Unit

6

GENERAL PRINCIPLES AND PROCESSES OF ISOLATION OF ELEMENTS

I. Multiple Choice Questions (Type-I)

1. In the extraction of chlorine by electrolysis of brine _____.

(i) oxidation of Cl^- ion to chlorine gas occurs.

(ii) reduction of Cl^- ion to chlorine gas occurs.

(iii) For overall reaction $\Delta G^\ominus$ has negative value.

(iv) a displacement reaction takes place.

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

(i) sulphides of copper (II) and iron (II)

(ii) sulphides of copper (II) and iron (III)

(iii) sulphides of copper (I) and iron (II)

(iv) sulphides of copper (I) and iron (III)

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

(i) $Fe_3O_4 + 4CO \longrightarrow 3Fe + 4CO_2$

(ii) $Cu_2O + C \longrightarrow 2Cu + CO$

(iii) $Cu^{2+}(aq) + Fe(s) \longrightarrow Cu(s) + Fe^{2+}(aq)$

(iv) $Cu_2O + \frac{1}{2}Cu_2S \longrightarrow 3Cu + \frac{1}{2}SO_2$

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

(i) Al and Fe

(ii) Al and Cu

(iii) Fe and Cu

(iv) Cu and Ag

5. Zone refining is based on the principle that _____.

(i) impurities of low boiling metals can be separated by distillation.

(ii) impurities are more soluble in molten metal than in solid metal.

(iii) different components of a mixture are differently adsorbed on an adosrbent.

(iv) 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 Cu_2O with

(i) FeS

(ii) CO

(iii) Cu_2S

(iv) SO_2

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

(i) $Cl^-(aq.) \longrightarrow \frac{1}{2} Cl_2(g) + e^-$; $E^{\ominus}_{Cell} = 1.36V$

(ii) $2H_2O(l) \longrightarrow O_2(g) + 4H^+ + 4e^-$; $E^{\ominus}_{Cell} = 1.23V$

(iii) $Na^+(aq.) + e^- \longrightarrow Na(s)$; $E^{\ominus}_{Cell} = 2.71V$

(iv) $H^+(aq.) + e^- \longrightarrow \frac{1}{2} H_2(g)$; $E^{\ominus}_{Cell} = 0.00V$

8. In the metallurgy of aluminium _____.

(i) Al^{3+} is oxidised to Al (s).

(ii) graphide anode is oxidised to carbon monoxide and carbon dioxide.

(iii) oxidation state of oxygen changes in the reaction at anode.

(iv) 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?

(i) Cu and Zn

(ii) Ge and Si

(iii) Zr and Ti

(iv) Zn and Hg

10. Extraction of gold and silver involves leaching the metal with CN^- ion. The metal is recovered by _____.

(i) displacement of metal by some other metal from the complex ion.

(ii) roasting of metal complex.

(iii) calcination followed by roasting.

(iv) thermal decomposition of metal complex.

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

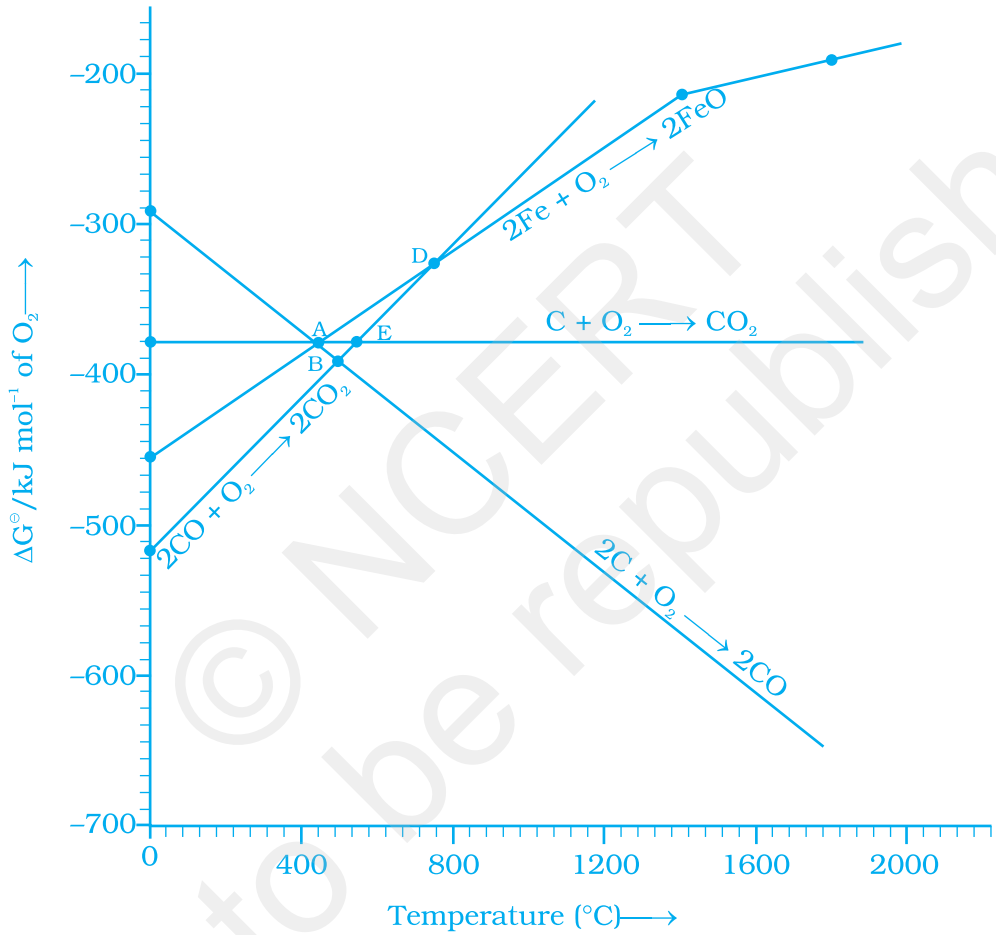

Fig. 6.1

11. Choose the correct option of temperature at which carbon reduces FeO to iron and produces CO.

(i) Below temperature at point A.

