Chapter:-6 General Principles & Process of Isolation of Elements

Important Points :

1. The chemical substances in the earth's crust obtained by mining are called Minerals.
2. Minerals, which act as source for metal, are called Ore. From ore metal can be obtained economically .
3. The unwanted impurities present in ore are called Gangue.
4. The entire process of extraction of metal from its ore is called Metallurgy.
5. Removal of gangue from ore is called Concentration, Dressing or Benefaction of ore.
6. Concentration by Hydraulic washing is based on the difference in gravities of ore and gangue particles.
7. Concentration by Magnetic separation is based on differences in magnetic properties of ore components. If either of ore or gangue is capable of attracted by a magnet field, then such separation is carried out.
8. Concentration by Froth Flotation Process is based on the facts that sulphide ore is wetted by oil & gangue particles are wetted by water.
9. Concentration by Leaching is based on the facts that ore is soluble in some suitable reagent & gangue is insoluble in same reagent. e.g. Bauxite ore contains impurities of silica, iron oxide & TiO_2 .The powdered ore is treated with NaOH which dissolve Al & impurities remains insoluble in it.

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

10. Calcination involves heating of ore in absence of air below melting point of metal. In this process volatile impurities escapes leaving behind metal oxide.

$$Fe_2O_3.xH_2O \longrightarrow Fe_2O_3 + xH_2O$$
$$ZnCO_3 \longrightarrow ZnO + CO_2$$
$$CaCO_3.MgCO_3 \longrightarrow CaO + MgO + 2CO_2$$

11. Roasting involves heating of ore in presence of air below melting point of metal in reverberatory furnace. In this process volatile impurities escapes leaving behind metal oxide and metal sulphide converts to metal oxide.

$$2\ ZnS + 3\ O_2 \longrightarrow 2ZnO + 2SO_2$$
$$2PbS + 3\ O_2 \longrightarrow 2\ PbO + 2\ SO_2$$
$$2\ Cu_2S + 3\ O_2 \longrightarrow 2Cu_2O + 2\ SO_2$$

12. Reduction of metal oxide involves heating of metal in presence of suitable reagent Coke or CO_2.

13. Reactions taking place at different zones of blast furnace in extraction of iron:-

(i) Zone of reduction:- Temperature range 250^oC-700^oC

$$3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$$
$$Fe_3O_4 + CO \longrightarrow 3FeO + CO_2$$
$$FeO + CO \longrightarrow Fe + CO_2$$

(ii) Zone of slag formation:- Temperature range 800^oC-1000^oC

$CaCO_3 \longrightarrow CaO+CO_2$

$CaO+SiO_2 \longrightarrow CaSiO_3$, $P_4O_{10}+10C \longrightarrow 4P+10CO$,

$SiO_2+2C \longrightarrow Si+2CO$, $MnO_2+2C \longrightarrow Mn+2CO$

(iii) Zone of fusion: - Temperature range 1150°C-1350°C

$CO_2 + C \longrightarrow 2CO$

(iv) Zone of fusion: - Temperature range 1450°C-1950°C

$C + O_2 \longrightarrow CO_2$

14. FLOW SHEET FOR EXTRACTION OF IRON:-

Iron ore(Magnetite Fe_3O_4)(Haematite Fe_2O_3)

↓

Concentration is done by Gravity separation followed by magnetic separation

↓

Calcination &Roasting i.e. Ore + Air +Heat→Moisture,CO_2,SO_2, As_2O_3 removed And FeO oxidized to Fe_2O_3

↓

Smelting of charge i.e. mixture of ore, coke & $CaCO_3$ takes place in long BLAST FURNACE. Following reaction take place at different zones:-
(refer to point 13)

↓

Pig iron is obtained, which is remelted and cooled then cast iron is obtained

15. Pig Iron: - It contains Fe 93-95%, Carbon 2.5-5%, and Impurities 3%.
16. Cast Iron: - It contains Fe 99.5-99.8%, Carbon 0.1-0.2% Impurities 0.3%.
17. Spongy iron: - Iron formed in the zone of reduction of blast furnace is called spongy iron. It contains impurities of C, Mn , Si, etc.

