19

Extraction of Metals

Objective Questions I (Only one correct option)

1. The correct statement is

(a) leaching of bauxite using concentrated NaOH solution gives sodium aluminate and sodium silicate. **(2019 Main, 12 April II)**

(b) the hall-heroult process is used for the production of aluminium and iron.

(c) pig iron is obtained from cast iron.

(d) the blistered appearance of copper during the metallurgical process is due to the evolution of CO_2.

2. The idea of froth floatation method came from a person X and this method is related to the process Y of ores. X and Y, respectively, are **(2019 Main, 12 April I)**

(a) fisher woman and concentration
(b) washer woman and concentration
(c) fisher man and reduction
(d) washer man and reduction

3. The correct statement is **(2019 Main, 10 April II)**

(a) zone refining process is used for the refining of titanium.
(b) zincite is a carbonate ore.
(c) sodium cyanide cannot be used in the metallurgy of silver.
(d) aniline is a froth stabiliser.

4. Match the refining methods Column I with metals Column II.

	Column I (Refining Methods)		**Column II** (Metals)
I.	Liquation	(A)	Zr
II.	Zone refining	(B)	Ni
III.	Mond process	(C)	Sn
IV.	van Arkel method	(D)	Ga

(2019 Main, 10 April I)

(a) I- (C) ; II-(D); III-(B) ; IV-(A)
(b) I- (B) ; II-(C); III-(D) ; IV-(A)
(c) I- (C) ; II-(A); III-(B) ; IV-(D)
(d) I- (B) ; II-(D); III-(A) ; IV-(C)

5. The one that is not a carbonate ore is **(2019 Main, 9 April II)**

(a) siderite (b) calamine (c) malachite (d) bauxite

6. **Assertion** For the extraction of iron, haematite ore is used.

Reason Heamatite is a carbonate ore of iron. **(2019 Main, 9 April II)**

(a) Only the reason is correct.

(b) Both the assertion and reason are correct explanation for the assertion.

(c) Both the assertion and reason are correct and the reason is the correct explanation for the assertion.

(d) Only the assertion is correct.

7. The ore that contains the metal in the form of fluoride is **(2019 Main, 9 April I)**

(a) magnetite (b) sphalerite (c) malachite (d) cryolite

8. The Mond process is used for the **(2019 Main, 8 April II)**

(a) purification of Ni (b) extraction of Mo
(c) purification of Zr and Ti (d) extraction of Zn

9. With respect to an ore, Ellingham diagram helps to predict the feasibility of its **(2019 Main, 8 April I)**

(a) electrolysis (b) zone refining
(c) vapour phase refining (d) thermal reduction

10. The pair that does not require calcination is **(2019 Main, 12 Jan II)**

(a) ZnO and MgO (b) ZnO and $Fe_2O_3 \cdot xH_2O$
(c) $ZnCO_3$ and CaO (d) Fe_2O_3 and $CaCO_3 \cdot MgCO_3$

11. In the Hall-Heroult process, aluminium is formed at the cathode. The cathode is made out of **(2019 Main, 12 Jan I)**

(a) platinum (b) carbon
(c) pure aluminium (d) copper

12. The reaction that does not define calcination is

(a) $Fe_2O_3 \cdot XH_2O \xrightarrow{\Delta} Fe_2O_3 + XH_2O$ **(2019 Main, 11 Jan II)**

(b) $ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2$

(c) $CaCO_3 \cdot MgCO_3 \xrightarrow{\Delta} CaO + MgO + 2CO_2$

(d) $2Cu_2S + 3O_2 \xrightarrow{\Delta} 2Cu_2O + 2SO_2$

13. Match the ores (Column A) with the metals (Column B).

Column A		**Column B**	
	Ores		**Metals**
A.	Siderite	P.	Zinc
B.	Kaolinite	Q.	Copper
C.	Malachite	R.	Iron
D.	Calamine	S.	Aluminium

(2019 Main, 11 Jan I)

(a) A - P; B- Q; C - R; D- S
(b) A - R; B- S; C - P; D- Q
(c) A - Q; B- R; C - S; D- P
(d) A - R; B- S; C - Q; D- P

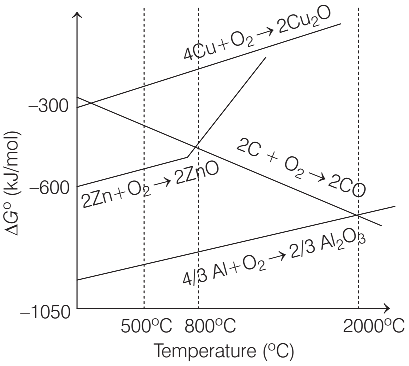
14. The electrolytes usually used in the electroplating of gold and silver, respectively, are **(2019 Main, 10 Jan II)**

(a) $[Au(OH)_4]^-$ and $[Ag(OH)_2]^-$
(b) $[Au(NH_3)_2]^+$ and $[Ag(CN)_2]^-$
(c) $[Au(CN)_2]^-$ and $[Ag(CN)_2]^-$
(d) $[Au(CN)_2]^-$ and $[AgCl_2]^-$

15. Hall-Heroult's process is given by **(2019 Main, 10 Jan I)**

(a) $ZnO + C \xrightarrow{\text{Coke, 1673 K}} Zn + CO$
(b) $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$
(c) $2Al_2O_3 + 3C \longrightarrow 4Al + 3CO_2$
(d) $Cu^{2+}(aq) + H_2(g) \longrightarrow Cu(s) + 2H^+(aq)$

16. The correct statement regarding the given Ellingham diagram is **(2019 Main, 9 Jan II)**



(a) At 800°C, Cu can be used for the extraction of Zn from ZnO
(b) At 1400°C, Al can be used for the extraction of Zn from ZnO
(c) At 500°C, coke can be used for the extraction of Zn from ZnO
(d) Coke cannot be used for the extraction of Cu from Cu_2O

17. The ore that contains both iron and copper is **(2019 Main, 9 Jan I)**

(a) malachite (b) azurite
(c) dolomite (d) copper pyrites

18. Which one of the following ores is best concentrated by froth floatation method? **(2016 Main)**

(a) Siderite (b) Galena
(c) Malachite (d) Magnetite

19. From the following statements regarding H_2O_2 choose the incorrect statement. **(2015 Main)**

(a) It can act only as an oxidising agent
(b) It decomposed on exposure to light
(c) It has to be stored in plastic or wax lined glass bottles in dark
(d) It has to be kept away from dust

20. In the context of the Hall-Heroult process for the extraction of Al, which of the following statements is false? **(2015 Main)**

(a) CO and CO_2 are produced in this process
(b) Al_2O_3 is mixed with CaF_2 which lowers the melting point of the mixture and brings conductivity
(c) Al^{3+} is reduced at the cathode to form Al
(d) Na_3AlF_6 serves as the electrolyte

21. The metal that cannot be obtained by electrolysis of an aqueous solution of its salts is **(2014 Main)**

(a) Ag (b) Ca
(c) Cu (d) Cr

22. Sulphide ores are common for the metals **(2013 Adv.)**

(a) Ag, Cu and Pb (b) Ag, Cu and Sn
(c) Ag, Mg and Pb (d) Al, Cu and Pb

23. In the cyanide extraction process of silver from argentite ore, the oxidising and reducing agents used are **(2012)**

