GENERAL PRINCIPLES AND PROCESSES OF ISOLATION OF ELEMENTS

SOLVED SUBJECTIVE EXERCISE

Very Short Answer Type Questions (1 mark)

1. The reaction, $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr \quad (\Delta G^\circ = -421\ kJ)$ is thermodynamically feasible as is apparent from the Gibbs energy value. Why does it not take place at room temperature ?

Ans. Certain amount of energy of activation is essential even for such reactions which are thermodynamically feasible, therefore heating is required.

2. State the role of silica in the metallurgy of copper.

Ans. Silica acts as a flux to remove iron oxide (FeO) as slag in the metallurgy of copper.

$$\underset{\text{Flux}}{FeO} + \underset{\text{Gangue}}{SiO_2} \longrightarrow \underset{\text{Slag}}{FeSiO_3}$$

3. What is meant by the term chromatography ?

Ans. The term chromatography was originally derived from the Greek word chroma meaning colour and graphy meaning writing because it was first used for the separation of coloured substances (plant pigments) into individual components. Presently the term chromatography means the method widely used for separation, purification and characterisation of the components of a mixture whether coloured or colourless.

4. How is leaching carried in case of low grade copper ores ?

Ans. The leaching of the low grade copper ores is carried out with acids in the presence of air when copper goes into solution as Cu^{2+} ions. Therefore,

$$2Cu(s) + 2H_2SO_4(aq) + O_2(g) \longrightarrow 2CuSO_4(aq) + 2H_2O(\ell)$$

or $$Cu(s) + 2H^+(aq) + \frac{1}{2}O_2(g) \longrightarrow Cu^{2+}(aq) + H_2O(\ell)$$

5. An ore sample of galena (PbS) is contaminated with zinc blende (ZnS). Name one chemical which can be used to concentrate galena selectively by froth floatation method.

Ans. NaCN (sodium cyanide) used as a depressant.

6. What is meant by beneficiation process ?

Ans. The process of removal of unwanted earthy and silicious impurities (gangue) from the ore is known as beneficiation process.

7. What is liquation ?

Ans. Liquation is a method of refining of metals and is used when the impurities are not miscible with the metal and the melting temperature of the metal is lower than that of the impurities.

8. What is the principle of zone refining ?

Ans. When the molten solution of an impure metal is allowed to cool, the pure metal crystallizes out while the impurities remain in solution.

9. What is the role of a stabilizer in froth floatation process ?

Ans. Chemical compounds like cresols and aniline which tend to stabilize the froth are called froth stabilizers.

10. What is the role of collectors in froth floatation process ?

Ans. Substances such as pine oil, xanthates and fatty acids which enhance the non-wettability of the ore particles thereby indirectly favouring froth formation are called collectors.

11. (a) Why is it that only sulphide ores are concentrated by froth floatation process ?

OR

Why is the froth floatation process selected for the concentration of sulphide ores ?

(b) Which of the following ores can be concentrated by froth floatation method ?

Fe_2O_3, ZnS, Al_2O_3

Ans. (a) The sulphide ore particles are preferentially wetted by oil, become lighter and thus rise to the surface along with the froth while the gangue particles are preferentially wetted by water, become heavier and thus settle at the bottom of the tank. In this way, sulphide ore particles are separated and hence concentrated from the gangue particles.

(b) Only sulphide ore, i.e., ZnS, is concentrated by froth floatation process.

12. Name the common elements present in the anode mud in electrolytic refining of copper. Why are they so present ?

Ans. The common elements present in the anode mud are antimony, selenium, tellurium, silver, gold and platinum. These elements, being less reactive, are not affected by $CuSO_4$ — H_2SO_4 solution and hence settle down under anode as anode mud.

Short Answer Type Questions (2 mark)

13. Copper can be extracted by hydrometallurgy but not zinc. Explain.

Ans. The E° of zinc ($Zn^{2+}/Zn = -0.76$ V) is lower than that of copper ($Cu^{2+}/Cu = +0.34$ V). This means that zinc is a stronger reducing agent and can displace copper from solution of Cu^{2+} ions.

$$Zn(s) + Cu^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cu$$

In order to extract zinc by hydrometallurgy, we need stronger reducing agent like K($E^{\circ}_{K^+/K} = -2.93$ V), Mg($E^{2}_{Mg^{2+}/Mg} = -2.37$ V), Al($E^{\circ}_{Al^{3+}/Al} = -1.66$ V), etc. However, all these metals reduce water to hydrogen gas. Therefore these metals cannot be used to displace Zn from solution of Zn^{2+} ions. Thus copper can be extracted by hydrometallurgy but not zinc.

