(11) of the periodic table constitute three metallic elements, namely copper ($_{29}Cu$), Silver ($_{47}Ag$) and gold ($_{79}Au$) . These metals are called coinage metals because of their use in making coins.

Occurrence of copper

Common ores of copper are:

- Chalcocite or copper glance (Cu_2S)
- Cuprite or ruby copper (Cu_2O)
- Chalcopyrite or copper pyrite ($CuFeS_2$)
- Azurite (blue) [$Cu(OH)_2.2CuCO_3$]
- Malachite[Green] $CuCO_3.Cu(OH)_2$

Extraction of copper from copper pyrite

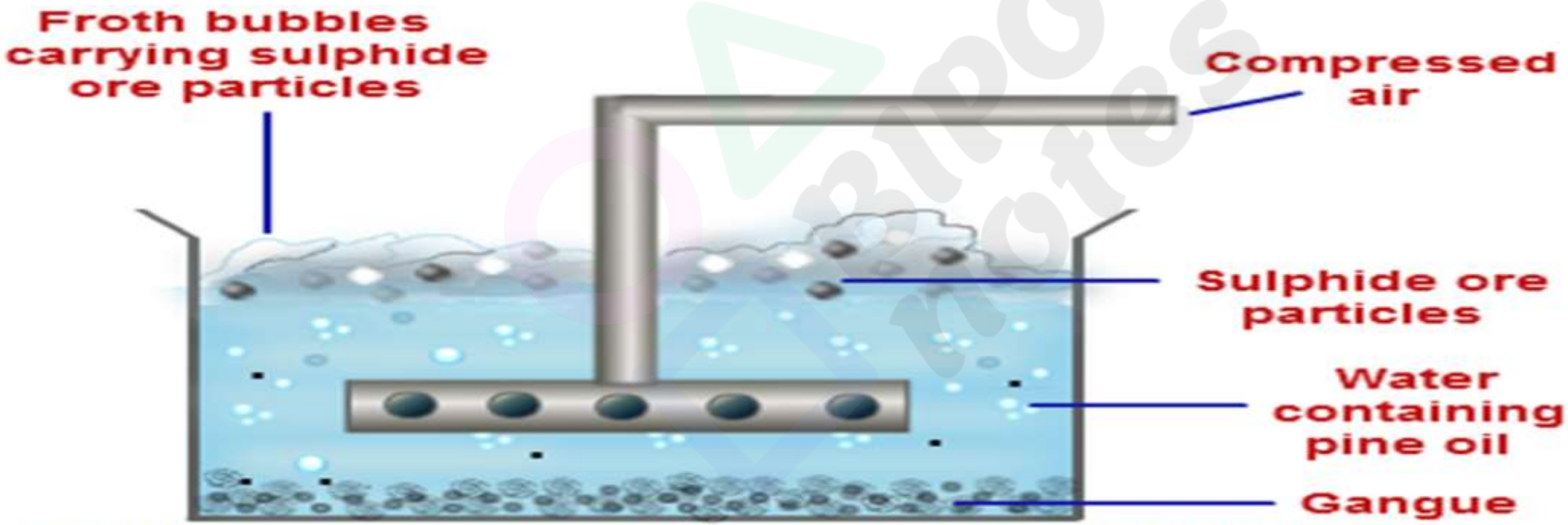
Copper is mainly extracted from its sulphide ores copper pyrite ($CuFeS_2$). The various steps involved in extraction are described below.

1.Crushing and pulverization.

The Big lumps of ore are broken to smaller pieces by the jaw crusher and then changed to a fine powder using ball mill.

2. Concentration

The powdered ore is concentrated by Froth floatation method. In this method, the powdered ore is mixed with water along with pine oil(or eucalyptus oil) in a large tank and agitated by blowing air. The ore particles come on the surface along with froth while the impurities are settled down



Froth floatation process for the concentration of sulphide ores.

