CBSE NCERT Solutions for Class 12 Chemistry Chapter 6

Back of Chapter Questions

1. Which of the ores mentioned in the following table can be concentrated by magnetic separation method?

Metal	Ores	Composition
Aluminium	Bauxite Kaolinite (a form of clay)	$AlO_x(OH)_{3-2x}$ [where $0 < x < 1$] $[Al_2(OH)_4Si_2O_5]$
Iron	Haematite Magnetite Siderite Iron Pyrites	Fe_2O_3 Fe_3O_4 $FeCO_3$ FeS_2
Copper	Copper Pyrites Malachite Cuprite Copper glance	$CuFeS_2$ $CuCO_3.Cu(OH)_2$ Cu_2O Cu_2S
Zinc	Zinc blende or sphalerite Calamine zincite	ZnS $ZnCO_3$ ZnO

Solution:

The magnetic separation method is used when the ore or the gangue can be attracted by the magnetic field. Among the ores mentioned in the given table, the ores of iron such as haematite Fe_2O_3, magnetite Fe_3O_4, siderite $FeCO_3$, and iron pyrites FeS_2 can be separated by the process of magnetic separation.

2. What is the significance of leaching in the extraction of aluminium?

Solution:

In the extraction of aluminium, the significance of leaching is to concentrate pure alumina Al_2O_3 from bauxite ore.

Bauxite usually contains impurities such as silica, iron oxide, and titanium oxide. 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_2O_3) dissolves as sodium meta-aluminate and silica SiO_2 dissolves as sodium silicate leaving the impurities behind.

3. The reaction,

$Cr_2O_3 + 2Al \rightarrow Al_2O_3 + 2Cr$ ($\Delta G^o = -421$ kJ mol^{-1})

is thermodynamically feasible as is apparent from the Gibbs energy value. Why does it not take place at room temperature?

Solution:

The change in Gibbs free energy is related to the equilibrium constant, K as

$\Delta G = -RT \ln K$

At room temperature, all the reactants and the products at room temperature are solids. Equilibrium does not exist between the reactants and products. Hence the reaction does not take place at room temperature. A certain amount of energy (activation energy) is required for even the reactions which are thermodynamically stable.

4. Is it true that under certain conditions, Mg can reduce Al_2O_3 and Al can reduce MgO? What are those conditions?

Solution:

Yes, it is true that magnesium (Mg) can reduce aluminium oxide (Al_2O_3) and aluminium (Al) can also reduce magnesium oxide (MgO). According to the Ellingham diagram, we find that below 1350°C, Mg can reduce aluminium oxide (Al_2O_3) and when the temperature is above 1350°C, Al can reduce magnesium oxide (MgO).

5. Explain why hydro-metallurgy can extract copper, but cannot extract zinc.

Solution:

The reduction potential of copper is higher than that of zinc and iron. Thus, in hydro-metallurgy iron and zinc can be used to displace copper from its solution.
$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$

But in order to displace a metal like zinc a metal more reactive than it is required e.g. K, Ca, Mg etc. The metals which are stronger reducing agent than zinc react with water to liberate hydrogen gas. Thus, hydro-metallurgy can extract copper but cannot extract zinc.

6. What role does a depressant play in the process of froth floatation?

Solution:

In the froth floatation process, the role of a depressant is to prevent certain types of substances from forming the froth with the air bubbles.

For example, NaCN is used as a depressant to separate two sulphide ores, PbS (Lead sulphide) and (Zinc sulphide). NaCN forms a complex, $Na_2[Zn(CN)_4]$ with zinc on the surface of zinc sulphide, thus preventing from forming the froth.

$4NaCN + Zns \rightarrow Na_2[Zn(CN)_4] + Na_2S$

7. Why is it more difficult to extract copper from pyrites than it is to extract copper from its oxide ore?

Solution:

$\Delta_f G$ (Gibbs free energy of formation) of copper (I) sulfite is less than that of hydrogen sulphite and carbon disulphite (CS_2). Therefore C and H_2S will not be able to reduce Cu_2S to Cu.

