

# 6

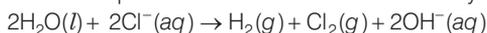
## General Principle and Processes of Isolation of Elements

### Multiple Choice Questions (MCQs)

**Q. 1** In the extraction of chlorine by electrolysis of brine .....

- (a) oxidation of  $\text{Cl}^-$  ion to chlorine gas occurs
- (b) reduction of  $\text{Cl}^-$  ion to chlorine gas occurs
- (c) for overall reaction  $\Delta G^\circ$  has negative value
- (d) a displacement reaction takes place

**Ans. (a)** Following reaction takes place in the extraction of chlorine by electrolysis



From the above reaction it is very clear that the oxidation of  $\text{Cl}^-$  ion to chlorine gas occurs. Thus, option (a) is the correct answer.

$\Delta^\circ G$  for this reaction is +422kJ. Therefore, thermodynamically reaction is not feasible. We know that

$$\Delta^\circ G = -nFE^\circ$$

By using this equation value of  $E^\circ$  can be calculated. Thus,

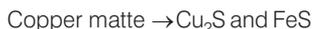
$$E^\circ = -\frac{\Delta G^\circ}{nF} = -2.2V$$

Therefore, for the occurrence of this reaction, external potential (emf) greater than 2.2V is required. Due to this fact (c) is not the correct option.

**Q. 2** When copper ore is mixed with silica, in a reverberatory furnace copper matte is produced. The copper matte contains

- (a) sulphides of copper (II) and iron (II)
- (b) sulphides of copper (II) and iron (III)
- (c) sulphides of copper (I) and iron (II)
- (d) sulphides of copper (I) and iron (III)

**Ans. (c)** When copper ore is mixed with silica in a reverberatory furnace copper matte is produced. The copper matte contains sulphide of copper (I) and iron (II).



**Q.3** Which of the following reactions is an example of autoreduction?

- (a)  $\text{Fe}_3\text{O}_4 + 4\text{CO} \longrightarrow 3\text{Fe} + 4\text{CO}_2$
- (b)  $\text{Cu}_2\text{O} + \text{C} \longrightarrow 2\text{Cu} + \text{CO}$
- (c)  $\text{Cu}^{2+}(\text{aq}) + \text{Fe}(\text{s}) \longrightarrow \text{Cu}(\text{s}) + \text{Fe}^{2+}(\text{aq})$
- (d)  $\text{Cu}_2\text{O} + \frac{1}{2}\text{Cu}_2\text{S} \longrightarrow 3\text{Cu} + \frac{1}{2}\text{SO}_2$

**Ans. (d)**  $\text{Cu}_2\text{O} + \frac{1}{2}\text{Cu}_2\text{S} \longrightarrow 3\text{Cu} + \frac{1}{2}\text{SO}_2$

This reaction includes reduction of copper (I) oxide by copper (I) sulphide. In this process, copper is reduced by itself hence this process is known as autoreduction and the solidified copper, so, obtained is known as blister copper.

**Q. 4** A number of elements are available in earth's crust but most abundant elements are .....

- (a) Al and Fe
- (b) Al and Cu
- (c) Fe and Cu
- (d) Cu and Ag

**Ans. (a)** Among a number of elements which are available in earth crust, the most abundant elements are aluminium and iron. Aluminium is third most abundant element in earth crust. *i.e.*, 8.3% by weight while iron present in earth crust with 4.2% by weight. Copper and silver are also found in earth crust but their abundance percentage is low.

**Q. 5** Zone refining is based on the principle that .....

- (a) impurities of low boiling metals can be separated by distillation.
- (b) impurities are more soluble in molten metal than in solid metal.
- (c) different components of a mixture are differently adsorbed on an adsorbent.
- (d) vapours of volatile compound can be decomposed in pure metal.

**Ans. (b)** Zone refining is based on the principle that the impurities are more soluble in molten state than in solid state of the metal. A circular mobile heater fixed at one end of impure metal rod. The molten zone moves along with heater which is moved forward.

As the heater moves forward, the pure metal crystallises out of the melt and the impurities pass on into adjacent molten zone. The process is repeated several times and the heater is moved in the same direction.

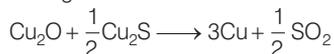
At one end, impurities get concentrated. This end is cut off. *e.g.*, germanium, silicon, gallium etc., are refined by this method.

**Q. 6** In the extraction of copper from its sulphide ore, the metal is formed by the reduction of  $\text{Cu}_2\text{O}$  with

- (a) FeS (b) CO  
(c)  $\text{Cu}_2\text{S}$  (d)  $\text{SO}_2$

**Ans.(c)** In the extraction of copper from its sulphide ore, the metal is formed by the reduction of  $\text{Cu}_2\text{O}$  with  $\text{Cu}_2\text{S}$ . This reaction completes with the process of autoreduction.