18. FLOW SHEET FOR EXTRACTION OF COPPER:-

Copper Pyrites $CuFeS_2$

↓

Concentration is done by Froth floatation process
Powdered ore + water +pine oil +air→ Sulphide ore in the froth

↓

Roasting is presence of air. following reactions take place:-
S+ O2→SO_2, $4As+3O_2 \rightarrow 2As_2O_3$, $2CuFeS_2+O_2 \rightarrow Cu_2S+2FeS+SO_2$

↓

Smelting in small blast furnace of a mixture of Roasted ore, coke, and silica.
$2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$, $FeO + SiO_2 \rightarrow FeSiO_3$(slag)

↓

A mixture of Cu_2S, FeS & silica is obtained from blast furnace known as Copper matte

↓

Bessemerisation of copper matte is done in Bessemer converter in presence of air. Following reactions take place:-

$2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$, $FeO + SiO_2 \rightarrow FeSiO_3$ (slag),

$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$, $2Cu_2O + 2Cu_2S \rightarrow 6Cu + SO_2$

↓

Melted copper is cooled, and then SO_2 is evolved. such copper is known as BLISTER COPPER(98%Cu+2% impurities)

19. **FLOW SHEET FOR EXTRACTION OF ALUMINIUM:-**

Bauxite $Al_2O_3.2H_2O$

↓

Concentration of ore is done by leaching .Bauxite is treated with NaOH .Following reaction takes place:-

$Al_2O_3 + 2NaOH + 3H_2O \longrightarrow 2Na[Al(OH)_4]$ and impurities of Fe_2O_3, TiO2 &SiO_2 are removed.

↓

$Na[Al(OH)_4]$,then reacts with CO_2 then pure Alumina is obtained.

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

↓

Electrolytic reduction of pure alumina takes place in iron box (cathode) with cryolite (Na_3AlF_6) & fluorspar CaF_2.Graphide rods act as anode. Following reactions take place:-

At cathode:- $Al^{3+} + 3e \rightarrow Al$, At Anode:- $2O^{2-} \rightarrow O_2 + 4e$

↓

By this process 98.8% pure Aluminum is obtained.

20. Vapour phase refining is used for extraction of Nickel (MOND PROCESS) and Zirconium &Titanium (VAN ARKEL PROCESS).

21. Zone refining is used for extraction of Si, Ge, Ga, etc.

22. Chromatography method is based on selective distribution of various constituents of a mixture between two phases, a stationary phase and a moving phase. The stationary phase can be either solid or liquid on solid support.

22. Column chromatography is based on adsorption phenomenon. This method is useful for those elements, which are available in small amounts and the impurities are not much different in chemical properties from the element to be purified.

VERY SHORT ANSWER TYPE QUESTION

(1 marks)

Q.1- What is slag?

A.1- It is easily fusible material fusible material, which is formed when gangue still present in roasted ore combines with the flux.

e.g. CaO (flux) + SiO_2 (gangue) $\rightarrow CaSiO_3$ (slag)

Q.2- Which is better reducing agent at 983K, carbon or CO?

A.2- CO, (above 983K CO being more stable & does not act as a good reducing agent but carbon does.)

Q.3- At which temperature carbon can be used as a reducing agent for Foe ?

A.3- Above 1123K, carbon can reduce FeO to Fe.

Q.4- What is the role of graphite rods in electrometallurgy of aluminium ?

A.4- Graphite rods act as anode, are attacked by oxygen to form CO_2 and so to be replace time to time.

Q.5- What is the role of cryolite in electrometallurgy of aluminium?

A.5- alumina cannot be fused easily because of high melting point. Dissolving of alumina in cryolite furnishes Al^{3+} ions, which can be electrolyzed easily.

Q.6- What are depressants?

A.6- It is possible to separate two sulphide ore by adjusting proportion of oil to water in froth flotation process by using a substance known as depressant.

e.g. NaCN is used to separate ZnS and PbS.

Q.7- Copper can be extracted by hydrometallurgy but not Zn. Why?

A.7- The E^0 of Zn is lower than that of Cu thus Zn can displace Cu^{2+} ion from its solution. On other hand side to displace Zn from Zn^{2+} ion, we need a more reactive metal than it.

Q.8- Give name and formula of important ore of iron .

A.8- Haematite – Fe_2O_3, Magnetite –Fe_3O_4, Iron pyrites FeS_2.

Q.9- Give name and formula of important ore of Copper .

A.9- Copper pyrites $CuFeS_2$, Malachite $CuCO_3 . Cu(OH)_2$, Cuprite Cu_2O.

Q.10- Give name and formula of important ore of Zinc .

A.10- Zinc blende - ZnS, Calamine- $ZnCO_3$, Zincite – ZnO .

SHORT ANSWER TYPE QUESTION

(2 marks)

Q.1 Describe the method of refining of nickel.

A.1- In the Mond Process, Ni is heated in a stream of CO forming a volatile complex, which then decomposes at higher temperature to give Ni.

At 330-350K: - $Ni + 4CO \rightarrow Ni(CO)_4$

At 450-470K $Ni(CO)_4 \rightarrow Ni + 4\,CO$

Q.2- What is Zone Refining? Explain with example.

A.2- Zone refining is a method of obtaining a metal in very pure state. It is based on the principal that impurities are more soluble in molten state of metal than solidified state.

In this method, a rod of impure metal is moved slowly over circular heater. The portion of the metal being heated melts & forms the molten zone. As this portion of the rod moves out of heater, it solidified while the impurities pass into molten zone. The process is repeated to obtain ultrapure metal and end of rod containing impure metal cutoff.

