CHAPTER

06

General Principles and Processes of Isolation of Elements

A Quick Recapitulation of the Chapter

1. **Minerals** are the naturally occurring chemical substances of metals present in the earth's crust.
2. **Ores** are the minerals from which a metal can be extracted profitably and conveniently.

Some Important Ores		
Cu	Copper pyrites	$CuFeS_2$
	Copper glance	Cu_2S
	Cuprite	Cu_2O
	Malachite	$CuCO_3 \cdot Cu(OH)_2$
	Malachite azurite	$2CuCO_3 \cdot Cu(OH)_2$
Fe	Haematite	Fe_2O_3
	Limonite	$Fe_2O_3 \cdot 3H_2O$
	Magnetite	Fe_3O_4
	Iron pyrite (Fool's gold)	FeS_2
	siderite	$FeCO_3$
Hg	Cinnabar	HgS
Zn	Zinc blende	ZnS
	Zincite or zinc red	ZnO
	Calamine (smithsonite)	$ZnCO_3$
Al	Bauxite	$Al_2O_3 \cdot xH_2O$
	Cryolite	Na_3AlF_6

3. The non-metallic impurities like sand, clay, quartz etc., associated with an ore are called **gangue** or **matrix**.
4. **Metallurgy** is the complete process of extraction of a pure metal from its ore. It involves various steps: concentration, roasting/calcination, reduction, refining etc.
5. Cryolite or flourspar reduce the melting point of alumina and increase its conductivity during the extraction of aluminium metal.
6. Method used for concentration or specification of ore

Method	Ores specification
Gravity separation (tabling) by hydraulic washing	Based on the difference in the specific gravities of the ore and gangue.
Magnetic separation	Based on the difference in magnetic properties of minerals. If the ore but not the gangue is attracted by a magnetic field, it can be concentrated to yield a sample which is rich in metal. Magnetite (Fe_3O_4), haematite (Fe_2O_3), wolframite ($FeWO_4$), chromite ($FeO \cdot Cr_2O_3$) and ilmenite ($FeO \cdot TiO_2$) separated from non-magnetic impurities.
Froth floatation process	Used to concentrate sulphide ores based on the difference in wettability of different minerals.
Leaching	The ore is made soluble in a suitable solvent leaving the insoluble gangue particles behind. Pure Al_2O_3 is obtained from the bauxite ore in the Baeyer's process by leaching, also employed in concentration of silver and gold ores, when leaching is done using NaCN in the presence of air.

7. **Roasting** is the process of heating of ore in excess of air below its melting point, so that the ore gets converted into oxide or sulphate. It is generally used for sulphide ores and is carried out in reverberatory furnace.

8. **Calcination** is the process of heating of ore in absence or limited supply of air below its melting point, to convert it into oxides. It is done in case of hydroxide or carbonate ore. It is also carried out in reverberatory furnace.
9. Oxides are reduced by using some reducing agent like C or CO (Smelting).
10. For the reduction of a metal oxide with a reducing agent, the plot of ΔG° (Gibbs free energy) against temperature is studied which is called **Ellingham diagram**.
11. If reactants and products of two reactions (i.e. reduction of metal oxide and oxidation of reducing agent) are put together and the net ΔG° of reactions is negative (–ve), the overall reaction will occur.
12. **Pyrometallurgy** is the process of reducing a metal oxide with some suitable reducing agent upon heating. If carbon is used as reducing agent, the process is called **smelting**.
13. **Hydrometallurgy** involves the isolation of metal present in the soluble complex by a more reactive metal.
14. **Flux** is an additional substance added to ore during reduction in order to remove impurities (gangue). It combines with the impurities to form molten slag.
15. Low grade copper ores are leached by using acid or bacteria.
16. Different methods used for refining of crude metal

Method	Metals purified
Distillation	Zinc and mercury.
Electrolysis	Copper, gold, silver, lead, zinc, aluminium. Impure metal is made of anode and the pure metal is made of cathode.
Zone refining	Metals of high purity are obtained. Silicon, germanium, boron, gallium, indium (which are used in semiconductors) are purified by this method. It is based on the fact that impurities are more soluble in the melting state than in the pure metal state.
Vapour phase refining	In Mond's process for the refining of nickel, $\underset{\text{Impure}}{Ni} + 4CO \xrightarrow{80^\circ C} Ni(CO)_4$ $\xrightarrow{200^\circ C} \underset{\text{Pure}}{Ni} + 4CO\uparrow$ In van-Arkel method for zirconium, $\underset{\text{Impure}}{Zr} + 2I_2 \xrightarrow{600^\circ C} ZrI_4 \xrightarrow{1800^\circ C} \underset{\text{Pure}}{Zr} + 2I_2$
Chromatography	based on adsorption.

17. Impure iron, pig iron contains Mn, Si, P, S, C etc., as impurities which are oxidised by the process of oxidative refining to form purest **wrought iron**.

Objective Questions Based on NCERT Text

Topic 1
Introduction

1. Which of the following elements occur in free state?
(a) Iodine
(b) Sulphur
(c) Phosphorus
(d) Magnesium

2. The earthly or undesired materials associated with an ore are called
(a) gangue
(b) mineral
(c) matrix
(d) Both (a) and (c)

3. The extraction and isolation of metals from ores involve the following steps:
I. Concentration of the ore.
II. Refining of metals.
III. Reduction of concentrated ore.
IV. Grinding of ore.
The option with correct sequence from the above steps will be
(a) I → II → III → IV (b) IV → II → III → I
(c) IV→ III → II → I (d) IV → I → III → II

4. The most abundant metal in the earth's crust is
(a) calcium (b) aluminium (c) iron (d) magnesium

5. Oxidation states of the metal in the minerals haematite and magnetite, respectively, are
(CBSE AIPMT 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

6. Most abundant element in the earth's crust by weight is
(a) oxygen (b) silicon
(c) aluminium (d) iron

7. Consider the following facts regarding different ores and choose the correct option.
(a) For the purpose of extraction, bauxite is chosen for Al
(b) Zinc blende or sphalerite is the same ore of zinc
(c) The chemical composition of copper pyrites is $CuFeS_2$
(d) All of the above

8. Which one of the following is a mineral of iron?
(CBSE AIPMT 2012)
(a) Malachite (b) Cassiterite
(c) Pyrolusite (d) Magnetite

Topic 2
Concentration of Ores

9. Gravity separation method is based upon
(a) difference in densities of ore particles and impurities
(b) difference in chemical properties of the particles and impurities
(c) preferential washing of ores and gangue particles
(d) None of the above

10. In a process of concentration of ore, an upward stream of running water is used to wash the powdered ore. The lighter gangue particles are washed away and the heavier ores are left behind. Which method of concentration of ore is discussed in the above passage?
(a) Hydraulic washing (b) Leaching
(c) Magnetic separation (d) Both (a) and (b)

11. The incorrect statement about magnetic separation method,
(a) it is used when ore is magnetic but impurities are not
(b) it is used when gangue are magnetic but ore is not
(c) wolframite is separated from cassiterite by this method
(d) iron ores are concentrated by only this process

12. Froth floatation method is based on the
(a) difference is the relative densities of matrix and ore particles
(b) difference in the solubility of matrix and ore in frothing agent and water
(c) differences in the wetting properties of matrix and ores in frothing agent and water
(d) difference in the reactivity of matrix and ore particles with frothing agent and water

13. In froth floatation method, the role of collectors is
(a) to enhance non-wettability of the mineral particles
(b) to enhance wettability of the mineral particles
(c) to stabilise the froth
(d) Both (a) and (c)

14. An ore contains lead sulphide and zinc sulphide. If froth floatation process is used, these can be separated
(a) by using excess of pine oil
(b) by using collection and froth stabilisers
(c) by adjusting proportion of oil to water
(d) by using some suitable solvent in which either lead sulphide or zinc sulphide is soluble.