Whereas $\Delta_f G$ of Cu_2O is larger than carbon monoxide(CO). Therefore C can reduce copper (I) oxide to copper.

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

Therefore, it is more difficult to extract copper from copper pyrites than it is to extract from its oxide ore.

8. Write notes on:

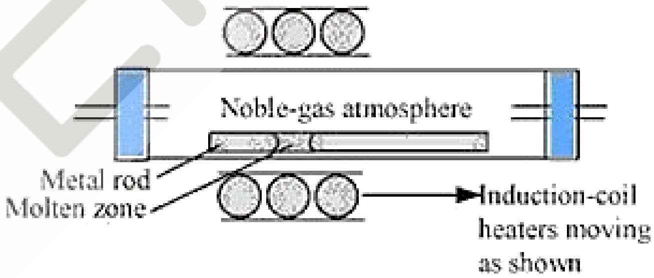
(a) Zone refining

(b) Column chromatography.

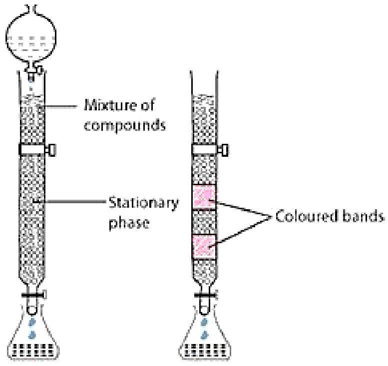
Solution:

(a) Zone refining is based on the principle that impurities are more soluble in the molten state of metal than in solid metal. In zone refining, a circular mobile heater slowly moves over the impure metal rod. As the heater is removed along with the length of the rod, the pure metal crystallizes out of the melt and impurities pass into the adjacent molten zone. This process is repeated several times, causing impurities to get collected at one end of the rod. This impure end is then cut off and discarded.

Semiconductors and some metals of high purity like Boron, silicon, gallium etc. are purified using this method.



(b) Column chromatography is a method used for purifying elements present in minute quantities. Column chromatography is based on the principle that various components of a mixture are adsorbed to different extents on an adsorbent. Chromatography includes two phases: Mobile phase and Stationary phase. A column of adsorbent e.g. aluminium oxide is used as the stationary phase. The mixture that is to be purified is dissolved in the mobile phase which can be either a liquid, gas or supercritical fluid. This is then poured onto the top of the column. The component which is more strongly adsorbed by the adsorbent takes more time to move through it than the component that is weakly adsorbed. This way the different components of the mixture are separated as they move through the stationary phase. There are several chromatographic techniques such as paper chromatography, column chromatography, gas chromatography



9. At 673 K, which is a more effective reducing agent, CO or C?

Solution:

Carbon monoxide is a more effective reducing agent at 673 K because the value of $\Delta G(C, CO)$ is greater than the value of $\Delta G(C, CO_2)$. This means that CO is more easily reduced to CO_2 than C to CO.

10. In the process of electrolytic refining of copper what are the common elements in the anode mud? What is the reason for their presence?

Solution:

During the electrolytic refining of copper - Silver, selenium, antimony, tellurium, platinum and gold are the common elements present in the anode mud.

As these metals are very less reactive, they are not affected during the purification method. Thus, they settle down under anode as anode mud.