Roasting

The concentrated ore is strongly heated in the presence of air in the reverberatory furnace. This process also helps to remove out impurities like P, S, As, Sb etc. in the form of volatile oxides.

Following changes occurs during roasting

1. Volatile impurities and moistures are removed.
2. Impurities like P_4, As, S etc are oxidized.

$$P_4 + O_2 \xrightarrow{\Delta} 2P_2O_5$$

$$S + O_2 \xrightarrow{\Delta} SO_2$$

$$4As + 3O_2 \xrightarrow{\Delta} 2As_2O_3$$

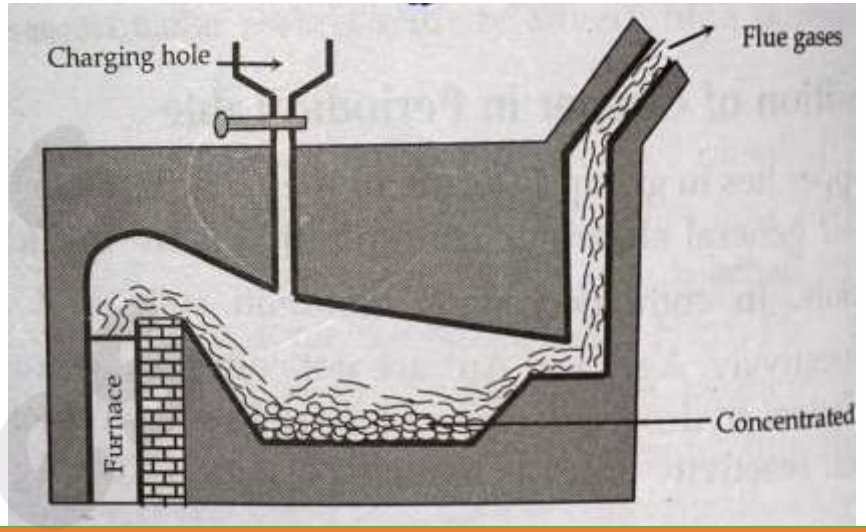


Fig : Roasting of ore in reverberatory furnance

3.Copper pyrite is decomposed in to cuprous sulphide and Ferrous sulphide.

$$CuFeS_2 + O_2 \xrightarrow{\Delta} Cu_2S + FeS + SO_2$$

4. There is conversion of FeS in to FeO and partial oxidation of Cu_2S in to Cu_2O

$$Cu_2S + O_2 \xrightarrow{\Delta} Cu_2O + SO_2$$

$$FeS + O_2 \xrightarrow{\Delta} FeO + SO_2$$

Smelting/ Reduction

The roasted ore is mixed with coke (C) and sand (SiO_2) and then heated strongly in the blast furnace about 15-20 feet high and 3-5 feet in diameter. The coke burns and temperature of about 1000 ^{O}C is produced. At this temperature,

FeS is oxidised to FeO. Thus formed FeO combines with SiO_2 to give fusible silicate slag which being lighter forms a layer on the surface and is removed through the slag hole time to time.

$FeO + SiO_2 \rightarrow FeSiO_3$ (fusible slag)

Cu_2O is also converted in to copper sulphide.

$Cu_2O + FeS \rightarrow Cu_2S + FeO$

Some Cu_2O are reduced by coke.

$Cu_2O + C \rightarrow Cu + CO$

The molten mass below the slag consists of a mixtures of Cu metal, Cu_2S and FeS is called matte or coarse metal.

Matte forms lower layer in the blast furnace and is taken out from the taping hole at the bottom.