(a) O_2 and CO respectively
(b) O_2 and Zn dust respectively
(c) HNO_3 and Zn dust respectively
(d) HNO_3 and CO respectively

24. Oxidation states of the metal in the minerals haematite and magnetite, respectively, are **(2011)**

(a) II, III in haematite and III in magnetite
(b) II, III in haematite and II in magnetite
(c) II in haematite and II, III in magnetite
(d) III in haematite and II, III in magnetite

25. Native silver metal forms a water soluble complex with a dilute aqueous solution of NaCN in the presence of **(2008, 3M)**

(a) nitrogen (b) oxygen
(c) carbon dioxide (d) argon

26. Extraction of zinc from zinc blende is achieved by **(2007, 3M)**

(a) electrolytic reduction
(b) roasting followed by reduction with carbon
(c) roasting followed by reduction with another metal
(d) roasting followed by self-reduction

27. Which ore contains both iron and copper? **(2005, 1M)**

(a) Cuprite (b) Chalcocite
(c) Chalcopyrite (d) Malachite

28. The methods chiefly used for the extraction of lead and tin from their ores are respectively **(2004, 1M)**

(a) self-reduction and carbon reduction
(b) self-reduction and electrolytic reduction
(c) carbon reduction and self-reduction
(d) cyanide process and carbon reduction

29. In the process of extraction of gold,

$$\text{Roasted gold ore} + CN^- + H_2O \xrightarrow{O_2} [X] + HO$$
$$[X] + Zn \longrightarrow [Y] + Au$$

Identify the complexes $[X]$ and $[Y]$. **(2003, 1M)**

(a) $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_4]^{2-}$
(b) $X = [Au(CN)_4]^{3-}$, $Y = [Zn\ (CN)_4]^{2-}$
(c) $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_6]^{4-}$
(d) $X = [Au(CN)_4]^-$, $Y = [Zn(CN)_4]^{2-}$

30. Anhydrous ferric chloride is prepared by **(2002)**
(a) heating hydrated ferric chloride at a high temperature in a stream of air
(b) heating metallic iron in a stream of dry chlorine gas
(c) reaction of ferric oxide with hydrochloric acid
(d) reaction of metallic iron with hydrochloric acid

31. Which of the following process is used in extractive metallurgy of magnesium? **(2002, 3M)**
(a) Fused salt electrolysis
(b) Self-reduction
(c) Aqueous solution electrolysis
(d) Thermite reduction

32. The chemical composition of 'slag' formed during the smelting process in the extraction of copper is **(2001, 1M)**
(a) $Cu_2O + FeS$ (b) $FeSiO_3$
(c) $CuFeS_2$ (d) $Cu_2S + FeO$

33. Electrolytic reduction of alumina to aluminium by Hall-Heroult process is carried out **(2000, 1M)**
(a) in the presence of NaCl
(b) in the presence of fluorite
(c) in the presence of cryolite which forms a melt with lower melting temperature
(d) in the presence of cryolite which forms a melt with higher melting temperature

34. The chemical process in the production of steel from haematite ore involve **(2000, 1M)**
(a) reduction
(b) oxidation
(c) reduction followed by oxidation
(d) oxidation followed by reduction

35. In the commercial electrochemical process for aluminium extraction, the electrolyte used is **(1999, 2M)**
(a) $Al(OH)_3$ in NaOH solution
(b) an aqueous solution of $Al_2(SO_4)_3$
(c) a molten mixture of Al_2O_3 and Na_3AlF_6
(d) a molten mixture of $AlO(OH)$ and $Al(OH)_3$

36. The major role of fluorspar (CaF_2) which is added in small amount in the electrolytic reduction of alumina dissolved in fused cryolite (Na_3AlF_6) is **(1993, 1M)**
(a) as a catalyst
(b) to make the fused mixture very conducting
(c) to increase the temperature of the melt
(d) to decrease the rate of oxidation of carbon at the anode

37. Hydrogen gas will not reduce **(1985, 1M)**
(a) heated cupric oxide
(b) heated ferric oxide
(c) heated stannic oxide
(d) heated aluminium oxide

38. In the alumino-thermite process, aluminium acts as **(1983, 1M)**
(a) an oxidising agent (b) a flux
(c) a reducing agent (d) a solder

39. Type of bonds present in $CuSO_4 \cdot 5H_2O$ are only **(1983)**
(a) electrovalent and covalent
(b) electrovalent and coordinate covalent
(c) electrovalent, covalent and coordinate covalent
(d) covalent and coordinate covalent

40. In metallurgy of iron, when limestone is added to the blast furnace, the calcium ion ends up in **(1982)**
(a) slag
(b) gangue
(c) metallic calcium
(d) calcium carbonate

41. Iron is rendered passive by treatment with concentrated **(1982)**
(a) H_2SO_4 (b) H_3PO_4
(c) HCl (d) HNO_3

Objective Questions II

(One or more than one correct option)

42. Extraction of copper from copper pyrite ($CuFeS_2$) involves **(2016 Adv.)**
(a) crushing followed by concentration of the ore by froth-floatation
(b) removal of iron as slag
(c) self reduction step to produce 'blister copper' following evolution of SO_2
(d) refining of 'blister copper' by carbon reduction

43. Copper is purified by electrolytic refining of blister copper. The correct statement(s) about this process is/are **(2015 Adv.)**
(a) impure Cu strip is used as cathode
(b) acidified aqueous $CuSO_4$ is used as electrolyte
(c) pure Cu deposits at cathode
(d) impurities settle as anode-mud

44. Upon heating with Cu_2S, the reagent(s) that give copper metal is/are **(2014 Adv.)**
(a) $CuFeS_2$ (b) CuO
(c) Cu_2O (d) $CuSO_4$

45. The carbon-based reduction method is not used for the extraction of **(2013 Adv.)**
(a) tin from SnO_2
(b) iron from Fe_2O_3
(c) aluminium from Al_2O_3
(d) magnesium from $MgCO_3$, $CaCO_3$

46. Extraction of metal from the ore cassiterite involves **(2011)**
(a) carbon reduction of an oxide ore
(b) self-reduction of a sulphide ore
(c) removal of copper impurity
(d) removal of iron impurity

47. Addition of high proportions of manganese makes steel useful in making rails **(1998)**
(a) gives hardness to steel
(b) helps the formation of oxides of iron
(c) can remove oxygen and sulphur
(d) can show highest oxidation state of + 7

48. Of the following, the metals that cannot be obtained by electrolysis of the aqueous solution of their salts are **(1990, 1M)**

(a) Ag (b) Mg (c) Cu
(d) Al (e) Cr

49. In the electrolysis of alumina, cryolite is added to **(1986, 1M)**

(a) lower the melting point of alumina
(b) increase the electrical conductivity
(c) minimise the anode effect
(d) remove impurities from alumina

Assertion and Reason

Read the following questions and answer as per the direction given below :

(a) Statement I is correct; Statement II is correct; Statement II is the correct explanation of Statement I.
(b) Statement I is correct; Statement II is correct; Statement II is not the correct explanation of Statement I.
(c) Statement I is correct; Statement II is incorrect.
(d) Statement I is incorrect; Statement II is true.

50. **Statement I** $Al(OH)_3$ is amphoteric in nature.