Chemical reaction occurring in this reaction is as follows

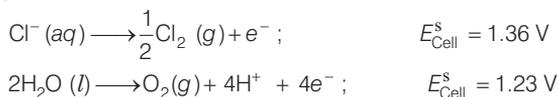


In this process, copper appears as blister copper.

**Q. 7** Brine is electrolysed by using inert electrodes. The reaction at anode is .....

- (a)  $\text{Cl}^- (\text{aq}) \rightarrow \frac{1}{2}\text{Cl}_2 (\text{g}) + \text{e}^-$ ;  $E_{\text{Cell}}^{\text{s}} = 1.36 \text{ V}$   
 (b)  $2\text{H}_2\text{O} (\text{l}) \rightarrow \text{O}_2 (\text{g}) + 4\text{H}^+ + 4\text{e}^-$ ;  $E_{\text{Cell}}^{\text{s}} = 1.23 \text{ V}$   
 (c)  $\text{Na}^+ (\text{aq}) + \text{e}^- \rightarrow \text{Na} (\text{s})$ ;  $E_{\text{Cell}}^{\text{s}} = 2.71 \text{ V}$   
 (d)  $\text{H}^+ (\text{aq}) + \text{e}^- \rightarrow \frac{1}{2}\text{H}_2 (\text{g})$ ;  $E_{\text{Cell}}^{\text{s}} = 0.00 \text{ V}$

**Ans. (a)** Brine is electrolysed by using inert electrodes. The possible reactions occurring at anode are



The reaction at anode with lower value of  $E^\circ$  is preferred and therefore water should get oxidised in preference to  $\text{Cl}^- (\text{aq})$ . However,  $\text{Cl}_2$  is produced instead of  $\text{O}_2$ . This unexpected result is explained on the basis of the fact that water needs greater voltage for oxidation to  $\text{O}_2$  (as it is kinetically slow process) than that needed for oxidation of  $\text{Cl}^-$  ions to  $\text{Cl}_2$ .

**Q. 8** In the metallurgy of aluminium .....

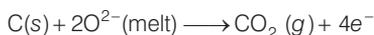
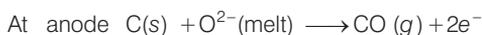
- (a)  $\text{Al}^{3+}$  is oxidised to Al (s).  
 (b) graphite anode is oxidised to carbon monoxide and carbon dioxide.  
 (c) oxidation state of oxygen changes in the reaction at anode.  
 (d) oxidation state of oxygen changes in the overall reaction involved in the process.

**Ans. (b)** In the metallurgy of aluminium, electrolysis is performed in a steel vessel with lining of carbon acts as cathode and graphite acts as anode. During this process graphite anode is oxidised to CO and  $\text{CO}_2$ .

Chemical reaction occurring in this process is as follows



This process is known as Hall - Heroult process. The electrolytic reactions are



**Q. 9** Electrolytic refining is used to purify which of the following metals?

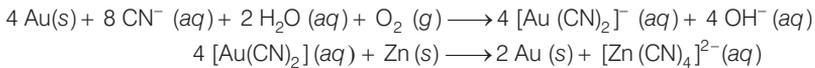
- (a) Cu and Zn      (b) Ge and Si      (c) Zr and Ti      (d) Zn and Hg

**Ans. (a)** Copper and zinc are two metals which are generally purified by using electrolyte refining. In this process, impure metal is used as anode and pure metal is used as a cathode. Impurities from the blister copper or impure zinc deposit as anode mud.

**Q. 10** Extraction of gold and silver involves leaching the metal with  $\text{CN}^-$  ion. The metal is recovered by .....

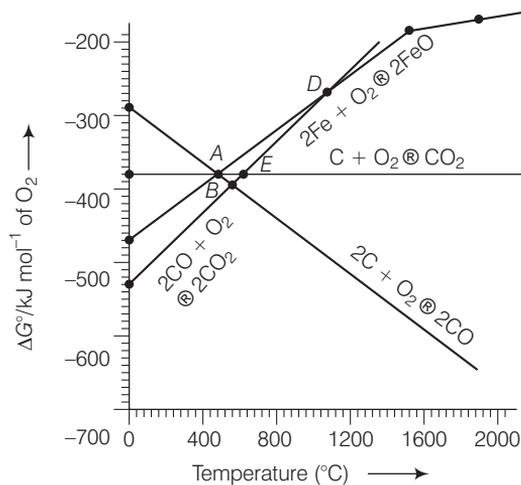
- (a) displacement of metal by some other metal from the complex ion.  
 (b) roasting of metal complex.  
 (c) calcination followed by roasting.  
 (d) thermal decomposition of metal complex.

