Occurance and Extraction of Metals

Source of metal: Metals occur in earth's crust and in sea water; in the form of ores. Earth's crust is the major source of metal. Sea water contains many salts; such as sodium chloride, magnesium chloride, etc.

Mineral: Minerals are naturally occurring substances which have uniform composition.

Ores: The minerals from which a metal can be profitably extracted are called ores.

Metals found at the bottom of reactivity series are least reactive and they are often found in nature in free-state; such as gold, silver, copper, etc. Copper and silver are also found in the form of sulphide and oxide ores.

Metals found in the middle of reactivity series, such as Zn, Fe, Pb, etc. are usually found in the form of oxides, sulphides or carbonates.

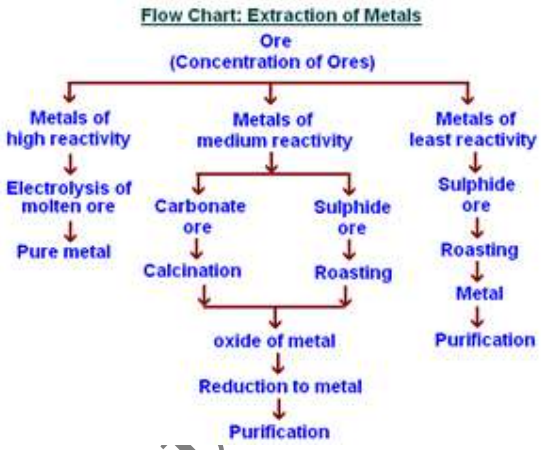
Metals found at the top of the reactivity series are never found in free-state as they are very reactive, e.g. K, Na, Ca, Mg and Al, etc.

Many metals are found in the form of oxides because oxygen is abundant in nature and is very reactive.

Extraction of Metals

Metals can be categorized into three parts on the basis of their reactivity: most reactive, medium reactive and least reactive.

Steps of Extraction of Metals



Concentration of ores: Removal of impurities, such as soil, sand, stone, silicates, etc. from mined ore is known as Concentration of Ores.

Ores which are mined often contain many impurities. These impurities are called gangue. First of all, concentration is done to remove impurities from ores. Concentration of ores is also known as enrichment of ores. Process of concentration depends upon physical and chemical properties of ores. Gravity separation, electromagnetic separation, froth flotation process, etc. are some examples of the processes which are applied for concentration of ores.

Conversion of metals ores into oxides:

It is easy to obtain metals from their oxides. So, ores found in the form of sulphide and carbonates are first converted to their oxides by the process of roasting and calcination. Oxides of metals so obtained are converted into metals by the process of reduction.

Roasting: Heating of sulphide ores in the presence of excess air to convert them into oxides is known as ROASTING.

Calcination: Heating of carbonate ores in the limited supply of air to convert them into oxides is known as CALCINATION.

Reduction: Heating of oxides of metals to turn them into metal is known as REDUCTION.

Purification: Metal; so obtained is refined using various methods.

Extraction of Metals of Least Reactivity

Mercury and copper, which belong to the least reactivity series, are often found in the form of their sulphide ores. Cinnabar (HgS) is the ore of mercury. Copper glance (Cu_2S) is the ore of copper.

Extraction of mercury metal: Cinnabar (HgS) is first heated in air. This turns HgS [mercury sulphide or cinnabar] into HgO (mercury oxide); by liberation of sulphur dioxide.

Mercury oxide so obtained is again heated strongly. This reduces mercury oxide to mercury metal.

$$2HgS + 3O_2 \Rightarrow 2HgO + 2SO_2$$

$$2HgO \Rightarrow 2Hg + O_2$$

Extraction of copper metal: Copper glance (Cu2S) is roasted in the presence of air. Roasting turns copper glance (ore of copper) into copper (I) oxide. Copper oxide is then heated in the absence of air. This reduces copper (I) oxide into copper metal.

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

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

Extraction of Metals of middle reactivity:

Iron, zinc, lead, etc. are found in the form of carbonate or sulphide ores. Carbonate or sulphide ores of metals are first converted into respective oxides and then oxides are reduced to respective metals.

Extraction of zinc: Zinc blende (ZnS: zinc sulphide) and smithsonite or zinc spar or calamine (ZnCO3: zinc carbonate) are ores of zinc. Zinc blende is roasted to be converted into zinc oxide. Zinc spar is put under calcination to be converted into zinc oxide.

$$2ZnS + 3O_2 \Rightarrow 2ZnO + 2SO_2$$

$$ZnCO_3 \Rightarrow ZnO + CO_2$$

Zinc oxide so obtained is reduced to zinc metal by heating with carbon (a reducing agent).

$$ZnO + C \Rightarrow Zn + CO$$

Extraction of iron from Hematite (Fe_2O_3): Hematite ore is heated with carbon to be reduced to iron metal.

$$Fe2O_3 + 3C \Rightarrow 4Fe + 3CO_2$$

Extraction of lead from lead oxide: Lead oxide is heated with carbon to be reduced to lead metal.

$2PbO + C \Rightarrow 2Pb + CO_2$

Reduction of metal oxide by heating with aluminium: Metal oxides are heated with aluminium (a reducing agent) to be reduced to metal. Following is an example:

Manganese dioxide and copper oxide are reduced to respective metals when heated with aluminium.

$3MnO_2 + 4Al \Rightarrow 3Mn + 2Al_2O_3$

$3CuO + 2Al \Rightarrow 3Cu + Al_2O_3 + heat$

Thermite Reaction: Ferric oxide; when heated with aluminium; is reduced to iron metal. In this reaction, lot of heat is produced. This reaction is also known as Thermite Reaction. Thermite reaction is used in welding of electric conductors, iron joints, etc. such as joints in railway tracks. This is also known as Thermite Welding (TW).

$Fe_2O_3 + 2Al \Rightarrow 2Fe + Al_2O_3 + heat$

Extraction of Metals of high reactivity

Metals of high reactivity; such as sodium, calcium, magnesium, aluminium, etc. are extracted from their ores by electrolytic reduction. These metals cannot be reduced using carbon because carbon is less reactive than them.

Electrolytic Reduction: Electric current is passed through the molten state of metal ores. Metal; being positively charged; is deposited over the cathode.

Example: When electric current is passed through molten state or solution of sodium chloride, sodium metal deposited over cathode.

$Na^+ + e^- \Rightarrow Na$

$2Cl^- - e^- \Rightarrow Cl2$

$2NaCl \Rightarrow 2Na + Cl_2$

Metals obtained from the process of electrolytic reduction are pure in form.

Refining or purification of metals:

Metals extracted from various methods contains some impurities, thus they are required to be refined. Most of the metals are refined using electrolytic refining.

Electrolytic Refining: In the process of electrolytic refining a lump of impure metal and a thin strip of pure metal are dipped in the salt solution of metal to be refined. When electric current is passed through the solution, pure metal is deposited over thin strip of pure metal; from lump of impure metal. In this, impure metal is used as anode and pure metal is used as cathode.

Electrolytic refining of copper:

A lump of impure copper metal and a thin strip of pure copper are dipped in the solution of copper sulphate. Impure lump of metal is connected with the positive pole and thin strip of pure metal is connected with the negative pole. When electric current is passed through the solution, pure metal from anode moves towards cathode and is deposited over it. Impurities; present in metal are settled near the bottom of anode in the solution. Settled impurities in the solution are called anode mud.

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

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