Statement II Al—O and O—H bonds can be broken with equal ease in $Al(OH)_3$. **(1998)**

Passage Based Questions

Passage

Copper is the most noble of the first row transition metals and occurs in small deposits in several countries. Ores of copper include chalcanthite ($CuSO_4 \cdot 5H_2O$), atacamite ($Cu_2Cl(OH)_3$), cuprite (Cu_2O), copper glance (Cu_2S) and malachite ($Cu_2(OH)_2CO_3$). However, 80% of the world copper production comes from the ore chalcopyrite ($CuFeS_2$). The extraction of copper from chalcopyrite involves partial roasting, removal of iron and self-reduction. **(2010)**

51. Partial roasting of chalcopyrite produces

(a) Cu_2S and FeO (b) Cu_2O and FeO
(c) CuS and Fe_2O_3 (d) Cu_2O and Fe_2O_3

52. Iron is removed from chalcopyrite as

(a) FeO (b) FeS (c) Fe_2O_3 (d) $FeSiO_3$

53. In self-reduction, the reducing species is

(a) S (b) O^{2-} (c) S^{2-} (d) SO_2

Match the Columns

54. Match the anionic species given in Column I that are present in the ore (s) given in Column II. **(2015 Adv.)**

	Column I		Column II
A.	Carbonate	p.	Siderite
B.	Sulphide	q.	Malachite
C.	Hydroxide	r.	Bauxite
D.	Oxide	s.	Calamine
		t.	Argentite

55. Match each of the reactions given in Column I with the corresponding product(s) given in Column II. **(2009)**

	Column I		Column II
A.	Cu + dil. HNO_3	p.	NO
B.	Cu + conc. HNO_3	q.	NO_2
C.	Zn + dil. HNO_3	r.	N_2O
D.	Zn + conc. HNO_3	s.	$Cu(NO_3)_2$
		t.	$Zn(NO_3)_2$

56. Match the conversions in Column I with the type(s) of reaction(s) given in Column II. **(2008, 6M)**

	Column I		Column II
A.	$PbS \longrightarrow PbO$	p.	Roasting
B.	$CaCO_3 \longrightarrow CaO$	q.	Calcination
C.	$ZnS \longrightarrow Zn$	r.	Carbon reduction
D.	$Cu_2S \longrightarrow Cu$	s.	Self-reduction

57. Match the extraction processes listed in Column I with metals listed in Column II. **(2006, 6M)**

	Column I		Column II
A.	Self-reduction	p.	Lead
B.	Carbon reduction	q.	Silver
C.	Complex formation and displacement by metal	r.	Copper
D.	Decomposition of iodide	s.	Boron

58. Each entry in Column *X* is in some way related to the entries in Columns *Y* and *Z*. Match the appropriate entries. **(1988, 3M)**

	Column *X*		Column *Y*		Column *Z*
A.	Invar	p.	Co, Ni	m.	Cutlery
B.	Nichrome	q.	Fe, Ni	n.	Heating element
C.	Stainless steel	r.	Fe, Cr, Ni	o.	Watch spring

59. Match the following choosing one item from Column *X* and the appropriate item from Column *Y*. **(1983, 2M)**

	Column *X*		Column *Y*
A.	Al	p.	Calamine
B.	Cu	q.	Cryolite
C.	Mg	r.	Malachite
D.	Zn	s.	Carnalite

60. Match the following metals listed in Column I with extraction processes listed in Column II. **(1979, 2M)**

	Column I		Column II
A.	Silver	p.	Fused salt electrolysis
B.	Calcium	q.	Carbon reduction
C.	Zinc	r.	Carbon monoxide reduction
D.	Iron	s.	Amalgamation
E.	Copper	t.	Self-reduction

Fill in the Blanks

61. Silver jewellery items tarnish slowly in the air due to their reaction with………… **(1997)**

62. In the extractive metallurgy of zinc, partial fusion of ZnO with coke is called …… and reduction of the ore to the molten metal is called …… (smelting, calcining, roasting, sintering). **(1988, 1M)**

63. Silver chloride is sparingly soluble in water because its lattice energy greater than ……….. energy. **(1987)**

64. Galvanisation of iron denote coating with …… **(1983)**

65. Cassiterite is an ore of …… **(1980, 1M)**

66. In the thermite process …… is used as a reducing agent. **(1980, 1M)**

67. In the basic Bessemer process for the manufacture of steel, the lining of the converter is made up of … . The slag formed consists of …… **(1980, 1M)**

68. AgCl dissolve in excess of KCN solution to give ………… complex compound. **(1980)**

True/False

69 Cu^+ disproportionate to Cu^{2+} and elemental copper in solution. **(1991)**

70. Silver chloride is more soluble in very concentrated sodium chloride solution than in pure water. **(1984, 1M)**

71. Dilute HCl oxidises metallic Fe to Fe^{2+}. **(1983, 1M)**

72. Silver fluoride is fairly soluble in water. **(1982)**

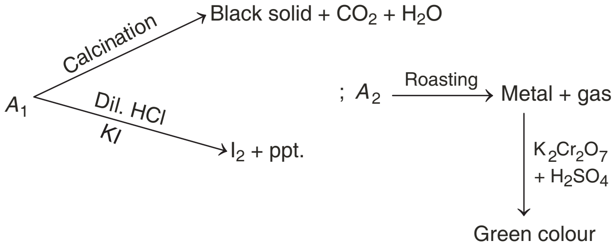
Subjective Questions

73. Give the coordination number of Al in the crystalline state of $AlCl_3$. **(2009, 2M)**

74. Give the number of water molecule (s) directly bonded to the metal centre in $CuSO_4 \cdot 5H_2O$. **(2009, 2M)**

75. Write balanced chemical equation for developing a black and white photographic film. Also give reason, why the solution of sodium thiosulphate on acidification turns milky white and give balance equation of this reaction. **(2005, 2M)**

76. A_1 and A_2 are two ores of metal M. A_1 on calcination gives black precipitate, CO_2 and water.



Identify A_1 and A_2. **(2004, 4M)**

77. Which of the two, anhydrous or hydrated $AlCl_3$ is more soluble in diethyl ether? Justify using the concepts of bonding in not more than 2 or 3 sentences. **(2003)**

78. Write the balanced chemical reactions involved in the extraction of lead from galena. Mention oxidation state of lead in litharge. **(2003, 2M)**

79. Write the balanced chemical equation for developing photographic films. **(2000)**

80. Write the chemical reactions involved in the extraction of silver from argentite. **(2000, 2M)**

81. Work out the following using chemical equations.
In moist air, copper corrodes to produce a green layer on the surface. **(1998)**

82. When the ore haematite is burnt in air with coke around 2000°C along with lime, the process not only produces steel but also produces a silicate slag, that is useful in making building materials such as cement. Discuss the same and show through balanced chemical equations. **(1998, 4M)**

83. Give balance equation for the reaction of aluminium with aqueous sodium hydroxide. **(1997)**

84. Write a balanced equation for the reaction of argentite with KCN and name the products in the solution. **(1996)**

85. Give reasons for the following

"Although aluminium is above hydrogen in the electrochemical series, it is stable in air and water." **(1994, 1M)**

86. Complete the following reaction :

$$Sn + 2KOH + 4H_2O \longrightarrow ...... + ...$$ **(1994)**

87. Give briefly the isolation of magnesium from sea water by the Dow's process.
Give equations for the steps involved. **(1993, 3M)**

88. Complete and balance the following reaction :
Copper reacts with HNO_3 to give NO and NO_2 in the molar ratio of 2:1

$$Cu + HNO_3 \longrightarrow ...... + NO + NO_2 + ...$$ **(1992)**

89. Write balanced equation for the extraction of "Copper from copper pyrites by self reduction." **(1990, 2M)**

90. Give balanced equations for the extraction of "Silver from silver glance by cyanide process." **(1988, 1M)**

91. Answer the following questions briefly

(i) What is the actual reducing agent of haematite in blast furnace?