**Ans. (a)** Extraction of gold and silver involves leaching the metal with  $\text{CN}^-$  ion. The metal is recovered by displacement of metal by some other metal from the complex ion. This is an oxidation reaction.



Here, Zn acts as a reducing agent.

**Direction** (Q. Nos. 11-13) Answer the questions on the basis of figure



**Q. 11** Choose the correct option of temperature at which carbon reduces  $\text{FeO}$  to iron and produces  $\text{CO}$ .

- (a) Below temperature at point A  
 (b) Approximately at the temperature corresponding to point A  
 (c) Above temperature at point A but below temperature at point D  
 (d) Above temperature at point A

**Thinking Process**

This problem is based on concept of Ellingham diagram which relates Gibbs free energy of reaction and temperature. The point above which greater the negative value of formation of compound is observed, compound will form at that temperature. At a particular temperature compound having higher negative value of Gibbs free energy will be formed first.

**Ans. (d)** In the figure shown above point A

$$\Delta_f G^\circ_{(C,CO)} < \Delta_f G^\circ_{(Fe, FeO)}$$

Therefore, above point A, C reduces FeO to Fe forming carbon monoxide. Hence, reduction of FeO by carbon occurs above point A only.

**Q. 12** Below point 'A' FeO can .....

- (a) be reduced by carbon monoxide only.
- (b) be reduced by both carbon monoxide and carbon.
- (c) be reduced by carbon only.
- (d) not be reduced by both carbon and carbon monoxide.

**Ans. (a)** Below point A Gibbs free energy change for the formation of CO<sub>2</sub> from CO ( $\Delta G^\circ_{CO,CO_2}$ ) has lower value (more negative value) than Gibbs free energy change for the formation of FeO ( $\Delta G^\circ_{Fe,FeO}$ ). Hence, FeO will be reduced by CO only below point A.

**Q. 13** For the reduction of FeO at the temperature corresponding to point D, which of the following statements is correct?

- (a)  $\Delta G$  value for the overall reduction reaction with carbon monoxide is zero.
- (b)  $\Delta G$  value for the overall reduction reaction with a mixture of 1 mol carbon and 1 mol oxygen is positive.
- (c)  $\Delta G$  value for the overall reduction reaction with a mixture of 2 mol carbon and 1 mol oxygen will be positive.
- (d)  $\Delta G$  value for the overall reduction reaction with carbon monoxide is negative.

**Ans. (a)** At point D,  $\Delta G$  curve for formation of CO<sub>2</sub> from CO and FeO from Fe intersect each other therefore, overall reduction of FeO with CO is zero.  
Hence, (a) is the correct choice.

## Multiple Choice Questions (More Than One Options)

**Q. 14** At the temperature corresponding to which of the points in Fig. FeO will be reduced to Fe by coupling the reaction  $2FeO \longrightarrow 2Fe + O_2$  with all of the following reactions?

1.  $C + O \longrightarrow CO_2$
2.  $2C + O_2 \longrightarrow 2CO$
3.  $2CO + O_2 \longrightarrow 2CO_2$

- (a) Point A                      (b) Point B                      (c) Point D                      (d) Point E

**Ans. (b, d)**

Below point B and E, FeO will be reduced to Fe by all the three reactions shown above in the question.  $\Delta G^\circ_{(C, CO_2)}$ ,  $\Delta G^\circ_{(C, CO)}$ ,  $\Delta G^\circ_{(CO, CO_2)}$  lie below  $\Delta_f G^\circ_{(Fe, FeO)}$  curve at point B and E. Therefore, FeO will be reduced by all three reactions.

Hence, options (b) and (d) are correct choice.

**Q. 15** Which of the following options are correct?

- (a) Cast iron is obtained by remelting pig iron with scrap iron and coke using hot air blast.
- (b) In extraction of silver, silver is extracted as cationic complex.
- (c) Nickel is purified by zone refining.
- (d) Zr and Ti are purified by van Arkel method.

**💡 Thinking Process**

*This process is based on concept of purification techniques and formation of cast iron.*

**Ans. (a, d)**

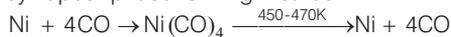
*Correct statements are*

- (a) Cast iron is obtained by remelting pig iron with scarp iron and coke using hot air blast.
- (d) Zr and Ti are purified by van Arkel method as



(b) and (c) can be correctly stated as

- (b) In extraction of silver, silver is extracted as anionic complex  $[\text{Ag}(\text{CN})_2]^-$
- (c) Nickel is purified by vapour phase refining method.