(ii) Approximately at the temperature corresponding to point A.

(iii) Above temperature at point A but below temperature at point D.

(iv) 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) ΔG value for the overall reduction reaction with carbon monoxide is zero.

(ii) ΔG value for the overall reduction reaction with a mixture of 1 mol carbon and 1 mol oxygen is positive.

(iii) ΔG value for the overall reduction reaction with a mixture of 2 mol carbon and 1 mol oxygen will be positive.

(iv) ΔG 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 $2FeO \longrightarrow 2Fe + O_2$ with all of the following reactions?

(a) $C + O_2 \longrightarrow CO_2$ (b) $2C + O_2 \longrightarrow 2CO$ and (c) $2CO + O_2 \longrightarrow 2\,CO_2$

(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 Al_2O_3 is mixed with CaF_2 to

(i) lower the melting point of Al_2O_3.

(ii) increase the conductivity of molten mixture.

(iii) reduce Al^{3+} into Al(s).

(iv) acts as catalyst.

17. Which of the following statements is correct about the role of substances added in the froth floation 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_2O_3

(iv) SiO_2

20. Which of the following ores are concentrated by froth floation?

(i) Haematite

(ii) Galena

(iii) Copper pyrites

(iv) Magnetite

21. Which of the following reactions occur during calcination?

(i) $CaCO_3 \longrightarrow CaO + CO_2$

(ii) $2FeS_2 + \frac{11}{2} O_2 \longrightarrow Fe_2O_3 + 4SO_2$

(iii) $Al_2O_3.x\ H_2O \longrightarrow Al_2O_3 + x\ H_2O$

(iv) $ZnS + \frac{3}{2} O_2 \longrightarrow ZnO + SO_2$

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) $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

(ii) $FeO + SiO_2 \longrightarrow FeSiO_3$

(iii) $Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$

(iv) $CaO + SiO_2 \longrightarrow CaSiO_3$

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 Cu_2S and ZnS.

(iii) The solidified copper obtained from reverberatory furnace has blistered appearance due to evolution of 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

27. Why is an external emf of more than 2.2V required for the extraction of Cl_2 from brine?

28. At temperatures above 1073K coke can be used to reduce FeO to 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 Floatation 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 Al_2O_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	**Column II**
(A) Pendulum	(1) Chrome steel
(B) Malachite	(2) Nickel steel
(C) Calamine	(3) Na_3AlF_6
(D) Cryolite	(4) $CuCO_3.Cu(OH)_2$
	(5) $ZnCO_3$

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	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 Process
(D) Purification of mercury	(4) Chromatography
	(5) Liquation

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	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

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	Column II
(A) Sapphire	(1) Al_2O_3
(B) Sphalerite	(2) NaCN
(C) Depressant	(3) Co
(D) Corundum	(4) ZnS
	(5) Fe_2O_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	**Column II**
(A) Blisterred Cu	(1) Aluminium
(B) Blast furnace	(2) $2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2$
(C) Reverberatory furnace	(3) Iron
(D) Hall-Heroult process	(4) $FeO + SiO_2 \longrightarrow FeSiO_3$
	(5) $2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$

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 : $Ni(CO)_4$ is a volatile compound which decomposes at 460K to give pure Ni.

51. **Assertion** : Zirconium can be purificed by Van Arkel method.

Reason : 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

55. Explain the following :

(a) CO_2 is a better reducing agent below 710K whereas CO is a better reducing agent above 710K.

(b) Generally sulphide ores are converted into oxides before reduction.

(c) Silica is added to the sulphide ore of copper in the reverberatory furnace.

(d) Carbon and hydrogen are not used as reducing agents at high temperatures.

(e) 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

$$2Cl^-(aq) + 2H_2O\ (l) \longrightarrow 2OH^-(aq) + H_2(g) + Cl_2\ (g)$$

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 Cl_2 from brine will require an external emf of greater than 2.2*V*.

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

ΔG (C, CO) < ΔG (Fe, FeO). Hence coke can reduce FeO to Fe.

29. $Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$

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 Cu^{2+} is treated with scrap iron, Zn or H_2.

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

$$Cu^{2+} + Fe(s) \longrightarrow Fe^{2+}(aq) + Cu(s)$$

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

$Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$

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.

$FeO + SiO_2 \longrightarrow FeSiO_3$

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.

$Zr + 2I_2 \longrightarrow ZrI_4$

$ZrI_4 \xrightarrow{1800K} Zr + 2I_2$

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. $3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$

$Fe_3O_4 + 4CO \longrightarrow 3Fe + 4CO_2$

$Fe_2O_3 + CO \longrightarrow 2FeO + CO_2$

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. $4Au\ (s) + 8CN^-(aq) + 2H_2O\ (aq) + O_2\ (g) \longrightarrow 4\ [Au\ (CN)_2]^-\ (aq) + 4OH^-\ (aq)$

$2[Au(CN)_2]^-\ (aq) + Zn(s) \longrightarrow 2Au(s) + [Zn\ (CN)_4]^{2-}\ (aq)$

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)

$$FeO + SiO_2 \longrightarrow \underset{\text{(Slag)}}{FeSiO_3}$$

(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 TiI_4 which decomposes at high temperature to give extra pure titanium.