15. Which of the following ore is concentrated by froth floatation process?
(a) Haematite (b) Carnalite (c) Sphalerite (d) Calamine

16. Froth floatation process for the concentration of ores is an illustration of the practical application of
(a) absorption (b) adsorption
(c) sedimentation (d) coagulation

17. If ore is soluble in some suitable solvent but impurities are not, then the most suitable method of concentration of ore is
(a) leaching (b) froth floatation method
(c) hydraulic washing (d) None of these

18. Complete the following equation,
$Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \longrightarrow \ldots A \ldots$
Here, A refers to
(a) $2Na[Al(OH)_4]\,(aq)$ (b) $Na_2[Al(OH)_4]$
(c) Al_2O_3 (d) $Al_2O_3 \cdot xH_2O$

19. A metal M is extracted based on the following equation,
$4M + 8CN^- + 2H_2O + O_2 \longrightarrow 4[M(CN)_2]^- + 4OH^-$
$2[M(CN)_2]^- + Zn \longrightarrow [Zn(CN)_4]^{2-} + 2M$
Identify M
(a) Au (b) Hg
(c) Cu (d) Ni

Topic 3
Extraction of Crude Metal from Concentrated Ore

20. The concentrated ore are generally converted into oxides because
(a) oxides are generally unstable
(b) oxides generally have high melting point
(c) oxides are easier to reduce
(d) All of the above

21. Which of the following equations represents calcination?
(a) $2Zn + O_2 \longrightarrow 2ZnO$
(b) $MgCO_3 \longrightarrow MgO + CO_2\uparrow$
(c) $2Ag + 2HCl + [O] \longrightarrow 2AgCl + H_2O$
(d) $2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2\uparrow$

22. Some reactions are given below,
I. $\ldots A \ldots \longrightarrow Fe_2O_3(s) + xH_2O(g)$
II. $ZnCO_3(s) \longrightarrow ZnO(s) + \ldots B \ldots$
III. $CaCO_3 \cdot MgCO_3(s) \longrightarrow \ldots C \ldots + \ldots D \ldots + 2CO_2(g)$
In these reactions, *A, B, C* and *D* corresponding to
(a) $A \rightarrow Fe_2O_3(s); B \rightarrow CO_2(g); C \rightarrow ZnO(s); D \rightarrow MgO(s)$
(b) $A \rightarrow Fe_2O_3 \cdot xH_2O(s); B \rightarrow ZnO(s); C \rightarrow CO_2(g);$ $D \rightarrow MgO(g)$
(c) $A \rightarrow Fe_2O_3 \cdot xH_2O(s); B \rightarrow CO_2(s); C \rightarrow CaO(g);$ $D \rightarrow MgO(g)$
(d) $A \rightarrow Fe_2O_3 \cdot xH_2O(s); B \rightarrow CO_2(g); C \rightarrow CaO(s);$ $D \rightarrow MgO(s)$

23. Sulphide ores are common for the metals **(JEE Main 2014)**
(a) Ag, Cu and Pb (b) Ag, Cu and Sn
(c) Ag, Mg and Pb (d) Al, Cu and Pb

24. The true statement about roasting process is
(a) impurities are removed as their volatile oxide
(b) ore is converted into its oxide
(c) processes like oxidation, chlorination etc, takes place
(d) All of the above

25. The process which involves smelting is
(a) $Fe_2O_3 + 3C \xrightarrow{\text{Heat}} 2Fe + 3CO$
(b) $2PbS + 3O_2 \xrightarrow{\text{Heat}} 2PbO + 2SO_2$
(c) $Al_2O_3 \cdot 2H_2O \xrightarrow{\text{Heat}} Al_2O_3 + 2H_2O$
(d) $ZnCO_3 \xrightarrow{\text{Heat}} ZnO + CO_2$

26. Roasting of sulphides gives the gas *X* as a by-product. This is a colourless gas with choking smell of burnt sulphur and causes great damage to respiratory organs as a result of acid rain.
Its aqueous solution is acidic acts as a reducing agent and its acid has never been isolated. The gas *X* is **(CBSE AIPMT 2013)**
(a) H_2S (b) SO_2
(c) CO_2 (d) SO_3

Topic 4
Principles of Metallurgy (Thermodynamic and Electrochemical)

27. An example of auto-reduction is
(a) $Cu_2O + C \longrightarrow 2Cu + CO$
(b) $Cu^{2+}(aq) + Fe(s) \longrightarrow Cu(s) + Fe^{2+}(aq)$
(c) $Cu_2O + \frac{1}{2}Cu_2S \longrightarrow 3Cu + \frac{1}{2}SO_2$
(d) $Fe_3O_4 + 4CO \longrightarrow 3Fe + 4CO_2$

28. The change in Gibbs energy, ΔG for any process at any specified temperature, is expressed as
(a) $\Delta G = \Delta H \cdot T\Delta S$ (b) $\Delta G = \Delta H - T\Delta S$
(c) $\Delta G = \Delta H + T\Delta S$ (d) $\Delta G = \frac{\Delta H}{T\Delta S}$

29. A reaction process towards products, if
(a) $\Delta G > 1$ and $k > 1$ (b) $\Delta G < 1$ and $k > 1$
(c) $\Delta G > 1$ and $k < 1$ (d) $\Delta G < 1$ and $k < 1$

30. Ellingham diagram is infact the plots of
(a) ΔG *vs* pressure (b) ΔG *vs* temperature
(c) $(\Delta G - T\Delta S)$ *vs* temperature (d) ΔH *vs* temperature

31. For a reaction to proceed
(a) ΔG should be negative
(b) ΔS must be less than zero
(c) ΔH must be less than zero
(d) ΔH must zero and ΔS must be less than zero

32. Carbon and hydrogen although are good reductant but they cannot be used to reduce metal oxides at higher temperature because
(a) of their vaporisation at high temperature
(b) of the formation of carbides and hydrides respectively
(c) of the formation of solid by products during the reaction
(d) such a high temperature is unbearable for them

33. The ΔG° is negative for the reduction of Cr_2O_3 with Al but the reaction does not take place at room temperature because
(a) the net value of ΔG° becomes positive
(b) the orientation of molecules of Al and Cr_2O_3 is not process
(c) certain amount of activation energy is required to start the reaction
(d) melting point of Cr_2O_2 is very high so no reaction take place

34. If a metal is to be extracted from its ore and suppose the gangue associated with the ore is silica, then
(a) a basic flux is required
(b) an acidic flux is required
(c) Both (a) and (b)
(d) None of the above

35. Which of the following reactions is not occurring in blast furnace during the extraction of iron in the temperature range 500-800 K?
(a) $FeO + CO \longrightarrow Fe + CO_2$
(b) $3Fe_2O_3 + CO \longrightarrow 2\,Fe_3O_4 + 4CO_2$
(c) $Fe_3O_4 + 4CO \longrightarrow 3\,Fe + 4CO_2$
(d) $Fe_2O_3 + CO \longrightarrow 2\,FeO + CO_2$

