

Chapter.6

General Principles & Processes of Isolation of Elements

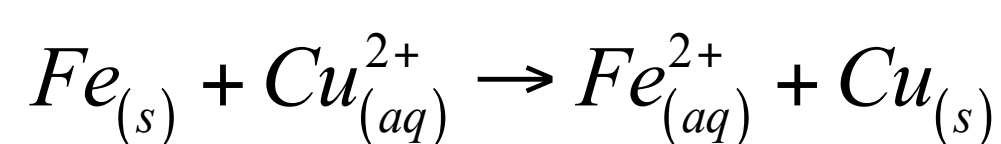
Class-XII

Subject-Chemistry

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

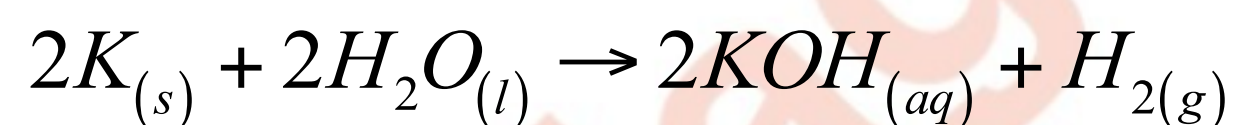
Answer 6.1

In hydrometallurgy, zinc and iron can be used to displace copper from their solution because zinc and iron has lower reduction potentials than that of copper



If we have to displace zinc, more reactive metals which mean metals which have lower reduction potentials than zinc such as Mg, Ca, K, etc. are required.

But these metals react with water with the evolution of H₂ gas. Hence, these metals cannot be used in hydrometallurgy to extract zinc.



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

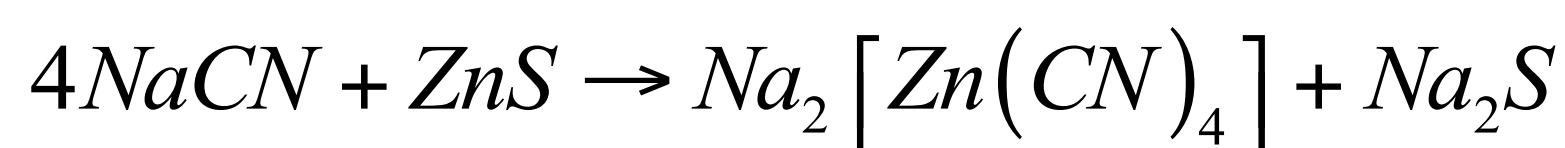
6.2 What is the role of depressant in froth floatation process?

Answer 6.2

Role of the depressants in the froth floatation process: - To separate two sulphide ores by selectively preventing one ore from forming froth.

Example- if we have to separate two sulphide ores say zinc sulphide & lead sulphide, then NaCN is used as a depressant which selectively allows lead sulphide to mix with froth, by preventing zinc sulphide to react with froth.

This happens because of the following reaction:

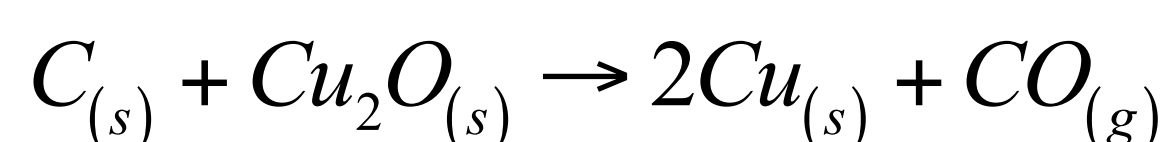


6.3 Why is the extraction of copper from pyrites more difficult than that from its oxide ore through reduction?

Answer 6.3

Gibbs energy of formation of Cu_2O is less than that of carbon disulphide & hydrogen sulphide. Thus, hydrogen & carbon can't reduce copper sulphide to copper.

Whereas, Gibbs energy of formation of Cu_2O is greater than that of carbon monoxide & therefore, carbon can reduce Cu_2O to Cu.



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

6.4 Explain:

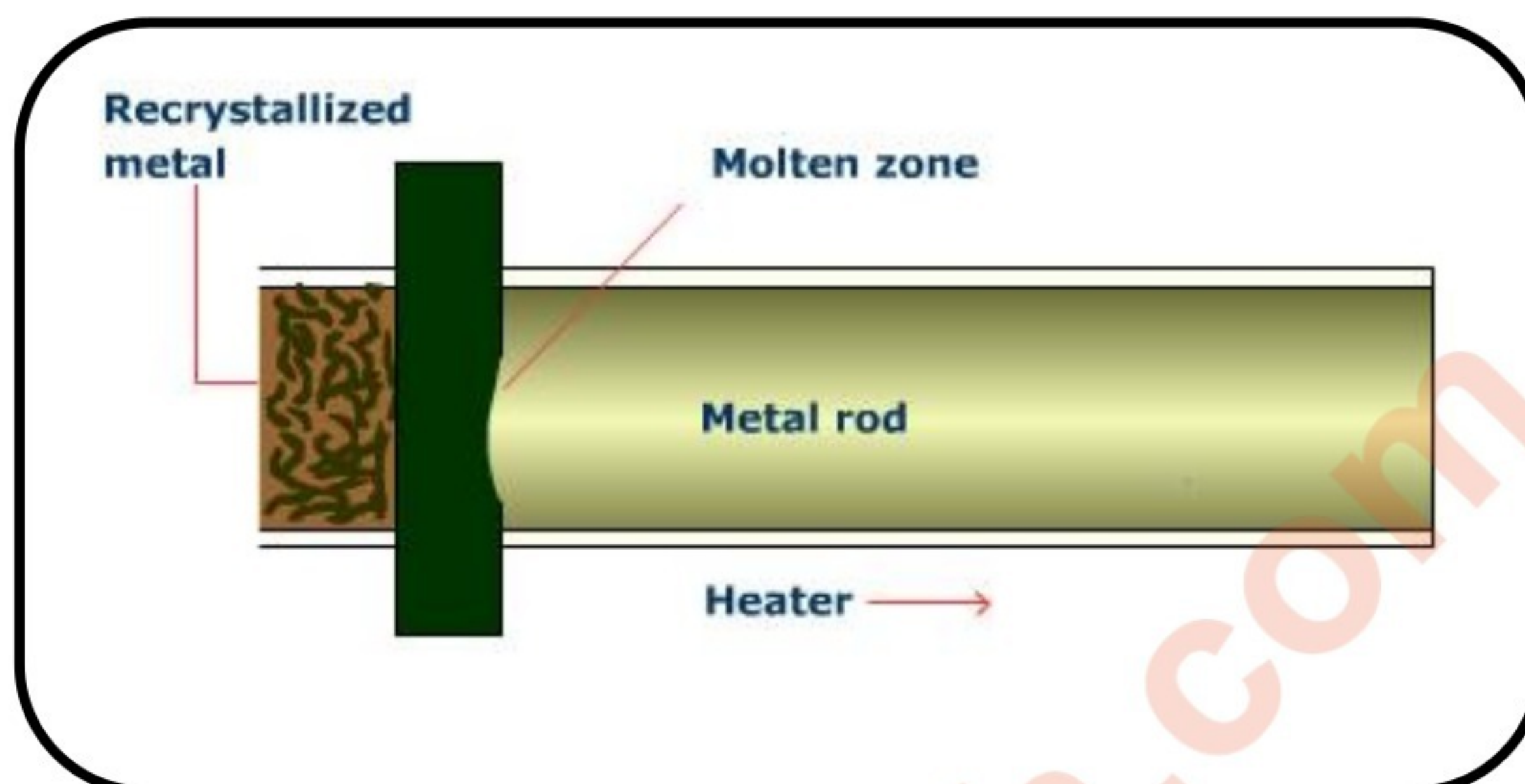
- I. Zone refining
- II. Column chromatography

Answer 6.4

I. Zone refining:

Principle: - Impurities are more soluble in the molten state of metal (the melt) than in the solid state.