(ii) Give the equation for the recovery of lead from galena by air reduction.

(iii) Why is sodium chloride added during electrolysis of fused anhydrous magnesium chloride?

(iv) Zinc, not copper is used for the recovery of metallic silver from complex $[Ag(CN)_2]^-$, explain.

(v) Why is chalcocite roasted and not calcinated during recovery of copper? **(1987, 5M)**

92. Write balanced chemical equation for the following "Gold is dissolved in aqua regia." **(1987)**

93. Each of the following statement is true, only under some specific conditions. Write the condition for each subquestion in not more than 2 sentences.

(i) Metals can be recovered from their ores by chemical methods

(ii) High purity metals can be obtained by zone refining method. **(1984, 2M)**

94. Give reason for the following in one or two sentences : "Silver bromide is used in photography." **(1983)**

95. State the conditions under which the preparation of alumina from aluminium is carried out. Give the necessary equations which need not be balanced. **(1983, 2M)**

96. Write the chemical equations involved in the extraction of lead from galena by self reduction process. **(1979, 2M)**

97. Write balanced equation involved in the preparation of tin metal from cassiterite. **(1979)**

Answers

1. (a) **2.** (b) **3.** (d) **4.** (a)
5. (d) **6.** (d) **7.** (d) **8.** (a)
9. (d) **10.** (a) **11.** (b) **12.** (d)
13. (d) **14.** (c) **15.** (c) **16.** (b)
17. (d) **18.** (b) **19.** (a) **20.** (d)
21. (b) **22.** (a) **23.** (b) **24.** (d)
25. (b) **26.** (b) **27.** (c) **28.** (a)
29. (a) **30.** (b) **31.** (a) **32.** (b)
33. (c) **34.** (a) **35.** (c) **36.** (b)
37. (d) **38.** (c) **39.** (c) **40.** (a)
41. (d) **42.** (a,b,c) **43.** (b,c,d) **44.** (b,c,d)
45. (c,d) **46.** (a,d) **47.** (a,c) **48.** (b,d)
49. (a,b) **50.** (b) **51.** (b) **52.** (d)

53. (c) **54.** A → p, q, s; B → t; C → q; D → r
55. A → p, s; B → q, s; C → r, t; D → q, t
56. A → p; B → q; C → r, s; D → p, s
57. A → p, r; B → p; C → q; D → s
58. A → q, o; B → p, n; C → r, m
59. A → q; B → r; C → s; D → p
60. A → s; B → p; C → q; D → q, r; E → t
61. H_2S **62.** Sintering, Smelting
63. Hydration **64.** Zn **65.** Sn **66.** Al
67. Lime, calcium phosphate **68.** $K[Ag(CN)_2]$
69. T **70.** T **71.** T **72.** T
73. (6) **74.** (4) **78.** (2)

Hints & Solutions

1. The correct statement is ''leaching of bauxite using concentrated NaOH solution gives sodium aluminate and sodium silicate''. Bauxite usually contains SiO_2, iron oxides and titanium oxide (TiO_2) as impurities. Concentration is carried out by digesting the powdered ore with a concentrated solution of NaOH at 473-523 K and 35-36 bar pressure. Al_2O_3 is leached out as sodium aluminate (and SiO_2 too as sodium silicate) leaving the impurities behind.

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

The aluminate in solution is neutralised by passing CO_2 gas and hydrated Al_2O_3 is precipitated. Here, the solution is seeded with freshly prepared samples of hydrated Al_2O_3 which induces precipitation.

$$2Na[Al(OH)_4](aq) + CO_2(g) \longrightarrow Al_2O_3 \cdot xH_2O(s) + 2NaHCO_3(aq)$$

The sodium silicate remains in the solution and hydrated alumina is filtered, dried and heated to give back pure Al_2O_3.

$$Al_2O_3 \cdot xH_2O(s) \xrightarrow{1470\text{ K}} Al_2O_3(s) + xH_2O(g)$$

2. The idea of froth floatation method came from a person 'washer woman' (X) and this method is related to the process concentration (Y) of ores.

This method is based upon the preferential wetting properties with the frothing agent (collector) and water.

3. The explanation of given statements are as follows:

(a) Zone refining process is used for the refining of B, Ga, In, Si and Ge.

Ti is refined by van Arkel method.

Thus, statement (a) is incorrect.

(b) Zincite (ZnO) is an oxide ore of Zn.

Thus, statement (b) is incorrect.

(c) NaCN is used in the hydrometallurgy of silver. It is known as Mc. Arthur Forrest process.

The reactions occuring during the process are as follows:

$$Ag_2S + 4NaCN \longrightarrow 2Na[Ag(CN)_2] + Na_2S$$
$$4Na_2S + 2H_2O + 5O_2 \longrightarrow 2Na_2SO_4 + 4NaOH + 2S$$
$$2Na[Ag(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + 2Ag$$

Thus, statement (c) is incorrect.

(d) Aniline and cresol help in stabilising the froth in froth floatation process.

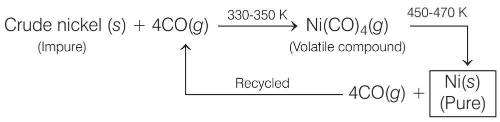
Thus, statement (d) is correct.

4. Refining of crude metals results pure metals and its impurities get separated out.

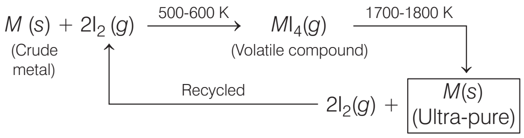
I. **Liquation** In this method low melting metals like Sn, Pb, Bi and Hg can be made to flow down through a sloping surface leaving behind the higher melting impurities on the hearth.

II. **Zone refining** The basic principle of the method is, impurities are more soluble in the molten metal than in the solid state of the metal. This method is useful to produce semiconductors and ultra-pure metals like B, Ga, In, Si and Ge.

III. **Mond process**



IV. van Arkel method



Here, M = Zr, Hf, Ti

Hence, the correct matching is

$$\text{I}\rightarrow\text{(C)},\ \text{II}\rightarrow\text{(D)},\ \text{III}\rightarrow\text{(B)},\ \text{IV}\rightarrow\text{(A)}.$$

5. Bauxite is not a carbonate ore. Its chemical formula is Al_2O_3 or $AlO_x(OH)_{3-2x}$, where $0 < x < 1$. Chemical formula of other ores given in options are as follows:

Siderite-$FeCO_3$

Calamine-$ZnCO_3$

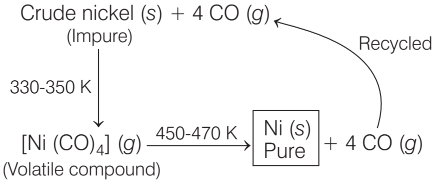
Malachite-$CuCO_3 \cdot Cu(OH)_2$

6. Only assertion is correct and reason is incorrect. Haematite is not a carbonate ore. It is an oxide ore, i.e. Fe_2O_3. Cast iron is extracted chiefly from its oxide ore (haematite) by heating in the presence of coke and limestone in a blast furnace.

