

Unit

6

# GENERAL PRINCIPLES AND PROCESSES OF ISOLATION OF ELEMENTS

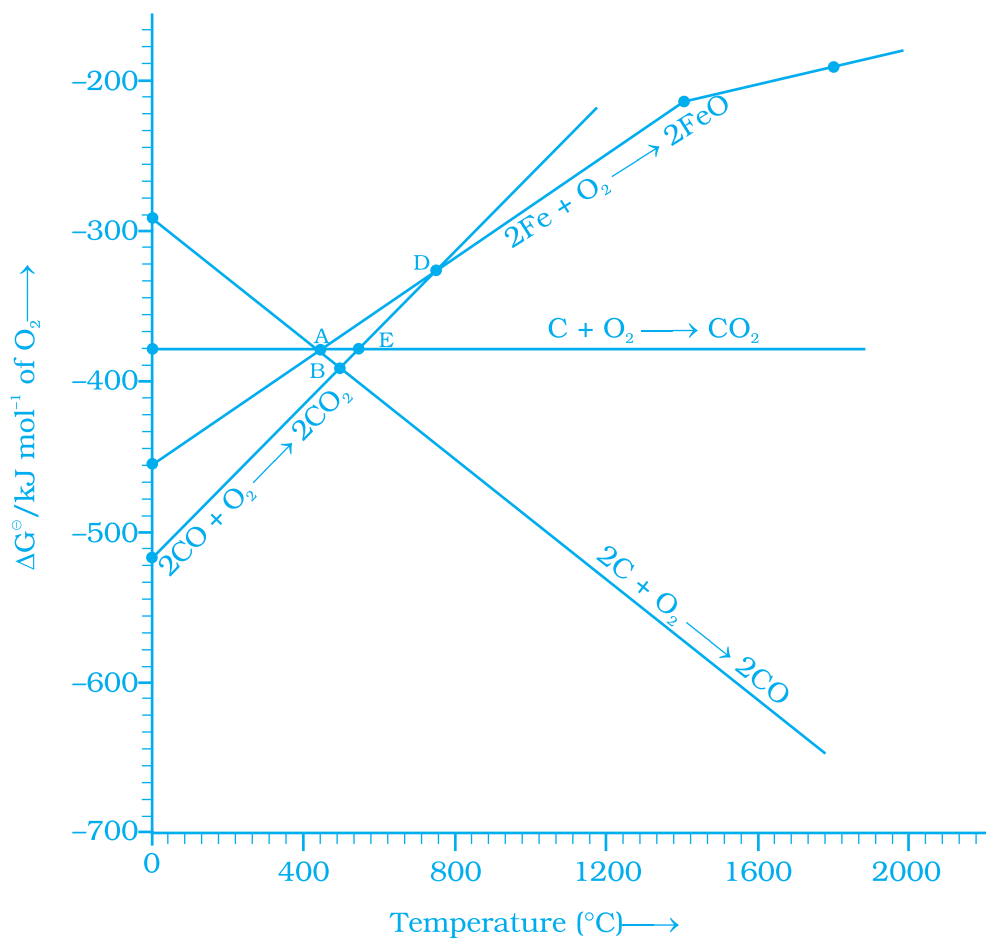
## I. Multiple Choice Questions (Type-I)

- In the extraction of chlorine by electrolysis of brine \_\_\_\_\_.
  - oxidation of  $\text{Cl}^-$  ion to chlorine gas occurs.
  - reduction of  $\text{Cl}^-$  ion to chlorine gas occurs.
  - For overall reaction  $\Delta G^\ominus$  has negative value.
  - a displacement reaction takes place.
- When copper ore is mixed with silica, in a reverberatory furnace copper matte is produced. The copper matte contains \_\_\_\_\_.
  - sulphides of copper (II) and iron (II)
  - sulphides of copper (II) and iron (III)
  - sulphides of copper (I) and iron (II)
  - sulphides of copper (I) and iron (III)
- Which of the following reactions is an example of autoreduction?
  - $\text{Fe}_3\text{O}_4 + 4\text{CO} \longrightarrow 3\text{Fe} + 4\text{CO}_2$
  - $\text{Cu}_2\text{O} + \text{C} \longrightarrow 2\text{Cu} + \text{CO}$
  - $\text{Cu}^{2+}(\text{aq}) + \text{Fe}(\text{s}) \longrightarrow \text{Cu}(\text{s}) + \text{Fe}^{2+}(\text{aq})$
  - $\text{Cu}_2\text{O} + \frac{1}{2}\text{Cu}_2\text{S} \longrightarrow 3\text{Cu} + \frac{1}{2}\text{SO}_2$