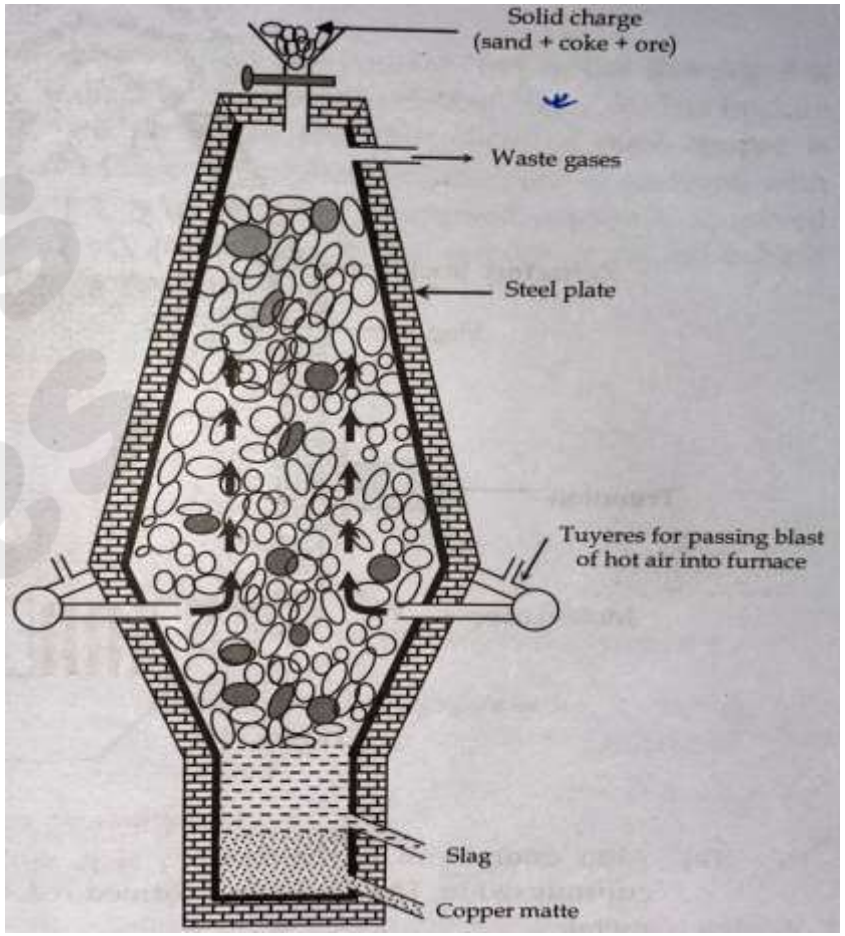


Fig: Smelting process in blast furnance

Bessemerization

Molten mass is mixed with SiO_2 in a Bessemer converter lined with SiO_2 and a blast of hot air is introduced. The following changes take place here.

Fes present in matte gets oxidised to FeO which then combines with Silica (SiO_2) lining to form slag.

$FeS + O_2 \rightarrow FeO + SO_2$

$FeO + SiO_2 \rightarrow FeSiO_3$ (slag)

The slag being light forms a layer on the surface which is skimmed off.

The Cu_2S gets oxidised to Cu_2O which is then combines with remaining Cu_2S to give free copper.

$Cu_2S + O_2 \rightarrow Cu_2O + SO_2$

$Cu_2O + Cu_2S \rightarrow Cu + SO_2$

The molten mass is then cooled. Then the dissolved SO_2 gas escapes out forming large blister on the metal surface. The copper metal thus formed is therefore called ***blister copper*** which is 98% pure.

