Question 6.1:
Copper can be extracted by hydrometallurgy but not zinc. Explain.

Answer
The reduction potentials of zinc and iron are lower than that of copper. In hydrometallurgy, zinc and iron can be used to displace copper from their solution.

\[ \text{Fe}^{(s)} + \text{Cu}^{2+}_{(aq)} \rightarrow \text{Fe}^{2+}_{(aq)} + \text{Cu}^{(s)} \]

But to displace zinc, more reactive metals i.e., metals having lower reduction potentials than zinc such as Mg, Ca, K, etc. are required. But all these metals react with water with the evolution of H\(_2\) gas.

\[ 2\text{K}^{(s)} + 2\text{H}_2\text{O}^{(l)} \rightarrow 2\text{KOH}^{(aq)} + \text{H}_2^{(g)} \]

As a result, these metals cannot be used in hydrometallurgy to extract zinc.

Hence, copper can be extracted by hydrometallurgy but not zinc.

Question 6.2:
What is the role of depressant in froth floatation process?

Answer
In the froth floatation process, the role of the depressants is to separate two sulphide ores by selectively preventing one ore from forming froth. For example, to separate two sulphide ores (ZnS and PbS), NaCN is used as a depressant which selectively allows PbS to come with froth, but prevents ZnS from coming to froth. This happens because NaCN reacts with ZnS to form Na\(_2\)[Zn(CN)\(_4\)].

\[ 4\text{NaCN} + \text{ZnS} \rightarrow \text{Na}_2[\text{Zn(CN)}]_4 + \text{Na}_2\text{S} \]

Question 6.3:
Why is the extraction of copper from pyrites more difficult than that from its oxide ore through reduction?

Answer
The Gibbs free energy of formation (\(\Delta G\)) of Cu\(_2\)S is less than that of \(\text{H}_2\text{S}\) and CS\(_2\). Therefore, H\(_2\) and C cannot reduce Cu\(_2\)S to Cu.
On the other hand, the Gibbs free energy of formation of $\text{Cu}_2\text{O}$ is greater than that of CO. Hence, C can reduce $\text{Cu}_2\text{O}$ to Cu.

$$\text{C}_(s) + \text{Cu}_2\text{O}(s) \longrightarrow 2\text{Cu}_(s) + \text{CO}_(g)$$

Hence, the extraction of copper from its pyrite ore is difficult than from its oxide ore through reduction.

**Question 6.4:**
Explain: (i) Zone refining (ii) Column chromatography.

**Answer**

(i) **Zone refining:**
This method is based on the principle that impurities are more soluble in the molten state of metal (the melt) than in the solid state. In the process of zone refining, a circular mobile heater is fixed at one end of a rod of impure metal. As the heater moves, the molten zone of the rod also moves with it. As a result, pure metal crystallizes out of the melt and the impurities pass onto the adjacent molten zone. This process is repeated several times, which leads to the segregation of impurities at one end of the rod. Then, the end with the impurities is cut off. Silicon, boron, gallium, indium etc. can be purified by this process.

(ii) **Column chromatography:**
Column chromatography is a technique used to separate different components of a mixture. It is a very useful technique used for the purification of elements available in minute quantities. It is also used to remove the impurities that are not very different in chemical properties from the element to be purified. Chromatography is based on the principle that different components of a mixture are differently adsorbed on an adsorbent. In chromatography, there are two phases: mobile phase and stationary phase. The stationary phase is immobile and immiscible. $\text{Al}_2\text{O}_3$ column is usually used as
the stationary phase in column chromatography. The mobile phase may be a gas, liquid, or supercritical fluid in which the sample extract is dissolved. Then, the mobile phase is forced to move through the stationary phase. The component that is more strongly adsorbed on the column takes a longer time to travel through it than the component that is weakly adsorbed. The adsorbed components are then removed (eluted) using a suitable solvent (eluant).

Question 6.5:
Out of C and CO, which is a better reducing agent at 673 K?
Answer

At 673 K, the value of \( \Delta G_{(CO,CO_2)} \) is less than that of \( \Delta G_{(C,CO)} \). Therefore, CO can be reduced more easily to CO\(_2\) than C to CO. Hence, CO is a better reducing agent than C at 673 K.

Question 6.6:
Name the common elements present in the anode mud in electrolytic refining of copper. Why are they so present?
Answer

In electrolytic refining of copper, the common elements present in anode mud are selenium, tellurium, silver, gold, platinum, and antimony.
These elements are very less reactive and are not affected during the purification process. Hence, they settle down below the anode as anode mud.

**Question 6.7:**
Write down the reactions taking place in different zones in the blast furnace during the extraction of iron.

**Answer**

During the extraction of iron, the reduction of iron oxides takes place in the blast furnace. In this process, hot air is blown from the bottom of the furnace and coke is burnt to raise the temperature up to 2200 K in the lower portion itself. The temperature is lower in the upper part. Thus, it is the lower part where the reduction of iron oxides (Fe$_2$O$_3$ and Fe$_3$O$_4$) takes place.