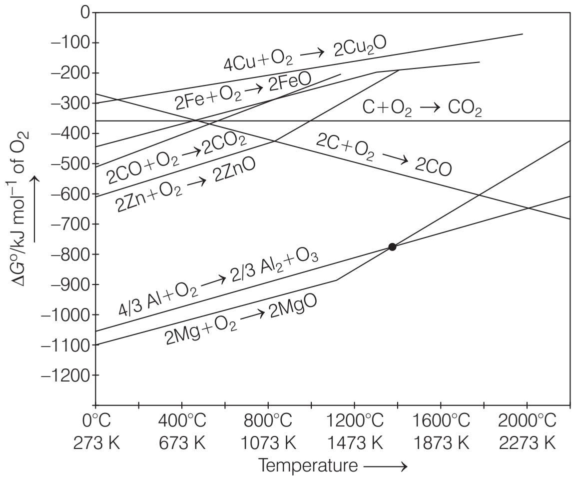
7. Cryolite ore (Na_3AlF_6, sodium hexafluoroaluminate) contain fluorine while other given options such as malachite ($Cu_2(CO)_3(OH)_2$), sphalerite ((Zn,Fe)S) and bauxite (Al_2O_3) does not contain fluorine.

8. Mond process is used in the purification of Ni. It is a vapour phase refining process.

It is based on the principle that Ni is heated in the presence of carbon monoxide to form nickel tetracarbonyl, which is a volatile complex. This complex is then decomposed by subjecting it to a higher temperature (450-470 K) to obtain pure nickel metal.



9. With respect to an ore, Ellingham diagram helps to predict the feasibility of its thermal reduction. It is a graph representation of Gibbs energy change *versus* absolute temperature.



Gibbs energy ($\Delta G°$) *versus* T plots (schematic) for the formation of some oxides (Ellingham diagram)

Generally, the diagram consists of plots of $\Delta G°$ *versus* T for the formation of oxides of elements

$$2xM(s) + O_2(g) \longrightarrow \underset{\text{Thermal reduction product}}{2M_xO(s)}$$

In this reaction, amount of gas decreases thus, randomness decreases. Hence, ΔS becomes negative. Therefore, the value of free energy increases with increase in temperature. There is a point in a curve below which ΔG is negative. So, M_xO is stable. Above this point, M_xO will decompose on its own.

10. The hydroxide, hydrated oxides and carbonate ores, after concentration, are subjected to calcination. In the process, the ore is heated below its melting point in the limited supply or absence of air. As the result, these are converted into their oxides.

So, among the given options, the options having either carbonates (e.g. $ZnCO_3$ and $CaCO_3 \cdot MgCO_3$) or hydrated oxide (e.g. $Fe_2O_3 \cdot xH_2O$), require calcination while pair of option (a), i.e. ZnO and MgO does not require calcination.

11. In the Hall - Heroult's process, aluminium in formed at the cathode. The cathode is made out of carbon. In this method, Al_2O_3 is melted with cryolite, $Na_3[AlF_6]$ and electrolysed in a graphite lined steel tank, which serves as the cathode. The anode is also made of graphite.

The cell runs continuously and at intervals molten aluminium is drained from the bottom of the cell and more bauxite is added. The electrolytic reactions are as follows:

At cathode $\quad Al^{3+} + 3e^- \longrightarrow Al$

At anode $\quad C(s) + O^{2-}\text{(melt)} \longrightarrow CO(g) + 2e^-$

$C(s) + 2O^{2-}\text{(melt)} \longrightarrow CO_2(g) + 4e^-$

12. Calcination is one of the pyrometallurgical process, like roasting by which a concentrated ore gets converted into its oxide.

In calcination, a hydrated carbonate or bicarbonate ore or a hydrated ore is heated at lower temperature (compared to roasting) in absence of air to give its oxide as in options (a), (b) and (c). Here, volatile non-metallic oxides like H_2O, CO_2, are also produced.

Roasting is valid mainly for sulphide ores like option (d), where SO_2 gets liberated. In this reaction, calcination cannot be used.

13. The correct match is: A → R; B → S; C → Q; D → P.

(A) Siderite is an ore of iron with molecular formula $FeCO_3$(R).

(B) Kaolinite is an ore of aluminium with molecular formula $Al_2Si_2(OH)_2O_5$ (S).

(C) Malachite is an ore of copper with molecular formula $CuCO_3 \cdot Cu(OH)_2$ (Q).

(D) Calamine is an ore of zinc with molecular formula $ZnCO_3$(P).

14. Electroplating is a process of coating one metal or metal object with a very thin layer of another metal typically applying a direct electric current.

Electrolytes used in the electroplating of gold and silver are given in the table below:

	Process	Article to be plated out acts as cathode	Pure metal block acts an anode by which electroplating will be done	Electrolyte (aqueous solution)
(a)	Gold plating	Article	$Au(s)$	$Na[\overset{I}{A}u(CN)_2]$ (Sodium auro-cyanide)
(b)	Silver plating	Article	$Ag(s)$	$Na[\overset{I}{A}g(CN)_2]$ (Sodium argento cyanide)

15. Hall-Heroult's process is an electro-reduction process by which pure alumina (Al_2O_3) is reduced to crude Al.

In this process, electrolysis of a fused mixture of Al_2O_3, $Na_3[AlF_6]$(cryolite) and CaF_2 (fluorspar) is carried out at carbon cathode and graphite anode.

The overall reaction is represented as:

$$2Al_2O_3 + 3C \longrightarrow 4Al + 3CO_2$$

16. From the Ellingham diagram, we can say that any oxide with lower value of $\Delta G°$ is more stable than a oxide with higher value of $\Delta G°$. We can also predict that the oxide placed higher in the diagram can be reduced by the element involved in the formation of its oxide placed lower at that temperature in the diagram.

It is happening in case of ZnO for its reduction by Al at 1400°C.

17. The formulae of the given ores are as follows:

Malachite	: $CuCO_3 \cdot Cu(OH)_2$
Copper pyrites	: $CuFeS_2$
Dolomite	: $CaMg(CO_3)_2$
Azurite	: $Cu_3(CO)_3(OH)_2$

18. Sulphide ores are concentrated by froth floatation method e.g. Galena (PbS)

19. H_2O_2 acts as an oxidising as well as reducing agent, because oxidation number of oxygen in H_2O_2 is –1. So, it can be oxidised to oxidation state 0 or reduced to oxidation state –2.

H_2O_2 decomposes on exposure to light. So, it has to be stored in plastic or wax linked glass bottles in dark for the prevention of exposure. It also has to be kept away from dust.

20. (a) In Hall-Heroult process for extraction Al, carbon anode is oxidised to CO and CO_2.

(b) When Al_2O_3 is mixed with CaF_2, it lowers the melting point of the mixture and brings conductivity.

(c) Al^{3+} is reduced at cathode to form Al.

(d) Here, Al_2O_3 is an electrolyte, undergoing the redox process. Na_3AlF_6 although is an electrolyte but serves as a solvent, not electrolyte.

21. Higher the position of element in the electrochemical series more difficult is the reduction of its cations.

If $Ca^{2+}(aq)$ is electrolysed, water is reduced in preference to it. Hence, it cannot be reduced electrolytically from their aqueous solution.

$$Ca^{2+}(aq) + H_2O \longrightarrow Ca^{2+} + OH^- + H_2\uparrow$$

22.