Process: - In this process, a circular mobile heater is fixed at one end of a rod of impure metal. As we move heater, the molten zone of the rod also moves with it. This results in, crystallization of pure metal out of the melt and the impurities pass onto the adjacent molten zone. This process is repeated several times, because of which impurities segregate at the end of the rod. Then, the impurity end is cut off. This process is used for purification of many elements like Silicon, boron, gallium, indium etc.



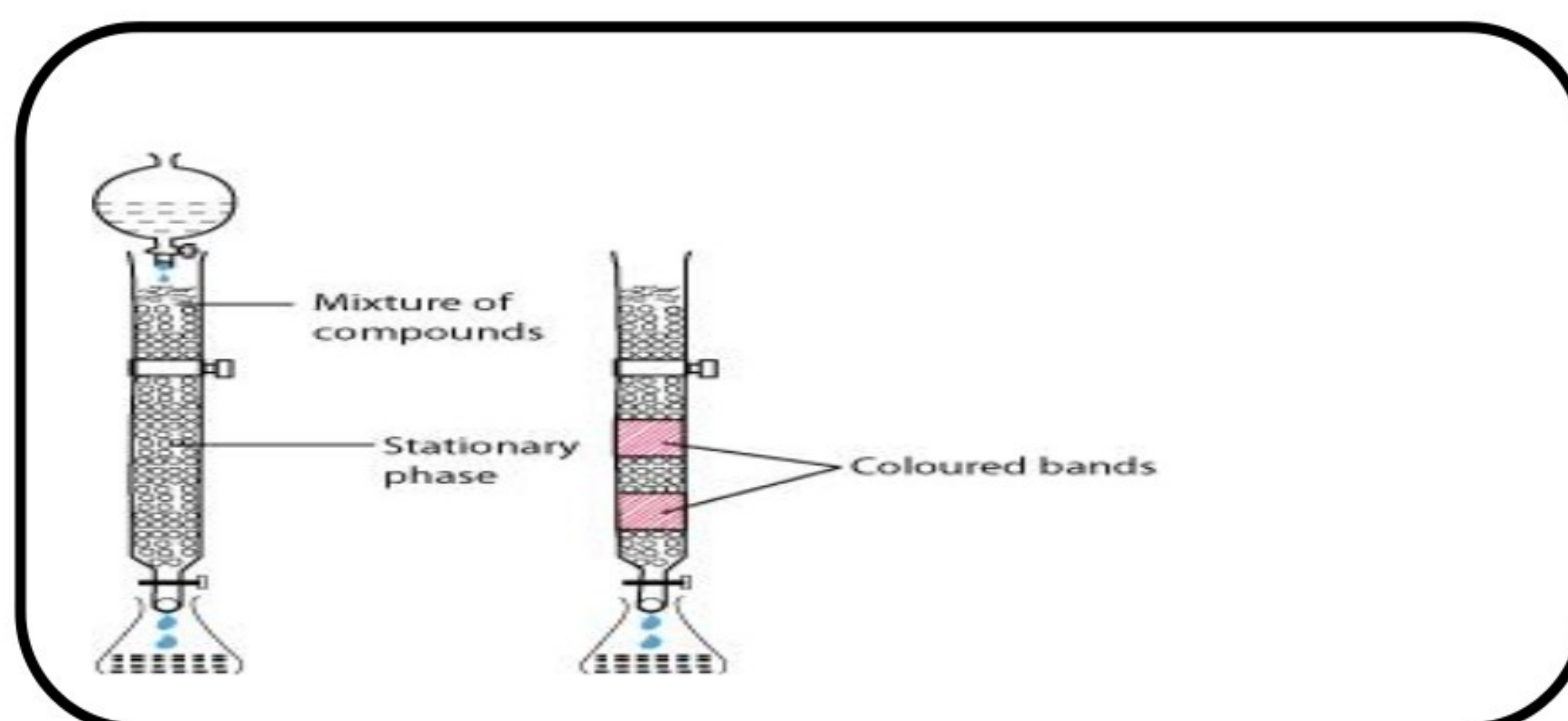
II. Column chromatography:

It is a very useful for the purification of elements which are present in minute quantities. It is a technique used to separate different components of a mixture.

Principle of chromatography: -

It is based on the principle that different components of a mixture are differently adsorbed on an adsorbent.

In this, there are two phases, one is mobile phase and another one is stationary phase. The stationary phase is immobile and immiscible. In column chromatography, Al_2O_3 column is usually used as the stationary phase. 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 using a suitable solvent.



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

Answer 6.5

At 673 K, the value of free enthalpy change for CO to convert into carbon monoxide that is $\Delta G_{(CO,CO_2)}$ is less than that of $\Delta G_{(C,CO)}$. Therefore, CO can be oxidised more easily to carbon dioxide than Carbon to Carbon monoxide.

Hence, CO is a better reducing agent than C at 673 K.

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

Answer 6.6

In electrolytic refining of copper, the common elements present in anode mud are: -

1. Selenium
2. Tellurium
3. Silver
4. Gold
5. Platinum, and
6. Antimony

These elements are very less reactive. Thus, they are not affected during the purification process. Hence, settle down below the anode as anode mud.

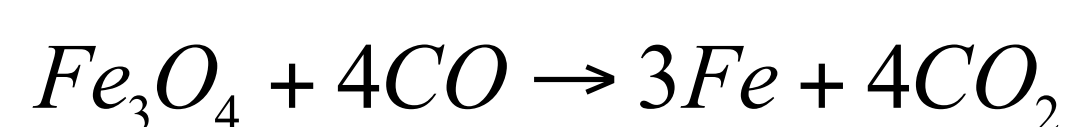
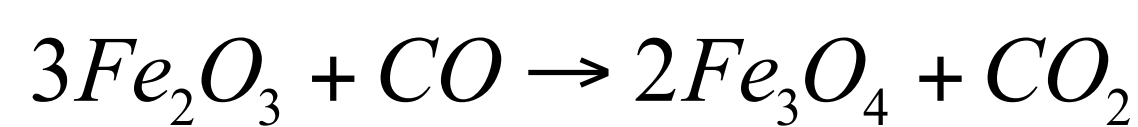
6.7 Write down the reactions taking place in different zones in the blast furnace during the extraction of iron.

Answer 6.7

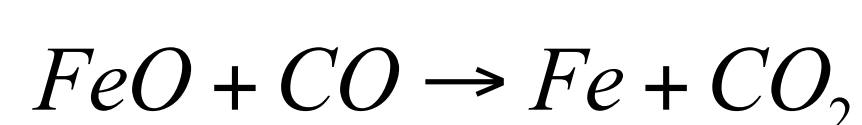
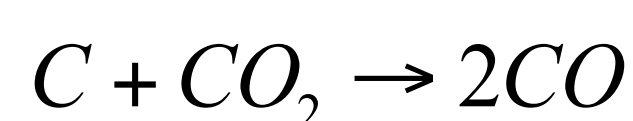
Reduction of iron oxides takes place in the blast furnace.

In this process, hot air is blown from the bottom of the furnace. Through burning coke helps in raising the temperature of blast furnace by 2200 K in the lower portion itself. The temperature is lower in the upper part. In the lower part, reduction of iron oxides (Fe_2O_3 and Fe_3O_4) takes place.