4. A number of elements are available in earth's crust but most abundant elements are \_\_\_\_\_.
- Al and Fe
  - Al and Cu
  - Fe and Cu
  - Cu and Ag
5. Zone refining is based on the principle that \_\_\_\_\_.
- impurities of low boiling metals can be separated by distillation.
  - impurities are more soluble in molten metal than in solid metal.
  - different components of a mixture are differently adsorbed on an adsorbent.
  - vapours of volatile compound can be decomposed in pure metal.
6. In the extraction of copper from its sulphide ore, the metal is formed by the reduction of  $\text{Cu}_2\text{O}$  with
- FeS
  - CO
  - $\text{Cu}_2\text{S}$
  - $\text{SO}_2$
7. Brine is electrolysed by using inert electrodes. The reaction at anode is \_\_\_\_\_.
- $\text{Cl}^- (\text{aq.}) \longrightarrow \frac{1}{2} \text{Cl}_2 (\text{g}) + \text{e}^- ; E_{\text{Cell}}^\ominus = 1.36\text{V}$
  - $2\text{H}_2\text{O} (\text{l}) \longrightarrow \text{O}_2 (\text{g}) + 4\text{H}^+ + 4\text{e}^- ; E_{\text{Cell}}^\ominus = 1.23\text{V}$
  - $\text{Na}^+ (\text{aq.}) + \text{e}^- \longrightarrow \text{Na} (\text{s}) ; E_{\text{Cell}}^\ominus = 2.71\text{V}$
  - $\text{H}^+ (\text{aq.}) + \text{e}^- \longrightarrow \frac{1}{2} \text{H}_2 (\text{g}) ; E_{\text{Cell}}^\ominus = 0.00\text{V}$
8. In the metallurgy of aluminium \_\_\_\_\_.
- $\text{Al}^{3+}$  is oxidised to Al (s).
  - graphite anode is oxidised to carbon monoxide and carbon dioxide.
  - oxidation state of oxygen changes in the reaction at anode.
  - oxidation state of oxygen changes in the overall reaction involved in the process.
9. Electrolytic refining is used to purify which of the following metals?
- Cu and Zn
  - Ge and Si
  - Zr and Ti
  - Zn and Hg

10. 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.
  - roasting of metal complex.
  - calcination followed by roasting.
  - thermal decomposition of metal complex.

**Note :** Answer the questions 11-13 on the basis of Fig. 6.1.



**Fig. 6.1**

11. Choose the correct option of temperature at which carbon reduces  $\text{FeO}$  to iron and produces  $\text{CO}$ .
- Below temperature at point A.
  - Approximately at the temperature corresponding to point A.
  - Above temperature at point A but below temperature at point D.
  - Above temperature at point A.

12. Below point 'A' FeO can \_\_\_\_\_.
- (i) be reduced by carbon monoxide only.
  - (ii) be reduced by both carbon monoxide and carbon.
  - (iii) be reduced by carbon only.
  - (iv) not be reduced by both carbon and carbon monoxide.
13. For the reduction of FeO at the temperature corresponding to point D, which of the following statements is correct?
- (i)  $\Delta G$  value for the overall reduction reaction with carbon monoxide is zero.
  - (ii)  $\Delta G$  value for the overall reduction reaction with a mixture of 1 mol carbon and 1 mol oxygen is positive.
  - (iii)  $\Delta G$  value for the overall reduction reaction with a mixture of 2 mol carbon and 1 mol oxygen will be positive.
  - (iv)  $\Delta G$  value for the overall reduction reaction with carbon monoxide is negative.