The reactions taking place in the lower temperature range (500 − 800 K) in the blast furnace are:

\[
3\text{Fe}_2\text{O}_3 + \text{CO} \rightarrow 2\text{Fe}_3\text{O}_4 + \text{CO}_2
\]

\[
\text{Fe}_3\text{O}_4 + 4\text{CO} \rightarrow 3\text{Fe} + 4\text{CO}_2
\]

\[
\text{Fe}_2\text{O}_3 + \text{CO} \rightarrow 2\text{Fe} + \text{CO}_2
\]

The reactions taking place in the higher temperature range (900 − 1500 K) in the blast furnace are:

\[
\text{C} + \text{CO}_2 \rightarrow 2\text{CO}
\]

\[
\text{FeO} + \text{CO} \rightarrow \text{Fe} + \text{CO}_2
\]

The silicate impurity of the ore is removed as slag by calcium oxide (CaO), which is formed by the decomposition of limestone (CaCO$_3$).

\[
\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2
\]

\[
\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3
\]

Calcium silicate

(Slag)
Question 6.8:
Write chemical reactions taking place in the extraction of zinc from zinc blende.

Answer
The different steps involved in the extraction of zinc from zinc blende (ZnS) are given below:

(i) Concentration of ore
First, the gangue from zinc blende is removed by the froth floatation method.

(ii) Conversion to oxide (Roasting)
Sulphide ore is converted into oxide by the process of roasting. In this process, ZnS is heated in a regular supply of air in a furnace at a temperature, which is below the melting point of Zn.

\[ 2\text{ZnS} + 3\text{O}_2 \rightarrow 2\text{ZnO} + 2\text{SO}_2 \]

(iii) Extraction of zinc from zinc oxide (Reduction)
Zinc is extracted from zinc oxide by the process of reduction. The reduction of zinc oxide is carried out by mixing it with powdered coke and then, heating it at 673 K.
ZnO + C $\xrightarrow{\text{coke, 671K}}$ Zn + CO

(iv) Electrolytic Refining

Zinc can be refined by the process of electrolytic refining. In this process, impure zinc is made the anode while a pure copper strip is made the cathode. The electrolyte used is an acidified solution of zinc sulphate (ZnSO₄). Electrolysis results in the transfer of zinc in pure from the anode to the cathode.

Anode: \( \text{Zn} \rightarrow \text{Zn}^{2+} + 2e^- \)

Cathode: \( \text{Zn}^{2+} + 2e^- \rightarrow \text{Zn} \)

Question 6.9:
State the role of silica in the metallurgy of copper.

Answer
During the roasting of pyrite ore, a mixture of FeO and Cu₂O is obtained.

\[
2 \text{CuFeS}_2 + \text{O}_2 \xrightarrow{\Delta} \text{Cu}_2\text{S} + 2 \text{FeS} + \text{SO}_2
\]

\[
2\text{Cu}_2\text{S} + 3\text{O}_2 \xrightarrow{\Delta} 2\text{Cu}_2\text{O} + 2\text{SO}_2
\]

\[
2\text{FeS} + 3\text{O}_2 \xrightarrow{\Delta} 2\text{FeO} + 2\text{SO}_2
\]

The role of silica in the metallurgy of copper is to remove the iron oxide obtained during the process of roasting as ‘slag’. If the sulphide ore of copper contains iron, then silica (SiO₂) is added as flux before roasting. Then, FeO combines with silica to form iron silicate, FeSiO₃ (slag).

\[
\text{FeO} + \text{SiO}_2 \xrightarrow{\Delta} \text{FeSiO}_3
\]

(Slag)

Question 6.10:
What is meant by the term “chromatography”?

Answer
Chromatography is a collective term used for a family of laboratory techniques for the separation of mixtures. The term is derived from Greek words ‘chroma’ meaning ‘colour’ and ‘graphein’ meaning ‘to write’. Chromatographic techniques are based on the principle that different components are absorbed differently on an absorbent. There are
several chromatographic techniques such as paper chromatography, column chromatography, gas chromatography, etc.

**Question 6.11:**
What criterion is followed for the selection of the stationary phase in chromatography?

**Answer**
The stationary phase is selected in such a way that the components of the sample have different solubility’s in the phase. Hence, different components have different rates of movement through the stationary phase and as a result, can be separated from each other.

**Question 6.12:**
Describe a method for refining nickel.

**Answer**
Nickel is refined by Mond’s process. In this process, nickel is heated in the presence of carbon monoxide to form nickel tetracarbonyl, which is a volatile complex.

\[
\text{Ni} + 4\text{CO} \xrightarrow{330-340 K} \text{Ni(CO)}_4 \\
\text{Nickel tetracarbonyl}
\]

Then, the obtained nickel tetracarbonyl is decomposed by subjecting it to a higher temperature (450 – 470 K) to obtain pure nickel metal.

\[
\text{Ni(CO)}_4 \xrightarrow{450-470 K} \text{Ni} + 4\text{CO} \\
\text{Nickel tetracarbonyl}
\]

**Question 6.13:**
How can you separate alumina from silica in bauxite ore associated with silica? Give equations, if any.