**Q. 16** In the extraction of aluminium by Hall-Heroult process, purified  $\text{Al}_2\text{O}_3$  is mixed with  $\text{CaF}_2$  to

- (a) lower the melting point of  $\text{Al}_2\text{O}_3$
- (b) increase the conductivity of molten mixture.
- (c) reduce  $\text{Al}^{3+}$  into  $\text{Al}(s)$
- (d) acts as catalyst

**💡 Thinking Process**

*This problem is based on extraction of aluminium using Hall-Heroult process.*

**Ans. (a, b)**

In the metallurgy of aluminium  $\text{Al}_2\text{O}_3$  is mixed with  $\text{Na}_3\text{AlF}_6$  and  $\text{CaF}_2$  which causes following affects.

- (i) Lower the melting point of  $\text{Al}_2\text{O}_3$
- (ii) Increase the conductivity of molten mixture

**Q. 17** Which of the following statements is correct about the role of substances added in the froth floatation process?

- (a) Collectors enhance the non-wettability of the mineral particles.
- (b) Collectors enhance the wettability of gangue particles.
- (c) By using depressants in the process two sulphide ores can be separated.
- (d) Froth stabilisers decrease wettability of gangue.

**💡 Thinking Process**

*This problem is based on the method involved in froth floatation method and function of collector and depressants.*

**Ans. (a, c)**

Froth floatation process is used to extract metal from sulphide ore. *This method utilises collectors and depressants whose functions are as follows*

- (i) Collectors enhance the non-wettability of the mineral particles.
- (ii) By using depressants in the process two sulphide ores can be separated. e.g., sodium cyanide is used as a depressant to separate lead sulphide ore from zinc sulphide ore.

**Q. 18** In the froth floatation process, zinc sulphide and lead sulphide can be separated by .....

- (a) using collectors (b) adjusting the proportion of oil to water  
(c) using depressant stabilisers (d) using froth stabilisers

**Ans. (b, c)**

Froth floatation method is used to extract metal from sulphide ore. ZnS and PbS can be separated by using depressant and adjusting the proportion of oil to water. Depressant used for this purpose is NaCN. It selectively prevents ZnS from coming to the froth. Hence, (b) and (c) are correct choices.

**Q. 19** Common impurities present in bauxite are .....

- (a) CuO (b) ZnO (c) Fe<sub>2</sub>O<sub>3</sub> (d) SiO<sub>2</sub>

**Ans. (c, d)**

Bauxite is an ore of aluminium which contain Fe<sub>2</sub>O<sub>3</sub> and SiO<sub>2</sub> as common impurities.

**Q. 20** Which of the following ores are concentrated by froth floatation?

- (a) Haematite (b) Galena (c) Copper pyrites (d) Magnetite

**Ans. (b, c)**

Haematite (Fe<sub>2</sub>O<sub>3</sub>) and magnetite (Fe<sub>3</sub>O<sub>4</sub>) are oxide ores while galena (PbS) and copper pyrites (CuFeS<sub>2</sub>) are sulphide ores. As we know sulphide ores are extracted by using froth floatation method. Hence, (b) and (c) are the correct choices.

**Q. 21** Which of the following reactions occur during calcination?

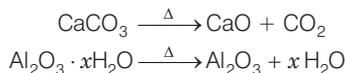
- (a)  $\text{CaCO}_3 \longrightarrow \text{CaO} + \text{CO}_2$   
(b)  $2\text{FeS}_2 + \frac{11}{2}\text{O}_2 \longrightarrow \text{Fe}_2\text{O}_3 + 4\text{SO}_2$   
(c)  $\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O} \longrightarrow \text{Al}_2\text{O}_3 + x\text{H}_2\text{O}$   
(d)  $\text{ZnS} + \frac{3}{2}\text{O}_2 \longrightarrow \text{ZnO} + \text{SO}_2$

**Thinking Process**

*This process is based on concept of calcination.*

**Ans. (a, c)**

Calcination involves heating of the ore below its melting point in the absence of air or in limited supply of air. Oxygen containing ores like oxide, hydroxides and carbonates are calcined. Thus, the following reactions occur during calcination.



**Q. 22** For the metallurgical process of which of the ores calcined ore can be reduced by carbon?

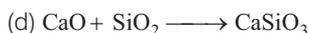
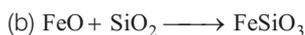
- (a) Haematite (b) Calamine (c) Iron pyrites (d) Sphalerite

**Ans. (a, b)**

In the metallurgical process, the oxide ores are reduced by carbon. Sulphide ore cannot be reduced by carbon. Here, haematite (Fe<sub>2</sub>O<sub>3</sub>) and calamine (ZnO) are oxide ores of iron and zinc respectively while iron pyrites (FeS<sub>2</sub>) and sphalerite (ZnS) are sulphide ores of iron and zinc respectively.

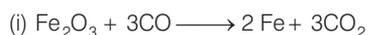
Therefore, haematite and calamine can be reduced by carbon.

**Q.23** The main reactions occurring in blast furnace during extraction of iron from haematite ore .....

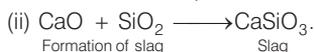


**Ans. (a, d)**

In extraction of iron from haematite ore following reactions take place.