14. What is the role of a depressant in froth floatation process?

Ans. In froth floatation process, the role of the depressant is to prevent certain type of particles from forming the froth with the air bubbles. For example, NaCN is used as a depressant separate lead sulphide ore from zinc sulphide ore (ZnS). NaCN forms a zinc complex $Na_2[Zn(CN)_4]$ on the surface of Zns thereby preventing it from the formation of froth.

15. What criterion is followed for selection of the stationary phase in chromatography ?

Ans. The stationary phase is selected in such a way that the impurities are more strongly adsorbed or are more soluble in the stationary phase than element to be purified. Under these conditions, when the column is extracted, the impurities will be retained by the stationary phase and the pure component is easily eluted.

16. How is cast iron different from pig iron ?

Ans. The iron obtained from blast furnace is called pig iron. It contains about 4% carbon and many other impurities in smaller amount (e.g., S, P, Si, Mn).

Cast iron, is different from pig iron and is made by melting pig iron with scrap iron and coke using hot air blast. It has slightly lower carbon content (about 3%) and is extremely hard and brittle.

17. Why copper matte is put in silica lined converter ?

Ans. Copper matte consists of Cu_2S and FeS. When a blast of hot air is passed through molten matte taken in a silica lined converter, FeS present in matte is oxidised to FeO which combines with silica (SiO_2) to form $FeSiO_3$ – slag.

$$2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2$$

$$\underset{\text{Silica}}{FeS + SiO_2} \longrightarrow \underset{\text{Slag}}{FeSiO_3}$$

18. The purest form of iron is prepared by oxidising impurities from cast in a reverberatory furnace. Which iron ore is used to line the furnace? Explain by giving reaction.

Ans. The reverberatory furnace is lined inside with hematite. It supplies the necessary oxygen required for oxidation of impurities of C to CO_2, S to SO_2, Si to SiO_2, P to P_4O_{10}, Mn to MnO, etc.

$$Fe_2O_3(s) + 3C(s) \longrightarrow 2Fe(s) + 3CO(g)$$

$$2\,Fe_2O_3(s) + 3S(s) \longrightarrow 4Fe(s) + 3SO_2(g)$$

19. Why is the extraction of copper from pyrite difficult than that from its oxide ore through reduction?

Ans. The standard free energy ($\Delta_f G^\circ$) of formation of Cu_2S is more negative than those of CS_2 and H_2S (CS_2 is, in fact, an endothermic compound). Therefore, neither carbon nor hydrogen can reduce Cu_2S to Cu metal.

$$Cu_2S + H_2 \longrightarrow\!\!\!\!\!\!\times\ 2Cu + H_2S; \qquad 2Cu_2S + C \longrightarrow\!\!\!\!\!\!\times\ 4Cu + CS_2$$

In contrast, $\Delta_f G^\circ$ of Cu_2O is less –ve than that of CO and hence carbon can easily reduce Cu_2O to Cu

$$Cu_2O(s) + C(s) \longrightarrow 2Cu(s) + CO(g)$$

It is because of this reason that the extraction of copper from pyrite is difficult than from its oxide ore through reduction. Alternatively, $\Delta G^\circ/T$ line for CO has a –ve slope and there is no compound CS analogous to CO with a steep negative $\Delta G^\circ/T$ line. Thus, carbon is a good reducing agent for oxides but a poor reducing agent for sulphides. Therefore, sulphides are normally roasted in air to form oxides before reducing them with carbon.

20. Why is the reduction of a metal oxide easier if the metal formed is in the liquid state at the temperature of reduction?

OR

Account for the following fact. The reduction of a metal oxide is easier if the metal is formed in the liquid state at the temperature of reduction.

Ans. Entropy is higher when a metal is in the liquid state than when it is in the solid state. Therefore, the value of entropy change (ΔS) of the reduction process is more on the +ve side when the metal formed is in the liquid state and the metal oxide being reduced is in the solid state. Since the value of $T\Delta S$ increases and that of ΔH remains constant, therefore, the value of $\Delta_r G^\circ$($\Delta G = \Delta H - T\Delta S$) becomes more –ve and hence the reduction becomes easier.

Short Answer Type Questions (3 mark)

21. The choice of a reducing agent in a particular case depends on thermodynamic factor. How far do you agree with this statement ? Support your opinion with two examples.