Element	Ores	Name
Ag	Ag_2S	Argentite
Cu	$CuFeS_2$	Copper pyrites
Pb	PbS	Galena
Sn	SnO_2	Cassiterite
Mg	$MgCO_3 \cdot CaCO_3$	Dolomite
Al	$Al_2O_3 \cdot xH_2O$	Bauxite

23. The reactions involved in extraction of silver by cyanide process are

$$Ag_2S + CN^- + O_2 \longrightarrow [Ag(CN)_2]^- + SO_2 \quad \text{...(i)}$$

$$[Ag(CN)_2]^- + Zn \longrightarrow [Zn(CN)_4]^{2-} + Ag \quad \text{...(ii)}$$

In reaction (i), sulphide is oxidised to SO_2 by oxygen. In the reaction (ii), silver ion (Ag^+) is reduced to Ag by Zn. Therefore, O_2 is oxidising agent and Zn is reducing agent.

24. Haematite is Fe_2O_3, in which oxidation number of iron is III. Magnetite is Fe_3O_4 which is infact a mixed oxide ($FeO \cdot Fe_2O_3$), hence iron is present in both II and III oxidation state.

25. A water soluble complex with silver and dilute aqueous solution of NaCN is $Na[Ag(CN)_2]$. In the cyanide process, the native silver is crushed and treated with aqueous NaCN solution and aerated.

$$4Ag + 8NaCN + 2H_2O + O_2 \longrightarrow 4Na[Ag(CN)_2] + 4NaOH$$

26. Zinc blende contain ZnS which is first roasted partially and then subjected to reduction with carbon

$$ZnS + O_2 \longrightarrow ZnO + SO_2 \text{ Roasting}$$

$$ZnO + C \xrightarrow{\Delta} Zn + CO\uparrow \text{Carbon reduction}$$

27. Chalcopyrite contain both iron and copper.

28. Lead is mainly extracted by self-reduction process while tin is extracted by carbon reduction method.

29.
$$\underset{X}{\mathrm{Au} + 2\mathrm{CN}^- \longrightarrow [\mathrm{Au(CN)_2}]^-}$$
$$2\mathrm{Au(CN)}_2^- + \mathrm{Zn} \longrightarrow \underset{Y}{[\mathrm{Zn(CN)_4}]^{2-}} + 2\mathrm{Au}$$

30. Heating iron in stream of dry chlorine gas gives $FeCl_3$ in anhydrous form. In all other cases (*a* and *c*) hydrated $FeCl_3$ is obtained while in (*d*), $FeCl_2$ is formed.

31. Mg is extracted by electrolysis of molten $MgCl_2$.

32. Iron present in copper pyrite is removed by forming $FeSiO_3$ as slag.

33. Cryolite is added to alumina in order to lower the melting point.

34. Haematite ore contain Fe_2O_3 which is reduced by CO in the blast furnace as
$$Fe_2O_3 + CO \longrightarrow Fe + CO_2$$

35. Al_2O_3 mixed with cryolite $Na_3[AlF_6]$ is fused and electrolysed in the extraction of Al.

36. Fluorspar (CaF_2) improve the electrical conductivity during electrolytic reduction of alumina.

37. Al itself is a very strong reducing agent.

38. In thermite welding, Al acts as a reducing agent
$$2Al + Fe_2O_3 \longrightarrow Al_2O_3 + 2Fe + \text{Heat}$$

39. The actual representation of $CuSO_4 \cdot 5H_2O$ (blue vitriol) is $[Cu(H_2O)_4]SO_4 \cdot H_2O$ and it has covalent, ionic and coordinate covalent bonds.

40. Ca^{2+} end up in $CaSiO_3$ (slag).

41. Iron is rendered passive by concentrated HNO_3 due to formation of a thick protective layer of Fe_3O_4.

42. $CuFeS_2$ (copper pyrite) is converted into copper into following steps:

Step I Crushing (grinding) followed by concentration by froth-floatation process.

Step II Roasting of ore in the presence of SiO_2 which removes iron as slag ($FeSiO_3$).
$$2CuFeS_2 + O_2 \longrightarrow Cu_2S + 2FeS + SO_2$$
$$2FeS + 3O_2 \longrightarrow 2SO_2 + 2FeO$$
$$FeO + SiO_2 \longrightarrow FeSiO_3\text{(Slag)}$$

Step III Self-reduction in Bessemer converter
$$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$$
$$2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2$$
Copper obtained is blister copper (98% pure).

Step IV Refining of blister copper is done by electrolysis

Impure copper—Anode

Pure copper— Cathode

At anode : $Cu \longrightarrow Cu^{2+} + 2e^-$

At cathode : $Cu^{2+} + 2e^- \longrightarrow Cu$

Carbon-reduction method is not used. Thus, (d) is incorrect.

43. (a) is wrong statement. Impure copper is set as anode where copper is oxidised to Cu^{2+} and goes into electrolytic solutions.

(b) $CuSO_4$ is used as an electrolyte in purification process.

(c) Pure copper is deposited at cathode as:

$Cu^{2+} + 2e^- \longrightarrow Cu$: (At cathode)

(d) Less active metals like Ag, Au etc settle down as anode mud.

44. (b) $4CuO \xrightarrow{1100°C} 2Cu_2O + O_2$
$$2Cu_2O + Cu_2S \xrightarrow{\Delta} 6Cu + SO_2$$

(c) $Cu_2S + 2Cu_2O \xrightarrow{\Delta} 6Cu + SO_2$

(d) $CuSO_4 \xrightarrow{720°C} CuO + SO_2 + \frac{1}{2}O_2$
$$4CuO \xrightarrow{1100°C} 2Cu_2O + O_2$$
$$2Cu_2O + Cu_2S \xrightarrow{\Delta} 6Cu + SO_2$$

Reaction is believed to proceed as
$$Cu_2S \rightleftharpoons 2Cu^+ + S^{2-}$$
$$2Cu_2O \rightleftharpoons 4\,Cu^+ + 2O^{2-}$$
$$S^{2-} + 2O^{2-} \longrightarrow SO_2 + 6e^-$$
$$6Cu^+ + 6e^- \longrightarrow 6Cu;\ E^\circ_{\text{cell}} = 0.52$$

Here, copper sulphide is reduced to copper metal. Solidified copper has blistered appearance due to evolution of SO_2 and thus obtained copper is known as blister copper.

Other compounds which give Cu are

(i) CuO as $4CuO \xrightarrow{1100°C} 2Cu_2O + O_2$
$$2Cu_2O + Cu_2S \xrightarrow{\Delta} 6Cu + SO_2$$

(ii) $CuSO_4$ as $CuSO_4 \xrightarrow{720°C} CuO + SO_2 + \frac{1}{2}O_2$
$$4CuO \xrightarrow{\Delta} 2Cu_2O + O_2$$
$$2Cu_2O + Cu_2S \xrightarrow{\Delta} 6Cu + SO_2$$

While $CuFeS_2$ will not give Cu on heating. The heating in the presence of O_2 gives Cu_2S and FeS with the evolution of SO_2.

45. Al has greater affinity for oxygen, hence oxide is not reduced by carbon. MgO and CaO (formed in the calcination from carbonates) are stable species and not reduced by carbon.