This reaction represents reduction of  $\text{Fe}_2\text{O}_3$  to Fe.



Formation of slag

Slag

**Q. 24** In which of the following method of purification, metal is converted to its volatile compound which is decomposed to give pure metal?

(a) Heating with stream of carbon monoxide

(b) Heating with iodine

(c) Liquation

(d) Distillation

**💡 Thinking Process**

*This problem is based on purification of metal using vapour phase refining method.*

**Ans. (a, b)**

Vapour phase refining method includes

(i) Heating of metal with stream of CO



(ii) Heating with iodine



**Q. 25** Which of the following statements are correct?

(a) A depressant prevents certain type of particle to come to the froth.

(b) Copper matte contains  $\text{Cu}_2\text{S}$  and  $\text{ZnS}$ .

(c) The solidified copper obtained from reverberatory furnace has blistered appearance due to evolution of  $\text{SO}_2$  during the extraction.

(d) Zinc can be extracted by self-reduction.

**Ans. (a, c)**

*Correct statements are*

(i) A depressant prevents certain type of particle to come to the froth. e.g.,  $\text{NaCN}$  is added as a depressant during separation of  $\text{PbS}$  and  $\text{ZnS}$ .

(ii) The solidified copper obtained from reverberatory furnace has blistered appearance due to evolution of  $\text{SO}_2$  during the extraction.

(b) and (d) are incorrect statements, and can be correctly stated as

(iii) Copper matte contains  $\text{Cu}_2\text{S}$  and  $\text{FeS}$ .

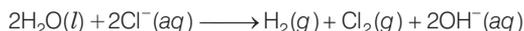
(iv) Zinc can be extracted by reduction of  $\text{ZnO}$  with carbon.

**Q. 26** In the extraction of chlorine from brine .....

- (a)  $\Delta G^s$  for the overall reaction is negative.
- (b)  $\Delta G^s$  for the overall reaction is positive.
- (c)  $E^s$  for the overall reaction has negative value.
- (d)  $E^s$  for the overall reaction has positive value.

**Ans. (b, c)**

Electrolysis of brine solution is used to extract chlorine. Overall chemical reaction occurring in this process and value of  $\Delta G^\circ$  can be shown as



For the given reaction, value of  $\Delta G^\circ$  is 422 kJ

Using  $\Delta G^\circ = -nFE^\circ$ , the value of  $E^\circ = E^\circ - 2.2\text{V}$ .

Therefore,  $\Delta G^\circ$  for the overall reaction is positive and  $E^\circ$  has negative value.

## Short Answer Type Questions

**Q. 27** Why is an external emf of more than 2.2V required for the extraction of  $\text{Cl}_2$  from brine?

**Ans.**  $2\text{Cl}^-(aq) + 2\text{H}_2\text{O}(l) \longrightarrow 2\text{OH}^-(aq) + \text{H}_2(g) + \text{Cl}_2(g)$

For the given reaction, value of  $\Delta G^\circ$  is + 422 kJ.

Using  $\Delta G^\circ = -nFE^\circ$ , the value of  $E^\circ = -2.2\text{V}$ .

Therefore, an external emf greater than 2.2 V is required for the extraction of  $\text{Cl}_2$  from brine.

**Q. 28** At temperature above 1073 K, coke can be used to reduce FeO to Fe. How can you justify this reduction with Ellingham diagram?

**Ans.** Using Ellingham diagram, we observe that at temperature greater than 1073 K;  $\Delta G_{(\text{C}, \text{CO})} < \Delta G_{(\text{Fe}, \text{FeO})}$ . We know that according to Ellingham diagram, compound having lower  $\Delta_r G^s$  undergo its formation.

Hence, coke can reduce FeO to Fe.

**Q. 29** Wrought iron is the purest form of iron. Write a reaction used for the preparation of wrought iron from cast iron. How can the impurities of sulphur, silicon and phosphorus be removed from cast iron?

**Ans. (a)** 
$$\underset{\substack{\text{Haematite} \\ \text{lining}}}{\text{Fe}_2\text{O}_3} + \underset{\substack{\text{Impurities} \\ \text{(present in cast iron)}}}{3\text{C}} \longrightarrow \underset{\substack{\text{Wrought} \\ \text{iron}}}{2\text{Fe}} + 3\text{CO}$$

This reaction takes place in reverberatory furnace lined with haematite.

(b) The haematite oxidises S to  $\text{SO}_2$ , Si to  $\text{SiO}_2$  and P to  $\text{P}_4\text{O}_{10}$ . Sometimes limestone is added as flux. Impurities of S, Si and P oxidise and pass into slag. The metal is removed and freed from slag by passing through rollers.