36. The reducing agent used to reduce iron oxide in blast furnace is
(a) silica (b) CO
(c) C (d) dimension

37. Which of the following elements is present as the impurity to the maximum extent in the pig iron?
(CBSE AIPMT 2011)
(a) Carbon (b) Silicon
(c) Phosphorus (d) Manganese

38. Which among the following is the purest form of commercial iron?
(a) Wrought iron (b) Malleable iron
(c) Pig iron (d) Cast iron

39. The chemical process in the production of steel from haematite ore involves
(a) oxidation
(b) reduction
(c) oxidation followed by reduction
(d) reduction followed by oxidation

40. In the Hall-Heroult process of reduction of Al
(a) Steel anode and graphite cathode are used
(b) The liberated oxygen reacts with carbon to form CO and CO_2
(c) For the production of 1 kg of Al, 1 kg of carbon is burnt away
(d) All of the above

41. Silica is added to the copper pyrites ore, when taken in reverberatory furnace for extraction of Cu. This is because
(a) it removes the impurity of iron as slag
(b) it reacts with Cu_2O to form slag
(c) it reduce Cu_2O to Cu
(d) it helpes in separation of Cu from Fe

42. Blister copper obtained during the extraction of copper is so called because
(a) its surface is shining like blister
(b) it is the most impure form of copper
(c) it has blisters on its surface because of the evolution of SO_2 gas
(d) its surface 31, due to different thickness at different places

43. The correct statement related to reduction of zinc oxide to zinc is
(a) it is done by using CO
(b) the temperature required in case of Zn is higher than that required in case of Cu
(c) For heating ZnO is made into briquette with CO
(d) All of the above

44. The metal that cannot be obtained by electrolysis of an aqueous solution of its salts is **(JEE Main 2014)**
(a) Ag (b) Ca
(c) Cu (d) Cr

45. Cryolite is
(a) Na_3AlF_6 and is used in the electrolysis of alumina
(b) Na_3AlF_6 and is used in the electrolytic purification of alumina
(c) Na_3AlF_6 and is used in the electrolysis of alumina for lowering electrical conductivity
(d) Na_3AlF_6 and is used in the electrolysis of alumina for lowering the melting point of alumina

46. In the context of the Hall-Heroult process for the extraction of Al, which of the following statements is false? **(JEE Main 2015)**
(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) $Na_3\ AlF_6$ serves as the electrolyte

47. In the cyanide extraction process of silver from argentite ore, the oxidising and reducing agents used are **(JEE Main 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

48. The process of bringing the metal or its ore into solution by the action of a suitable chemical reagent followed by extraction of the metal either by electrolysis or by a suitable precipitating agent is known as

(a) zone refining (b) electrometallurgy
(c) electrorefining (d) hydrometallurgy

49. In the extraction of copper from its sulphide ore, the metal finally obtained by the reduction of cuprous oxide with **(CBSE AIPMT 2012)**

(a) copper (I) sulphide (Cu_2S)
(b) sulphur dioxide (SO_2)
(c) iron sulphide (FeS)
(d) carbon monoxide (CO)

Topic 5
Refining

50. Which of the following is not used for refining of metals?

(a) Liquation (b) Chromatographic methods
(c) Distillation (d) Leaching

51. In electrolytic refining method

(a) the impure metal is made to act as anode
(b) a strip of the pure metal is used as cathode
(c) they are kept in a suitable electrolytic both containing soluble salt of the same metal
(d) All the above are true

52. In the electrolytic refining of Cu, the cathode, anode and the electrolyte are

(a) impure Cu–cathode, pure Cu–anode, acidified $CuSO_4$ solution electrolyte
(b) pure Cu–cathode, impure Cu–anode, acidified $CuSO_4$ solution electrolyte
(c) impure Cu–cathode, pure Cu–anode, $CuCl_2$–electrolyte
(d) pure Cu–cathode, impure Cu–anode, $CuCl_2$–electrolyte

53. Zone refining method of the metals is based on the principle that the

(a) impurities are more soluble in the melt than in the solid state of the metal
(b) impurities are less soluble in the melt than in the solid state of the metal
(c) metal should be volatile
(d) Both (a) and (c)

54. Zone refining method is very useful for producing

(a) semiconductors (b) metals of very high purity
(c) germanium (d) All of these

55. Which of the following steps is/are involved in vapour phase refining?

(a) The metal is converted into its volatile compound and collected else
(b) It is then decomposed to give pure metal
(c) Both (a) and (b)
(d) None of the above

56. Nickel is purified by thermal decomposition of its

(a) chloride (b) azide (c) carbonyl (d) hydride

57. $\underset{\text{Impure}}{Ni} + 4CO \xrightarrow{330\text{-}350\ K} Ni(CO)_4$

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

The above reactions are of the purification of Ni by

(a) Mond's process (b) van-Arkel method
(c) Hall-Heroult process (d) None of these

58. Which of the following pairs of metals is purified by van-Arkel method? **(CBSE AIPMT 2011)**

(a) Zr and Ti (b) Ag and Au
(c) Ni and Fe (d) Ga and In

59. The process of purification is represented by the following equation,

$$\underset{\text{Impure}}{Ti} + 2I_2 \xrightarrow{250^\circ C} TiI_4 \xrightarrow{1400^\circ C} \underset{\text{Pure}}{Ti} + 2I_2$$

Correct name of the process is

(a) van-Arkel (b) Poling
(c) zone refining (d) cupellation

60. Aluminium is extracted from alumina (Al_2O_3) by electrolysis of a molten mixiture of **(CBSE AIPMT 2012)**

(a) $Al_2O_3 + HF + NaAlF_4$ (b) $Al_2O_3 + CaF_2 + NaAlF_4$
(c) $Al_2O_3 + Na_3AlF_6 + CaF_2$ (d) $Al_2O_3 + KF + Na_3AlF_6$

61. Chromatographic method is based on the principle that

(a) different components of a mixture are differently adsorbed on an adsorbent
(b) same components of a mixture are differently adsorbed on an adsorbent
(c) different components of a mixture are differently absorbed on an absorbent
(d) None of the above

62. Which of the following technique is used to purify the impurities that are not very different in chemical properties of element?
(a) Gas chromatography
(b) Column chromatography
(c) TLC
(d) HPLC

63. A mixture of components X, Y and Z is passed through the column of Al_2O_3. On adding eluent, compound X is eluted first and Z at the end. The correct order of adsorption of components is
(a) $Z > Y > X$ (b) $X > Y > Z$
(c) $Y > X > Z$ (d) $Y > Z > X$

Topic 6
Uses of Aluminium, Copper, Zinc and Iron

64. Which of the following metal is used making wires, used in electrical industry and water and steam pipes.
(a) Copper (b) Nickel
(c) Tungsten (d) Silicon

65. Usually copper is added to gold and silver to be used in jewellery to
(a) increase the hardness
(b) increase malleability
(c) increase the shine
(d) lower the cost

66. Which of the following is used for galvanising iron?
(a) Aluminium (b) Copper
(c) Zinc (d) Nickel

67. Some special characteristics of metal A are given below.
I. The most important form of iron, used for casting stoves, railway sleepers, gutter pipes, toys etc.
II. It also used in making of wrought iron and steel.
On the basis of the above information, identify A.
(a) Iron (b) Cast iron
(c) Steel (d) None of these

68. Stainless steel is rust proof because
(a) an oxide layer of chromium protects it
(b) a stoichiometric compound is formed
(c) interstitial compound is formed between Cr and Fe
(d) galvanisation of iron takes place