**Answer**
To separate alumina from silica in bauxite ore associated with silica, first the powdered ore is digested with a concentrated NaOH solution at 473 – 523 K and 35 – 36 bar.
pressure. This results in the leaching out of alumina (Al₂O₃) as sodium aluminate and silica (SiO₂) as sodium silicate leaving the impurities behind.

\[ \text{Al}_2\text{O}_3(s) + 2\text{NaOH}_{(aq)} + 3\text{H}_2\text{O}_{(l)} \rightarrow 2\text{Na}[^\text{Al(OH)}_4]_{(aq)} \]

Alumina  
Sodium aluminate

\[ \text{SiO}_2 + 2\text{NaOH}_{(aq)} \rightarrow \text{Na}_2\text{SiO}_3_{(aq)} + \text{H}_2\text{O}_{(l)} \]

Silica  
Sodium silicate

Then, CO₂ gas is passed through the resulting solution to neutralize the aluminate in the solution, which results in the precipitation of hydrated alumina. To induce precipitation, the solution is seeded with freshly prepared samples of hydrated alumina.

\[ 2\text{Na}[^\text{Al(OH)}_4]_{(aq)} + \text{CO}_2_{(g)} \rightarrow \text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}_{(s)} + 2\text{NaHCO}_3_{(aq)} \]

Sodium aluminate  
Hydrated alumina  
Sodium hydrogen carbonate

During this process, sodium silicate remains in the solution. The obtained hydrated alumina is filtered, dried, and heated to get back pure alumina.

\[ \text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}_{(s)} \xrightarrow{\text{1470 K}} \text{Al}_2\text{O}_3(s) + x\text{H}_2\text{O}_{(g)} \]

Hydrated alumina  
Alumina

**Question 6.14:**

Giving examples, differentiate between ‘roasting’ and ‘calcination’.

**Answer**

Roasting is the process of converting sulphide ores to oxides by heating the ores in a regular supply of air at a temperature below the melting point of the metal. For example, sulphide ores of Zn, Pb, and Cu are converted to their respective oxides by this process.

\[ 2\text{ZnS} + 3\text{O}_2 \xrightarrow{\Delta} 2\text{ZnO} + 2\text{SO}_2 \]

Zinc blende

\[ 2\text{PbS} + 3\text{O}_2 \xrightarrow{\Delta} 2\text{PbO} + 2\text{SO}_2 \]

Galena

\[ 2\text{Cu}_2\text{S} + 3\text{O}_2 \xrightarrow{\Delta} 2\text{Cu}_2\text{O} + 2\text{SO}_2 \]

Copper
On the other hand, calcination is the process of converting hydroxide and carbonate ores to oxides by heating the ores either in the absence or in a limited supply of air at a temperature below the melting point of the metal. This process causes the escaping of volatile matter leaving behind the metal oxide. For example, hydroxide of Fe, carbonates of Zn, Ca, Mg are converted to their respective oxides by this process.

\[
\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O} \xrightarrow{\Delta} \text{Fe}_2\text{O}_3 + 3\text{H}_2\text{O} \\
\text{Limonite} \\
\text{ZnCO}_3 \xrightarrow{\Delta} \text{ZnO} + \text{CO}_2 \\
\text{Calamine} \\
\text{CaMg(}\text{CO}_3\text{)}_2 \xrightarrow{\Delta} \text{CaO} + \text{MgO} + 2\text{CO} \\
\text{Dolomite}
\]

**Question 6.15:**
How is 'cast iron' different from 'pig iron'?

**Answer**
The iron obtained from blast furnaces is known as pig iron. It contains around 4% carbon and many impurities such as S, P, Si, Mn in smaller amounts.

Cast iron is obtained by melting pig iron and coke using a hot air blast. It contains a lower amount of carbon (3%) than pig iron. Unlike pig iron, cast iron is extremely hard and brittle.

**Question 6.16:**
Differentiate between “minerals” and “ores”.

**Answer**
Minerals are naturally occurring chemical substances containing metals. They are found in the Earth’s crust and are obtained by mining.

Ores are rocks and minerals viable to be used as a source of metal. For example, there are many minerals containing zinc, but zinc cannot be extracted profitably (conveniently and economically) from all these minerals.

Zinc can be obtained from zinc blende (ZnS), calamine (ZnCO₃), Zincite (ZnO) etc. Thus, these minerals are called ores of zinc.
Question 6.17:
Why copper *matte* is put in silica lined converter?

Answer
Copper *matte* contains Cu$_2$S and FeS. Copper *matte* is put in a silica-lined converter to remove the remaining FeO and FeS present in the *matte* as slag (FeSiO$_3$). Also, some silica is added to the silica-lined converter. Then, a hot air blast is blown. As a result, the remaining FeS and FeO are converted to iron silicate (FeSiO$_3$) and Cu$_2$S is converted into metallic copper.

\[
2\text{FeS} + 3\text{O}_2 \rightarrow 2\text{FeO} + 2\text{SO}_2 \\
\text{FeO} + \text{SiO}_2 \rightarrow \text{FeSiO}_3
\]

\[
2\text{Cu}_2\text{S} + 3\text{O}_2 \rightarrow 2\text{Cu}_2\text{O} + 2\text{SO}_2 \\
2\text{Cu}_2\text{O} + \text{Cu}_2\text{S} \rightarrow 6\text{Cu} + \text{SO}_2
\]

Question 6.18:
What is the role of cryolite in the metallurgy of aluminium?

Answer
Cryolite (Na$_3$AlF$_6$) has two roles in the metallurgy of aluminium:

1. To decrease the melting point of the mixture from 2323 K to 1140 K.
2. To increase the electrical conductivity of Al$_2$O$_3$.

Question 6.19:
How is leaching carried out in case of low grade copper ores?

