(iii) The ore is converted into it's oxide form in presence of oxygen

$$2PbS + 3O_2 \xrightarrow{\Delta} 2PbO + 2SO_2\uparrow$$

$$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2\uparrow$$

5. Reduction: In this step, the metal oxides are reduced to metal. Reduction can be done in following ways:-

(i) Carbon reduction (Smelting): It is a process in which the metal oxide is reduced by carbon into free metal. In this process, the roasted or calcined ore is mixed with suitable quantity of coke or charcoal (which acts as reducing agent) and is heated to a high temperature above it's melting point.

$$ZnO + C \longrightarrow Zn + CO$$

$$CuO + C \longrightarrow Cu + CO$$

(ii) Reduction with alumina (Thermite process): Certain oxides like Cr_2O_3, TiO_2, Mn_3O_4 are not reduced by carbon reduction process because the affinity of oxygen for the metal is greater than for carbon. For the reduction of such types of metal

oxides, aluminium powder is used as reducing agent because it is more electropositive than chromium, tin and manganese. The process of reduction of oxides with aluminium is called alumino-thermite process.

$$Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$$
$$3TiO_2 + 4Al \longrightarrow 2Al_2O_3 + 3Ti$$
$$3Mn_3O_4 + 8Al \longrightarrow 4Al_2O_3 + 9Mn$$

(iii) Electrolytic reduction: The oxides of alkali metal and alkaline earth metal are chemically stable. So, it is difficult to reduce their oxides by carbon reduction and alumino thermite process. Thus, they are reduced by the electrolysis of their oxides, hydroxides or chlorides in fused state. The metal is liberated at cathode.

For example, magnesium metal is extracted by the electrolysis of fused MgO.

$$MgO \rightleftharpoons Mg^{+2} + O^{2-}$$

At anode: $O^{2-} \longrightarrow \frac{1}{2}O_2 + 2e^-$

At cathode: $Mg^{+2} + 2e^- \longrightarrow Mg$

In this way, metal is liberated at cathode.

6. Refining of Metals:

The metals obtained from any methods still contain some impurities which can be purified by following methods:-

(i) Poling: The impure metal containing oxide impurities can be purified by this method. The impure metal is melted and the molten metal is stirred with green poles of wood. This method is applied for refining copper and tin. The green poles of wood liberate methane gas which reduces oxide of metals. For example,

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

(ii) Electrolytic refining: This method is based upon the phenomenon of electrolysis. The impure metal is made anode while the thin sheet of pure metal as cathode. The electrolyte is generally an aqueous solution of a salt of the same metal. On passing electric current, the pure metal deposits on the cathode. The soluble impurities pass in the solution, while the insoluble impurities collect below the anode as anode mud.

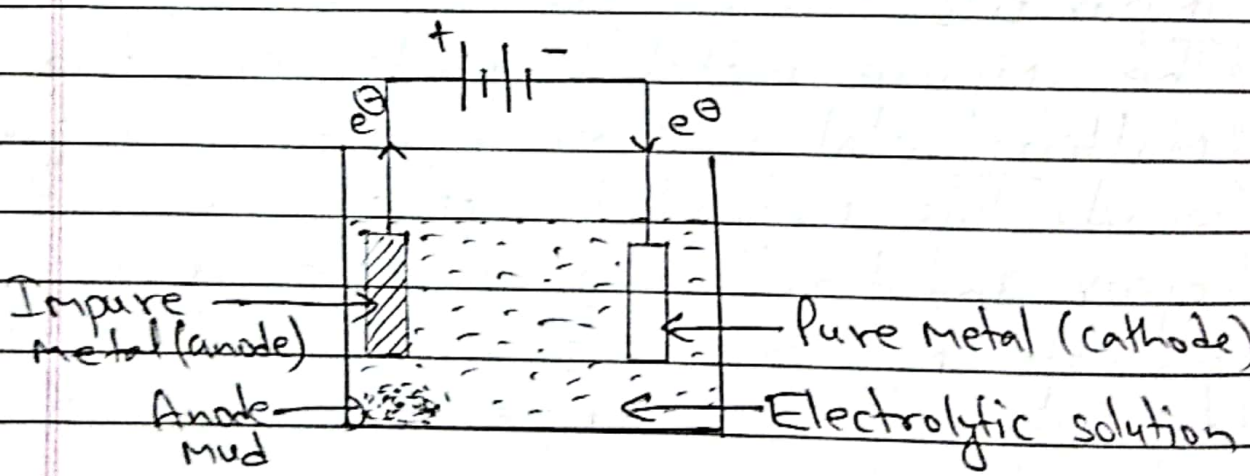

Fig: Electrolytic refining

Gangue or matrix, flux and slag:

Gangue or matrix: After calcination or roasting process, some impurities of ore do not get volatilized even at high temperature. Such impurities are called gangue or matrix.

Flux: During reduction, an additional reagent is added to remove such matrix or gangue present in ore. Such reagent is called flux.

Slag: Flux combines with impurities to form a fusible product called slag.

flux + matrix ⟶ slag