## II. Multiple Choice Questions (Type-II)

**Note :** In the following questions two or more options may be correct.

14. At the temperature corresponding to which of the points in Fig.6.1, FeO will be reduced to Fe by coupling the reaction  $2\text{FeO} \longrightarrow 2\text{Fe} + \text{O}_2$  with all of the following reactions?
- (a)  $\text{C} + \text{O}_2 \longrightarrow \text{CO}_2$     (b)  $2\text{C} + \text{O}_2 \longrightarrow 2\text{CO}$     and    (c)  $2\text{CO} + \text{O}_2 \longrightarrow 2\text{CO}_2$
- (i) Point A
  - (ii) Point B
  - (iii) Point D
  - (iv) Point E
15. Which of the following options are correct?
- (i) Cast iron is obtained by remelting pig iron with scrap iron and coke using hot air blast.
  - (ii) In extraction of silver, silver is extracted as cationic complex.
  - (iii) Nickel is purified by zone refining.
  - (iv) Zr and Ti are purified by van Arkel method.
16. In the extraction of aluminium by Hall-Heroult process, purified  $\text{Al}_2\text{O}_3$  is mixed with  $\text{CaF}_2$  to
- (i) lower the melting point of  $\text{Al}_2\text{O}_3$ .
  - (ii) increase the conductivity of molten mixture.
  - (iii) reduce  $\text{Al}^{3+}$  into  $\text{Al}(\text{s})$ .
  - (iv) acts as catalyst.

- 17.** Which of the following statements is correct about the role of substances added in the froth floatation process?
- (i) Collectors enhance the non-wettability of the mineral particles.
  - (ii) Collectors enhance the wettability of gangue particles.
  - (iii) By using depressants in the process two sulphide ores can be separated.
  - (iv) Froth stabilisers decrease wettability of gangue.
- 18.** In the Froth Floatation process, zinc sulphide and lead sulphide can be separated by \_\_\_\_\_.
- (i) using collectors.
  - (ii) adjusting the proportion of oil to water.
  - (iii) using depressant.
  - (iv) using froth stabilisers.
- 19.** Common impurities present in bauxite are \_\_\_\_\_.
- (i) CuO
  - (ii) ZnO
  - (iii) Fe<sub>2</sub>O<sub>3</sub>
  - (iv) SiO<sub>2</sub>
- 20.** Which of the following ores are concentrated by froth floatation?
- (i) Haematite
  - (ii) Galena
  - (iii) Copper pyrites
  - (iv) Magnetite
- 21.** Which of the following reactions occur during calcination?
- (i)  $\text{CaCO}_3 \longrightarrow \text{CaO} + \text{CO}_2$
  - (ii)  $2\text{FeS}_2 + \frac{11}{2}\text{O}_2 \longrightarrow \text{Fe}_2\text{O}_3 + 4\text{SO}_2$
  - (iii)  $\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O} \longrightarrow \text{Al}_2\text{O}_3 + x\text{H}_2\text{O}$
  - (iv)  $\text{ZnS} + \frac{3}{2}\text{O}_2 \longrightarrow \text{ZnO} + \text{SO}_2$
- 22.** For the metallurgical process of which of the ores calcined ore can be reduced by carbon?
- (i) haematite
  - (ii) calamine
  - (iii) iron pyrites
  - (iv) sphalerite

- 23.** The main reactions occurring in blast furnace during extraction of iron from haematite are \_\_\_\_\_.
- (i)  $\text{Fe}_2\text{O}_3 + 3\text{CO} \longrightarrow 2\text{Fe} + 3\text{CO}_2$
  - (ii)  $\text{FeO} + \text{SiO}_2 \longrightarrow \text{FeSiO}_3$
  - (iii)  $\text{Fe}_2\text{O}_3 + 3\text{C} \longrightarrow 2\text{Fe} + 3\text{CO}$
  - (iv)  $\text{CaO} + \text{SiO}_2 \longrightarrow \text{CaSiO}_3$
- 24.** In which of the following method of purification, metal is converted to its volatile compound which is decomposed to give pure metal?
- (i) heating with stream of carbon monoxide.
  - (ii) heating with iodine.
  - (iii) liquation.
  - (iv) distillation.
- 25.** Which of the following statements are correct?
- (i) A depressant prevents certain type of particle to come to the froth.
  - (ii) Copper matte contains  $\text{Cu}_2\text{S}$  and  $\text{ZnS}$ .
  - (iii) The solidified copper obtained from reverberatory furnace has blistered appearance due to evolution of  $\text{SO}_2$  during the extraction.
  - (iv) Zinc can be extracted by self-reduction.
- 26.** In the extraction of chlorine from brine \_\_\_\_\_.
- (i)  $\Delta G^\ominus$  for the overall reaction is negative.
  - (ii)  $\Delta G^\ominus$  for the overall reaction is positive.
  - (iii)  $E^\ominus$  for overall reaction has negative value.
  - (iv)  $E^\ominus$  for overall reaction has positive value.