11. State the various reactions that take place inside the different zones of a blast furnace during iron extraction.

Solution:

During the process of extraction of iron, iron oxide is reduced at different temperature ranges inside a blast furnace. The reactions taking place are:

At 500 – 800 K temperature zone:

$3Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$

$Fe_2O_3 + CO \rightarrow 2FeO + CO_2$

At 850 K temperature zone:

$Fe_3O_4 + CO \rightarrow 3FeO + CO_2$

At 900 – 1500 K temperature zone:

$FeO + CO \rightarrow Fe + CO_2$

$CO_2 + C \rightarrow 2CO$

Above 1570 K temperature zone:

$C + O_2 \rightarrow CO_2$

$FeO + C \rightarrow Fe + CO$

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

$SiO_2 + CaO \rightarrow CaSiO_3$ (slag)

12. Write the chemical reactions involved in zinc extraction from zinc blende.

Solution:

The steps involved in the extraction of zinc from zinc blende are:

(1) Concentration of ore

Firstly, zinc blende is crushed and the concentration of ore is done by froth floatation method.

(2) Roasting(Conversion to oxide)

In this step, ZnS is roasted in the presence of an excess of air at about 1200 K in a furnace. This results in the formation of zinc oxide.

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

(3) Reduction(Extraction of Zn from ZnO):

Zinc oxide obtained after roasting is mixed with powdered coke and then heated to get zinc.

$ZnO + C \rightarrow Zn + CO$

(4) Electrolytic Refining:

In electrolytic refining, impure zinc is taken as the anode while the cathode is a pure copper strip. The electrolyte is an acidified solution of zinc sulphate ($ZnSO_4$) with dilute sulfuric acid. On passing current, electrolysis takes place in which pure zinc is deposited on the copper strip.

13. What role does silica play in copper metallurgy?

Solution:

Copper pyrites are converted to a mixture of Cu_2O and FeO during roasting.

$2CuFeS_2 + O_2 \rightarrow Cu_2S + 2FeS + SO_2$

$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$

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

Silica is used in the metallurgy of copper to remove the iron oxide obtained during the process of roasting as slag. SiO_2 and FeO form $FeSiO_3$ (slag) which floats on the molten matter.

$FeO + SiO_2 \rightarrow FeSiO_3$(slag)

14. "Chromatography", What do you understand by this term?

Solution:

Chromatography is a term used for a range of laboratory techniques for the separation and purification of mixtures. The word has been derived from Greek words; 'chroma' meaning 'colour' and 'graphein' meaning 'to write'. There are various chromatographic techniques like column chromatography, paper chromatography, gas chromatography, etc.

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

Solution:

The stationary phase during chromatography is selected in such a way that the components of the sample have different solubilities in the phase. Different components have different rates of movement through the stationary phase and hence can be separated from each other. The stationary phase used is immobile and immiscible.

16. Write about a technique used to refine nickel?

Solution:

Mond's process is the technique used to refine nickel. In this process, heat is supplied to nickel in the presence of carbon monoxide to produce nickel tetracarbonyl(volatile complex).

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

The nickel tetracarbonyl obtained is then decomposed by heating it at a higher temperature (450 − 470 K) to form pure nickel.

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

17. How is alumina separated from silica in a bauxite ore associated with silica? Provide equations, if present.

Solution:

Alumina separated from silica in a bauxite ore associated with silica is as follows:

Firstly, a concentrated NaOH solution is used to digest the powdered ore at a temperature of 473 − 523 K and at a pressure of 35 − 36 bar. This causes leaching of alumina (Al_2O_3) and silica (SiO_2) as sodium aluminate and sodium silicate respectively leaving the impurities behind.

$$Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \rightarrow 2Na[Al(OH)_4](aq)$$

and

$$SiO_2 + 2NaOH(aq) \rightarrow Na_2SiO(aq) + H_2O(l)$$

To neutralize the aluminate present in the solution, carbon dioxide gas is passed through the solution we obtained. This causes the sodium meta-aluminate to precipitate as hydrated alumina.