Ans. Thermodynamic factor helps us in choosing a suitable reducing agent for the reduction of a particular metal oxide to the metal state as described below.

From Ellingham diagram, it is evident that metals for which the standard free energy of formation of their oxides is more negative can reduce those metal oxides for which the standard free energy of formation of their respective oxides is less negative. In other words, any metal will reduce the oxides of other metals which lie above it in the Ellingham diagram because the standard free energy change ($\Delta_r G^\circ$) of the combined redox reaction will be negative by an amount equal to the difference in $\Delta_f G^\circ$ of the two metal oxides. Hence, both Al, Zn can reduce FeO to Fe but Fe cannot reduce Al_2O_3 to Al and ZnO to Zn. Similarly, C can reduce ZnO to Zn but not CO.

22. What is the role of graphite in the electrometallurgy of aluminium ?

Ans. In this process, a fused mixture of alumina, cryolite and flourspar (CaF_2) is electrolysed using graphite as anode and graphite lined iron as cathode. During electrolysis, Al is liberated at the cathode whereas CO and CO_2 are liberated at the anode.

Cathode: Al_3^+ (melt) $\longrightarrow$ Al(*l*)

Anode: $C(s) + O^{2-}$ (melt) $\longrightarrow CO(g) + 2e^-$

$C(s) + 2O^{2-}$ (melt) $\longrightarrow CO_2(g) + 4e^-$

If some other metal is used as the anode other than graphite, then O_2 liberated will not only oxidise the metal of the electrode but would also convert some of the Al liberated at the cathode back to Al_2O_3. So, the role of graphite in electrometallurgy of Al is to prevent the liberation of O_2 at the anode which may otherwise oxidise some of the liberated Al back to Al_2O_3.

23. (a) Name the method used for refining of (i) Nickel (ii) Zirconium

(b) The extraction of Au by leaching with NaCN involves both oxidation and reduction. Justify giving equations.

Ans. (a) (i) Mond Process (ii) Van Arkel method

(b) $4Au(s) + 8CN^-(aq) + 2H_2O(aq) + O_2(g) \longrightarrow 4[Au(CN)_2]^-(aq) + 4OH^-(aq)$

$2[Au(CN)_2]^-(aq) + Zn(s) \longrightarrow 2Au(s) + [Zn(CN)_4]^{2-}(aq)$

In the first reaction Au changes into Au^+ i.e., its oxidation takes place. In the second case

$Au^+ \longrightarrow Au^0$

i.e., reduction takes place.

24. Explain the basic principle of following metallurgical operations :
(i) Zone refining (ii) Vapour phase refining (iii) Electrolytic refining

Ans. (i) Zone refining is based on the principle that the impurities are more soluble in the melt in the solid state of the metal.

(ii) Vapour phase refining.

In this, metal is converted into its volite compound and collected elsewhere. It is then decomposed to give pure metal. So, the two requirements are:

(a) the metal should form a volatile compound with an available reagent.

(b) the volatile compound should be easily decomposable, so the recovery is easy.

(iii) In electrolytic refining impure metal is made to act as anode. A strip of the same metal in pure form is used as cathode. They are put in a suitable electrolytic bath containing soluble salt of the same metal. When electric current is passed, impure metal forms metal ions which are discharged at cathode forming pure metal.

Anode : $M \longrightarrow M^{n+} + ne^-$

Cathode: $M^{n+} + ne^- \longrightarrow M$

25. Write the chemical reactions which take place in the following operations:
(i) Electrolytic reduction of Al_2O_3
(ii) Isolation of zinc from zinc blende
(iii) Mond's process for refining nickel.

Ans. ***(i) Electrolytic reduction of Al_2O_3***

Cathode: $Al^{3+}(melt) + 3e^- \longrightarrow Al$

Anode: $C(s) + O^{2-}(melt) \longrightarrow CO(g) + 2e^-$

$C(s) + 2O^{2-}(melt) \longrightarrow CO_2(g) + 4e^-$

(ii) Isolation of zinc from zinc blende :

Roasting : $\underset{\text{Zinc blende}}{2ZnS} + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2$

Reduction: $ZnO + C \xrightarrow{1673K} Zn + CO$

(iii) Mond's process for refining nickel.

$Ni + 4CO \xrightarrow{330-350K} Ni(CO)_4$

$Ni(CO)_4 \xrightarrow{450-470K} Ni + 4CO$

26. Explain the role of
(i) Cryolite in the electrolytic reduction of alumina.
(ii) Carbon monoxide in the purification of nickel.