**Q. 30** How is copper extracted from low grade copper ores?

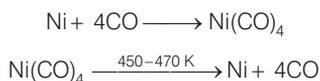
**Ans.** Copper is extracted from low grade copper ore using hydrometallurgy method. For this purpose, ore is leached out using bacteria. The solution containing  $\text{Cu}^{2+}$  is treated with scrap iron and  $\text{H}_2$ .



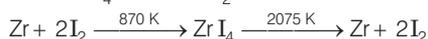
**Q. 31** Write two basic requirements for refining of a metal by Mond's process and by van Arkel Method.

**Ans.** Two basic requirements are

- (i) Metal should form volatile compound with available reagent.
- (ii) The volatile compound should be easily decomposable so that it can be recovered easily.
  - (a) **Mond's process** includes conversion of Ni to  $\text{Ni}(\text{CO})_4$  and then decomposition of  $\text{Ni}(\text{CO})_4$  to Ni.



- (b) **van Arkel method** includes conversion of Zr to volatile  $\text{ZrI}_4$  and then decomposition of  $\text{ZrI}_4$  to Zr and  $\text{I}_2$ .



**Q. 32** Although carbon and hydrogen are better reducing agents but they are not used to reduce metallic oxides at high temperatures. Why?

**Ans.** Because at high temperatures, carbon and hydrogen react with metals to form carbides and hydrides respectively. So, carbon and hydrogen are not better reducing agents to reduce metallic oxide.

**Q. 33** How do we separate two sulphide ores by froth floatation method? Explain with an example.

**Ans.** Two sulphide ores can be separated by adjusting the proportion of oil and water or by using depressants, e.g., if an ore contains ZnS and PbS both, a depressant NaCN is added during froth floatation. It forms a complex with ZnS and prevents it from coming into froth. PbS comes into the froth and thus separated.

**Q. 34** The purest form of iron is prepared by oxidising impurities from cast iron in a reverberatory furnace. Which iron ore is used to line the furnace? Explain by giving reaction.

**Ans.** (a) Haematite ( $\text{Fe}_2\text{O}_3$ ) ore is used to line the furnace.

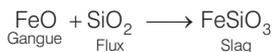


**Q. 35** The mixture of compounds A and B is passed through a column of  $\text{Al}_2\text{O}_3$  by using alcohol as eluant. Compound A is eluted in preference to compound B. Which of the compounds A or B, is more readily adsorbed on the column?

**Ans.** Compounds which are adsorbed to the more extent comes out later while the another one which absorbed to the less extent comes out readily. Since, compound 'A' comes out before compound 'B', the compound 'B' is more readily adsorbed on the column.

**Q. 36** Why is sulphide ore of copper heated in a furnace after mixing with silica?

**Ans.** Silica (flux) being an acidic flux removes the impurities of iron oxide the basic impurity, by reacting with it. Thus, iron silicate (slag) is formed.



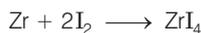
**Q. 37** Why are sulphide ores converted to oxide before reduction?

**Ans.** This is because oxides are reduced to metals easily while sulphides are not. So, sulphide ores are converted to oxide before reduction.

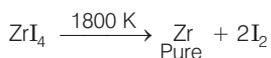
**Q. 38** Which method is used for refining Zr and Ti? Explain with equation.

**Ans.** Zr and Ti are refined by van Arkel method. It involves 2 steps

(a) **Formation of iodide** e.g., zirconium



(b) **Decomposition of iodide**



**Q. 39** What should be the considerations during the extraction of metals by electrochemical method?

**Ans.** During extraction of metals by electrochemical method the following two points must be considered

- (i) **Reactivity of metals** If the metals are quite reactive and are expected to react with water then the metals should be extracted by the electrolysis of their purified molten ore rather than their aqueous solution.
- (ii) **Suitability of electrodes** The electrodes selected should not react with the product of electrolysis. If at all they react, then the electrodes must be made up of a material which is quite cheap since their periodic replacement should not increase the cost of the process.

**Q. 40** What is the role of flux in metallurgical processes?

**Ans.** *Role of flux in metallurgical process*

- (i) Flux is used to remove the gangue by combining with it. Thus, slag formation takes place.
- (ii) It makes the molten mass more conducting.

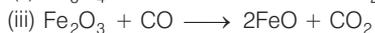
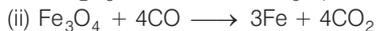
**Q. 41** How are metals used as semiconductors refined? What is the principle of the method used like germanium, silicon etc?

**Ans.** Metals of high grade like germanium, silicon etc., used as semiconductors are refined by zone refining method.

**Principle** This method is based upon the principle that impurities are more soluble in molten state of metal than in solid state.

**Q. 42** Write down the reactions taking place in blast furnace related to the metallurgy of iron in the temperature range 500-800 K.

