Unit - VI

General Principles And Processes of Isolation of elements

Element → It is the simplest and purest form of a substance.

Occurrence of elements →

1) Minerals → The natural occuring substance in the form of which element occurs is called as mineral.
eg → The main minerals of Al ore clay and Bauxite.

2) Ore → The mineral from which the element is easily and economically can be extracted is called as ore.
eg → Bauxite is a ore of Al.
Thus all the ores are minerals but all the minerals are not ores.

Metallurgy → The process of extration of metal from its ores is called as metallurgy or metallurgical operation.
Metallurgy involves following steps →

1) crushing and grinding of ore portiles.
2) Concentration / benification of ore portiles
3) Extration of crude metal from ore
4) Refining of crude metal

⇒ Crushing and grinding of ore portiles
→ The big portiles are converted into small portiles and these small portiles are further converted into powder with

the help of ball mills or stamp mills. This process is known as pulverisation.

→ Concentration / benification of ore particles → The process of removal of impurities (gangue or matrix) from the ore particles is known as concentration or benification of ore particles.

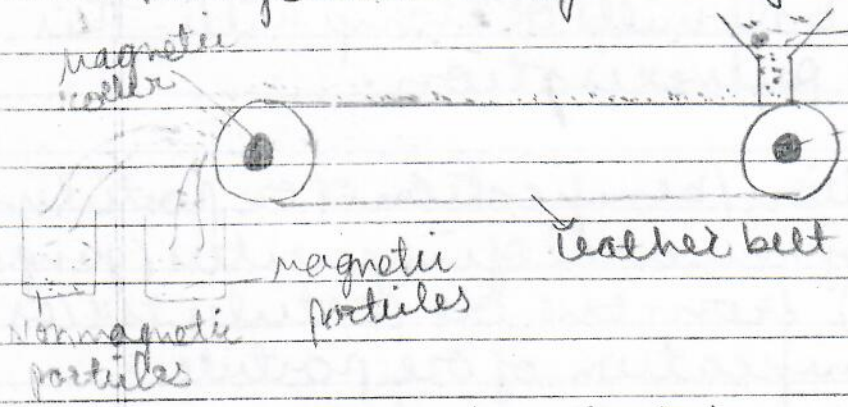
Depending upon the nature of impurities and ore particles we have different methods of removal of impurities from ore particles

1) Hand picking
2) Gravity separation / levigation → when the ore particles are heavier than impurities this process is used for the concentration or benification of ore particles.

This process is carried out in a specially designed table known as Wilfley table. In this process the impurities are removed by putting water on the top of a wilfley table. The impurities moves down with water whereas ore particles remains on the table. The ores of Fe, Sn, Ag etc. can be purified by this method.

3) Electromagnetic separation → This method is used when either ore particles or impurities are magnetic in nature. This method consists of two roller out of which one is electromagnetic in nature. A belt is moving around these two rollers. The impure ore particles is introduced on the belt & in this method pure ore particles are dropped at one position & the

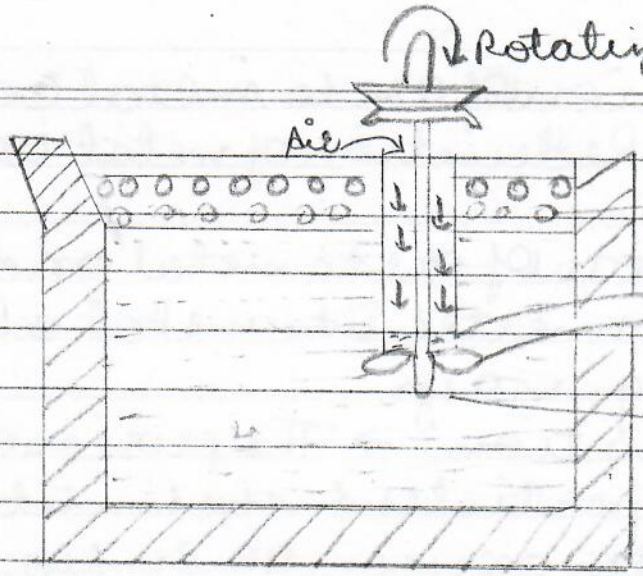
impurities are dropped at other position. This method is generally used for the purification of ores of Fe.



5)

4) For Froth floatation method/process → This method of conc of ore portiles is used when there is a differene in wetting property of ore and impurities. This method is generally used for the conc of sulphide ores because sulphide ores are wetted by oils whereas their impurities are wetted by water.

During this process, there are two container separated by a portation - one of them contains sulphide ore &, oil and water. Then compressed air ~~through it~~ draws through it. The ore portiles which are not wet by oils become lighter. Now these lighter podicles rise to the surface along with the froth. The impurities which are wet by water being heavier settle down in the container. Lastly the froth is transferred to another tank and is washed again & again with water to get the concentrated ore.