Special Format Questions

I. More Than One Correct Option

69. The correct statements among the following are
(a) oxide ores of iron are more abundant
(b) aluminium is the major component of many igneous minerals like mica and clay
(c) aluminium is the most abundant element in the earth's crust
(d) siderite is an ore of copper

70. The examples of oxide ores are
(a) copper glance (b) sphalerite
(c) zincite (d) cuprite

71. The froth stabilisers among the following are
(a) pine oil (b) cresol
(c) aniline (d) benzene

72. The ores that can be concentrated by froth floatation method are
(a) copper pyrites (b) zinc blende
(c) pyrolusite (d) siderite

73. Which of the following statement is are correct regarding concentration of ores?
(a) Methods for the concentration of ores depends on the differences in physical properties of a compound
(b) Froth floatation method is used for removing gangue from sulphide ores
(c) Collectors are pine oils, fatty acids, xanthates etc
(d) To separate two sulphide ores, depressants are used

74. The correct statements among the following are
(a) the principal ore of aluminium is bauxite
(b) the aluminate in solution is neutralised by passing CO_2 gas and hydrated Al_2O_3 is precipitated
(c) impurities present in bauxite are SiO_2 and TiO_2
(d) sodium silicate remain intact with hydrated alumina

75. The ores that are concentrated by leaching process are
(a) cuprite (b) argentite
(c) bauxite (d) haematite

76. The main requirements for roasting process in
(a) the ore is heated in a regular supply of air
(b) the sulphide ores of copper are heated in reverberatory furnace
(c) $2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$ is a reaction that involves roasting process
(d) Mg, Al and Zn oxides can be reduced by roasting process

77. The correct statements regarding Ellingham's diagram are
(a) below 710°C, CO is a more effective reducing agent than carbon
(b) a metal can reduce the oxide of only those metal which lies above it in the Ellingham diagram
(c) metal oxides have less negative value of ΔG° as compared to CO_2 hence, oxidation of metal sulphides to oxides is not favourable
(d) it gives a clear explanation of need for the conversion of metal sulphide to corresponding oxides before reduction

78. The processes involve in the extraction of aluminium metal are
(a) Hall's process (b) Hoopes' process
(c) Baeyer's process (d) Bett's process

79. Auto-reduction is involved in the extraction of
(a) copper (b) mercury
(c) lead (d) aluminium

80. Metal that are extracted by electrolytic reduction are
(a) copper (b) aluminium
(c) magnesium (d) silver

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

82. The main requirements for vapour phase refining are
(a) metal should form volatile compound with the suitable reagent
(b) metal should be highly reactive
(c) metal should form stable compound with suitable reagent
(d) volatile compound should be easily decomposable to give back pure metal

83. Which of the following statements are correct?
(a) Mercury can be transported in iron containers
(b) Zone refining method is used to obtain highly pure metals
(c) Distillation or liquation can be used to refine silver
(d) In reverberatory furnace, both oxidation and reduction can be carried out

II. Statement Based Questions Type I

■ **Directions** (Q. Nos. 84-89) *In the following questions, a Statement* I *is followed by a corresponding Statement* II *of the following Statements, choose the correct one.*
(a) Statement I and Statement II are correct and Statement II is the correct explanation of Statement I.
(b) Statement I and statement II are correct but, Statement II is not the correct explanation of Statement I.
(c) Statement I is correct but, Statement II is incorrect.
(d) Statement II is correct but, Statement I is incorrect.

84. **Statement I** Nitrate ores are very rare.
Statement II Bond dissociation energy of N_2 is very high.

85. **Statement I** Reduction of the metal oxide usually involves heating it with some other substance acting as a reducing agent.
Statement II The reducing agent combines with the oxygen of the metal oxide.

86. **Statement I** At temperature above 1073 K (approx.) the C, CO line comes below the Fe, FeO line $[\Delta G_{(C, CO)} < \Delta G_{(Fe, FeO)}]$.
Statement II In this range, coke will reduce the FeO and itself get oxidised to CO.

87. **Statement I** In the equation, $\Delta G^\circ = -nFE^\circ$, E° is the electrode potential of the redox couple formed in the system.
Statement II More reactive metals have large negative values of the electrode potential.

88. **Statement I** Cu is leached out using acid or bacteria.
Statement II The solution containing Cu^{2+} is treated with scrap iron or H_2.

89. **Statement I** Distillation is very useful for low boiling metals like Zn and Hg.
Statement II In liquation, a low melting metal like tin can be made to flow on a sloping surface in order to separate it from higher melting impurities.

III. Statement Based Questions Type II

90. Commonly used collectors in froth floatation method are
I. pine oil II. coconut oil
III. fatty acids IV. xanthates
Choose the most suitable set containing option from the choices given below.
(a) I, II, and III (b) II, III and IV
(c) I, III, and IV (d) I, II, and IV

91. Cosider the following statements, about extraction of copper.

I. The sulphide ores of Cu are heated in…*A*…furnace.

II. If the ore contains Fe, it is mixed with…*B*…before heating.

III. Iron oxide…*C*…as iron silicate and Cu is produced in the form of copper matte which contains Cu_2S and …*D*…

IV. $FeO + SiO_2 \longrightarrow \underset{\text{(Slag)}}{\ldots E \ldots}$

Fill up the missing words (*A*, *B*, *C*, *D* and *E*) from the following options.

(a) $A \rightarrow$ blast; $B \rightarrow$ iron silicate; $C \rightarrow$ produced; $D \rightarrow Fe_2S$; $E \rightarrow FeSiO_3$

(b) $A \rightarrow$ blast; $B \rightarrow$ silica; $C \rightarrow$ slags of ; $D \rightarrow FeSiO_3$ $E \rightarrow Fe_2S$

(c) $A \rightarrow$ reverberatory; $B \rightarrow$ silica; $C \rightarrow$ slags of ; $D \rightarrow$ FeS; $E \rightarrow FeSiO_3$

(d) $A \rightarrow$ reverberatory; $B \rightarrow$ silicate; $C \rightarrow$ produced; $D \rightarrow Fe_2S$; $E \rightarrow FeSiO_3$

92. The fluorspar (CaF_2) is added in small quantities in the electrolytic reduction of alumina dissolved in fused cryolite (Na_3AlF_6). The role of fluorspar is/are

I. to decrease the rate of oxidaton of carbon at anode.

II. to act as a catalyst.

III. to lower the temperature of the melt.

IV. to make the fused mixture very conducting.

Choose the correct statement(s).

(a) I and II (b) II and III

(c) I and IV (d) III and IV

93. In roasting

I. no metal impurities are removed.

II. ore becomes porous.

III. moisture is removed.

Which of the above facts are true about roasting?

(a) Both I and II (b) Both II and III

(c) Both I and III (d) I, II and III

94. Which of the following statements are incorrect?

I. Zinc can be extracted by self-reduction.

II. A depressant prevents certain type of particle to come to the froth.

III. Copper matte contains ZnS and Cu_2S.

IV. The solidified copper obtained from reverberatory furnace has blistered appearance due to evolution of SO_2 during the extraction.

The option containing incorrect statements is

(a) Both I and II (b) Both II and III

(c) Both I and III (d) II and IV

95. Consider the following statements related to Ellingham diagram

I. It consists of plots of $\Delta_f G^\circ$ *vs* T for formation of oxides of elements.

$$2xM(s) + O_2(g) \longrightarrow 2M_xO(s)$$

II. Each plot is a straight line. No effect of change in phase.

III. In Ellingham diagram, the plots of ΔG° for oxidation of common metals and some reducing agents are given

IV. 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.

Which of these statements are correct?