### III. Short Answer Type

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- 27.** Why is an external emf of more than 2.2V required for the extraction of  $\text{Cl}_2$  from brine?
- 28.** At temperatures above 1073K coke can be used to reduce  $\text{FeO}$  to  $\text{Fe}$ . How can you justify this reduction with Ellingham diagram?
- 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?
- 30.** How is copper extracted from low grade copper ores?
- 31.** Write two basic requirements for refining of a metal by Mond process and by Van Arkel Method.
- 32.** Although carbon and hydrogen are better reducing agents but they are not used to reduce metallic oxides at high temperatures. Why?

33. How do we separate two sulphide ores by Froth Flootation Method? Explain with an example.
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.
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?
36. Why is sulphide ore of copper heated in a furnace after mixing with silica?
37. Why are sulphide ores converted to oxide before reduction?
38. Which method is used for refining Zr and Ti? Explain with equation.
39. What should be the considerations during the extraction of metals by electrochemical method?
40. What is the role of flux in metallurgical processes?
41. How are metals used as semiconductors refined? What is the principle of the method used?
42. Write down the reactions taking place in Blast furnace related to the metallurgy of iron in the temperature range 500-800 K.
43. Give two requirements for vapour phase refining.
44. Write the chemical reactions involved in the extraction of gold by cyanide process. Also give the role of zinc in the extraction.

## IV. Matching Type

**Note :** Match the items given in Column I and Column II in the following questions.

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

**Column I**

- (A) Pendulum  
(B) Malachite  
(C) Calamine  
(D) Cryolite

**Column II**

- (1) Chrome steel  
(2) Nickel steel  
(3)  $\text{Na}_3\text{AlF}_6$   
(4)  $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$   
(5)  $\text{ZnCO}_3$

**Code :**

- (i) A (1)    B (2)    C (3)    D (4)  
(ii) A (2)    B (4)    C (5)    D (3)  
(iii) A (2)    B (3)    C (4)    D (5)  
(iv) A (4)    B (5)    C (3)    D (2)

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

**Column I**

- (A) Coloured bands  
(B) Impure metal to volatile complex  
(C) Purification of Ge and Si  
(D) Purification of mercury

**Column II**

- (1) Zone refining  
(2) Fractional distillation  
(3) Mond Process  
(4) Chromatography  
(5) Liqutation

**Code :**

- (i) A (1) B (2) C (4) D (5)  
(ii) A (4) B (3) C (1) D (2)  
(iii) A (3) B (4) C (2) D (1)  
(iv) A (5) B (4) C (3) D (2)

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

**Column I**

- (A) Cyanide process  
(B) Froth Floatation Process  
(C) Electrolytic reduction  
(D) Zone refining

**Column II**

- (1) Ultrapure Ge  
(2) Dressing of ZnS  
(3) Extraction of Al  
(4) Extraction of Au  
(5) Purification of Ni

**Code :**

- (i) A (4) B (2) C (3) D (1)  
(ii) A (2) B (3) C (1) D (5)  
(iii) A (1) B (2) C (3) D (4)  
(iv) A (3) B (4) C (5) D (1)

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

**Column I**

- (A) Sapphire  
(B) Sphalerite  
(C) Depressant  
(D) Corundum

**Column II**

- (1)  $\text{Al}_2\text{O}_3$   
(2) NaCN  
(3) Co  
(4) ZnS  
(5)  $\text{Fe}_2\text{O}_3$