Ans. (i) ***Role of Cryolite***

- It lowers the melting point of the mixture.
- It makes alumina a good conductor of electricity.

(ii) When nickel is heated with carbon monoxide it forms a volatile complex nickel tetracarbonyl which on furth heating at higher temperature decomposes to give pure nickel.

$Ni + 4CO \xrightarrow{330-350K} Ni(CO)_4 \xrightarrow{450-470K} Ni + 4CO$

27. Name the chief ore of silver. Describe with chemical equations the extraction of silver from this ore.

Ans. The chief ore of silver is argentite or silver glance (Ag_2S).

The extraction of silver from argentite : Argentite ore is treated with dilute solution of NaCN in presence of oxygen to form complex.

$$2Ag_2S + 8CN^- + O_2 + 2H_2O \rightarrow 4[Ag(CN)_2] + 2S + 4OH^-$$

Zn acts as reducing agent and displaces silver from the complex.

$$2[Ag(CN)_2]^- + Zn \rightarrow [Zn(CN)_4]^{2-} + 2Ag$$

The crude Ag metal thus obtained is refined by fusion with borax or by electrolysis.

28. Copper can be extracted by hydrometallurgy but not zinc. Explain.

Ans. The E° of zinc ($Zn^{2+}/Zn = -0.76V$) or iron ($Fe^{2+}/Fe = -0.44V$) is lower than that of copper ($Cu^{2+}/Cu = +0.34V$) and hence both zinc and Fe, can displace Cu from solutions of Cu^{2+} ions. Although zinc is a stronger reducing agent than iron, yet iron scrap is chiefly used in hydrometallurgy of copper because it is much cheaper than zinc.

$$Fe(s) + Cu^{2+}(aq) \longrightarrow Fe^{2+}(aq) + Cu(s)$$

In contrast, to displace zinc from solution of Zn^{2+} ions, we need a more reactive metal than it, i.e.,

$Al(E^\circ_{Al^{3+}/Al} = -1.66V)$, $Mg(E^\circ_{Mg^{2+}/Mg} = -2.37V)$,

$Ca(E^\circ_{Ca^{2+}/Ca} = -2.87V)$, $K(E^\circ_{k^+/k} = -2.93V)$, etc.

But all these metals react with water [$2H_2O + 2e^- \longrightarrow H_2(g) + 2OH^-(aq)$, $E^\circ = -0.83V$] forming their corresponding ions with the evolution of H_2 gas.

Thus, Al, Mg, etc, cannot be used to displace zinc from solution of Zn^{2+} ions. Thus, copper can be extracted by hydrometallurgy but not zinc.

29. Out of C and CO which is a better reducing agent for FeO

(i) In the lower part of blast furnace (higher temperature)

(ii) In the upper part of blast furnace (lower temperature)

Ans. Although both C and CO can reduce FeO to Fe, but C is a better reducing agent than CO in the lower part of the blast furnace where temperature is high (> 1073K) while CO is a better reducing than C in the upper part of the blast furnace where the temperature is low (< 1073 K actually between 500 – 900 K) as explained below:

(i) In the lower part of the blast furnace, temperature is high (> 1073 K). Above 1073 K, the $\Delta_f G^\circ$ for CO from C is than that of FeO from Fe. Therefore, at high temperatures (> 1073 K), C can easily reduce FeO to Fe.

$$FeO + C \xrightarrow{>1073K} Fe + CO$$

(ii) However, in the upper part of blast furnace, temperature is low (< 1073 K, actually between 500 – 900 K). Below 1073 K $\Delta_f G^\circ$ of FeO from Fe is more negative than that of CO_2 from CO.

$$FeO + CO \xrightarrow{500-900K} Fe + CO_2$$

30. What is the principle of thermite process? Name two metals which can be extracted with the help of this process.

Ans. Thermite is a mixture of aluminium powder and ferric oxide. When this mixture is ignited, Al reduces Fe_2O_3 to Fe while it itself gets oxidised to Al_2O_3. This is called thermite process.

$$2Al(s) + Fe_2O_3(s) \xrightarrow{Ignite} Al_2O_3(s) + Fe(\ell)$$

The underlying principle of thermite process is that $\Delta_f G^\circ$ of Al_2O_3 is much more negative than that of Fe_2O_3. Besides, Fe two other metals which can be extracted by thermite process are Cr and Mn.

$$Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$$

$$3Mn_3O_4 + 8Al \longrightarrow 4Al_2O_3 + 9Mn$$

EXERCISE-1

PREVIOUS YEARS BOARD PROBLEMS

CBSE 2016

1. (i) Name the method of refining which is based on the principle of adsorption.
(ii) What is the role of depressant in froth floatation process?
(iii) What is the role of limestone in the extraction of iron from its oxides?