During Smelting $SnO_2 + C \xrightarrow{1300°C} Sn + CO$
$$2Fe_2O_3 + 3\,C \xrightarrow{\Delta} 4Fe + 3\,CO_2$$

46. The important ore of tin is cassiterite (SnO_2). Tin is extracted from cassiterite ore by carbon reduction method in a blast furnace.
$$SnO_2 + 2C \longrightarrow Sn + 2CO$$
The product often contain traces of iron which is removed by blowing air through the melt to oxidise to FeO which then floats to the surface.
$$2Fe + O_2 \longrightarrow 2FeO$$

47. Addition of manganese to iron improve hardness of steel as well as remove oxygen and sulphur.

48. Magnesium and aluminium are both highly electropositive, more electropositive than water cannot be obtained by electrolysis of aqueous solution of their salts.

49. Alumina (Al_2O_3) has very high melting point and it is poor conductor of electricity. Both these factors posses difficulty in electrolysis of molten alumina.

Cryolite, Na_3AlF_6, when mixed with alumina, lowers melting point as well as improve electrical conductivity, hence helps in electrolysis of Al_2O_3.

50. $Al(OH)_3$ is amphoteric

$$\underset{\text{Base}}{Al(OH)_3} + 3HCl \longrightarrow AlCl_3 + 3H_2O$$

$$\underset{\text{Acid}}{Al(OH)_3} + NaOH \longrightarrow Na[Al(OH)_4]$$

High charge and small size of Al^{3+} makes Al—O and O—H bonds equally ionisable.

51. $2CuFeS_2 + O_2 \longrightarrow Cu_2S + 2FeS + SO_2\uparrow$

$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2\uparrow$

$2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2\uparrow$

52. $FeO + SiO_2 \longrightarrow FeSiO_3$ (Slag)

53. $Cu_2S + 2Cu_2O \longrightarrow 6Cu + SO_2$

In Cu_2S, sulphur is S^{2-} and in SO_2, sulphur is in +4 state.

Hence, S^{2-} is acting as reducing agent.

54. Siderite $= FeCO_3$, Malachite $= CuCO_3 \cdot Cu(OH)_2$

Bauxite $= Al_2O_3 \cdot 2H_2O_2$ consisting some $Al(OH)_3$

Calamine $= ZnCO_3$, Argentite $= Ag_2S$

55. A. $3Cu + \underset{\text{Dil.}}{8HNO_3} \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

B. $Cu + \underset{\text{Conc.}}{4HNO_3} \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

C. $4Zn + \underset{\text{Dil.}}{10HNO_3} \longrightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$

D. $Zn + \underset{\text{Conc.}}{4HNO_3} \longrightarrow Zn(NO_3)_2 + 2NO_2 + 2H_2O$

56. A. $PbS \xrightarrow{O_2} PbO + SO_2$, roasting

B. $CaCO_3 \longrightarrow CaO + CO_2\uparrow$; calcination

C. $ZnS \longrightarrow Zn$, can be done by carbon reduction or self reduction

D. $Cu_2S \longrightarrow Cu$, roasting followed by self reduction

57.

	Extraction methods		**Metals extracted**
A.	Self reduction	r.	Copper, (P) Lead
B.	Carbon reduction	p.	Lead
C.	Complex formation and displacement by metal	q.	Silver : $Ag_2S + NaCN \longrightarrow Na[Ag(CN)_2]$ $Na[Ag(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + Ag$
D.	Decomposition of iodide	s.	Boron : $BI_3 \xrightarrow{\Delta} B + \frac{3}{2} I_2$

58.

Column *X*	**Column *Y***	**Column *Z***
Invar	Fe, Ni	Watch spring
Nichrome	Co, Ni	Heating element
Stainless steel	Fe, Cr, Ni	Cutlery

59.

	Column *X* (Metals)		**Column *Y*** (Ores)
A.	Al	q.	Cryolite
B.	Cu	r.	Malachite
C.	Mg	s.	Carnalite
D.	Zn	p.	Calamine

60. A. Silver is extracted by amalgamation process

$$Ag + Hg \longrightarrow \underset{\text{Amalgam}}{Ag(Hg)} \xrightarrow{\text{Distillation}} Ag(s) + Hg(v)\uparrow$$

B. Calcium is extracted by electrolysis of fused $CaCl_2$.

C. Zinc is extracted by carbon reduction method

$$ZnO + C \longrightarrow Zn + CO$$

D. Iron is extracted by both carbon reduction method and CO reduction methods

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

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

E. Copper is extracted by self reduction methods

$$Cu_2S + O_2 \longrightarrow Cu_2O + SO_2$$

$$Cu_2O + Cu_2S \longrightarrow Cu + SO_2$$

61. **H_2S** Ag_2S (black) is formed on the surface.

62. $ZnO + C \underset{\text{sintering}}{\xrightarrow{\Delta}} Zn + CO$ = Smelting

63. **Hydration energy** Energy required to break the crystal lattice during dissolving process comes from hydration. If lattice energy is very high and hydration energy is low, salt becomes sparingly soluble.

64. **Zn** Galvanisation involves coating of iron with zinc metal in order to prevent if from rusting.

65. **Sn** Cassiterite is an ore of tin.

66. **Al** Aluminium reduces Fe_2O_3 to Fe.

67. **Lime, calcium phosphate** In basic Bessemer process, the Bessemer converter is lined with lime but in acid Bessemer process, it is lined with silica. In basic Bessemer process, phosphorus is slagged off as calcium phosphate :

$$P_4 + 5O_2 \longrightarrow P_4O_{10}$$
$$6CaO + P_4O_{10} \longrightarrow \underset{\text{Thomas slag}}{2Ca_3(PO_4)_2}$$

68. $K[Ag(CN)_2]$: $AgCl + 2KCN \longrightarrow K[Ag(CN)_2] + KCl$

69. **True**: Cu^+ is unstable

$$2Cu^+ \xrightarrow{H^+} Cu^{2+} + Cu$$

70. **True** Complex ($Na[AgCl_2]$) formation increases solubility of otherwise sparingly soluble AgCl.

71. **True** Iron is more electropositive than hydrogen

$$Fe + 2HCl \longrightarrow FeCl_2 + H_2\uparrow$$

72. True : Solubility of silver halides decreases down in the group

Solubility : $AgF > AgCl > AgBr > AgI$

73. In crystalline state, $AlCl_3$ has rock-salt like structure with coordination number of Al = 6.

74. Four, the complex has formula $[Cu(H_2O)_4]SO_4 \cdot H_2O$

75. (a) $2AgBr + \underset{\substack{\text{Hydroquinone}\\\text{(developer)}}}{C_6H_4(OH)_2} \longrightarrow 2Ag + 2HBr + \underset{\text{Quinone}}{C_6H_4O_2}$

$$AgBr + 2Na_2S_2O_3 \longrightarrow Na_3[Ag(S_2O_3)_2] + NaBr$$

(b) $Na_2S_2O_3 + 2H^+ \longrightarrow 2Na^+ + H_2SO_3 + \underset{\substack{\text{Colloidal}\\\text{sulphur}}}{S\downarrow}$

76. A_1 is basic copper carbonate ($Cu(OH)_2 \cdot CuCO_3$) while A_2 is Cu_2S. The confirmatory reactions are :

(i) $CuCO_3 \cdot Cu(OH)_2 \xrightarrow{\Delta} \underset{\text{Black}}{CuO} + CO_2\uparrow + H_2O$