Q.3 Write the principal of electro-refining.

A.3- In this method of purification impure metal is made Anode and pure metal is made the cathode. On passing electricity, pure metal is deposited at the cathode while the impurities dissolve dissolve in solution as anode mud. E.g. electro- refining of copper:-

At Cathode: - $Cu^{2+} + 2e \rightarrow Cu$

At Anode: - $Cu \rightarrow Cu^{2+} + 2e$

Q.4- Write difference between calcinations and roasting .

A.4- Refer points no 10 &11.

Q.5- Describe the method of refining of Zirconium and Titanium.

A.5- Van Arkel process is used for obtaining ultrapure metal. The impure metal is converted into volatile compound, which then decomposes electrically to get pure metal.

At 850K: - Zr impure) + 2 $I_2 \rightarrow ZnI_4$

At 2075K:- $ZnI_4 \rightarrow$ Zr (pure) + 2 I_2

Q.6- Out of C & CO, which is better reducing agent for ZnO?

A.6- Since free energy of formation of CO from C is lower at temperature above 1120K while that of CO_2 from carbon is lower above 1323K than free energy of formation 0f ZnO. However, the free energy of formation of CO_2 from CO is always higher than that of ZnO. Hence, C is better reducing agent of ZnO.

Q.7- The value of $\Delta_f G^0$ for Cr_2O_3 is -540kJ/mole & that of Al_2O_3 is -827kJ/mole. Is the reduction of Cr_2O_3 possible with aluminium?

A.7- The desired conversion is

$$4\,Al + 2Cr_2O_3 \rightarrow 2Al_2O_3 + 4Cr$$

It is obtained by addition of following two reactions:-

$4Al + 3O_2 \rightarrow 2\,Al_2O_3 \qquad \Delta_f G^0 = -827$kJ/mole

$2Cr_2O_3 \rightarrow 4Cr + 3O_2 \qquad \Delta_f G^0 = = +540$ kJ/mole

Therefore, ΔG^0 for desired reaction is -827+540=-287, as a result reduction is possible.

Q.8:- Why copper matte is put in silica lined converter?

A.8:- Copper matte consists of Cu_2S and FeS. When blast of air is passed through molten matte in silica-lined converter, FeS present in matte is oxidized to FeO, which combines with silica to form slag.

(i) $2FeS + 3O_2 \rightarrow 2FeO + 2\,SO_2$, (ii) $FeO + SiO_2 \rightarrow FeSiO_3$ (slag),

(III) $2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$, (IV) $2Cu_2O + 2Cu_2S \rightarrow 6Cu + SO_2$

Q.9- What is meant by term chromatography?

A.9-Chromato means Colour and graphy means writing because the method was first used for separation of coloured substance. It is based on selective distribution of various constituents of a mixture between two phases, a stationary phase and a moving phase. The stationary phase can be either solid or liquid on solid support.

Q.10-Why is reduction of metal oxide easier if metal formed is in liquid state at temperature of reduction.

A.10- The entropy of a substance is higher in liquid state than solid state. In the reduction of metal oxide, the entropy change will be positive if metal formed is in liquid state. Thus, the value of ΔG^0 becomes negative and reduction occurs easily.

SHORT ANSWER TYPE QUESTION

(3 marks)

Q.1- Explain the following:-

(i) Zinc but not copper is used for recovery of Ag from the complex $[Ag(CN)_2]^-$.

(ii) Partial roasting of sulphide ore is done in the metallurgy of copper.

(iii) Extraction of Cu from pyrites is difficult than that from its oxide ore through reduction.

A.1- (i) Zn is more powerful reducing agent in comparison to copper.Zn is also cheaper than Cu.

(ii) Partial roasting of sulphide ore forms some oxide. This oxide then reacts with remaining sulphide ore to give copper i.e. self-reduction occurs.

$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2,$$
$$2Cu_2O + 2Cu_2S \rightarrow 6Cu + SO_2.$$

(iii) Though carbon is good reducing agent for oxide but it is poor reducing agent for sulphides. The reduction of metal sulphide does not have large negative value.

Q.2- Explain the method for obtaining pig iron from magnetite.

A.2- Extraction of iron from Magnetite takes place in following steps:-

(i) Concentration of ore: - It is done by Gravity separation followed by magnetic separation process.

(ii) Calcination: - It involve heating when the volatile matter escapes leaving behind metal oxide.

$$Fe_2O_3.xH_2O \rightarrow Fe_2O_3 + xH_2O.$$

(iii) Roasting: - It involves heating of ore in presence of air, thus moisture, CO_2, SO_2, As_2O_3 removed And FeO oxidized to Fe_2O_3.