CBSE 2015

1. (i) Name the method used for the refining of titanium.
(ii) What is the role of Zn in the extraction of silver?
(iii) Reduction of metal oxide to metal becomes easier if the metal obtained is in liquid state. Why?

CBSE 2014

1. Name the method used for refining of copper metal.
2. Write the principle behind the froth floatation process. What is the role of collectors in this process?
3. What is the role of zinc metal in the extraction of silver ?
4. Name the method that is used for refining of nickel.
5. Describe the role of the following:
(i) SiO_2 in the extraction of copper from copper matte
(ii) NaCN in froth floatation process

CBSE 2013

1. Name the method used for refining of copper metal.
2. (i) Name the method used for removing gangue from sulphide ores.
(ii) How is wrought iron different from steel?
3. Name the principal ore of aluminium. Explain the significance of leaching in the extraction of aluminium.
4. Outline the principles of refining of metals by the following methods
(i) Zone refining (ii) Vapour phase refining

CBSE 2012

1. How is copper extracted form a low grade ore of it?
2. What is the role of collectors in froth floatation process?
3. Which methods are usually employed for purifying the following metals ?
(i) Nickel (ii) Germanium
Mention the principle behind each one of them.
4. Explain the role of the following
(i) NaCN in the extraction of silver (ii) SiO_2 in the extraction of copper

CBSE 2011

1. Differentiate between a mineral and an ore.
2. What types of ores can be concentrated by magnetic separation method ?
3. Describe the principle controlling each of the following processes
   (i) Vapour phase refining of titanium metal
   (ii) Froth floatation method of concentration of a sulphide ore.
4. Describe the principle controlling each of the following process.
   (i) Zone refining of metals
   (ii) Electrolytic refining of metals
5. Describe the principle controlling e ach of the following processes.
   (i) Preparation of cast iron from pig iron.
   (ii) Preparation of pure alumina (Al_2O_3) from bauxite ore.
6. State the principles of the following methods of refining crude metals
   (i) Zone refining (ii) Liquation method (iii) Chromatographic method

   OR

   How can you obtain pure alumina from a bauxite ore associated with silica? Write the reactions involved in this process.

CBSE 2010

1. Copper matte is charged into a silica lined converter in extraction of copper. What is the role of silica lining here ?
2. How is chemical reduction different from electrolyte reduction? Name a metal each which is obtained by
   (i) Electrolyte reduction
   (ii) Chemical reduction.
3. Describe the role of the following:
   (i) NaCN in the extraction of silver from a silver ore.
   (ii) Iodine in the refining of titanium
   (iii) Cryolite in the metallurgy of aluminium

   OR

   Describe the principle involved in each of the following processes of metallurgy
   (i) Froth floatation method
   (ii) Electrolytic refining of metals
   (iii) Zone refining of metals

CBSE 2009

1. What is meant by the term pyrometallurgy ?
2. Which of the two scraps, zinc or iron, would be preferred for the recovery of copper from the leached copper ore and why?
3. Why is electrolytic reduction preferred over chemical reduction for the isolation of certain metals ?
4. Describe the underlying principle of each of the following metal refining methods
   (i) Electrolytic refining of metals
   (ii) Vapour phase refining of metals
5. Describe the role of the following
   (i) NaCN in the extraction of silver from a silver ore.
   (ii) Cryolite in the extraction of aluminium from pure alumina.

EXERCISE-1

SOLUTION OF PREVIOUS YEARS BOARD PROBLEMS

GENERAL PRINCIPLES AND PROCESSES OF ISOLATION OF ELEMENTS

CBSE 2016

Sol. 1 1. Chromatography

2. To Separate two sulphide ores

3. It decomposes to CaO which removes impurity (silica) as slag/ Acts as flux.

CBSE 2015

Sol. 1 (i) Van Arkel Method / vapour phase refining

(ii) Zn acts as a reducing agent

(iii) As ΔS is positive /ΔG is more negative

CBSE 2014

Sol.1 Electrolytic refining.

Sol.2 The method has been in use for removing gangue from sulphide ores. In this process, a suspension of the powered ore is made with water. *Collectors* added. Collectors (e.g., pine oils, fatty acids, xanthates, etc.) enhance non-wettability of the mineral particles.