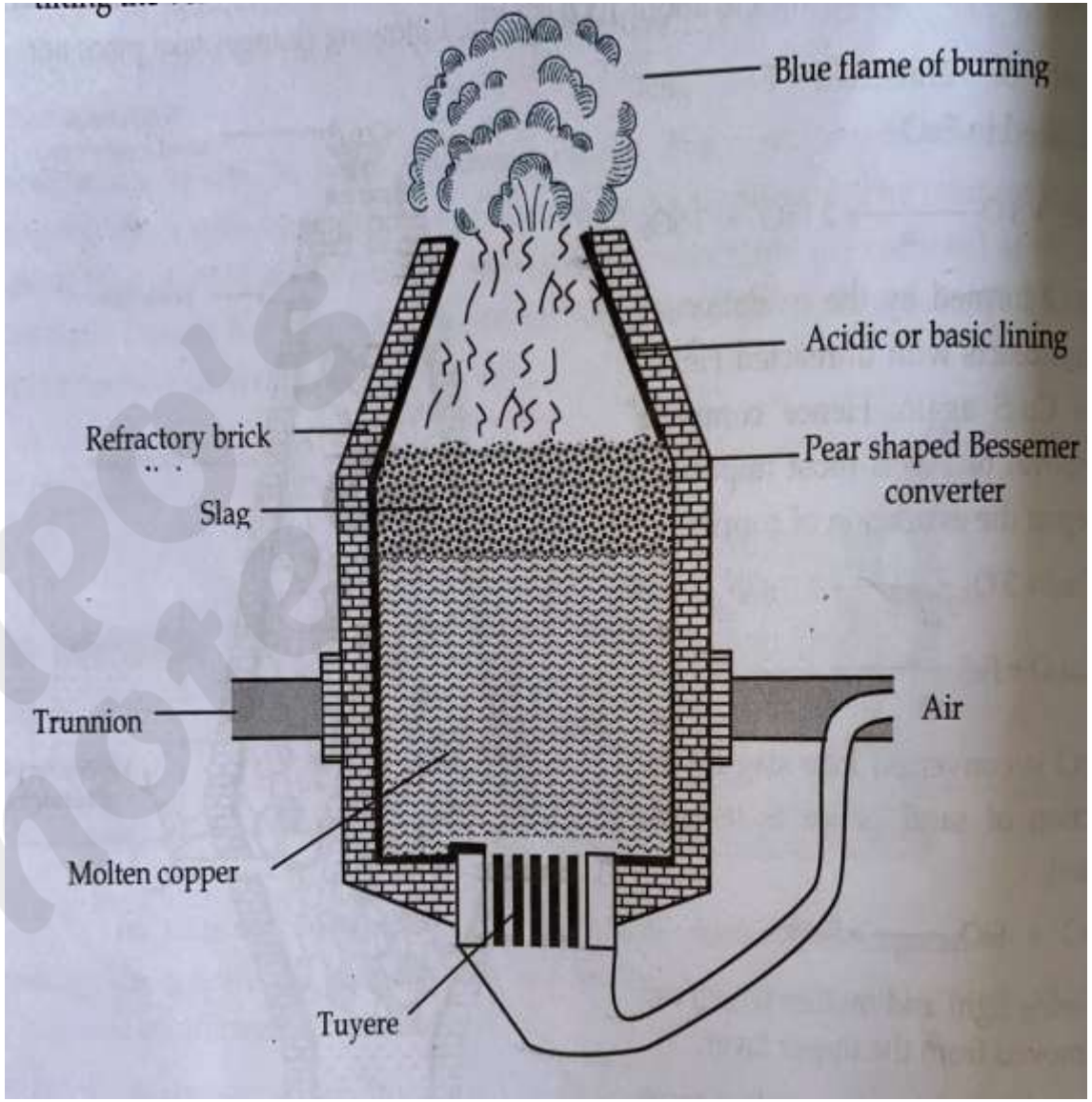


Fig: Bessemer Converter

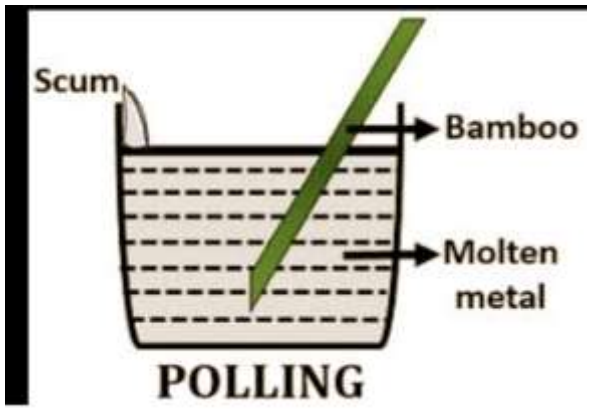
Refining of Blister of copper (Purification)