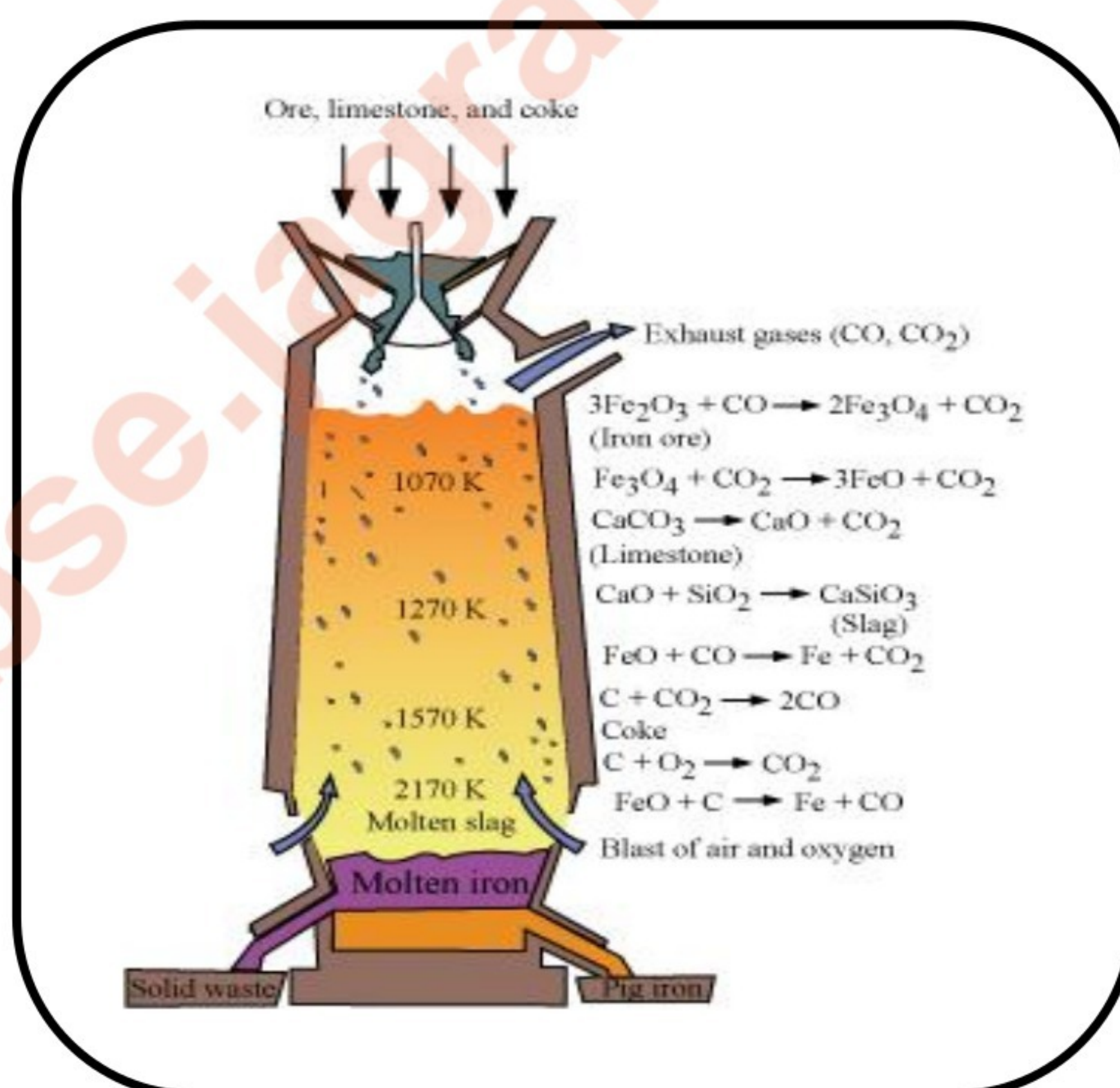
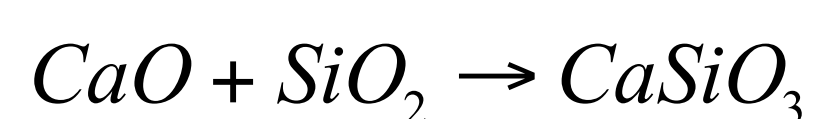
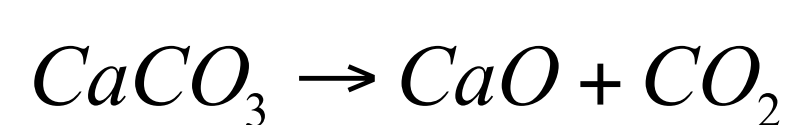
At lower temperature range (500 – 800 K):



At higher temperature range (900 – 1500 K):



The silicate impurity of the ore is removed as slag by calcium oxide, which is formed by the decomposition of limestone.



6.8 Write chemical reactions taking place in the extraction of zinc from zinc blende.

The different steps involved in the extraction are:

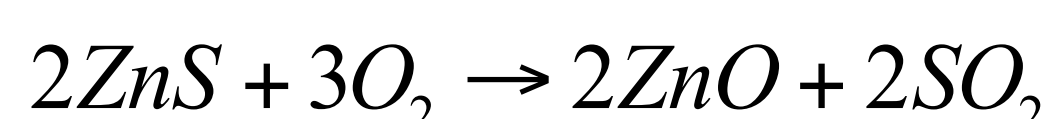
1. Concentration of ore: -

In first step, froth floatation method is used to remove the gangue particles from zinc blende.

2. Roasting: - Conversion to oxide

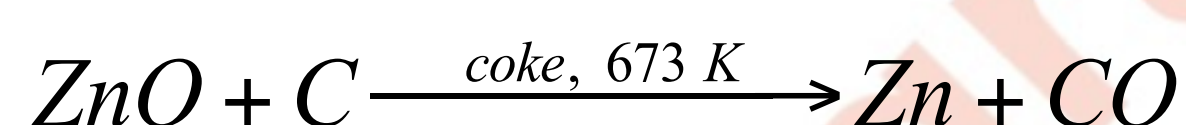
Sulphide ore is converted into oxide by the process of roasting.

In this process, Zinc sulphide is heated in a regular supply of air in a furnace at a temperature, below the melting point of Zn.



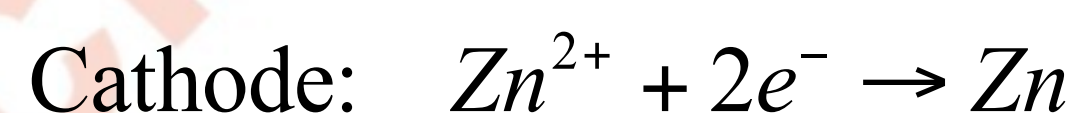
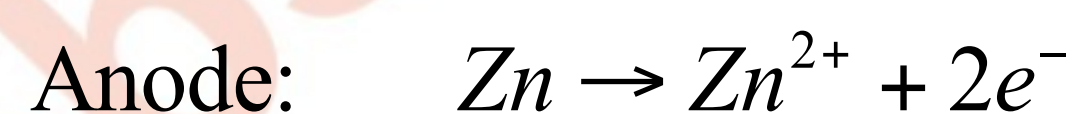
3. Reduction: - Extraction of zinc from zinc oxide

Zinc is extracted from zinc oxide by the process of reduction. It is carried out by mixing zinc with powdered coke and then, heating it at 673 K.