**Code :**

- (i) A (3) B (4) C (2) D (1)  
 (ii) A (5) B (4) C (3) D (2)  
 (iii) A (2) B (3) C (4) D (5)  
 (iv) A (1) B (2) C (3) D (4)

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

**Column I**

- (A) Blistered Cu  
 (B) Blast furnace  
 (C) Reverberatory furnace  
 (D) Hall-Heroult process

**Column II**

- (1) Aluminium  
 (2)  $2\text{Cu}_2\text{O} + \text{Cu}_2\text{S} \longrightarrow 6\text{Cu} + \text{SO}_2$   
 (3) Iron  
 (4)  $\text{FeO} + \text{SiO}_2 \longrightarrow \text{FeSiO}_3$   
 (5)  $2\text{Cu}_2\text{S} + 3\text{O}_2 \longrightarrow 2\text{Cu}_2\text{O} + 2\text{SO}_2$

**Code :**

- (i) A (2) B (3) C (4) D (1)  
 (ii) A (1) B (2) C (3) D (5)  
 (iii) A (5) B (4) C (3) D (2)  
 (iv) A (4) B (5) C (3) D (2)

## V. Assertion and Reason Type

**Note :** In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

- (i) Both assertion and reason are true and reason is the correct explanation of assertion.  
 (ii) Both assertion and reason are true but reason is not the correct explanation of assertion.  
 (iii) Assertion is true but reason is false.  
 (iv) Assertion is false but reason is true.  
 (v) Assertion and reason both are wrong.
- 50. Assertion :** Nickel can be purified by Mond process.  
**Reason :**  $\text{Ni}(\text{CO})_4$  is a volatile compound which decomposes at 460K to give pure Ni.
- 51. Assertion :** Zirconium can be purified by Van Arkel method.  
**Reason :**  $\text{ZrI}_4$  is volatile and decomposes at 1800K.

- 52. Assertion** : Sulphide ores are concentrated by Froth Flotation method.  
**Reason** : Cresols stabilise the froth in Froth Flotation method.
- 53. Assertion** : Zone refining method is very useful for producing semiconductors.  
**Reason** : Semiconductors are of high purity.
- 54. Assertion** : Hydrometallurgy involves dissolving the ore in a suitable reagent followed by precipitation by a more electropositive metal.  
**Reason** : Copper is extracted by hydrometallurgy.

## VI. Long Answer Type

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- 55.** Explain the following :
- $\text{CO}_2$  is a better reducing agent below 710K whereas CO is a better reducing agent above 710K.
  - 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.

## ANSWERS

### I. Multiple Choice Questions (Type-I)

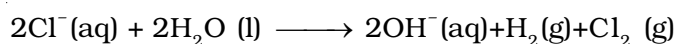
1. (iii)      2. (iii)      3. (iv)      4. (i)      5. (ii)      6. (iii)  
 7. (i)      8. (ii)      9. (i)      10. (i)      11. (iv)      12. (i)  
 13. (i)

### II. Multiple Choice Questions (Type-II)

14. (ii), (iv)      15. (i), (iv)      16. (i), (ii)      17. (i), (iii)  
 18. (ii), (iii)      19. (iii), (iv)      20. (ii), (iii)      21. (i), (iii)  
 22. (i), (ii)      23. (i), (iv)      24. (i), (ii)      25. (i), (iii)  
 26. (ii), (iii)

### III. Short Answer Type

27. For the reaction



Value of  $\Delta G^\ominus$  is + 422kJ. Using the equation  $\Delta G^\ominus = -nFE^\ominus$  the value of  $E^\ominus$  comes out to be -2.2V. Therefore extraction of  $\text{Cl}_2$  from brine will require an external emf of greater than 2.2V.

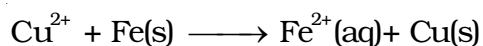
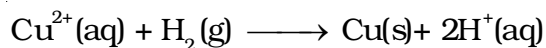
28. As per Ellingham diagram at temperatures greater than 1073 K

$\Delta G(\text{C}, \text{CO}) < \Delta G(\text{Fe}, \text{FeO})$ . Hence coke can reduce FeO to Fe.

29.  $\text{Fe}_2\text{O}_3 + 3\text{C} \longrightarrow 2\text{Fe} + 3\text{CO}$

Limestone is added as flux and sulphur, silicon and phosphorus change to their oxides and pass into the slag.