(a) I, II and III (b) II, III and IV

(c) I, II and IV (d) I, III and IV

96. Which of the following statements about the advantage of roasting of sulphide ore before reduction are true?

I. ΔG_f° is negative for roasting sulphide ore to oxide.

II. ΔG_f° of the sulphide ore is greater than H_2S and CS_2.

III. Carbon and hydrogen are suitable reducing agents for metal sulphides.

IV. Roasting of the sulphide to oxide is thermodynamically feasible.

Choose the option with all true statements.

(a) I, II and III (b) II, III and IV

(c) I, III and IV (d) I, II and IV

97. In electrorefining of metal, the impure metal is made the anode and a strip of pure metal, the cathode during electrolysis of an aqueous solution of a complex metal. This method of refining is useful in case of refining of

I. Al II. Na III. Ag IV. Cu

Choose the correct option.

(a) I, II and III (b) II, III and IV

(c) I, III and IV (d) I, II, III and IV

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

I. Heating with I_2

II. Liquation

III. Distillation

IV. Heating with stream of CO

Choose the correct option.

(a) Both I and II (b) Both II and III

(c) Boh I and III (d) Both I and IV

99. The requirements for vapour phase refining method are

I. The metal should never form a volatile compound with an available reagent.

II. The volatile compound should be easily decomposable so that the recovery is easy.

Which of the above statements are the requirements of vapour phase refining methods?

(a) Only I
(b) Only II
(c) Both I and II
(d) None of the above

100. I. The mobile phase may be a gas, a liquid or a supercritical fluid.

II. The stationary phase is immobile and immiscible.

Which of the above two statements are correct regarding chromatography? Choose the correct option.

(a) Only I
(b) Only II
(c) Both I and II
(d) Neither I nor II

IV. Assertion-Reason Type Questions

■ **Directions** (Q. Nos. 101-107) *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 A and R are correct; R is the correct explanation of A.
(b) Both A and R are correct; R is not the correct explanation of A.
(c) A is correct; R is incorrect.
(d) R is correct; A is incorrect.

101. Assertion (A) A mineral is called ore, when metal is extracted from it conveniently and economically.

Reason (R) All ores are minerals but all minerals are not ores.

102. Assertion (A) Gold is isolated from other impurities by Arndt forest cyanide process.

Reason (R) The cyanide which is used here dissolve all possible impurities.

103. Assertion (A) In the metallurgy of Al, purified Al_2O_3 is mixed with Na_3AlF_6 or CaF_2.

Reason (R) It lowers the melting point of the mixture and brings conductivity.

104. Assertion (A) Iron pyrite is not useful in the extraction of Fe.

Reason (R) SO_2 polluting gas is produced during extraction.

105. Assertion (A) Usually the sulphide ore is converted to oxide before reduction.

Reason (R) Reduction of oxides occurs easier.

106. Assertion (A) While the extraction of copper, one of the steps involved is

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

Reason (R) In this reaction Cu_2S is the reducing agent whereas Cu_2O is the oxidising agent.

107. Assertion (A) In alumino thermite process, the metals like iron melts due to the heat evolved in the reaction.

Reason (R) The reaction like

$$Fe_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Fe$$

is highly exothermic in nature

V. Matching Type Questions

108. Match the terms of Column I with the items of Column II and choose the correct option from the codes given below.

	Column I (Ores)		**Column II** (Composition)
A.	Kaolinite	1.	Cu_2O
B.	Cuprite	2.	$[Al_2(OH)_4Si_2O_5]$
C.	Sphalerite	3.	$CuCO_3 \cdot Cu(OH)_2$
D.	Malachite	4.	ZnS

Codes

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

109. Match the terms of Column I with the items of Column II and choose the correct option from the codes given below.

	Column I (Metal)		**Column II** (Ores)
A.	Al	1.	Malachite
B.	Fe	2.	Calamine
C.	Cu	3.	Siderite
D.	Zn	4.	Bauxite

Codes

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

110. Match the Column I with Column II and choose the correct option from the codes give below.

	Column I (Ore)		Column II (Concentration method)
A.	Bauxite	1.	Froth floatation method
B.	Haematite	2.	Magnetic separation
C.	Copper pyrites	3.	hydraulic washing
D.	Cassiterite	4.	Leaching

Codes

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

111. Match the Column I with Column II and choose the correct option from the codes given below.

	Column I		Column II
A.	Calamine	1.	Sulphide of Cu and Fe
B.	Copper matte	2.	Leaching
C.	Silver	3.	Calcination
D.	Cu_2S	4.	Roasting

Codes

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

VI. Matrix Matching Type Questions

112. Match the ores given in Column I with their composition given in Column II.

	Column I		Column II
A.	Malachite	p.	Sulphide ore
B.	Azurite	q.	Carbonate ore
C.	Chalcopyrites	r.	Oxide ore
D.	Copper glance	s.	Roasting

Codes

	A	B	C	D
(a)	s	p	q	q,s
(b)	p,q	q	p,q	s
(c)	q	q	p,s	p,s
(d)	s	r	s	p

113. Match the follwoing columns.

	Column I		Column II
A.	Iron pyrites	p.	FeS_2
B.	Fools's gold	q.	Sulphide ore
C.	Galena	r.	Fe_2O_3
D.	Haematite	s.	Froth floatation process

Codes

	A	B	C	D		A	B	C	D
(a)	r	p,q	r,s	r,p	(b)	p,q,s	p,q,s	q,s	r
(c)	p,q,r	p,q	r,s	s	(d)	p,q,r	q,r	r,s	p,q

114. Match the following columns.

	Column I		Column II
A.	Magnetite	p.	Ore of Mg
B.	Dolomite	q.	Ore of Al
C.	Corundum	r.	Oxide ore
D.	Bauxite	s.	Carbonate ore

Codes

	A	B	C	D		A	B	C	D
(a)	p,r	p,s	p,q	p,r	(b)	q,r	p,r	p,s	p,r
(c)	p,s	p,s	q,r	q,r	(d)	p	q,r	s	p,s

115. Match the metals given in Column I with the relative procedure of extraction given in Column II

	Column I		Column II
A.	Iron	p.	Reduction by carbon
B.	lead	q.	Auto-reduction
C.	Copper	r.	Reduction by Al
D.	Chromium	s.	Hydrometallurgical process

Codes

	A	B	C	D		A	B	C	D
(a)	p	p,q	q,s	r	(b)	q,p	q,r	s	p
(c)	p	q,r	r	s,p	(d)	s	p,r	q	r,p

116. Match the metals given in Column I with the processes used in their refining, given in column II.

	Column I		Column II
A.	Nickel	p.	Mond's process
B.	Titanium	q.	van-Arkel method
C.	Zirconium	r.	Distillation
D.	Zinc	s.	Involve pyrometallury

Codes

	A	B	C	D		A	B	C	D
(a)	r	q	p,q	r	(b)	p	q	p,r	s
(c)	q	p	q	r,s	(d)	p	q	q	r,s

VIII. Passage Based Questions

■ **Directions** (Q. Nos. 117-119) *Study the following, passage and answer the questions on the basis of the passage.*

Froth floatation method is used for the concentration of sulphide ores and depends upon the non-wettability of mineral particles in water. In this process, a suspension of the powdered ore is made with water and it is agitated by using paddle and air is passed. Consequently, froth is formed, ore particles goes with froth. Sometime two sulphide ore may also be present together. Froth floatation method is also helpful in their separation.