4. Electrolytic Refining

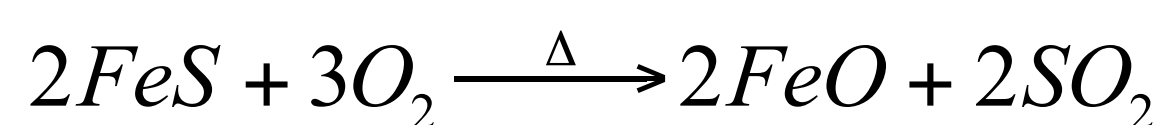
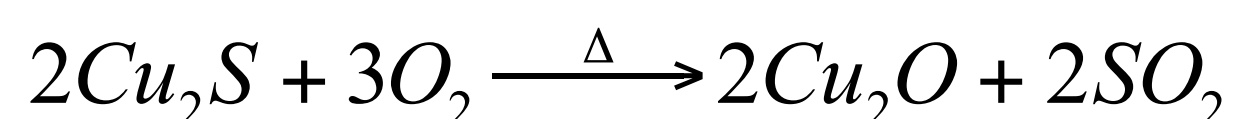
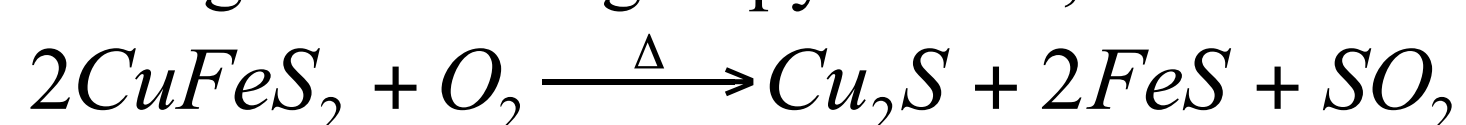
Zinc can be refined by this process. In this process, impure zinc is made the anode while a pure copper strip is made the cathode. The electrolyte used is an acidified solution of zinc sulphate. In this process, following reactions are carried out which involves transfer of zinc in pure from the anode to the cathode.



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

Answer 6.9

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



The role of silica in the metallurgy of copper: -

To remove the iron oxide obtained during above process 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).



6.10 What is meant by the term “chromatography”?

Answer 6.10

Chromatography: - it is a technique used 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.

Examples of such techniques are column chromatography, paper chromatography, gas chromatography, etc.

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

Answer 6.11

Components of the sample which is used for separation have different solubility's in the phase. Thus, the stationary phase is selected accordingly.

Hence, different components have different rates of movement through the stationary phase and thus, they can be separated from each other.

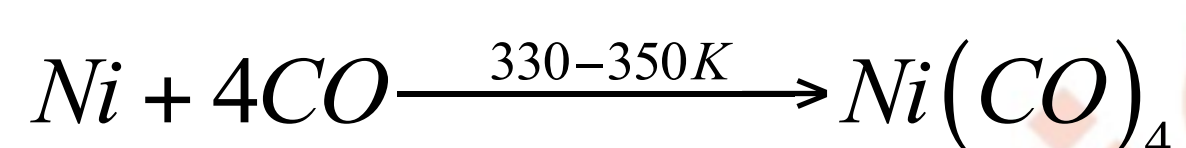
6.12 Describe a method for refining nickel.

Answer 6.12

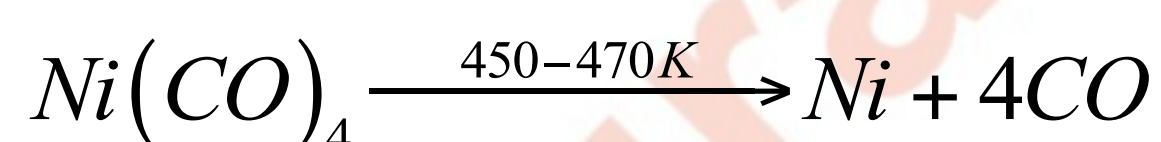
Mond's process: - Refining of nickel

Two steps are involved in this process.

1. Nickel is heated in the presence of carbon monoxide to form a volatile complex, nickel tetracarbonyl.



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

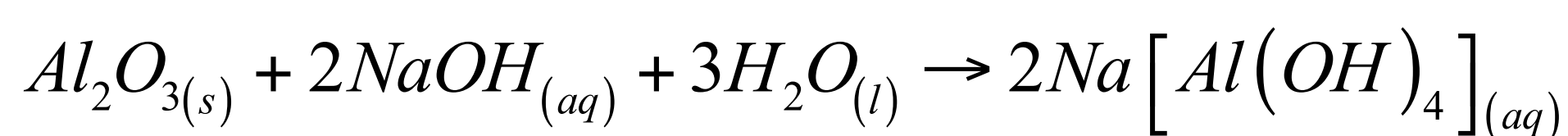


6.13 How can you separate alumina from silica in bauxite ore associated with silica? Give equations, if any.

Answer 6.13

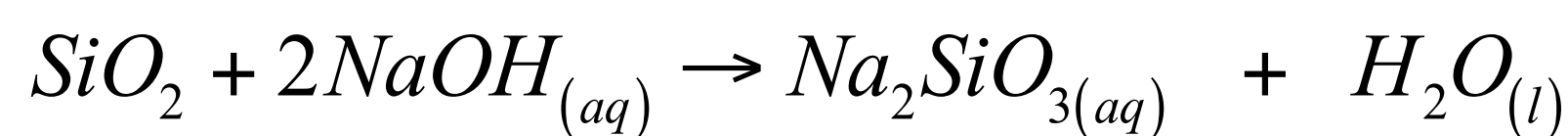
This separation is carried out in two steps:

1. 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 as sodium aluminate and silica as sodium silicate leaving the impurities behind.



Alumina

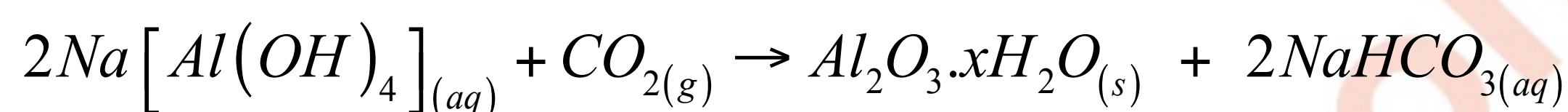
Sodium aluminate



Silica

Sodium silicate

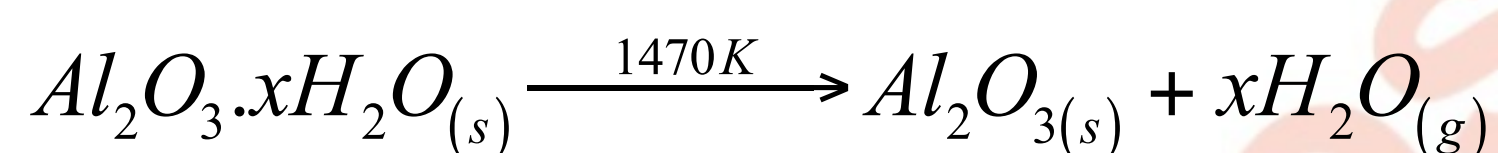
2. Then, CO₂ gas is passed through the resulting solution to neutralize the aluminate in the solution, which results in the precipitation of hydrated alumina. To induce precipitation, the solution is seeded with freshly prepared samples of hydrated alumina.



Sodium aluminate

Hydrated alumina

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



6.14 Giving examples differentiate between 'roasting' and 'calcination'.

Answer 6.14

Roasting	Calcination
It 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.	It 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.
Examples- Sulphide ores of lead, copper, and zinc are converted to their respective oxides by this process.	This process causes the escaping of volatile matter leaving behind the metal oxide.
$2PbS + 3O_2 \xrightarrow{\Delta} 2PbO + 2SO_2$ $2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2$ $2Cu_2S + 3O_2 \xrightarrow{\Delta} 2Cu_2O + 2SO_2$	Examples- Carbonates of Zn, Ca, Mg & hydroxide of Fe, are converted to their respective oxides by this process. $CaMg(CO_3)_2 \xrightarrow{\Delta} CaO_{(s)} + MgO_{(s)} + 2CO$ $ZnCO_{3(s)} \xrightarrow{\Delta} ZnO_{(s)} + CO_{2(g)}$ $Fe_2O_3.3H_2O \xrightarrow{\Delta} Fe_2O_3 + 3H_2O$

6.15 How is ‘cast iron’ different from ‘pig iron’?

Answer 6.15

Pig iron	Cast iron
The iron obtained from blast furnaces is known as pig iron.	Cast iron is obtained by melting pig iron and coke using a hot air blast.
It contains around 4% carbon and many impurities such as S, P, Si, Mn in smaller amounts.	It contains a lower amount of carbon (3%) than pig iron. Unlike pig iron, cast iron is extremely hard and brittle.