Answer
In case of low grade copper ores, leaching is carried out using acid or bacteria in the presence of air. In this process, copper goes into the solution as Cu$^{2+}$ ions.

\[
\text{Cu}_{(s)} + 2\text{H}^+_{(aq)} + \frac{1}{2}\text{O}_2_{(s)} \rightarrow \text{Cu}^{2+}_{(aq)} + 2\text{H}_2\text{O}_{(l)}
\]

The resulting solution is treated with scrap iron or H$_2$ to get metallic copper.

\[
\text{Cu}^{2+}_{(aq)} + \text{H}_2_{(s)} \rightarrow \text{Cu}_{(s)} + 2\text{H}^+_{(aq)}
\]
Question 6.20:
Why is zinc not extracted from zinc oxide through reduction using CO?
Answer
The standard Gibbs free energy of formation of ZnO from Zn is lower than that of CO₂ from CO. Therefore, CO cannot reduce ZnO to Zn. Hence, Zn is not extracted from ZnO through reduction using CO.

Question 6.21:
The value of $\Delta_f G^\circ$ for formation of Cr₂O₃ is $-540$ kJmol$^{-1}$ and that of Al₂O₃ is $-827$ kJmol$^{-1}$. Is the reduction of Cr₂O₃ possible with Al?
Answer
The value of $\Delta_f G^\circ$ for the formation of Cr₂O₃ from Cr ($-540$ kJmol$^{-1}$) is higher than that of Al₂O₃ from Al ($-827$ kJmol$^{-1}$). Therefore, Al can reduce Cr₂O₃ to Cr. Hence, the reduction of Cr₂O₃ with Al is possible.
Alternatively,
\[2\text{Al} + \frac{3}{2} \text{O}_2 \rightarrow \text{Al}_2\text{O}_3 \quad \Delta_f G^\circ = -827 \text{ kJmol}^{-1}\]
\[2\text{Cr} + \frac{3}{2} \text{O}_2 \rightarrow \text{Cr}_2\text{O}_3 \quad \Delta_f G^\circ = -540 \text{ kJmol}^{-1}\]
Subtracting equation (ii) from (i), we have
\[2\text{Al} + \text{Cr}_2\text{O}_3 \rightarrow \text{Al}_2\text{O}_3 + 2 \text{Cr} \]
\[\Delta_f G^\circ = -827 - (-540) = -287 \text{ kJmol}^{-1}\]
As $\Delta_f G^\circ$ for the reduction reaction of Cr₂O₃ by Al is negative, this reaction is possible.

Question 6.22:
Out of C and CO, which is a better reducing agent for ZnO?
Answer
Reduction of ZnO to Zn is usually carried out at 1673 K. From the above figure, it can be observed that above 1073 K, the Gibbs free energy of formation of CO from C and above 1273 K, the Gibbs free energy of formation of CO\textsubscript{2} from C is lesser than the Gibbs free energy of formation of ZnO. Therefore, C can easily reduce ZnO to Zn.

On the other hand, the Gibbs free energy of formation of CO\textsubscript{2} from CO is always higher than the Gibbs free energy of formation of ZnO. Therefore, CO cannot reduce ZnO. Hence, C is a better reducing agent than CO for reducing ZnO.

**Question 6.23:**
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.

**Answer**
The above figure is a plot of Gibbs energy ($\Delta G^\circ$) vs. $T$ for formation of some oxides. It can be observed from the above graph that a metal can reduce the oxide of other metals, if the standard free energy of formation ($\Delta G^\circ$) of the oxide of the former is more negative than the latter. For example, since $\Delta G^\circ_{(\text{Al}_{2}\text{O}_3)}$ is more negative than $\Delta G^\circ_{(\text{Cu}_2\text{O})}$, Al can reduce Cu$_2$O to Cu, but Cu cannot reduce Al$_2$O$_3$. Similarly, Mg can reduce ZnO to Zn, but Zn cannot reduce MgO because $\Delta G^\circ_{(\text{MgO})}$ is more negative than $\Delta G^\circ_{(\text{ZnO})}$.

**Question 6.24:**

Name the processes from which chlorine is obtained as a by-product. What will happen if an aqueous solution of NaCl is subjected to electrolysis?

**Answer**

In the electrolysis of molten NaCl, Cl$_2$ is obtained at the anode as a by product.

$$\text{NaCl}_{(\text{melt})} \rightarrow \text{Na}^{+}_{(\text{melt})} + \text{Cl}^{-}_{(\text{melt})}$$

At cathode:

$$\text{Na}^{+}_{(\text{melt})} + \text{e}^- \rightarrow \text{Na}_{(s)}$$

At anode:

$$\text{Cl}^{-}_{(\text{melt})} \rightarrow \text{Cl}_2(g) + \text{e}^-$$

$$2\text{Cl}_2(g)$$
The overall reaction is as follows:

\[ \text{NaCl}_{(\text{melt})} \xrightarrow{\text{Electrolysis}} \text{Na}^+_{(aq)} + \frac{1}{2}\text{Cl}_2^{(g)} \]

If an aqueous solution of NaCl is electrolyzed, Cl\(_2\) will be obtained at the anode but at the cathode, H\(_2\) will be obtained (instead of Na). This is because the standard reduction potential of Na (E\(^\circ\) = –2.71 V) is more negative than that of H\(_2\)O (E\(^\circ\) = –0.83 V). Hence, H\(_2\)O will get preference to get reduced at the cathode and as a result, H\(_2\) is evolved.