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

Sodium silicate present cannot be precipitated so it is filtered. The hydrated alumina is dried, heated and filtered to obtain the pure alumina.

$$Al_2O_3.xH_2O(s) \rightarrow Al_2O_3(s) + xH_2O(g)[1470\ K]$$

18. Differentiate between 'calcination' and 'roasting' with the help of examples.

Solution:

Calcination	Roasting
Calcination is the process of conversion of carbonate and hydroxide ores to oxides by heating them at a temperature below their melting points and in the absence or in a very limited supply of air.	Roasting is the process of conversion of sulphide ores into their metallic oxides by heating at a temperature below their melting points in the excess presence of air.
Water and organic impurities are removed	Volatile impurities are removed as oxides such as SiO_2, Al_2O_3
Example: $ZnCO_3 \xrightarrow{heat} ZnO + CO_2 \uparrow$	**Example:** $2ZnS + 3O_2 \xrightarrow{heat} 2ZnO + 2SO_2 \uparrow$

19. What is the difference between 'cast iron' and 'pig iron'?

Solution:

Cast iron is made by melting pig iron and coke using a hot air blast. It has low levels of carbon in it (3%). Cast iron is brittle and extremely hard unlike pig iron obtained from blast furnace.

Pig iron is the iron obtained from blast furnaces. It is around 4% carbon and contains many impurities like Si, P, S, Mn in smaller amounts.

20. What is the difference between "ores" and "minerals"?

Solution:

The naturally occurring substances in the form of which metals occur in the earth's crust along with impurities are called minerals.

Ores are rocks and minerals from which metals can be conveniently obtained and is economically viable.

For example, aluminium occurs in the earth's crust both in the form of bauxite and clay. Therefore both bauxite and clay are minerals that contain aluminium. But out of these two minerals, aluminium can be only conveniently and economically extracted from the bauxite. Therefore bauxite is the ore.

21. Why is copper matte put in converters lined with silica?

Solution:

Copper matte consists of Cu_2S and some FeS. When a hot blast of air is blown through a molten matte placed in a silica lined converter, FeS of the matte oxidizes to FeO. This FeO combines with SiO_2 (silica) to produce $FeSiO_3$ (slag).

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

$FeO + SiO_2 \rightarrow FeSiO_3$

When all of the iron has been removed as slag Cu_2S is oxidized to Cu_2O which then undergoes a reaction with Cu_2S to give copper metal.

$2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$

22. In the metallurgy of aluminium, what role does Cryolite play?

Solution:

Cryolite (Na_3AlF_6) has two basic roles in the metallurgy of aluminium

1. The melting point of the solution is decreased from 2323 K to1140 K.
2. It increases the electrical conductivity of the mixture.
3. How is leaching done in when dealing with low grade copper ores?

Solution:

For low-grade copper ores, bacteria or acids are used in the presence of air to leach the copper. In this method, copper goes into the solution as Cu^{2+} ions.

$$Cu(s) + 2H^+(aq) + \frac{1}{2}O_2(g) \rightarrow Cu^{2+}(aq) + 2H_2O(l)$$

This solution so obtained is then treated with H_2 or scrap iron to obtain copper metal.

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

24. Why isn't zinc oxide reduction (using carbon monoxide) used to extract zinc?

Solution:

The standard Gibbs free energy of formation of ZnO from Zn is lower than that of CO_2 from CO. So CO cannot reduce ZnO to Zn. Therefore zinc oxide reduction using carbon monoxide is not used to extract zinc.

25. $\Delta_f G^\theta$ has a value of -540 kJ mol^{-1} for Cr_2O_3 formation and -827 kJ mol^{-1} for Al_2O_3 formation. Can Cr_2O_3 be reduced by Al?

Solution:

Cr_2O_3 has a higher $\Delta_f G^0$ (-540 kJ mol^{-1}) than Al_2O_3 (-827 kJ mol^{-1}). Thus, Al can reduce Cr_2O_3 to Cr.