117. Select the correct statement?

(a) Argentite ore is concentrated by froth floatation method
(b) Aniline increases the non-wettability of ore in oil
(c) Xanthates increases the non-wettability of ore in water
(d) Fatty acids increases the non-wettability of ore in oil

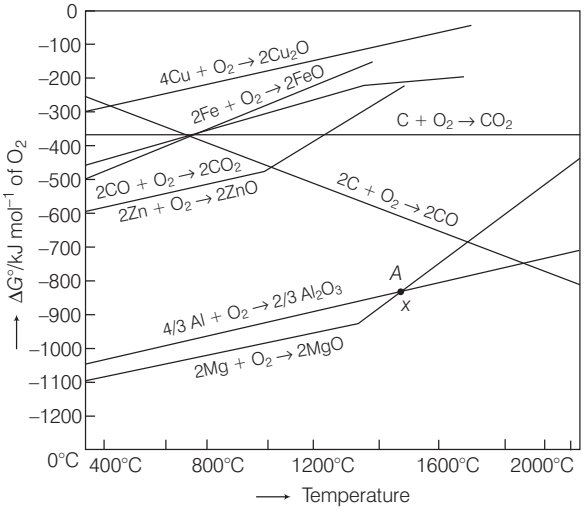
118. A mixture contains sulphides of lead and zinc. These two sulphides can be separated by the use of

(a) xanthates (b) aniline (c) sodium cyanide (d) hydrogen sulphide

119. Select the true statement.

(a) NaCN selectively prevents PbS from coming to the froth
(b) NaCN increases the solubility of PbS in water
(c) NaCN selectively prevents ZnS from coming to the froth
(d) Both (b) and (c)

■ **Directions** (Q. Nos. 120-122) *Study the following graph and answer the question on the basis of it, mentioned below.*



120. When the Ellingham plots of Al and Mg intersects, ΔG° becomes zero for the reaction,

$$2Al_2O_3 + 6\ Mg \longrightarrow 6\ MgO + 4Al$$

Above this point, Mg can be used to reduce alumina but it is not generally preferred because

(a) a very high temperature is required at this stage
(b) value of ΔG° becomes positive
(c) yield of metal is very low
(d) the statement is wrong. Hg can never reduce Al_2O_3

121. The correct statement for the reaction of iron oxide with carbon at point B is

(a) carbon reduces FeO at a temperature lower than that at point B
(b) below point B, the metal exists in molten state
(c) ΔG° value for the reaction at point B becomes positive
(d) ΔG° value for overall reduction with CO is zero

122. Given, $\Delta G_f^\circ(CuO) = -129.7\ kJ\ mol^{-1}$, $\Delta G_f^\circ(H_2O) = -237.2\ kJ\ mol^{-1}$ and $\Delta G_f^\circ(CO) = -137.2\ kJ\ mol^{-1}$

The better reducing agent for the reduction of CuO is

(a) H_2 (b) CO (c) C (d) Any of these

NCERT & NCERT Exemplar Questions

NCERT

123. Copper can be extracted by hydrometallurgy but not zinc. Because
(a) $E°$ value of Zn^{2+}/Zn is less than that of Cu^{2+}/Cu
(b) $E°$ value of Zn^{2+}/Zn is move than that of Cu^{2+}/Cu
(c) During extraction zinc forms complex
(d) Both (a) and (c)

124. Why is the extraction of copper from pyrites more difficult than that from its oxide ore through reduction?
(a) $\Delta_r G°$ of Cu_2S is greater than those of CS_2 and H_2S
(b) Cu_2S cannot be reduced by carbon or hydrogen
(c) $\Delta_f G°$ of copper oxide is less than that of CO_2
(d) All of the above

125. Name the common elements present in the anode mud in electrolytic refining of copper.
(a) Silver (b) Gold
(c) Platinum (d) All of these

126. What criterion is followed for the selection of the stationary phase in chromatography?
(a) It should be volatile
(b) It should have less adsorption capacity
(c) The stationary phase should react with the mobile phase
(d) All of the above

127. 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

128. 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

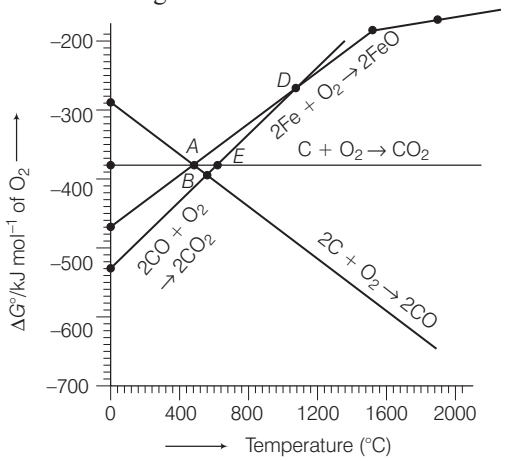
129. In the froth floatation process, zinc sulphide and lead sulphide can be separated by
(a) using collectors
(b) adjusting the proportion of oil to water
(c) using depressant
(d) using froth stabilisers

130. Which of the following ores are concentrated by froth floatation?
(a) Haematite (b) Galena
(c) Copper pyrites (d) Magnetite

131. Which of the following reactions occur during calcination?
(a) $CaCO_3 \longrightarrow CaO + CO_2$
(b) $2FeS_2 + \frac{11}{2}O_2 \longrightarrow Fe_2O_3 + 4SO_2$
(c) $Al_2O_3 \cdot xH_2O \longrightarrow Al_2O_3 + xH_2O$
(d) $ZnS + \frac{3}{2}O_2 \longrightarrow ZnO + SO_2$

132. 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

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



1. $C + O_2 \longrightarrow CO_2$
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*

134. The main reactions occurring in blast furnace during extraction of iron from haematite ore?
(a) $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$
(b) $FeO + SiO_2 \longrightarrow FeSiO_3$
(c) $Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$
(d) $CaO + SiO_2 \longrightarrow CaSiO_3$

135. 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)

136. In the extraction of copper from its sulphide ore, the metal is formed by the reduction of Cu_2O with
(a) FeS (b) CO
(c) Cu_2S (d) SO_2

137. Common impurities present in bauxite ore are
(a) CuO (b) ZnO (c) Fe_2O_3 (d) SiO_2

NCERT Exemplar

138. In the extraction of aluminium by Hall-Heroult process, purified Al_2O_3 is mixed with CaF_2 to
(a) lower the melting point of Al_2O_3
(b) increase the conductivity of molten mixture
(c) reduce Al^{3+} into Al(s)
(d) acts as catalyst

139. In the extraction of chlorine from brine
(a) $\Delta G°$ for the overall reaction is negative
(b) $\Delta G°$ for the overall reaction is positive
(c) $E°$ for the overall reaction has negative value
(d) $E°$ for the overall reaction has positive value

140. Extraction of gold and silver involves leaching the metal with 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

141. 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

142. Which of the following statements are correct?
(a) A depressant prevents certain type of particle to come to the froth
(b) Copper matte contains Cu_2S and ZnS
(c) The solidified copper obtained from reverberatory furnace has blistered appearance due to evolution of SO_2 during the extraction
(d) Zinc can be extracted by self-reduction

143. 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

■ **Directions** (Q. Nos. 144-148) *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.*
(a) Both A and R are correct; R is the correct explanation of A.
(b) Both A and R are correct; R is not the correct explanation of A.
(c) A is correct; R is incorrect.
(d) R is correct; A is incorrect.

144. **Assertion** (A) Sulphide ores are concentrated by froth flotation method.
Reason (R) Cresols stabilise the froth in froth floatation method.