Sol.3 Zn acts as a reducing agent.

Sol.4 Mond's process

Sol.5 (i) Copper is extracted from cooper matte which contains iron as impurity. Sillica is added to ramove this impurity as iron silica in the form of fusible slag.

$$FeO + SiO_2 \longrightarrow \underset{\text{(slag)}}{FeSiO_3}\ \text{Iron silicate}$$

(ii) NaCl selectively prevents ZnS from coming to the froth by forming a layer of Zinc complex $Na_2[Zn(CN)_4]$ on the surface of ZnS but allows PbS to come within forth.

CBSE 2013

Sol.1 Electrolytic Refining.

Sol.2 (i) Froth flootation

(ii) Wrought iron is the purest form of iron but steel is an alloy of iron which is less pure than iron.

Sol.3 Aluminium's principle ore is Hauxite (Al_2O_3 + impurities of SiO_2, Fe_2O_3 and TiO_2 etc.) These impurities can be removed by process of leaching. During leaching the powdered bauxide and is heated with concentrated (45%) solution of NaOH at 473 - 523 K, when Alumina dissolves as sodium meta aluminate and silica as sodium silicate leaving (SiO_2, Fe_2O_3 and TiO_2 and other impurities behind.

$$Al_2O_3(s) + 2NaOH(aq] + 3H_2O(\ell)$$

Alumina $\xrightarrow{473-523K}$ Na $[Al(OH)_4]$ sodium meta aluminate

$SiO_2 + 2NaOH \longrightarrow Na_2SiO_3\,(aq) + H_2O(\ell)$.

The impurities are filtered off and $Na[Al(OH)_4]$ is neutralised by passing CO_2 when hydrated alumina separates out. Then hydrated alumina is filtered, dried and heated to give back pure alumina.

$$Al_2O_3 \cdot xH_2O\,(s) \xrightarrow{1473\,K} Al_2O_3(s) + xH_2O(g)$$

The significance of leaching in the extraction of aluminium is to prepare pure alumina from bauxite ore.

Sol.4 (i) Zone refining is based on the principle that the impurities are more soluble in the melt in the solid state of the metal.

(ii) Vapour phase refining.

In this, metal is converted into its volite compound and collected elsewhere. It is then decomposed to give pure metal. So, the two requirements are:

(a) the metal should form a volatile compound with an available reagent.

(b) the volatile compound should be easily decomposable, so the recovery is easy.

CBSE 2012

Sol.1 Cu is extracted by hydrometallurgy from low grade ores.

$Cu^{2+}(aq) + H_2(g) \longrightarrow Cu(s) + 2H^+(aq)$

Sol.2 Substances such as pine oil, xanthates and fatty acids which enhance the non-wettability of the ore particles thereby indirectly favouring froth formation are called collectors.

Sol.3 Nickel by Mond process Germanium by Zone refining.

Sol.4 (i) NaCl selectively prevents ZnS from coming to the froth by forming a layer of Zinc complex $Na_2[Zn(CN)_2]$ on the surface of ZnS but allows PbS to come within forth.

(ii) Copper is extracted from cooper matte which contains iron as impurity. Sillica is added to ramove this impurity as iron silica in the form of fusible slag.

$FeO + SiO_2 \longrightarrow FeSiO_3$ Iron silicate

(slag)

CBSE 2011

Sol.1 **Minerals :** Which are naturally occurring chemical substances in the earth's crust obtainable by mining.

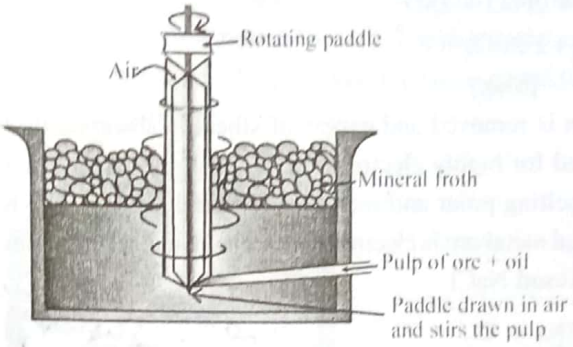
Ores : Only a few are viable to be used as sources of that metal. Such minerals are known as ores.

Sol.2 Meganatic from non megnatic impurities

Sol.3 (i) **Vapour phase refining of titanium metal:** In this method crude metal is freed from impurities by first converting it a suitable volatile compound by heating it with a specific reagent at a lower temperature then decomposing the volatile compound at some higher temperature to give the pure metal. Thus , the two requirements are :

- the metal should form a volatile compound with a suitable reagent.
- the volatile compound should be easily decomposable so that the recovery is easy.