Alternatively,

$2Al + \left(\frac{3}{2}\right)O_2 \rightarrow Al_2O_3$ ...(i)

$2Cr + \left(\frac{3}{2}\right) O_2 \rightarrow Cr_2O_3$ ...(ii)

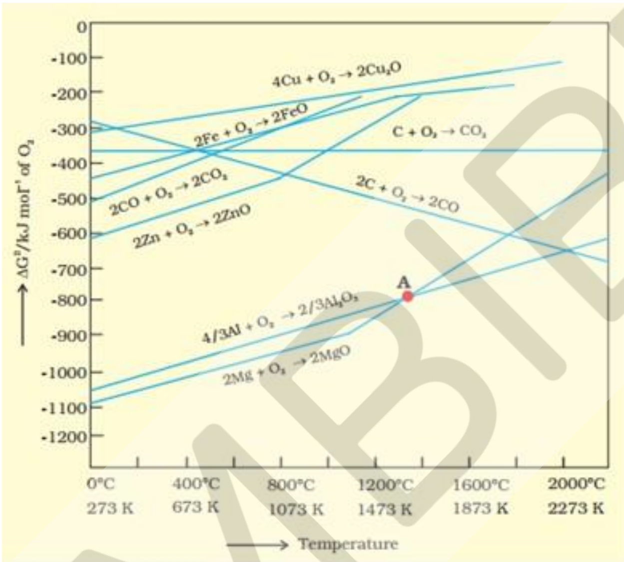
Subtracting equation (ii) from (i), we get

$2Al + Cr_2O_3 \rightarrow Al_2O_3 + 2Cr; \Delta_f G^0 = -827 - (-540) = -287 \text{ kJ mol}^{-1}$

As $\Delta_f G^0$ is negative for the reduction reaction of Cr_2O_3 by Al, the reaction can take place.

26. Which one is better at reducing ZnO, C or CO_2?

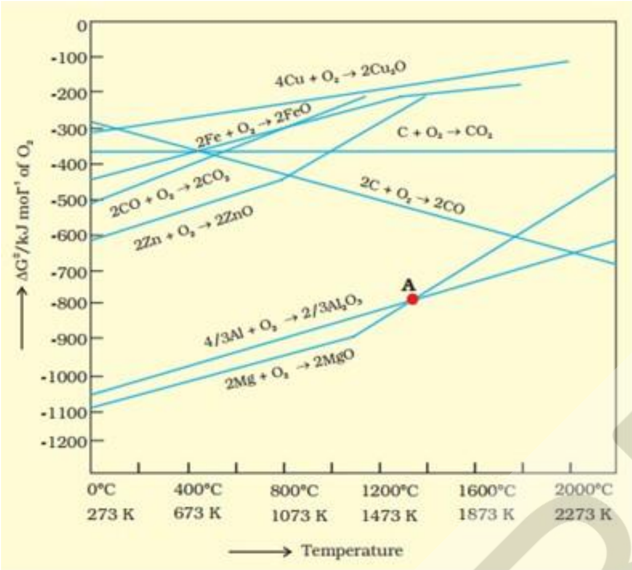
Solution:



ZnO is reduced to Zn at around 1673 K. From the figure above, we observe that beyond 1073 K the Gibbs free energy of formation($\Delta_f G^0$) of CO from C and beyond 1273 K, the Gibbs free energy of formation of CO_2 from C is less than the Gibbs free energy of formation of ZnO. Thus, C can reduce ZnO to Zn. However, the Gibbs free energy of formation of CO_2 from CO is greater than the Gibbs free energy of formation of ZnO. Thus, CO is not able to reduce ZnO. Therefore, out of C and CO, C is a better reducing agent than CO for ZnO.

27. In some particular case, the thermodynamic factor dictates the choice of the reducing agent. To what extent do you believe this statement to be true? Provide two examples to back your opinion.

Solution:



From the above Ellingham diagram, we observe that metals for which the standard free energy of formation of their oxides is more negative can reduce the metal oxides for which the standard free energy of formation of their respective oxides is less negative.

Example 1: $\Delta_f G^\theta(Al, Al_2O_3)$ is more negative than $\Delta_f G^\theta(Cu, Cu_2O)$, thus Al can readily reduce Cu_2O to Cu but it is not possible for Cu to reduce Al_2O_3.