145. **Assertion** (A) Hydrometallurgy involves dissolving the ore in a suitable reagent followed by precipitation of a more electropositive metal.
Reason (R) Copper is extracted by hydrometallurgy.

146. **Assertion** (A) Zone refining method is very useful for producing semiconductors.
Reason (R) Semiconductors are of high purity.

147. **Assertion** (A) Nickel can be purified by Mond's process.
Reason (R) $Ni(CO)_4$ is a volatile compound which decomposes at 460 K to give pure Ni.

148. **Assertion** (A) Zirconium can be purified by van-Arkel method.
Reason (R) ZrI_4 is volatile and decomposes at 1800K.

149. 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

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

150. 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
(b)	2	3	1	5
(c)	1	2	3	4
(d)	3	4	5	1

151. 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.	$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$

Codes

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

152. 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
C.	Calamine	3.	Na_3AlF_6
D.	Cryolite	4.	$CuCO_3 \cdot Cu(OH)_2$
		5.	$ZnCO_3$

Codes

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

153. 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.	Liquation

Codes

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

Answers

1.	(b)	**2.**	(a)	**3.**	(d)	**4.**	(b)	**5.**	(d)	**6.**	(a)	**7.**	(d)	**8.**	(d)	**9.**	(a)	**10.**	(a)	**11.**	(d)	**12.**	(c)	**13.**	(a)	**14.**	(c)	**15.**	(c)
16.	(b)	**17.**	(a)	**18.**	(a)	**19.**	(a)	**20.**	(c)	**21.**	(c)	**22.**	(d)	**23.**	(a)	**24.**	(d)	**25.**	(a)	**26.**	(b)	**27.**	(c)	**28.**	(b)	**29.**	(b)	**30.**	(b)
31.	(a)	**32.**	(b)	**33.**	(c)	**34.**	(a)	**35.**	(a)	**36.**	(b)	**37.**	(a)	**38.**	(a)	**39.**	(c)	**40.**	(b)	**41.**	(a)	**42.**	(c)	**43.**	(b)	**44.**	(b)	**45.**	(d)
46.	(d)	**47.**	(b)	**48.**	(d)	**49.**	(a)	**50.**	(d)	**51.**	(d)	**52.**	(b)	**53.**	(a)	**54.**	(d)	**55.**	(c)	**56.**	(c)	**57.**	(a)	**58.**	(a)	**59.**	(a)	**60.**	(c)
61.	(a)	**62.**	(b)	**63.**	(a)	**64.**	(a)	**65.**	(a)	**66.**	(c)	**67.**	(b)	**68.**	(b)	**69.**	(ab)	**70.**	(cd)	**71.**	(bc)	**72.**	(ab)	**73.**	(abcd)	**74.**	(abc)	**75.**	(bc)
76.	(abc)	**77.**	(abd)	**78.**	(abc)	**79.**	(abc)	**80.**	(bc)	**81.**	(ad)	**82.**	(ad)	**83.**	(abd)	**84.**	(a)	**85.**	(a)	**86.**	(b)	**87.**	(b)	**88.**	(b)	**89.**	(b)	**90.**	(c)
91.	(c)	**92.**	(d)	**93.**	(d)	**94.**	(c)	**95.**	(d)	**96.**	(d)	**97.**	(c)	**98.**	(d)	**99.**	(b)	**100.**	(c)	**101.**	(b)	**102.**	(c)	**103.**	(a)	**104.**	(a)	**105.**	(a)
106.	(c)	**107.**	(a)	**108.**	(b)	**109.**	(c)	**110.**	(a)	**111.**	(c)	**112.**	(c)	**113.**	(b)	**114.**	(c)	**115.**	(a)	**116.**	(d)	**117.**	(c)	**118.**	(c)	**119.**	(c)	**120.**	(a)
121.	(d)	**122.**	(a)	**123.**	(a)	**124.**	(d)	**125.**	(d)	**126.**	(b)	**127.**	(a)	**128.**	(ac)	**129.**	(bc)	**130.**	(bc)	**131.**	(ac)	**132.**	(ab)	**133.**	(bd)	**134.**	(ad)	**135.**	(c)
136.	(c)	**137.**	(cd)	**138.**	(ab)	**139.**	(bc)	**140.**	(a)	**141.**	(ad)	**142.**	(ac)	**143.**	(ab)	**144.**	(b)	**145.**	(b)	**146.**	(b)	**147.**	(a)	**148.**	(a)	**149.**	(a)	**150.**	(a)
151.	(a)	**152.**	(b)	**153.**	(c)																								

Hints & Explanations

3. (*d*) The extraction and isolation of metals from ores involve the following steps:

Grinding of ore
↓
Concentration of the ore
↓
Isolation of the metal from its concentrated ore, i.e. reduction of concentrated ore
↓
Purification of metal (i.e. refining of metal)

5. (*d*) 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.

7. (*d*) For the purpose of extraction, bauxite is chosen for aluminium. For copper and zinc, following ores can be used depending upon avilability and other relevant factors.

For copper Copper pyrites ($CuFeS_2$), malachite ($CuCO_3.Cu(OH)_2$), cuprite (Cu_2O), copper glance (Cu_2S).

For zinc Zinc blende or sphalerite (ZnS), calamine ($ZnCO_3$), zincite (ZnO).

8. (*d*) Malachite – $CuCO_3 \cdot Cu(OH)_2$, Cassiterite – SnO_2
Pyrolusite – MnO_2, Magnetite – Fe_3O_4
Thus, magnetite is a mineral of iron.

11. (*d*) Hydraulic washing can also be used to concentrate iron ores.

13. (*a*) In froth floatation method, the role of collectors is to enhance the non-wettability of the mineral particles.

15. (*c*) Sphalerite (ZnS) is a sulphide ore, so concentrated by froth floatation method.

17. (*a*) When the ore is soluble in some suitable solvent, then the most suitable method for concentration of ore is leaching.

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

19. (*a*) *M* is gold, i.e. Au

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

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

20. (*c*) Oxides are easier to reduce as compared to sulphides. That's why the concentrated ores (usually sulphide ores) are generally converted into oxide.

23. (*a*)

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

25. (*a*) $Fe_2O_3 + 3C \xrightarrow{\text{Heat}} 2Fe + 3CO$ reaction involves smelting.

26. (*b*) SO_2 gas is obtained when any sulphide ore is roasted.

$$2M_2S + 3O_2 \xrightarrow{\Delta} 2M_2O + 2SO_2$$

This gas exhibits all the characteristics given in the question.

29. (*b*) $\because \Delta G = -RT \ln k$

31. (*a*) For a reaction to proceed ΔG should be negative.
and $\Delta G = \Delta H - T\Delta S$

32. (*b*) At high temperature, carbon and hydrogen are converted into carbides and hydrides respectively.

33. (*c*) Several spontaneous reactions also require a certain amount of activation energy to overcome the forces of attraction, therefore heating is required.

34. (*a*) If a metal is to be extracted from its ore and suppose the gangue associated with the ore is silica, then a basic flux is required.

35. (*a*) Reduction of iron (II) oxide by carbon monoxide takes place in the temperature range of 900-1500 K.

36. (*b*) Carbon monoxide is the reducing agent which reduces iron oxide (Fe_2O_3) to iron.

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3O_2$$

37. (*a*) Pig iron contains about 4% carbon (major impurity)and other impurities (S, P, Si, Mn) in trace amounts.

39. (*c*) The chemical process in the production of steel from haematite ore involves oxidation followed by reduction.