**Ans.** Chemical reactions occurring in blast furnace related to the metallurgy of iron in the temperature range 500-800 K are

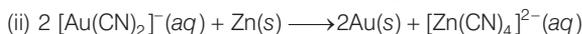
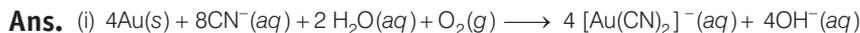


**Q. 43** Give two requirements for vapour phase refining.

**Ans.** Two requirements for vapour phase refining are

- (i) The metal should form a volatile compound with an available reagent.
- (ii) The volatile compound should be easily recovered by decomposition.

**Q. 44** Write the chemical reactions involved in the extraction of gold by cyanide process. Also give the role of zinc in the extraction.



Zinc acts as a reducing agent in this reaction.

## Matching The Columns

**Q. 45** Match the items of Column I with items of Column II and assign the correct code.

Column I	Column II
A. Pendulum	1. Chrome steel
B. Malachite	2. Nickel steel
C. Calamine	3. $\text{Na}_3\text{AlF}_6$
D. Cryolite	4. $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$
	5. $\text{ZnCO}_3$

**Codes**

A B C D  
 (a) 1 2 3 4  
 (c) 2 3 4 5

A B C D  
 (b) 2 4 5 3  
 (d) 4 5 3 2

**Ans. (b)** A. → (2) B. → (4) C. → (5) D. → (3)

A. Pendulum is made up of nickel steel.

B. Molecular formula of malachite is  $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ .

C. Molecular formula of calamine is  $\text{ZnCO}_3$ .

D. Molecular formula of cryolite is  $\text{Na}_3\text{AlF}_6$ .

**Q. 46** Match the items of Column I with the items of Column II and assign the correct code.

Column I	Column II
A. Coloured bands	1. Zone refining
B. Impure metal to volatile complex	2. Fractional distillation
C. Purification of Ge and Si	3. Mond's process
D. Purification of mercury	4. Chromatography
	5. Liqutation

**Codes**

A B C D  
 (a) 1 2 4 5  
 (c) 3 4 2 1

A B C D  
 (b) 4 3 1 2  
 (d) 5 4 3 2

**Ans. (b)** A. → (4) B. → (3) C. → (1) D. → (2)

- A. Coloured bands are observed in chromatography.  
 B. Impure metal is converted to volatile complex by using Mond's process.  
 C. Purification of Ge and Si are purified by zone refining method.  
 D. Purification of mercury is done by fractional distillation.

**Q. 47** Match items of Column I with the items of Column II and assign the correct code.

Column I	Column II
A. Cyanide process	1. Ultrapure Ge
B. Froth floatation process	2. Dressing of ZnS
C. Electrolytic reduction	3. Extraction of Al
D. Zone refining	4. Extraction of Au
	5. Purification of Ni

**Codes**

A B C D  
 (a) 4 2 3 1  
 (c) 1 2 3 4

A B C D  
 (b) 2 3 1 5  
 (d) 3 4 5 1

**Ans. (a)** A. → (4) B. → (2) C. → (3) D. → (1)

- A. Cyanide process is used for extraction of Au through formation of anionic complex  $[\text{Au}(\text{CN})_2]^-$ .  
 B. Froth floatation process is used for dressing of ZnS.  
 C. Electrolytic reduction method is used for extraction of aluminium. Graphite electrode is used for this purpose.  
 D. Zone-refining is used for purification of Ge.

**Q. 48** Match the items of Column I with the items of Column II and assign the correct code.

Column I	Column II
A. Sapphire	1. $\text{Al}_2\text{O}_3$
B. Sphalerite	2. NaCN
C. Depressant	3. Co
D. Corundum	4. ZnS
	5. $\text{Fe}_2\text{O}_3$

**Codes**

A	B	C	D	A	B	C	D
(a) 3	4	2	1	(b) 5	4	3	2
(c) 2	3	4	5	(d) 1	2	3	4

**Ans. (a)** A. → (3) B. → (4) C. → (2) D. → (1)

- A. Sapphire is a gemstone which contain Co.  
 B. Molecular formula of sphalerite is ZnS.  
 C. NaCN is used as a depressant in froth floatation method.  
 D. Molecular formula of corundum is  $\text{Al}_2\text{O}_3$ .