\[ \text{NaCl}_{(aq)} \longrightarrow \text{Na}^{+}_{(aq)} + \text{Cl}^{-}_{(aq)} \]

At cathode:

\[ 2\text{H}_2\text{O}^{(l)} + 2\text{e}^- \longrightarrow \text{H}_2^{(g)} + 2\text{OH}^{-}_{(aq)} \]

At anode:

\[ \text{Cl}^{-}_{(\text{melt})} \longrightarrow \text{Cl}^+_{(g)} + \text{e}^- \]

\[ 2\text{Cl}^+_{(g)} \longrightarrow \text{Cl}_2^{(g)} \]

**Question 6.25:**

What is the role of graphite rod in the electrometallurgy of aluminium?

**Answer**

In the electrometallurgy of aluminium, a fused mixture of purified alumina (Al\(_2\)O\(_3\)), cryolite (Na\(_3\)AlF\(_6\)) and fluorspar (CaF\(_2\)) is electrolysed. In this electrolysis, graphite is used as the anode and graphite-lined iron is used as the cathode. During the electrolysis, Al is liberated at the cathode, while CO and CO\(_2\) are liberated at the anode, according to the following equation.

**Cathode:**

\[ \text{Al}^{3+}_{(\text{melt})} + 3\text{e}^- \longrightarrow \text{Al}^{(l)} \]

**Anode:**

\[ \text{C}^{(s)} + \text{O}^{2-}_{(\text{melt})} \longrightarrow \text{CO}^{(g)} + 2\text{e}^- \]

\[ \text{C}^{(s)} + 2\text{O}^{2-}_{(\text{melt})} \longrightarrow \text{CO}_2^{(g)} + 4\text{e}^- \]

If a metal is used instead of graphite as the anode, then O\(_2\) will be liberated. This will not only oxidise the metal of the electrode, but also convert some of the Al liberated at the cathode back into Al\(_2\)O\(_3\). Hence, graphite is used for preventing the formation of O\(_2\) at the anode. Moreover, graphite is cheaper than other metals.
Question 6.27:
Outline the principles of refining of metals by the following methods:

(i) Zone refining
(ii) Electrolytic refining
(iii) Vapour phase refining

Answer

(i) Zone refining:
This method is based on the principle that impurities are more soluble in the molten state of metal (the melt) than in the solid state. In the process of zone refining, a circular mobile heater is fixed at one end of a rod of impure metal. As the heater moves, the molten zone of the rod also moves along with it. As a result, pure metal crystallizes out of the melt and the impurities pass to the adjacent molten zone. This process is repeated several times, which leads to the segregation of impurities at one end of the rod. Then, the end with the impurities is cut off. Silicon, boron, gallium, indium etc. can be purified by this process.

(ii) Electrolytic refining:
Electrolytic refining is the process of refining impure metals by using electricity. In this process, impure metal is made the anode and a strip of pure metal is made the cathode. A solution of a soluble salt of the same metal is taken as the electrolyte. When an electric current is passed, metal ions from the electrolyte are deposited at the cathode as pure metal and the impure metal from the anode dissolves into the electrolyte in the form of ions. The impurities present in the impure metal gets collected below the anode. This is known as anode mud.

Anode:  \[ M \rightarrow M^{n+} + ne^- \]
Cathode:  \[ M^{n+} + ne^- \rightarrow M \]
(iii) Vapour phase refining

Vapour phase refining is the process of refining metal by converting it into its volatile compound and then, decomposing it to obtain a pure metal. To carry out this process,

(i) the metal should form a volatile compound with an available reagent, and

(ii) the volatile compound should be easily decomposable so that the metal can be easily recovered.

Nickel, zirconium, and titanium are refined using this method.

Question 6.28:

Predict conditions under which Al might be expected to reduce MgO.

Answer

Above 1350°C, the standard Gibbs free energy of formation of Al₂O₃ from Al is less than that of MgO from Mg. Therefore, above 1350°C, Al can reduce MgO.
Text solution

Question 6.1:
Which of the ores mentioned in Table 6.1 can be concentrated by magnetic separation method?
Answer
If the ore or the gangue can be attracted by the magnetic field, then the ore can be concentrated by the process of magnetic separation. Among the ores mentioned in table 6.1, the ores of iron such as haematite (Fe$_2$O$_3$), magnetite (Fe$_3$O$_4$), siderite (FeCO$_3$), and iron pyrites (FeS$_2$) can be separated by the process of magnetic separation.