30. Copper is extracted by hydrometallurgy from low grade copper ores. It is leached out using acid or bacteria. The solution containing  $\text{Cu}^{2+}$  is treated with scrap iron, Zn or  $\text{H}_2$ .



31. Basic requirements for both processes are :

- (i) The metal should form a volatile compound with an available reagent.  
 (ii) The volatile compound should be easily decomposable, so that recovery of metal is easy.

32. It is because at high temperature carbon and hydrogen react with metals to form carbides and hydrides respectively.

33. Two sulphide ores can be separated by adjusting proportion of oil to water or by using depressants. For example, in the case of an ore containing ZnS and PbS, the depressant NaCN is used. It forms complex with ZnS and prevents it from coming with froth but PbS remains with froth.
34. Haematite  

$$\text{Fe}_2\text{O}_3 + 3\text{C} \longrightarrow 2\text{Fe} + 3\text{CO}$$
35. Since compound 'A' comes out before compound 'B', the compound 'B' is more readily adsorbed on column.
36. Iron oxide present as impurity in sulphide ore of copper forms slag which is iron silicate and copper is produced in the form of copper matte.  

$$\text{FeO} + \text{SiO}_2 \longrightarrow \text{FeSiO}_3$$
37. Sulphides are not reduced easily but oxides are easily reduced.
38. van Arkel method is used for refining Zr and Ti. In this method crude metal is heated with iodine.  

$$\text{Zr} + 2\text{I}_2 \longrightarrow \text{ZrI}_4$$

$$\text{ZrI}_4 \xrightarrow{1800\text{K}} \text{Zr} + 2\text{I}_2$$
39. Generally two things are considered so that proper precautions can be taken.  
 (i) reactivity of metal produced.  
 (ii) suitability of electrodes.
40. Flux is used for making the molten mass more conducting.
41. Semiconducting metal is produced by zone refining method which is based on the principle that the impurities are more soluble in melt than in the solid state of metals.
42. 
$$3\text{Fe}_2\text{O}_3 + \text{CO} \longrightarrow 2\text{Fe}_3\text{O}_4 + \text{CO}_2$$

$$\text{Fe}_3\text{O}_4 + 4\text{CO} \longrightarrow 3\text{Fe} + 4\text{CO}_2$$

$$\text{Fe}_2\text{O}_3 + \text{CO} \longrightarrow 2\text{FeO} + \text{CO}_2$$
43. (i) The metal should form a volatile compound with available reagent.  
 (ii) The volatile compound should be easily decomposable so that the recovery is easy.
44. 
$$4\text{Au}(\text{s}) + 8\text{CN}^-(\text{aq}) + 2\text{H}_2\text{O}(\text{aq}) + \text{O}_2(\text{g}) \longrightarrow 4[\text{Au}(\text{CN})_2]^- (\text{aq}) + 4\text{OH}^- (\text{aq})$$

$$2[\text{Au}(\text{CN})_2]^- (\text{aq}) + \text{Zn}(\text{s}) \longrightarrow 2\text{Au}(\text{s}) + [\text{Zn}(\text{CN})_4]^{2-} (\text{aq})$$
 In this reaction zinc acts as a reducing agent.

#### IV. Matching Type

45. (ii)      46. (ii)      47. (i)      48. (i)      49. (i)

#### V. Assertion and Reason Type

50. (i)      51. (i)      52. (ii)      53. (ii)      54. (ii)

#### VI. Long Answer Type

55. (a) **Hint** : Use Ellingham diagram
- (b) **Hint** : Oxides are easier to reduce. See Ellingham diagram.
- (c) **Hint** : Sulphide ore of copper contains iron as impurity which is removed as iron silicate (slag)
- $$\text{FeO} + \text{SiO}_2 \longrightarrow \text{FeSiO}_3$$
- (Slag)
- (d) **Hint** : Carbon and hydrogen react with metals at high temperature to form carbides and hydrides respectively.
- (e) **Hint** : Ti reacts with iodine to form volatile  $\text{TiI}_4$  which decomposes at high temperature to give extra pure titanium.