Refining is the process,which is usually done with the metal extracted by general mettalurgical process because metals thus extracted are not100% pure. Blister copper is about 98-99% pure. It may contain its oxide associated with Fe,As,Pb etc.as impurities. Therefore, blister copper is purified mainly by two methods.

1.Poling Process: The blister copper is purified by heating it strongly in a reverberatory furnace in presence of air. The impurities are either removed as volatile oxides or converted into slag.

some of the copper also changes to cuprous oxide(Cu_2O). This is reduced back to copper by stirring the molten metal with green poles of wood. The hydrocarbons present in these freshly cut poles reduce cuprous oxide to copper which is about 99.5% pure

$$3Cu_2O + CH_4 \longrightarrow 6Cu + CO + 2H_2O$$



Electrolysis

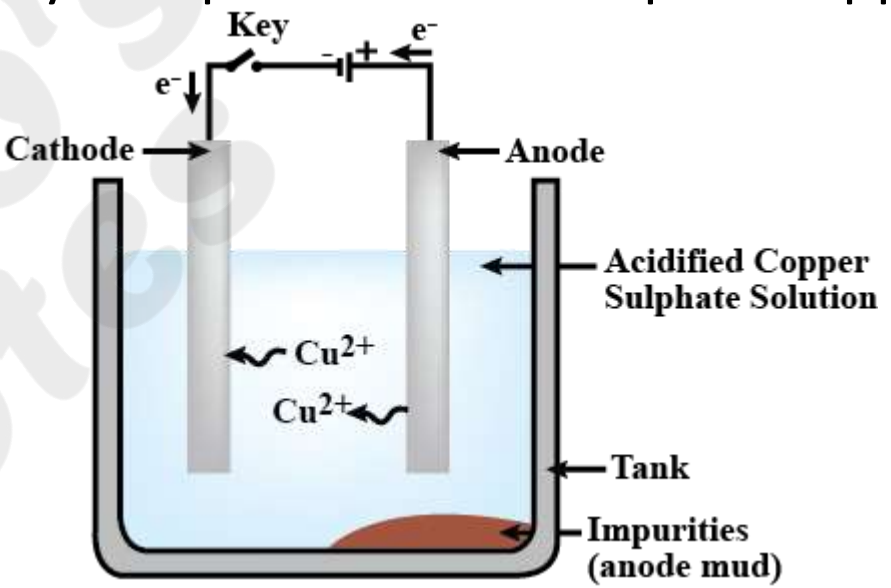
Purification is done by electrolysis method in which impure copper(copper to be purified) is made anode and pure copper is made cathode in an electrolytic cell containing acidified copper sulphate solution. On passing current pure copper is deposited at cathode and the impurities are collected at anode as anode mud just below the anode . By this process 99.95% pure copper is obtained.

At anode

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

At cathode

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



Some important questions

- Explain occurrence of heavy metals.
- Describe extraction of heavy metals.
- Describe properties (with air, acids, aqueous ammonia and metal ions) and uses of copper.
- Explain chemistry (preparation, properties and uses) of blue vitriol.
- Write formula and uses red and black oxide of copper
- Describe properties (with air, acid, alkali, displacement reaction) and uses of zinc.
- Explain chemistry (preparation, properties and uses) of white vitriol.
- State properties of mercury.
- Explain chemistry (preparation, properties and uses) of calomel and corrosive sublimate.
- Explain properties and uses of iron.
- Explain manufacture of steel by basic oxygen method and open hearth process.
- Explain corrosion of iron and its prevention.
- Explain preparation and uses of silver chloride and silver nitrate