Example 2: $\Delta_f G^\theta(Mg, MgO)$ is more negative than $\Delta_f G^\theta(Zn, ZnO)$, thus it is not possible for Zn to reduce MgO but Mg can reduce ZnO to Zn.

28. What are the processes that give chlorine as a by-product? What happens when an aqueous of NaCl is electrolyzed?

Solution:

Chlorine is obtained as a byproduct during the electrolysis of NaCl in Down's process. In this process a fused mixture of $CaCl_2$ and NaCl is electrolyzed at a temperature of 873 K. Sodium is liberated at the cathode and Cl_2 is liberated at the anode.

$$NaCl(l) \xrightarrow{\text{electrolysis}} Na^+ + Cl^-$$

Cathode: $Na^+(\text{melt}) + e^- \rightarrow Na(\text{solid})$

Anode: $Cl^-(\text{melt}) \rightarrow Cl(g) + e^-$

$2Cl(g) \rightarrow Cl_2(g)$

When an aqueous solution of NaCl is subjected to electrolysis, Cl_2 is discharged at the anode and at the cathode, H_2 is obtained (in place of Na). This is due to the fact that the standard reduction potential of H_2O ($E^o = -0.83$ V) is less negative than that of Na ($E^o = -2.71$ V). Thus, H_2O will get reduced at the cathode thereby discharging H_2.

$$NaCl(aq) \xrightarrow{\text{electrolysis}} Na^+(aq) + Cl^-(aq)$$

Cathode: $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^{-1}(aq)$

Anode: $2Cl(g) \rightarrow Cl_2(g)$

29. What role does a graphite rod play in the electrometallurgy of aluminium?

Solution:

In the electrometallurgy of aluminium, Graphite rod acts as anode and graphite lined iron acts as the cathode. The O_2 liberated due to electrolysis reacts with the graphite at the anode to liberate CO_2 and CO. The oxygen liberated would have reacted with the aluminium during the electrolysis to form Al_2O_3 if any other metal besides graphite was used. This would have resulted in the wastage of aluminium and as graphite is cheaper than aluminium it is more expendable.

30. What are the principles of refining a metal by the following processes:

(a) Zone refining

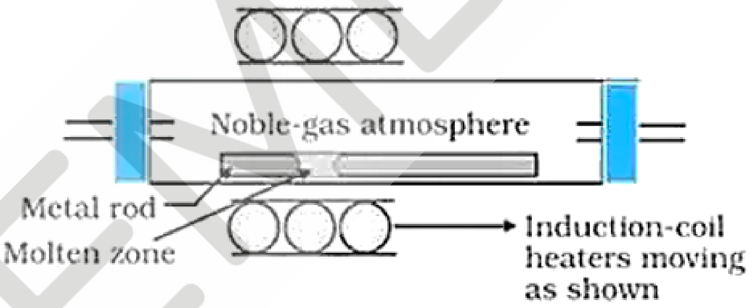
(b) Electrolytic refining

(c) Vapour phase refining

Solution:

(a) Zone refining:

This method is based on the principle that the impurities are more soluble in the melt than in the solid state of the metal.



Zone refining process

(b) Electrolytic refining:

Electrolytic refining works on the principle of refining impure metals by the use of electricity. In this process, the impure metal is placed as the anode and a strip of pure metal is made as the cathode. Soluble salt of the same metal in a solution 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 as the anode mud.

(c) Vapour phase refining:

In this method, the metal is converted into its volatile compound which is collected and decomposed to give pure metal. Thus, two requirements of this process are:

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

(ii) the volatile compound should be easily decomposable so that the recovery of the metal is easy.

31. Under what conditions could Al reduce MgO?

Solution:

Above 1350^oC, Al can reduce MgO. This is because, at temperatures above 1350^oC, the standard Gibbs free energy formation of Al_2O_3 from Al is less than that of MgO from Mg.

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