6.16 Differentiate between “minerals” and “ores”.

Answer 6.16

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

An **ore** is a mineral from which the metal can be extracted economically.

For example, bauxite & clay both are the sources of aluminium. But bauxite is used for commercial extraction of aluminium but not clay.

Thus, bauxite is ore & both of them are mineral.

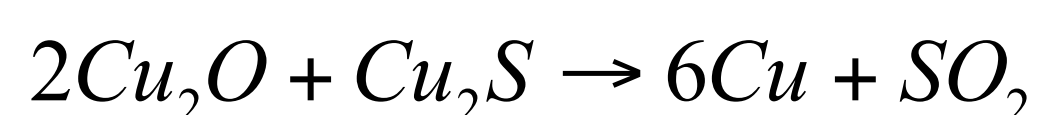
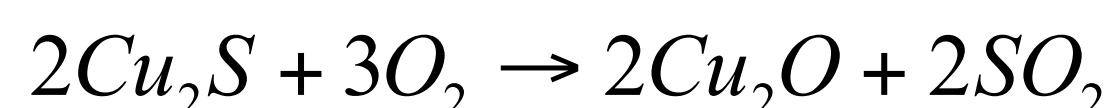
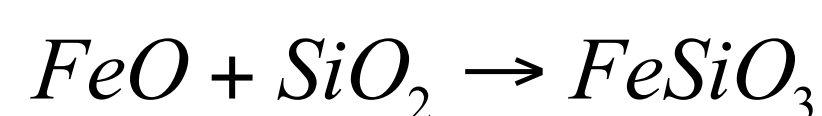
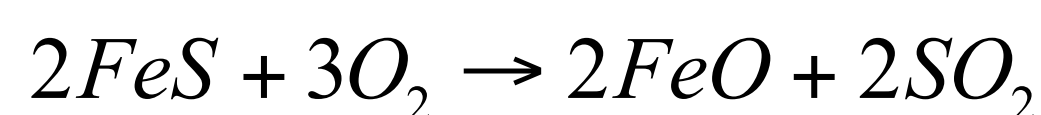
All ores are minerals, but all minerals are not necessarily ores.

6.17 Why copper matte is put in silica lined converter?

Answer 6.17

Copper matte contains Cu_2S and FeS which is put in a silica-lined converter to remove the remaining FeO and FeS present in the matte as slag (FeSiO_3).

Some silica is also added to the silica-lined converter and a hot air blast is blown. This result into conversion of the remaining FeS and FeO into iron silicate (FeSiO₃) and Cu₂S is converted into metallic copper.



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

Answer 6.18

Role of Cryolite - Na_3AlF_6 in the metallurgy of aluminium:

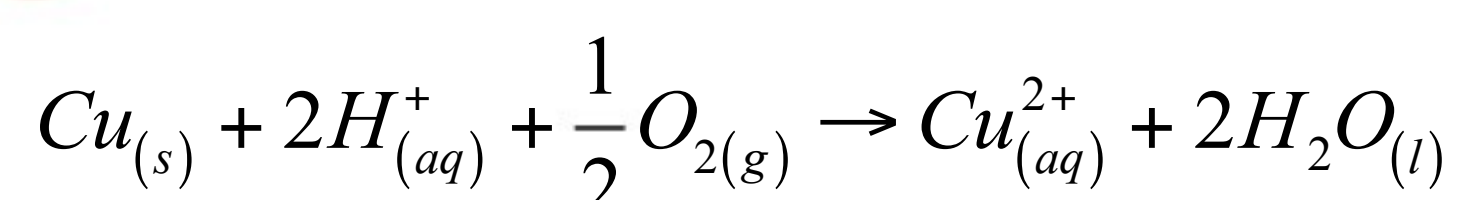
- a) To increase the electrical conductivity of Al₂O₃
- b) To decrease the melting point of the mixture from 2323 K to 1140 K

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

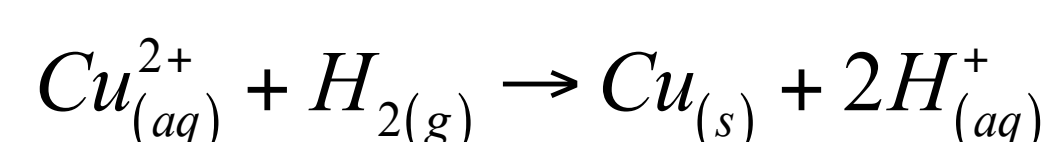
Answer 6.19

Leaching:

In this case, leaching is carried out using acid or bacteria in the presence of air and following reactions is carried out:



The resulting solution is treated with H₂ or scrap iron to get metallic copper.



6.20 Why is zinc not extracted from zinc oxide through reduction using CO?

Answer 6.20

The standard Gibbs free energy of formation of zinc oxide from zinc is lower than that of CO₂ from CO.

Thus, CO cannot reduce zinc oxide to zinc. Hence, CO can't be used for carrying out reduction of zinc.

6.21 The value of $\Delta_f G^\theta$ for formation of Cr₂O₃ is -540 kJmol^{-1} and that of Al₂O₃ is -827 kJmol^{-1} . Is the reduction of Cr₂O₃ possible with Al?