(ii) Froth floatation method :



Enlarged view of an air bubble showing mineral particles attached to it

The method has been in use for removing gangue from sulphide ores. In this process, a suspension of the powered ore is made with water. To it, *Collectors* and *froth stabilisers* are added. Collectors (e.g., pine oils, fatty acids, xanthates, etc.) enhance non-wettability of the mineral particles and froth stabilisers (e.g., Cresols, aniline) stabilise the froth.

The mineral particles become wet by oils while the gangue particles by water. A rotating paddle agitates the mixture and draws air in it. As a result, froth is formed which carries the mineral particles. The froth is light and is skimmed off. It is then dried for recovery of the particles.

Sol.4 (i) Zone refining is based on the principle that the impurities are more soluble in the melt in the solid state of the metal.

(iii) In electrolytic refining impure metal is made to act as anode. A strip of the same metal in pure form is used as cathode. They are put in a suitable electrolytic bath containing soluble salt of the same metal. When electric current is passed, impure metal forms metal ions which are discharged at cathode forming pure metal.

Anode : $M \longrightarrow M^{n+} + ne^-$

Cathode: $M^{n+} + ne \longrightarrow M$

Sol.5 (i) The iron obtained from blast furnace is called pig iron. It contains about 4% carbon and many other impurities in smaller amount (e.g., S, P, Si, Mn).

Cast iron, is different from pig iron and is made by melting pig iron with scrap iron and coke using hot air blast. It has slightly lower carbon content (about 3%) and is extremely hard and brittle.

(ii) Concentration of bauxite are is carrecal out by leaching. In this process, pure alumina is obtained.

Sol.6 (i) Zone refining is based on the principle that the impurities are more soluble in the melt in the solid state of the metal.

(ii) Liquation is a method of refining of metals and is used when the impurities are not miscible with the metal and the melting temperature of the metal is lower than that of the impurities.

(iii) This method is based on the principle of selective adsorption of different components in a mixture on an adsorbent

In involves a mobile phase and a stationary phase. The sample extract is dissolved in mobile phase which may be a liquid or gas. The stationary phase is immobile phase have different solubility for the component to be purifield. The mobile phase is formed to pass thought the stationary phase. process.

CBSE 2010

Sol.1 In coppel matte, some silica is added and a blast of hat air is blown in silica lined convertes. The remaining iron sulphide is oxidised.

$$2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$$
$$FeO + SiO_2 \rightarrow FeSiO_3$$
[Slag]

In this way, all the iron is removed and excess of silical is absorbed by lining.

Sol.2 (i) This method is used for highly electro positive metals. Sometimes, a small amount of flux is added which decreases melting point and increases conductivity, e.g. Na, K, Mg, etc.
In this method, fuced metal ore is electrolysed and pure metal is deposited at cathode. e.g. Na is obtained by electrolysis of fused NaCl.

$$2NaCl \longrightarrow \underset{[Cathode]}{2Na} + \underset{[Anode]}{Cl_2}$$

(ii) The reduction of any compound on molecule using a chemical substance without applying any external agency such as current or electrolytes etc. (b) Its reduction due to movement of atoms metals in the middle of the activity series (Fe, Zn, Ni, Sn etc.) can not be obtained by heating their compounds alone. They are heated with a reducing agent, usually carbon.

Sol.3 **(i)** Role of NaCN in the extraction of silver is to do the leaching of silver ore in the presence of air from which the silver in obtained later by replacement.

$$4\,Ag(s) + 8CN^-(aq) + 2\,H_2O(aq) + O_2(g) \rightarrow 4\,[Ag(CN)_2]^-(aq) + 4\,OH^-(aq)$$
$$2\,[Ag(CN)_2]^-(aq) + Zn(s) \rightarrow 2\,Ag(s) + [Zn(CN)_4]^{2-}(aq)$$

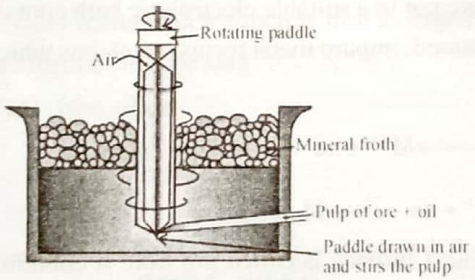
(ii) Iodine is heated with Titanium to form a volatile compound which on further heating decompose to give titanium.

$$Ti\ (impure) + 2I_2 \rightarrow TiI_4(g) \rightarrow Ti\ (s)\ (Pure) + 2I_2$$

(iii) Cryolite lowers the melting point of the mixture and improves the electrical conductivity of the cell.