(ii) $CuCO_3 \cdot Cu(OH)_2 \xrightarrow{HCl} CuCl_2 + CO_2\uparrow + H_2O$

$$CuCl_2 \xrightarrow{KI} \underset{D}{Cu_2I_2\downarrow} + KCl + I_2$$

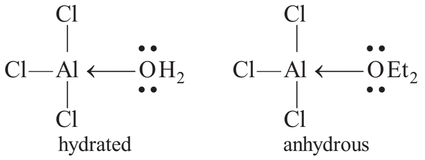
$$A_2 \xrightarrow{\text{Roasting}} Cu_2O + SO_2\uparrow$$

$$Cu_2S + Cu_2O \longrightarrow Cu + SO_2\uparrow$$

SO_2 is a reducing gas that gives green colour with acidified $K_2Cr_2O_7$ as

$$3SO_2 + K_2Cr_2O_7 + H_2SO_4 \longrightarrow K_2SO_4 + \underset{\text{Green}}{Cr_2(SO_4)_3} + 4H_2O$$

77. Anhydrous $AlCl_3$ is more soluble in diethyl ether as the oxygen atom of ether donate its lone-pair of electrons to the vacant orbital of Al in electron deficient $AlCl_3$. In case of hydrated $AlCl_3$, Al is not electron deficient as oxygen of water molecule has already donated its lone-pair of electrons to compensate electron deficiency of Al.



78. The reactions involved in the extraction of lead from galena (PbS) by self reduction are

$$2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$$
$$PbS + 2PbO \longrightarrow 3Pb + SO_2$$
$$PbS + 2O_2 \longrightarrow PbSO_4 \text{ (side reaction)}$$
$$PbSO_4 + PbS \longrightarrow 2Pb + 2SO_2$$

In litharge (PbO), the oxidation state of Pb is +2

79. The common photographic film is coated with AgBr and during developing of photographic film, the unreacted AgBr is removed by $Na_2S_2O_3$ as

$$AgBr + 2Na_2S_2O_3 \longrightarrow Na_3[Ag(S_2O_3)_2] + NaBr$$

80. $4NaCN + Ag_2S \longrightarrow 2Na[Ag(CN)_2] + Na_2S$

$$2Na[Ag(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + 2Ag$$

81. $2Cu + H_2O + CO_2 + O_2 \longrightarrow \underset{\substack{\text{Green}\\\text{(basic copper carbonate)}}}{Cu(OH)_2 \cdot CuCO_3}$

82. $C + O_2 \xrightarrow{2000°C} CO$

$$3CO + Fe_2O_3 \longrightarrow 2Fe + 3CO_2$$
$$CaCO_3 \longrightarrow CaO + CO_2$$
$$CaO + SiO_2 \longrightarrow \underset{\text{Slag}}{CaSiO_3}$$

83. $Al + NaOH \xrightarrow{H_2O} NaAlO_2 + \frac{3}{2}H_2$

84. $4KCN + Ag_2S \longrightarrow \underset{\substack{\text{Potassium}\\\text{dicyanoargentate (I)}}}{2K[Ag(CN)_2]} + K_2S$

85. Due to formation of protective, inert layer of Al_2O_3 on surface.

86. $Sn + 2KOH + 4H_2O \longrightarrow K_2[Sn(OH)_6] + 2H_2$

87. Sea water (contain $MgCl_2$) + $Ca(OH)_2$

$$\longrightarrow Mg(OH)_2\downarrow + CaCl_2(aq)$$

(i) $Mg(OH)_2 + 2HCl \longrightarrow MgCl_2 + 2H_2O$

$$\xrightarrow[\text{Dryness}]{\text{Heat to}} MgCl_2(s)$$

(ii) $MgCl_2(s) \xrightarrow[\text{NaCl}]{\text{Fusion}} Mg^{2+} + 2Cl^- \xrightarrow{\text{electrolysis}} Mg$

(At cathode)

88. $7Cu + 20HNO_3 \longrightarrow 7Cu(NO_3)_2 + 4NO + 2NO_2 + 10H_2O$

89.

$$\left.\begin{aligned}\underset{\text{Copper pyrite}}{2CuFeS_2} + O_2 &\longrightarrow Cu_2S + 2FeS + SO_2\\ 2Cu_2S + 3O_2 &\longrightarrow 2Cu_2O + 2SO_2\\ 2FeS + 3O_2 &\longrightarrow 2FeO + 2SO_2\\ FeS + \underset{\text{Flux}}{SiO_2} &\longrightarrow \underset{\text{Slag}}{FeSiO_3}\end{aligned}\right\}\text{Roasting}$$

$$2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2 \qquad \text{Bessemerisation}$$

90.

$$\begin{aligned}Ag_2S + 2NaCN &\longrightarrow 2AgCN + Na_2S\\ AgCN + NaCN &\longrightarrow Na[Ag(CN)_2]\\ 2Na[Ag(CN)_2] + Zn &\longrightarrow Na_2[Zn(CN)_4] + 2Ag\end{aligned}$$

91. (i) Carbon monoxide :

$$\begin{aligned}C + O_2 &\longrightarrow CO\\ CO + Fe_2O_3 &\longrightarrow CO_2 + Fe\end{aligned}$$

(ii)

$$\begin{aligned}2PbS + 3O_2 &\longrightarrow 2PbO + 2SO_2\\ 2PbO + PbS &\longrightarrow 3Pb + SO_2\end{aligned}$$

(iii) To improve electrical conductivity of melt.

(iv) A metal which is much more electropositive than Ag can only replace Ag^+ completely from $[Ag(CN)_2]^-$ as

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

(v) Chalcocite is a sulphide ore of copper, during roasting, SO_2 is liberated, which is not possible in calcination.

92. $2Au + 3HNO_3 + 11HCl \longrightarrow 2HAuCl_4 + 6H_2O + 3NOCl$

93. (i) If the metal is moderately electropositive, e.g. Fe, Sn, Pb or Cu, they can be obtained from their ore by chemical reduction methods.

However, if the metal is highly electropositive, e.g. Al, Mg etc., no reducing agent exist for reduction of their ions (Al^{3+}, Mg^{2+}) and they are obtained by electrolytic reduction of their molten salt.

(ii) Metals like Ge is required in high purity, can be readily melted and can easily crystallise out from the melt form.

94. AgBr is sensitive to visible light.

$$AgBr \xrightarrow{h\nu} Ag + \frac{1}{2}Br_2$$

A photographic plate coated with AgBr, when exposed to light, gets blackened due to the above reaction.

95. $Al + NaOH(aq) \longrightarrow NaAlO_2 + H_2$

$$NaAlO_2 + CO_2(aq) \longrightarrow Na_2CO_3 + Al(OH)_3\downarrow$$

$$Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + H_2O$$

96. In the first step, galena is heated in presence of O_2 (limited quantity) in a reverberatory furnace, where PbS is partially oxidised to PbO :

$$PbS + \frac{3}{2}O_2 \longrightarrow PbO + SO_2$$

In the second step, more PbS is added and heated in absence of O_2, where the following self reduction takes place

$$PbS + 2PbO \longrightarrow 3Pb + SO_2$$

97. $SnO_2 + 2C \longrightarrow Sn + 2CO(g)$, Carbon reduction method.