Question 6.2:
What is the significance of leaching in the extraction of aluminium?
Answer
In the extraction of aluminium, the significance of leaching is to concentrate pure alumina (Al$_2$O$_3$) from bauxite ore. Bauxite usually contains silica, iron oxide, and titanium oxide as impurities. In the process of leaching, alumina is concentrated by digesting the powdered ore with a concentrated solution of NaOH at 473-523 K and 35-36 bar. Under these conditions, alumina (Al$_2$O$_3$) dissolves as sodium meta-aluminate and silica (SiO$_2$) dissolves as sodium silicate leaving the impurities behind.

\[
\begin{align*}
\text{Al}_2\text{O}_3(s) + 2\text{NaOH}_{(aq)} + 3\text{H}_2\text{O}_{(l)} & \xrightarrow{473-523\ K, 35-36\ \text{bar}} 2\text{Na}[\text{Al(OH)}_4]_{(aq)} \\
\text{Alumina} & \quad \text{Sodium aluminate} \\
\text{SiO}_2(s) + 2\text{NaOH}_{(aq)} & \xrightarrow{473-523\ K, 35-36\ \text{bar}} \text{NaSiO}_3_{(aq)} + \text{H}_2\text{O}_{(l)} \\
\text{Silica} & \quad \text{Sodium silicate}
\end{align*}
\]
The impurities are then filtered and the solution is neutralized by passing CO₂ gas. In this process, hydrated Al₂O₃ gets precipitated and sodium silicate remains in the solution. Precipitation is induced by seeding the solution with freshly prepared samples of hydrated Al₂O₃.

\[
2 \text{Na}_2\text{[Al(OH)₄](aq)} + \text{CO}_2(g) \rightarrow \text{Al}_2\text{O}_3\cdot x\text{H}_2\text{O}(s) + 2\text{NaHCO}_3(aq)
\]

Hydrated alumina

Hydrated alumina thus obtained is filtered, dried, and heated to give back pure alumina (Al₂O₃).

\[
\text{Al}_2\text{O}_3\cdot x\text{H}_2\text{O}(s) \xrightarrow{1470K} \text{Al}_2\text{O}_3(s) + x\text{H}_2\text{O}(g)
\]

Question 6.3:
The reaction,

\[
\text{Cr}_2\text{O}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + 2\text{Cr} \quad (\Delta G_0 = -421 \text{ kJ})
\]

is thermodynamically feasible as is apparent from the Gibbs energy value.

Why does it not take place at room temperature?

Answer

The change in Gibbs energy is related to the equilibrium constant, \( K \) as

\[
\Delta G = -RT \ln K
\]

At room temperature, all reactants and products of the given reaction are in the solid state. As a result, equilibrium does not exist between the reactants and the products. Hence, the reaction does not take place at room temperature. However, at a higher temperature, chromium melts and the reaction takes place.

We also know that according to the equation

\[
\Delta G = \Delta H - T\Delta S
\]

Increasing the temperature increases the value of \( T\Delta S \), making the value of \( \Delta G \) more and more negative. Therefore, the reaction becomes more and more feasible as the temperature is increased.

Question 6.4:
Is it true that under certain conditions, Mg can reduce SiO$_2$ and Si can reduce MgO? What are those conditions?

Answer

\[
\text{Mg}_{(s)} + \frac{1}{2} \text{O}_{2(g)} \rightarrow \text{MgO}_{(s)} \quad \Delta G_{\text{Mg,MgO}}
\]

\[
\text{Si}_{(s)} + \text{O}_{2(g)} \rightarrow \text{SiO}_{2(s)} \quad \Delta G_{\text{Si, SiO}_2}
\]

The temperature range in which $\Delta G_{\text{Mg,MgO}}$ is lesser than $\Delta G_{\text{Si, SiO}_2}$, Mg can reduce SiO$_2$ to Si.

\[
2\text{Mg} + \text{SiO}_2 \rightarrow 2\text{MgO} + \text{Si} \quad \Delta G^0 = \text{ve}
\]

On the other hand, the temperatures range in which $\Delta G_{\text{Si, SiO}_2}$ is less than $\Delta G_{\text{Mg,MgO}}$, Si can reduce MgO to Mg.

\[
\text{SiO}_2 + 2\text{Mg} \rightarrow \text{SiO}_2 + 2\text{Mg} \quad \Delta G^0 = \text{ve}
\]

The temperature at which $\Delta G$ curves of these two substances intersect is 1966 K. Thus, at temperatures less than 1966 K, Mg can reduce SiO$_2$ and above 1966 K, Si can reduce MgO.
12. Write three applications of colloid.

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

3 Marks Chapter

**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.

$$\text{Al}_2\text{O}_3 + 2\text{NaOH} + 3\text{H}_2\text{O} \rightarrow 2\text{Na[Al(OH)$_4$].}$$

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.

$$\text{Fe}_2\text{O}_3.x\text{H}_2\text{O} \rightarrow \text{Fe}_2\text{O}_3 + x\text{H}_2\text{O}$$

$$\text{ZnCO}_3 \rightarrow \text{ZnO} + \text{CO}_2$$

$$\text{CaCO}_3.\text{MgCO}_3 \rightarrow \text{CaO} + \text{MgO} + 2\text{CO}_2$$

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.

$$2\text{ZnS} + 3\text{O}_2 \rightarrow 2\text{ZnO} + 2\text{SO}_2$$

$$2\text{PbS} + 3\text{O}_2 \rightarrow 2\text{PbO} + 2\text{SO}_2$$

$$2\text{Cu}_2\text{S} + 3\text{O}_2 \rightarrow 2\text{Cu}_2\text{O} + 2\text{SO}_2$$