OR

(i) Froth floatation method :



Enlarged view of an air bubble showing mineral particles attached to it

The method has been in use for removing gangue from sulphide ores. In this process, a suspension of the powered ore is made with water. To it, *Collectors* and *froth stabilisers* are added. Collectors (e.g., pine oils, fatty acids, xanthates, etc.) enhance non-wettability of the mineral particles and froth stabilisers (e.g., Cresols, aniline) stabilise the froth.

The mineral particles become wet by oils while the gangue particles by water. A rotating paddle agitates the mixture and draws air in it. As a result, froth is formed which carries the mineral particles. The froth is light and is skimmed off. It is then dried for recovery of the particles.

(ii) **Electrolytic refining of metals :** In this method, the impure metal is made to act as anode. A strip of the same metal in pure form is used as Cathode. They are put in a suitable electrolyte both containing soluble salt of the same metal. Metal remain in the solution and the less basic ones go to the anode mud. The reactions are:

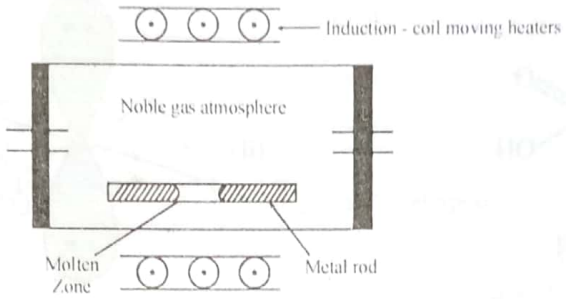
Anode: $M \rightarrow M^{n+} + ne^-$

Cathode: $M^{n+} + ne^- \rightarrow M$

Copper and zinc are refined by this method.

(iii) **Zone refining of metals :** This method is based on the principle that the impurities are more soluble in the melt than in the solid state of the metal.

A circular mobile heater is fixed at one end of the rod of the impure metal. The molten zone moves along with the heater which is moved forward. As the heater moves forward, The pure metal crystalises out of melt and the impurities pass on into the adjacent molten zone. This process is repeated several times and the heater is moved in the same direction. At one kind, impurities get concentrated.



This method is very useful for producing semiconductor and other metals of very high purity like germanium, silicon, boron etc.

CBSE 2009

Sol.1 **Pyrometallurgy :** The process of extracting the metal by heating the metal with a suitable reducing agent is called pyrometallurgy.

Sol.2 Zn is more electropositive than Fe so it is stronger reducing agent but it is costlier than Fe so Fe scrap is prefered over In for reacovery of copper from its are.

Sol.3 More reactive metals i.e, alkali metals and alkaline earth metals are ussially extracted by electroslysis of their fosed salts because in electrolytic reduction, by applying external potential from outside source reduction can be easily. Further, more reactive metals have more affinity with oxygen than that of carbon. That why electrolytic reduction is prefered over the chemical Reduction.

Sol.4 (i) **Electrolytic refining :** In this method, the impure metal is made to act as anode. A strip of the same metal in pure form is used as Cathode. They are put in a suitable electrolyte both containing soluble salt of the same metal. The more basic metal remains in the solution and the less basic ones go to the anode mud. The reactions are

Anode : $M \rightarrow M^{n+} + ne$

Cathode : $M^{n+} + ne^- \rightarrow M$

Copper and zinc are refined by this method.

(ii) **Vapour phase refining :** In this method, the metal is converted into its volatile compound and collected elsewhere. It is then decomposed to give pure metal. There are two requirements:

(a) the metal should form a volatile compound with an available reagent.

(b) the volatile compound should be easily decomposable, so that recovery is easy.

Sol.5 (i) Role of NaCN in the extraction of silver is to do the leaching of silver ore in the presence of air from which the silver in obtained later by replacement.

$4\,Ag(s) + 8CN^-(aq) + 2\,H_2O(aq) + O_2(g) \rightarrow 4\,[Ag(CN)_2]^-(aq) + 4\,OH^-(aq)$

$2\,[Ag(CN)_2]^-(aq) + Zn(s) \rightarrow 2\,Ag(s) + [Zn(CN)_4]^{2-}(aq)$

(ii) Cryolite lowers the melting point of the mixture and improves the electrical conductivity of the cell.