5) Leaching / chemical method → This method consists of treating the impure ore particles with suitable reagent which only dissolves ore particles but not the impurities. Then the pure ore particles dissolved ~~ore~~ are removed from the suitable reagent by treating it with another reagent - The ore particles of Al ore purified by this method. In this method the ore of Al i.e. bauxite is dissolved in sol. of NaOH. The pure ore particles get dissolved and forms Na meta alluminate whereas impurities as it is. The pure ore particles are removed from Na meta alluminate by passing CO_2 through it.

$$Al_2O_3 + 2NaOH + 3H_2O \longrightarrow 2Na[Al(OH)_4]$$

(Na meta alluminate)

$$2Na[Al(OH)_4] + 2CO_2 \longrightarrow Al_2O_3 \cdot xH_2O + 2NaHCO_3$$

$$Al_2O_3 \cdot xH_2O \longrightarrow Al_2O_3 + xH_2O$$

⇒ Extraction of crude metal from ore → In this process the crude metal is obtained

from core ore which involves following steps →

1) Conversion of ore to metal oxide
2) ~~Conver~~ Reduction of metal oxide to metal.

Conversion of ore to metal oxide → The core ore is converted into metal oxide by following ways

(i) Calcination → The process of heating the ore particles in the limited supply of air or oxygen or in the absence of air or oxygen is called as Calcination

During calcination →

- moisture is removed
- the water is removed from hydrated oxide

$$Al_2O_3 \cdot xH_2O \xrightarrow{\Delta} Al_2O_3 + xH_2O$$

- volatile impurities such as sulphur, P & As are removed.

$$S_8 + 8O_2 \longrightarrow 8SO_2 \uparrow$$
$$P_4 + 5O_2 \longrightarrow P_4O_{10} \uparrow$$

(ii) Roasting → The process of heating of ore particles in the excess of air or oxygen is called as roasting.

During roasting

- Moisture is removed
- volatile impurities such as S, P & As are removed.

$$S_8 + 8O_2 \longrightarrow 8SO_2 \uparrow$$
$$P_4 + 5O_2 \longrightarrow P_4O_{10} \uparrow$$

- The ores are converted into a metal

oxide.

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

Flux :→ is a substance which combines with impurities which are present in the roasted ~~ore~~ or a calcinated ore to form a fusable material called slag.

Flux + impurities = slag

The flux added depends upon the nature of impurities. If acidic impurities are present then basic flux is added

$$\underset{\text{Acidic impurities}}{SiO_2} + \underset{\text{Basic flux}}{CaO} \rightarrow \underset{\text{Slag}}{CaSiO_3}$$

If basic impurities are present then acidic flux is used.

$$\underset{\text{basic impurities}}{CaO} + \underset{\text{acidic flux}}{SiO_2} \rightarrow \underset{\text{Slag}}{CaSiO_3}$$

Reduction of metal oxide to metal →

The calcinated or roasted metal oxide is converted into a crude metal by treating it with suitable reducing agent. The reduction can be carried out following ways :→

- Reduction by C & CO (smelting) → The process of reduction of metal oxide to metal by heating it in presence of C in the form of a coke & CO is called smelting.

$$SnO_2 + \underset{\text{Coke}}{C} \rightarrow Sn + CO_2$$

$$FeO + CO \rightarrow Fe + CO_2$$

• Reduction with Al (Aluminothermy)
→ The proces of reduction of metal oxide to metal with the help of Al powder is also aluminothermy.

$$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe$$

The molten iron produced by thermide proces can be used to build a broken part of machinery. This is also thermide welding.

⇒ Refining of crude metal → The crude metal contains impurities in it which can be removed by following steps ⇒

• Electrolytic refining → This is the most common method of refining of crude metal - This method is based on the phenomenon of electrolysis. In this proces the impure metal behaves as an anode & the same pure metal behaves as cathode & their purification is carried out with the help of electrolysis.

at cathode → $Cu^{2+} + 2e^- \rightarrow Cu$

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

• Zone refining → This method is used for the refining of a metal which are required in a very high purity. This method is based on the principle that impurities are more soluble in the melt then in the solid state of a metal.

In this method, the impure metal is cast into a thin bar. A circular thin mobile heater is fixed at one end of the rod of impure metal. One zone of the bar is melted. At the heated zone, the metal melts & forms a molten zone or the melt. As the heater moves slowly the impurities will moves with heater in the same direction. In this way, the impurities are made to move into one end which is finally cut off & discarded the remain bar is pure metal.

• van Arkel method → This method is used to prepare ultra pure metal. In this method the crude metal is treated with a suitable reagent in such a way that pure metal forms unstable volatile compound whereas impurities remains as it is. The unstable volatile compound on dissociation gives pure metal & the reagent. eg → Zr metal is purified with this method.

$$Zr + 2I_2 \longrightarrow ZrI_4 \longrightarrow \underset{\text{Pure metal}}{Zr} + 2I_2$$

• Liquation → This method is used for the purification of metal which have low MP than those of impurities. In this method the crude metal is heated in a furnace having a standing surface to get a pure metal.