**Q.49** Match the items of Column I with items of Column II and assign the correct code.

Column I	Column II
A. Blistered Cu	1. Aluminium
B. Blast furnace	2. $2\text{Cu}_2\text{O} + \text{Cu}_2\text{S} \longrightarrow 6\text{Cu} + \text{SO}_2$
C. Reverberatory furnace	3. Iron
D. Hall-Heroult process	4. $\text{FeO} + \text{SiO}_2 \longrightarrow \text{FeSiO}_3$
	5. $2\text{Cu}_2\text{S} + 3\text{O}_2 \longrightarrow 2\text{Cu}_2\text{O} + 2\text{SO}_2$

**Codes**

A	B	C	D	A	B	C	D
(a) 2	3	4	1	(b) 1	2	3	5
(c) 5	4	3	2	(d) 4	5	3	2

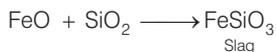
**Ans. (a)** A. → (2) B. → (3) C. → (4) D. → (1)

A. Blistered Cu can be prepared by means of following chemical reaction  

$$2\text{Cu}_2\text{O} + \text{Cu}_2\text{S} \longrightarrow 6\text{Cu} + \text{SO}_2$$

B. Iron is extracted by using blast furnace.

C. In reverberatory furnace formation of slag occurs as



D. Hall-Heroult process is used for extraction of aluminium.

## Assertion and Reason

*In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct answer out of the following choices.*

- (a) Both assertion and reason are true and reason is the correct explanation of assertion.
- (b) Both assertion and reason are true but reason is not the correct explanation of assertion.
- (c) Assertion is true but reason is false.
- (d) Assertion is false but reason is true.
- (e) Assertion and reason both are wrong.

**Q. 50** Assertion (A) Nickel can be purified by Mond's process.

Reason (R)  $\text{Ni}(\text{CO})_4$  is a volatile compound which decomposes at 460 K to give pure Ni.

**Ans. (a)** Both assertion and reason are true and reason is the correct explanation of assertion.

Nickel can be purified by Mond's process in which formation of a volatile compound  $\text{Ni}(\text{CO})_4$  takes place which further decomposes to Ni at 460K.

**Q. 51** Assertion (A) Zirconium can be purified by van Arkel method.

Reason (R)  $\text{ZrI}_4$  is volatile and decomposes at 1800K.

**Ans. (a)** Both assertion and reason are true and reason is the correct explanation of assertion.

Zirconium can be purified by van Arkel method which include formation of volatile  $\text{ZrI}_4$  which decomposes at 1800 K to Zr.

**Q. 52** Assertion (A) Sulphide ores are concentrated by froth floatation method.

Reason (R) Cresols stabilise the froth in froth floatation method.

**Ans. (b)** Both assertion and reason are true but reason is not the correct explanation of assertion.

Sulphide ores are concentrated by froth floatation method. Sulphide ore particles are preferentially wetted by oil, become lighter and rise to the surface along with the froth while gangue particles are preferentially wetted by water, become heavier and thus settle down at the bottom of the tank and cresols stabilise the froth in froth floatation method.

Formation of froth is main reason for extraction of metal. Metal ore comes out along with froth.

**Q. 53** Assertion (A) Zone refining method is very useful for producing semiconductors.

Reason (R) Semiconductors are of high purity.

**Ans. (b)** Both assertion and reason are true but reason is not the correct explanation of assertion.

Zone refining method is very useful for producing semiconductors of high purity as in this process pure metal crystallises while impurities pass on into adjacent molten zone when impure metal rod is heated.

**Q. 54** Assertion (A) Hydrometallurgy involves dissolving the ore in a suitable reagent followed by precipitation by a more electropositive metal.

Reason (R) Copper is extracted by hydrometallurgy.

**Ans. (b)** Assertion and reason both are correct but reason is not the correct explanation of assertion.

Hydrometallurgy involves dissolving the ore in suitable reagent followed by precipitation with the help of more electropositive metal in which pure metal is get replaced by more electropositive metal.

## Long Answer Type Questions

**Q. 55** Explain the following

- $\text{CO}_2$  is a better reducing agent below 710 K whereas CO is a better reducing agent above 710 K.
- Generally sulphide ores are converted into oxides before reduction.
- Silica is added to the sulphide ore of copper in the reverberatory furnace.
- Carbon and hydrogen are not used as reducing agents at high temperatures.
- Vapour phase refining method is used for the purification of Ti.

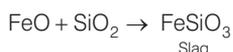
### 💡 Thinking Process

*This problem is based on concept of Ellingham diagrams and purification of metal.*

**Ans.** (a) As shown in Ellingham diagram which relates Gibbs free energy and temperature at below 710 K.

$\Delta G_{(\text{C},\text{CO}_2)} < \Delta G_{(\text{C},\text{CO})}$  So,  $\text{CO}_2$  is a better reducing agent than CO while above 710K it becomes a very good reducing agent.

- Generally, sulphide ores are converted to oxides before reduction as reduction of oxides can easily be done using C or CO depending upon metal ore and temperature.
- Silica is a flux added to the sulphide ore of copper in the reverberatory furnace leading to the formation of slag



- Carbon and hydrogen are not used as reducing agents at high temperature. At high temperature carbon and hydrogen readily form their carbides and hydrides respectively.
- Vapour phase refining method is used for the purification of Ti as