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°C-700°C

$$3\text{Fe}_2\text{O}_3 + \text{CO} \rightarrow 2\text{Fe}_3\text{O}_4 + \text{CO}_2$$

$$\text{Fe}_3\text{O}_4 + \text{CO} \rightarrow 3\text{FeO} + \text{CO}_2$$

$$\text{FeO} + \text{CO} \rightarrow \text{Fe} + \text{CO}_2$$

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

$$\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$$

$$\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3$$

$$\text{P}_4\text{O}_{10} + 10\text{C} \rightarrow 4\text{P} + 10\text{CO},$$

$$\text{SiO}_2 + 2\text{C} \rightarrow \text{Si} + 2\text{CO},$$

$$\text{MnO}_2 + 2\text{C} \rightarrow \text{Mn} + 2\text{CO}$$

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

$$\text{CO}_2 + \text{C} \rightarrow 2\text{CO}$$

(iv) Zone of fusion: - Temperature range 1450°C-1950°C
14. FLOW SHEET FOR EXTRACTION OF IRON:-

Iron ore (Magnetite Fe₃O₄)(Haematite Fe₂O₃)

Concentration is done by Gravity separation followed by magnetic separation

Calcination & Roasting i.e. Ore + Air + Heat → Moisture, CO₂, SO₂, As₂O₃ removed and FeO oxidized to Fe₂O₃

Smelting of charge i.e. mixture of ore, coke & CaCO₃ 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 CuFeS₂

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:

\[
\begin{align*}
&S + O_2 \rightarrow SO_2, \\
&4As + 3O_2 \rightarrow 2As_2O_3, \\
&2CuFeS_2 + O_2 \rightarrow Cu_2S + 2FeS + SO_2
\end{align*}
\]

Smelting in small blast furnace of a mixture of roasted ore, coke, and silica.

\[
\begin{align*}
2FeS + 3O_2 \rightarrow 2FeO + 2SO_2, & \quad FeO + SiO_2 \rightarrow FeSiO_3 (\text{slag})
\end{align*}
\]

A mixture of Cu$_2$S, 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:

\[
\begin{align*}
2FeS + 3O_2 \rightarrow 2FeO + 2SO_2, & \quad FeO + SiO_2 \rightarrow FeSiO_3 (\text{slag}), \\
2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2, & \quad 2Cu_2O + 2Cu_2S \rightarrow 6Cu + SO_2
\end{align*}
\]

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:

\[
\begin{align*}
&\text{Bauxite Al}_2O_3\cdot2H_2O \\
&\text{Concentration of ore is done by leaching. Bauxite is treated with NaOH. Following reaction takes place:-} \\
&Al_2O_3 + 2NaOH + 3 H_2O \rightarrow 2 Na [Al (OH)]_4 \text{ and impurities of Fe}_2O_3, \text{TiO}_2 \& \text{SiO}_2 \text{ are removed.} \\
&Na [Al (OH)]_4, \text{then reacts with CO}_2 \text{ then pure Alumina is obtained.} \\
&Na [Al(OH)]_4 + 2CO_2 \rightarrow Al_2O_3\cdot xH_2O + 2NaHCO_3
\end{align*}
\]
Electrolytic reduction of pure alumina takes place in iron box (cathode) with cryolite ($\text{Na}_3\text{AlF}_6$) & fluorspar $\text{CaF}_2$. Graphite rods act as anode. Following reactions take place:

At cathode: $\text{Al}^{3+} + 3e^{-} \rightarrow \text{Al}$, At Anode: $2\text{O}^{2-} \rightarrow \text{O}_2 + 4e^{-}$

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.

23. Ellingham diagrams:

The plots between $\Delta G^0$ for the formation of oxides of metal and temperature is called Ellingham’s diagram and

They are used to select the reducing agent during metallurgy.

- The plot steeply running down $\rightarrow$ element is better reducing agent
- At any temperature, the element of the plot which is below can reduce the oxide of the element whose plot is above it provided sufficient activation energy is offered.
- In case the metal formed during the reduction is in liquid or gas form then reduction is highly favored.
- Carbon is better reducing agent above 673K and CO is better reducing agent below 673K.
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.

\[ \text{e.g. } \text{CaO (flux) + SiO}_2 (\text{gangue}) \rightarrow \text{CaSiO}_3 (\text{slag}) \]

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 FeO?
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.

\[ \text{e.g. } \text{NaCN is used to separate ZnS and PbS.} \]

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\(_2\)O\(_3\), Magnetite –Fe\(_3\)O\(_4\), 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\(_2\)O.

Q.10- Give name and formula of important ore of Zinc.
A.10- Zinc blende - ZnS, Calamine- ZnCO\(_3\), Zincite – ZnO.
Q.11 – Which reducing agent is employed to get copper from the leached low grade copper ore? CBSE-2014

A.11 – Scrap Iron or H₂

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: \[ \text{Ni} + 4\text{CO} \rightarrow \text{Ni(CO)}_4 \]

At 450-470K \[ \text{Ni(CO)}_4 \rightarrow \text{Ni} + 4\text{CO} \]

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 in solution as anode mud. E.g. electro-refining of copper:

At Cathode: \[ \text{Cu}^{2+} + 2e \rightarrow \text{Cu} \]

At Anode: \[ \text{Cu} \rightarrow \text{Cu}^{2+} + 2e \]

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:  \( \text{Zr impure)} + 2 \text{I}_2 \rightarrow \text{ZnI}_4 \)

At 2075K:  \( \text{ZnI}_4 \rightarrow \text{Zr (pure)} + 2 \text{I}_2 \)

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 \( \text{CO}_2 \) from carbon is lower above 1323K than free energy of formation of ZnO. However, the free energy of formation of \( \text{CO}_2 \) from CO is always higher than that of ZnO. Hence, C is better reducing agent of ZnO.