(iv) Smelting of roasted ore: - A mixture of ore, coke & $CaCO_3$ is smelted in long BLAST FURNACE. Following reaction takes place at different temperature zones:-

(i) Zone of reduction: - Temperature range 250°C-700°C

$$3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$$
$$Fe_3O_4 + CO \longrightarrow 3FeO + CO_2$$
$$FeO + CO \longrightarrow Fe + CO_2$$

(ii) Zone of slag formation:- Temperature range 800°C-1000°C

$$CaCO3 \longrightarrow CaO + CO2$$
$$CaO + SiO_2 \longrightarrow CaSiO_3, \qquad P_4O_{10} + 10C \longrightarrow 4P + 10CO,$$
$$SiO_2 + 2C \longrightarrow Si + 2CO, \qquad MnO_2 + 2C \longrightarrow Mn + 2CO$$

(iii) Zone of fusion:- Temperature range 1150°C-1350°C

$$CO_2 + C \longrightarrow 2CO$$

(iv) Zone of fusion:- Temperature range 1450°C-1950°C

$$C + O_2 \longrightarrow CO_2$$

Thus, Pig iron is obtained from Blast Furnace.

Q.3- Describe the principles of extraction of copper from its ore .

A.3- Refer points no 18. For steps, involve in the extraction.

Q.4- Name the principal ore of aluminium and describe how Al is extracted from its ore.

A.4- Important ores -(i) Bauxite $Al_2O_3.xH_20$ (ii) Corrundum Al_2O_3. Bauxite is commercially important ore Al.

Extraction from Bauxite ore involves the following two stages:-

(i) Purification of bauxite to get pure alumina (Al_2O_3)

(ii) Electrolysis of pure alumina in molten cryolite

Step:-1 Bauxite is treated with NaOH .Following reaction takes place:-

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

and impurities of Fe_2O_3, TiO_2 &SiO_2 are removed . $Na\ [Al(OH)_4]$,then reacts with CO_2 then pure Alumina is obtained.

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

Step:-2 Electrolytic reduction of pure alumina takes place in iron box (cathode) with cryolite (Na_3AlF_6) & fluorspar CaF_2.Graphide rods act as anode. Following reactions take place:-

At cathode:- $Al^{3+} + 3e \rightarrow Al$, At Anode:- $2O^{2-} \rightarrow O_2 +$ By this process 98.8% pure Aluminum is obtained.

Q.5- Describe the principles of extraction of Zinc from zinc blende .

A.5- Important ores of Zn:-Zinc blende - ZnS, Calamine- $ZnCO_3$, and Zincite – ZnO. ZnS is commercially important ore of Zn.Various stages involved in the extraction of Zn from ZnS are as following:-

(i) Concentration of ore:-It is concentrated by Froth flotation process followed by gravity separation process.

(ii) Roasting:- The concentrated ore is roasted in presence of air. Following reactions take place:-

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

The mass obtained during roasting is porous and is called porous clinker.

(iii) Reduction of ZnO to Zn: - ZnO is made into bricketts with coke and clay and heated ai1163K.Zn formed distills off and is collected by rapid cooling of zinc vapours.

$$ZnO + C \rightarrow Zn + CO$$

Unit-16 CHEMISTRY IN EVERYDAY LIFE

POINTS TO BE REMEMBERED

1. **DRUGS – Drugs are chemical of low molecular masses, which interact with macromolecular targets and produce a biological response.**
2. **CHEMOTHERAPY- The use of chemicals for therapeutic effect is called chemotherapy.**
3. **CLASSIFICATION OF DRUGS –**

(a) *ON THE BASIS OF PHARMACOLOGICAL EFFECT*-drugs for a particular type of problem as analgesics-----for pain relieving.

(b) *ON THE BASIS OF DRUG ACTION*-Action of drug on a particular biochemical process.

(c) *ON THE BASIS OF CHEMICAL ACTION*-Drugs having similar structure .eg-sulpha drugs.

(d) *ON THE BASIS OF MOLECULAR TARGETS*- Drugs interacting with biomolecules as lipids, proteins.

4. **ENZYMES AS DRUG TARGETS**

(i) *CATALYTIC ACTION OF EN ZYMES*-

(a) Enzymes have active sites which hold the substrate molecule .it can be attracted by reacting molecules.

(b) Substrate is bonded to active sites through hydrogen bonds, ionic bonds, Vander Waal or dipole –dipole interactions.

(ii) *DRUG- ENZYME INTERACTIONS*-

(a)Drug complete with natural substrate for their attachments on the active sites of enzymes .They are called competitive inhibitors.

(b)Some drugs binds to a different site of the enzyme called allosteric sites which changes the shape of active sites.

5. **ANTAGONISTS- The drugs that bind to the receptor site and inhibit its natural function.**
6. **AGONISTS-Drugs mimic the natural messenger by switching on the receptor.**