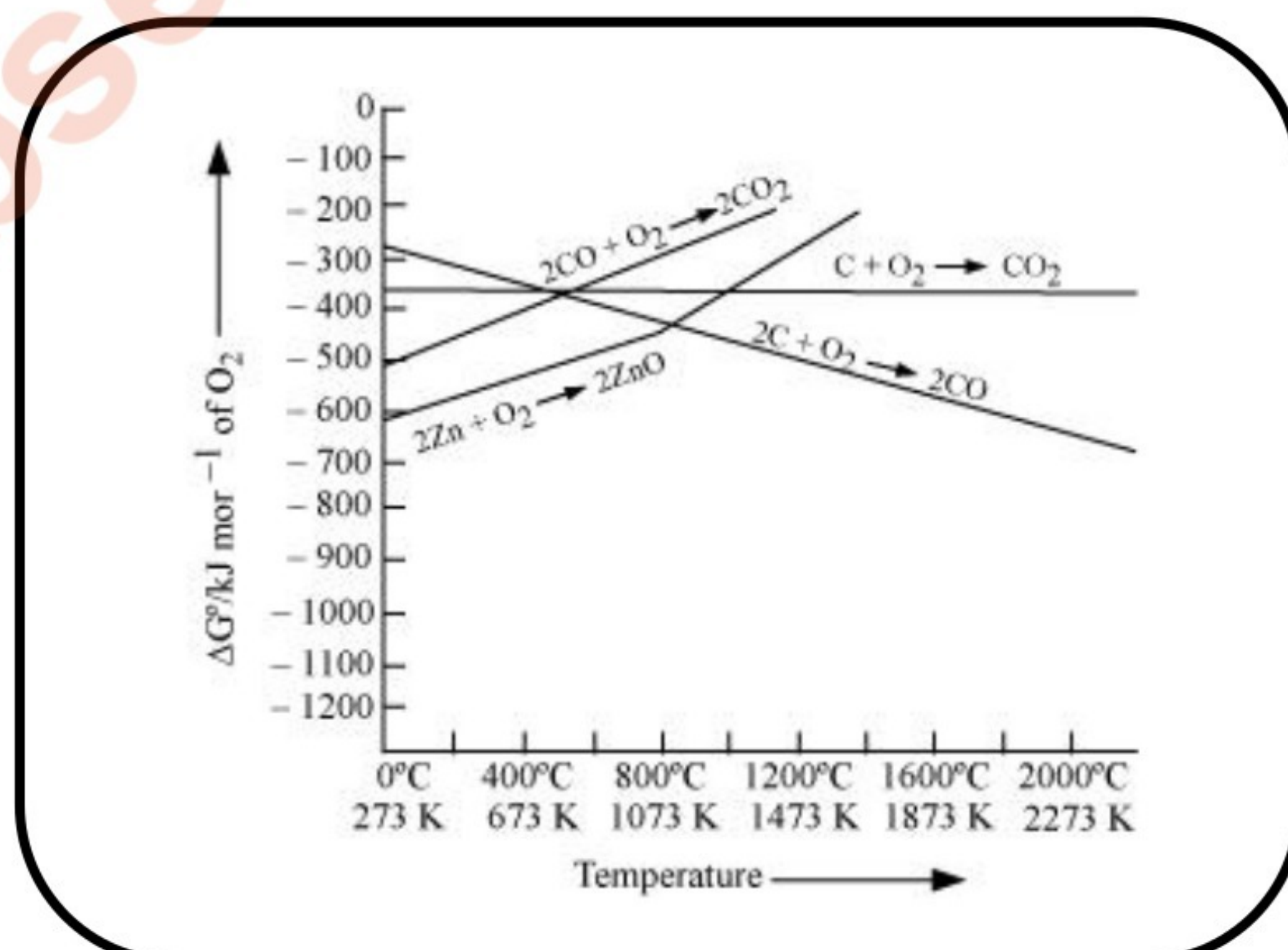
Answer 6.21

The value of $\Delta_f G^\theta$ for the formation of Cr₂O₃ from Cr is higher than that of Al₂O₃ from Al. Therefore, Al can reduce Cr₂O₃ to Cr.

Thus, the reduction of Cr₂O₃ with Al is possible.

6.22 Out of C and CO, which is a better reducing agent for ZnO ?

Answer 6.22



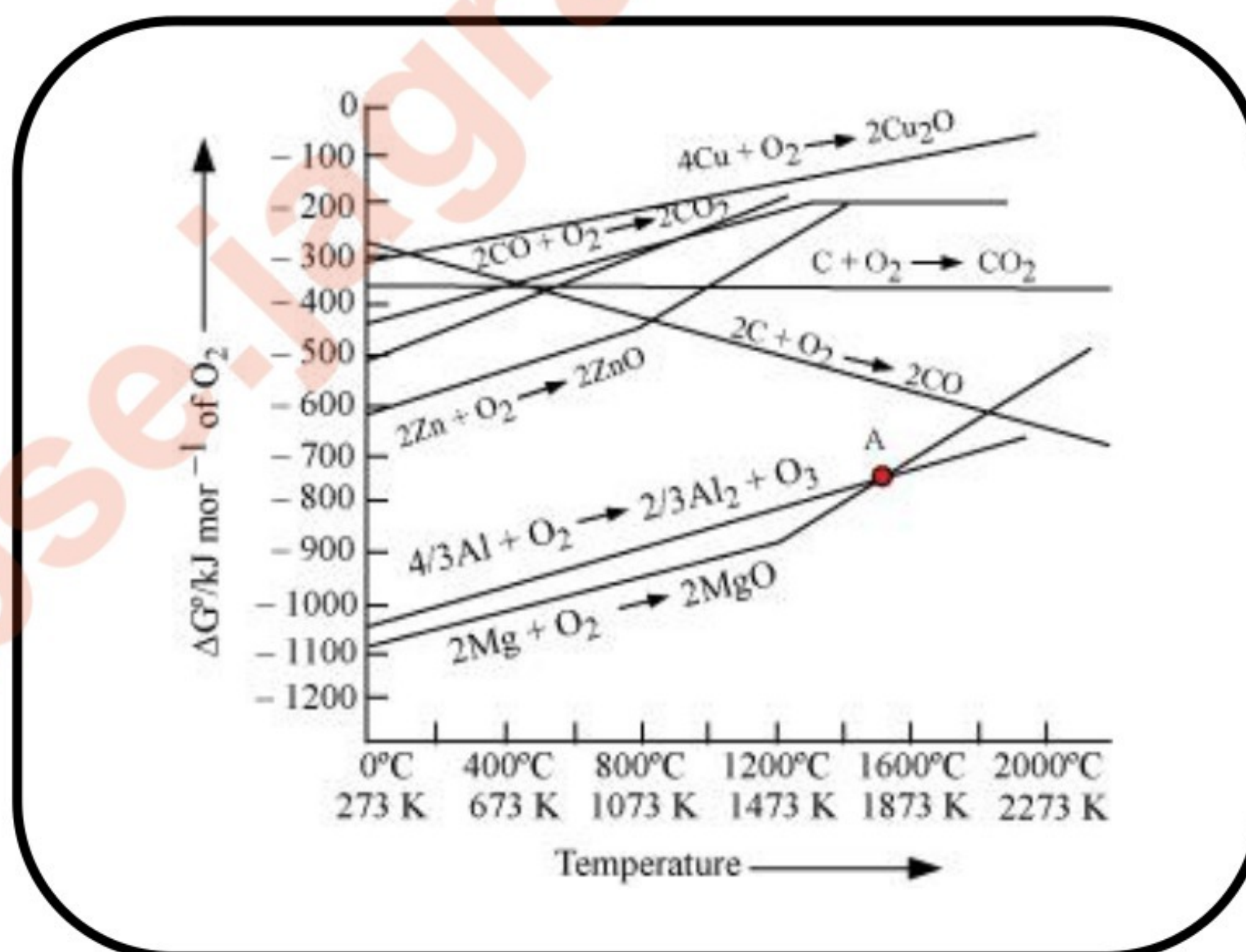
Reduction of ZnO to Zn is carried out nearly at 1673 K. From the graph, we can observe that above 1073 K, the Gibbs free energy of formation of CO from C and above 1273 K, the Gibbs free energy of formation of CO₂ from C is lesser than the Gibbs free energy of formation of ZnO. Thus, C can easily reduce ZnO to Zn.

Whereas, the Gibbs free energy of formation of CO₂ from CO is always higher than the Gibbs free energy of formation of ZnO.

Hence, CO cannot reduce ZnO. Thus, C is a better reducing agent than CO for reducing ZnO.

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 6.23



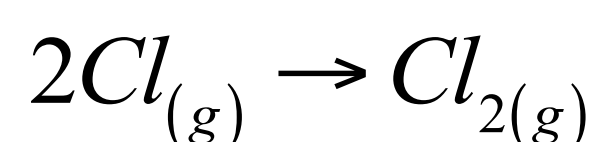
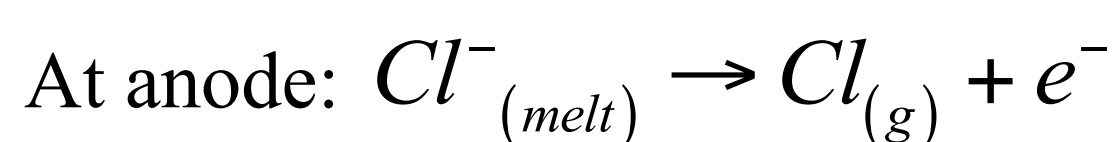
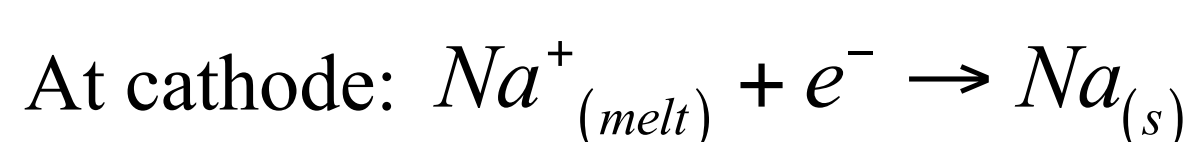
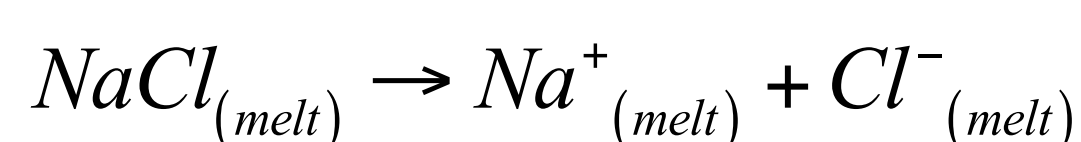
From the graph, we can observe that a metal can reduce the oxide of other metals, if the standard free energy of formation of the oxide of the first oxide is more negative than the second oxide.