Q.7- The value of \( \Delta G^0 \) for \( \text{Cr}_2\text{O}_3 \) is -540kJ/mole & that of \( \text{Al}_2\text{O}_3 \) is -827kJ/mole. Is the reduction of \( \text{Cr}_2\text{O}_3 \) possible with aluminium?

A.7- The desired conversion is

\[
4 \text{Al} + 2\text{Cr}_2\text{O}_3 \rightarrow 2\text{Al}_2\text{O}_3 + 4\text{Cr}
\]

It is obtained by addition of following two reactions:-

\[
4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3 \quad \Delta G^0=-827\text{kJ/mole}
\]

\[
2\text{Cr}_2\text{O}_3 \rightarrow 4\text{Cr} + 3\text{O}_2 \quad \Delta G^0=+ 540 \text{kJ/mole}
\]

Therefore, \( \Delta G^0 \) 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 \( \text{Cu}_2\text{S} \) 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) \( 2\text{FeS} + 3\text{O}_2 \rightarrow 2\text{FeO} + 2\text{SO}_2 \),  (ii) \( \text{FeO} + \text{SiO}_2 \rightarrow \text{FeSiO}_3 \) (slag),

(iii) \( 2\text{Cu}_2\text{S} + 3\text{O}_2 \rightarrow 2\text{Cu}_2\text{O} + 2\text{SO}_2 \),  (IV) \( 2\text{Cu}_2\text{O} + 2\text{Cu}_2\text{S} \rightarrow 6\text{Cu} + \text{SO}_2 \)

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 \( \Delta G^0 \) becomes negative and reduction occurs easily.
Q.1 - Explain the following:

(i) Zinc but not copper is used for recovery of Ag from the complex \([\text{Ag(CN)}_2]^\text{−}\).

(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.

\[
2\text{Cu}_2\text{S} + 3\text{O}_2 \rightarrow 2\text{Cu}_2\text{O} + 2\text{SO}_2,
\]

\[
2\text{Cu}_2\text{O} + 2\text{Cu}_2\text{S} \rightarrow 6\text{Cu} + \text{SO}_2.
\]

(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.

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 \(\text{Al}_2\text{O}_3.x\text{H}_2\text{O}\) (ii) Corrundum \(\text{Al}_2\text{O}_3\). Bauxite is commercially important ore Al.

Extraction from Bauxite ore involves the following two stages:-

(i) Purification of bauxite to get pure alumina (\(\text{Al}_2\text{O}_3\))

(ii) Electrolysis of pure alumina in molten cryolite

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

\[
\text{Al}_2\text{O}_3 + 2\text{NaOH} + 3\text{H}_2\text{O} \rightarrow 2\text{Na}[\text{Al(OH)}_4] + \text{impurities of Fe}_2\text{O}_3, \text{TiO}_2 \\
&\& \text{SiO}_2 \text{ are removed. Na}[\text{Al(OH)}_4] \text{,then reacts with CO}_2 \text{then pure Alumina is obtained.}
\]

\[
\text{Na}[\text{Al(OH)}_4] + 2\text{CO}_2 \rightarrow \text{Al}_2\text{O}_3.x\text{H}_2\text{O} + 2\text{NaHCO}_3
\]

Step:-2 Electrolytic reduction of pure alumina takes place in iron box (cathode) with cryolite (\(\text{Na}_3\text{AlF}_6\)) & fluor spar \(\text{CaF}_2\). Graphite rods act as anode. Following reactions take place:-

At cathode:- \(\text{Al}^{3+} + 3\text{e} \rightarrow \text{Al}\), At Anode:- \(2\text{O}^{2−} \rightarrow \text{O}_2 + \text{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:-

\[ 2\text{ZnS} + 3\text{O}_2 \rightarrow 2\text{ZnO} + 2\text{SO}_2 \]

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 at 1163K. Zn formed distills off and is collected by rapid cooling of zinc vapours.

\[ \text{ZnO} + \text{C} \rightarrow \text{Zn} + \text{CO} \]

Q6. Match the following:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Froth floatation process</td>
<td>Metal can form volatile compound which are easily decomposable</td>
</tr>
<tr>
<td>Zone refining</td>
<td>Either ore or impurities are magnetic</td>
</tr>
<tr>
<td>Vapour phase refining</td>
<td>Wettability of the sulphide ores</td>
</tr>
<tr>
<td>Magnetic separation</td>
<td>Breaks to form flux</td>
</tr>
<tr>
<td>Leaching</td>
<td>Impurities are more soluble in melt than the metal</td>
</tr>
<tr>
<td>CaCO$_3$ in blast furnace</td>
<td>Ore a is soluble in a given reagent</td>
</tr>
</tbody>
</table>

Q7. Write short note on following:

(a) Principle of zone refining
(b) Vapour phase refining
(c) Principle of chromatography

Ans. a. Impurities are more soluble in the melt than in the solid state of the metal.

b. Metal is converted into its volatile compound which on decomposition gives pure metal.

c. It is based on selective adsorption of various constituents of a mixture between two phases, a stationary phase and a moving phase.

Q8. Explain following terms:

(a) Flux  (b) Matrix  (c) Ore  (d) Slag