For example, Mg can reduce ZnO to Zn, but Zn cannot reduce MgO because standard free energy of formation of MgO from Mg is more negative than standard free energy of formation of ZnO from Zn.

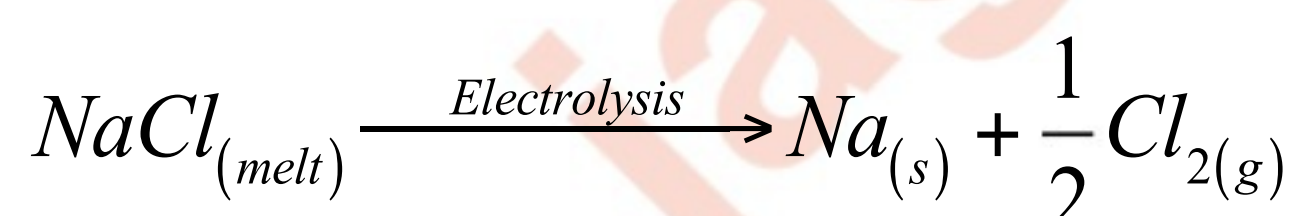
6.24 Name the processes from which chlorine is obtained as a by-product. What will happen if an aqueous solution of NaCl is subjected to electrolysis?

Answer 6.24

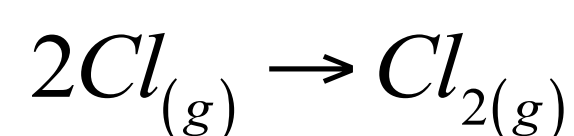
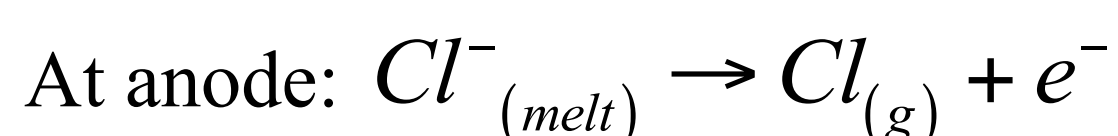
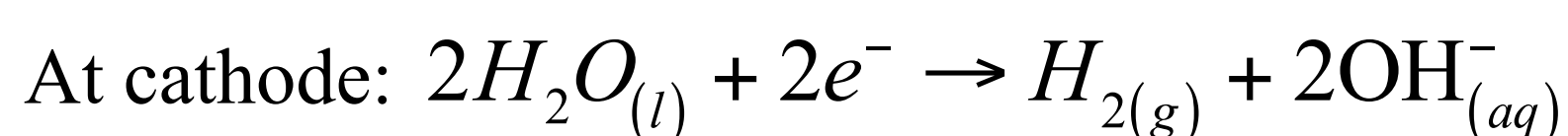
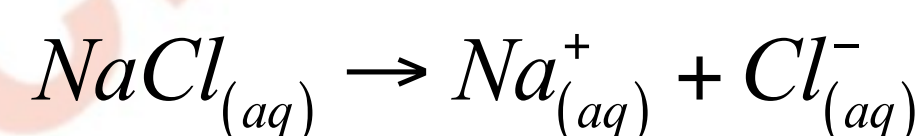
Cl₂ is obtained at the anode as a by product in the electrolysis of molten NaCl,



The overall reaction is as follows:



If an aqueous solution of NaCl is electrolyzed, Cl₂ will be obtained at the anode & hydrogen gas is obtained at the cathode. This is because the standard reduction potential of Na is more negative than that of H₂O. Thus, H₂O will get preference to get reduced at the cathode and as a result, H₂ is evolved.



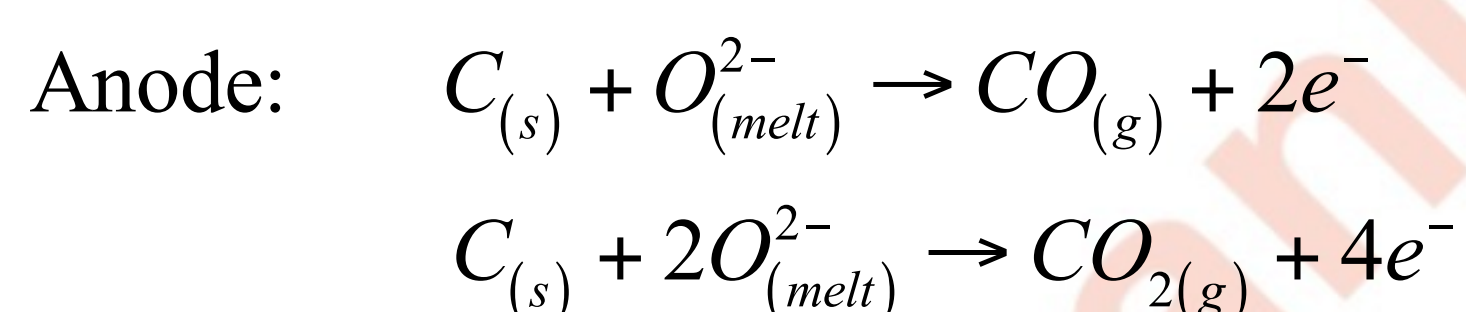
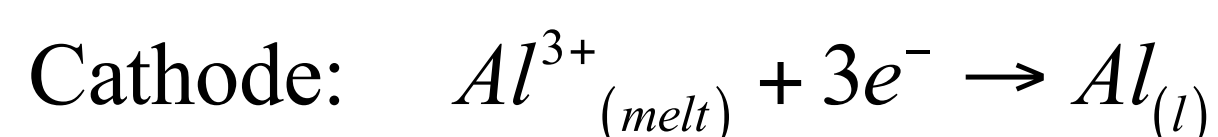
6.25 What is the role of graphite rod in the electrometallurgy of aluminium?

Answer 6.25

Electrometallurgy of aluminium: -

In this, a fused mixture of purified alumina (Al_2O_3), cryolite (Na_3AlF_6) and fluorspar (CaF_2) is electrolysed.

Here, 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.



If we use a metal other than 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_2O_3 .

Thus, graphite is used for preventing the formation of O_2 at the anode. Also, graphite is cheaper than other metals.

6.26 Outline the principles of refining of metals by the following methods:

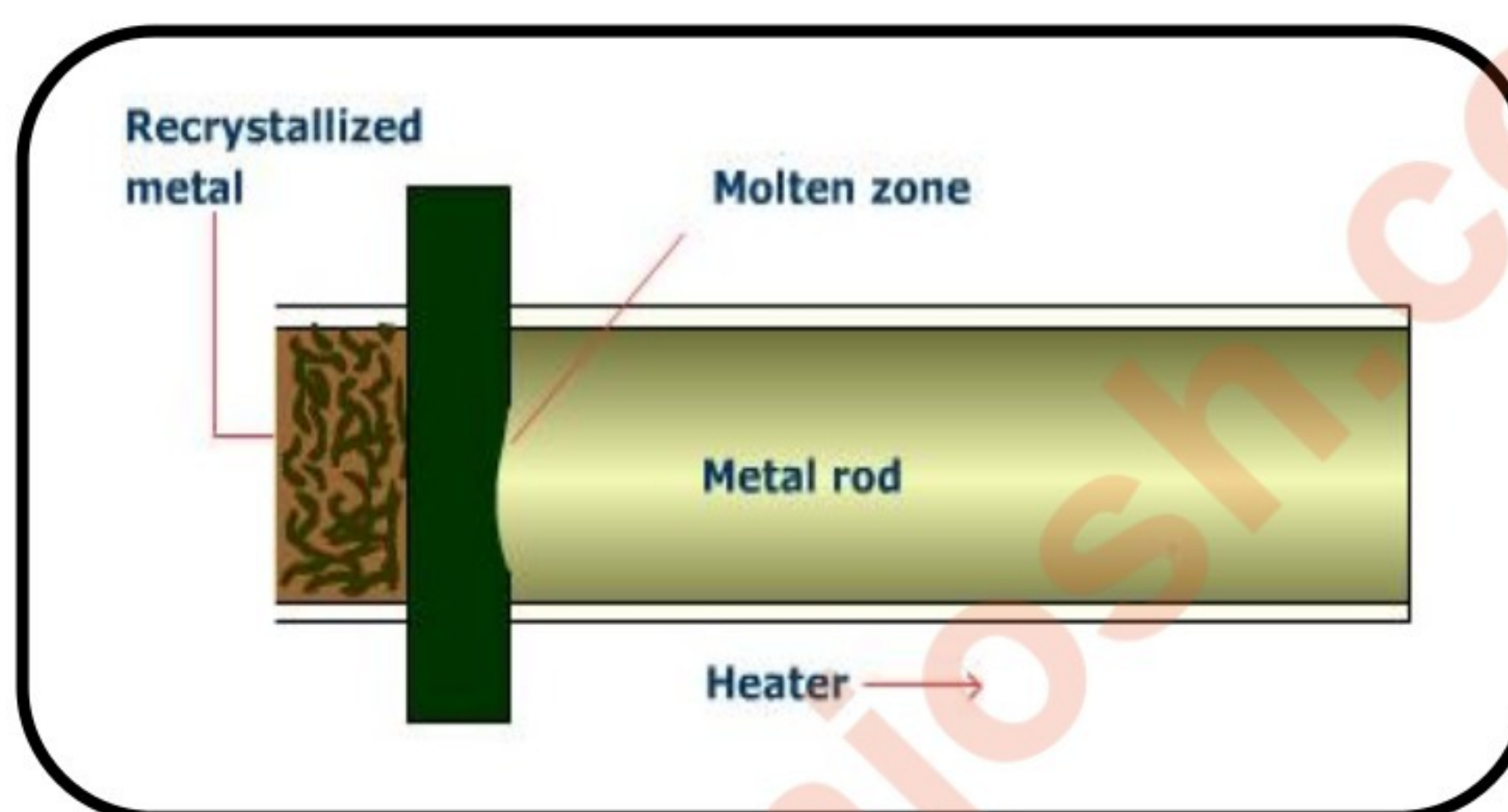
- Zone refining
- Electrolytic refining
- Vapour phase refining

Answer 6.26

a) Zone refining:

Principle: - Impurities are more soluble in the molten state of metal (the melt) than in the solid state

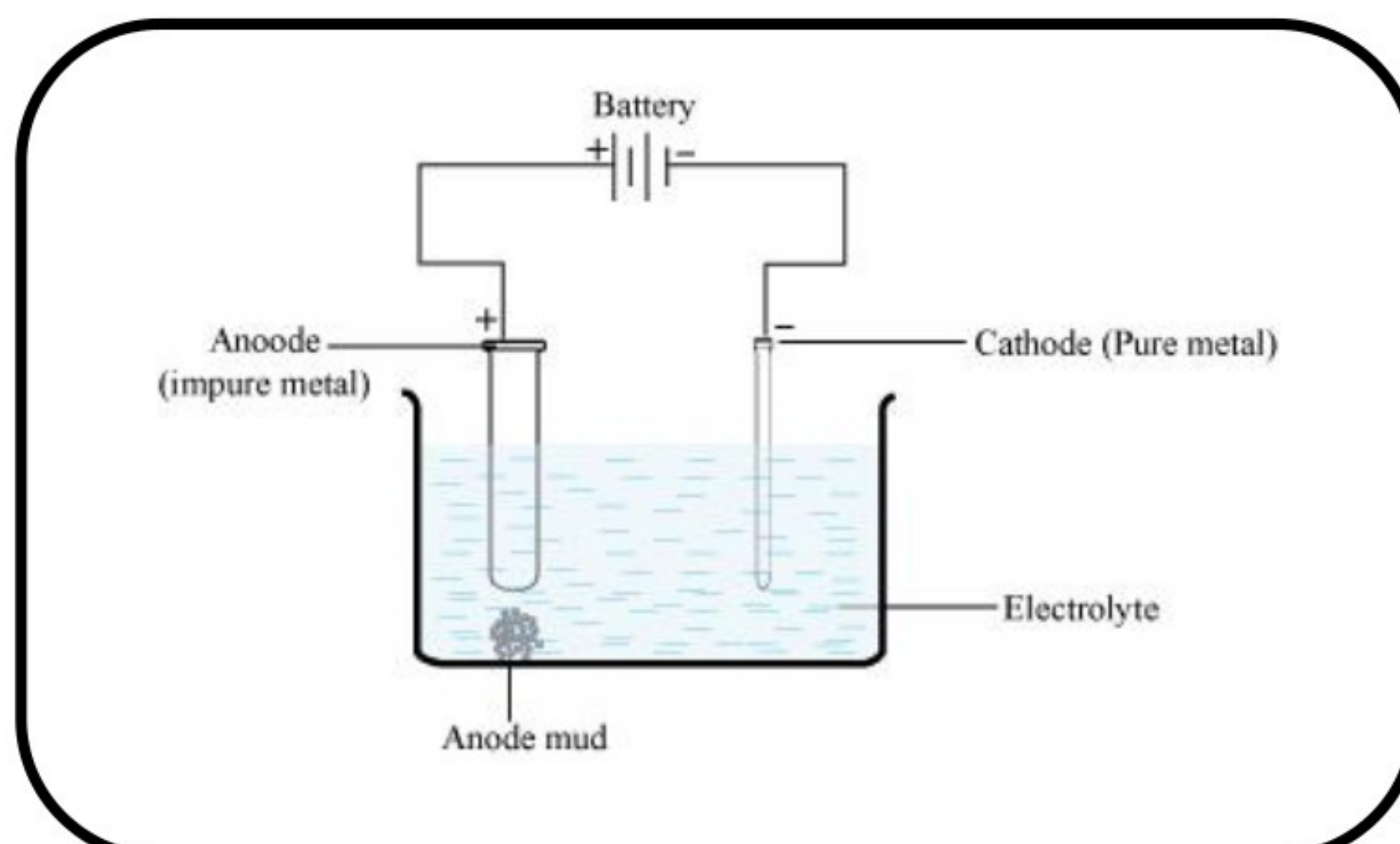
In this process, a circular mobile heater is fixed at one end of a rod of impure metal. As we move heater, the molten zone of the rod also moves with it. This results in, crystallization of pure metal out of the melt and the impurities pass onto the adjacent molten zone. This process is repeated several times, because of which impurities segregate at the end of the rod. Then, the impurity end is cut off. This process is used for purification of many elements like Silicon, boron, gallium, indium etc.



b) Electrolytic refining;

It is the process of refining impure metals by using electricity. In this process, anode is made up of impure metal and cathode is made up of a strip of pure metal. 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.



c) Vapour phase refining

It 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, metal should form a volatile compound with an available reagent, and the volatile compound should be easily decomposable so that the metal can be easily recovered.

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

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

Answer 6.27

Above 1350°C, the standard Gibbs free energy of formation of aluminium oxide from Aluminium is less than that of magnesium oxide from Magnesium.

Hence, above 1350°C, Al can reduce MgO.