41. (*a*) Silica removes the impurity of FeO, present in the extraction of copper pyrites as slag ($FeSiO_3$).

42. (*c*) The copper obtained from the Bassemer process, has blistered appearance because of the evolution of SO_2 gas and so it is called blister copper.

43. (*b*) Coke is used for the reduction of ZnO. The temperature required in case of zinc is higher than that required in case of copper.

For heating, the oxide is made into brickettes with coke and clay.

44. (*b*) 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.

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

45. (*d*) Cryolite is Na_3AlF_6 and is used in the electrolysis of alumina for lowering the melting point of alumina.

46. (*d*)

(a) In Hall-Heroult process for extraction of 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.

47. (*b*) The reactions involved in extraction of silver by cyanide process are

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

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

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.

49. (*a*) In the extraction of copper from its sulphide ore, when ore is subjected to roasting, some of it oxidised to Cu_2O which reacts with the remaining Cu_2S (sulphide ore) to give copper metal.

$$Cu_2S + 2Cu_2O \longrightarrow 6Cu + SO_2\uparrow$$

In this process Cu_2S behaves as reducing agent.

50. (*d*) Leaching is used in the concentration of ore, while others are refining methods.

51. (*d*) In electrolytic refining method, the impure metal is made to act as anode. A strip of the same metal in pure form is used as cathode. They are kept in a suitable electrolytic both containing soluble salt of the same metal. The more basic metal remains in the solution and the less basic ones go to the anode mud.

Anode $M \longrightarrow M^{n+} + ne^-$

Cathode $M^{n+} + ne^- \longrightarrow M$

53. (*a*) Zone refining method of the metals is based on the principle that the impurities are more soluble in the melt than in the solid state of the metal.

54. (*d*) Zone refining method is very useful for producing semiconductors and other metals of very high purity, e.g. Ge, Si, B, Ga etc.

55. (*c*) Vapour phase refining involves following steps:

(i) The metal is converted into its volatile compound and collected elsewhere.

(ii) It is then decomposed to give pure metal.

56. (*c*) Ni is purified by thermal decomposition of its carbonyl.

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

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

57. (*a*) Mond's process is used for the purification of Ni.

58. (*a*) Zr and Ti are purified by van-Arkel method.

$$\underset{\text{Impure}}{Zr} + 2I_2 \xrightarrow{600^\circ C} ZrI_4 \xrightarrow{1800^\circ C} \underset{\text{Pure}}{Zr} + 2\ I_2$$

This method is useful for removing all the oxygen and nitrogen present in the form of impurity in certain metals like Zr and Ti.

60. (*c*) Alumina, Al_2O_3 is a bad conductor of electricity and has very high melting point, so before subjecting to electrolysis, it is mixed with fluorspar (CaF_2) and cryolite (Na_3AlF_6), which lower its melting point and make it more conducting. Mainly CaF_2 and Na_3AlF_6 mixed with Al_2O_3 for converting in molten state.

61. (*a*) Chromatographic method is based on the principle that different components of a mixture are differently adsorbed on an adsorbent.

62. (*b*) Column chromatography

63. (*a*) Since, compound *X* comes out before *Y* so *Y* is adsorbed more readily than *X*. Similar is the case with *Y* and *Z*. Thus, the order of adsorption is $Z > Y > X$.

69. (*a, b*) Aluminium is the third most abundant element but most abundant metal in the earth's crust and siderite ($FeCO_3$) is an ore of iron, not of copper. Other statements are true.

70. (*c, d*) Copper glance– Cu_2S, Sphalerite– ZnS, zincite ZnO, Cuprite – Cu_2O.

Thus, zincite and cuprite are the examples of oxide ores.

71. (*b, c*) Cresol and aniline are froth stabilisers whereas pine oil is a collector.

72. (*a, b*) Only sulphide ores are concentrated by froth floatation method and copper pyrites ($CuFeS_2$) and Zinc blende (ZnS) are sulphide ores. Pyrolusite (MnO_2) is an oxide ore and siderite ($FeCO_3$) is a carbonate ore.

73. (*a, b, c, d*) All statements are correct.

74. (*a, b, c*) The sodium silicate remains in the solution and hydrated alumina is filtered, dried and heated.

75. (*b, c*) Argentite and bauxite, are the ores of less reactive and highly reactive metals and are soluble in some suitable reagent, that's why these are concentrated by leaching.

76. (*a, b, c*) Every sulphide can be converted into oxide by roasting process with a regular supply of air.

77. (*a, b, d*) ΔG° of metal oxides is lower than that of CO_2, hence, oxidation of metal sulphide to metal oxide is favourable.

79. (*a, b, c*) More electropositive metals like copper, mercury and lead involve auto-reduction in their extraction process.

80. (*b, c*) Highly reactive metals like Al, Mg, Na etc are extracted by the electrolytic reduction of their oxides of halides as no other suitable reducing agent is available for their reduction.

81. (*a, d*) The important ore of tin is cassiterite (tinstone, 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 contains traces of iron as an impurity which is removed by blowing air through the melted tin which oxidises Fe to FeO. This iron oxide, FeO floats on the surface of melted metal tin.

$$2Fe + O_2 \longrightarrow 2FeO$$

82. (*a, d*) Vapour phase refining involves following two steps:

$$\underset{\text{(Impure)}}{\text{Metal}} + X \longrightarrow \text{Metal}\,X \ \text{(volatile)}$$
$$\downarrow \Delta$$
$$\underset{\text{(Pure)}}{\text{Metal}} + X$$

83. (*a, b, d*) Distillation, or liquation is used for refining low boiling metals. Thus, silver is not refined by this method.

84. (*a*) Nitrate ores are very rare.

Bond dissociation energy of nitrogen is very high.

85. (*a*) Reduction of the metal oxide usually involves heating it with some other substance acting as reducing agent (C or CO or even another metal). The reducing agent (e.g. carbon) combines with the oxygen of the metal oxide.

$$M_xO_y + yC \longrightarrow xM + y\,CO$$

86. (*b*) At temperature above 1073K (approx.) the C,CO line comes below the Fe,FeO line [$\Delta G_{(Fe,FeO)} > \Delta G_{(C,CO)}$].

So, in this range, coke will reduce the FeO and will itself oxidised to CO.

87. (*b*) In the equation $\Delta G^\circ = -nE^\circ F$

n is the number of electrons and E° is the electrode potential of the redox couple formed in the system. More reactive metals have large negative values of the electrode potential. so their reduction is difficult.

88. (*b*) Copper is extracted by hydrometallurgy from low grade ores. It is leached out using acid or bacteria. The solution containing Cu^{2+} is treated with scrap iron.

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

89. (*b*) Distillation is very useful for low boiling metals like zinc and mercury. The impure metal is evaporated to obtain the pure metal as distillate. In liquation, a low melting metal like tin can be made to flow on a sloping surface. In this way, it is separated from higher melting impurities.

90. (*c*) Commonly used collectors in the froth floatation method are pine oil, fatty acids, xanthates (like amyl xanthate).

92. (*d*) The fluorspar (CaF_2) is added in small quantities in the electrolytic reduction of alumina dissolved in fused cryolite (Na_3AlF_6) which lowers the melting point of the mixture and increases conductivity.

93. (*d*) In roasting,

(i) ore becomes porous.

(ii) moisture is removed.

(iii) no metal impurities are removed.

94. (*c*) Zn can be extracted by electrolytic refining method.

Copper matte contains Cu_2S and FeS.

95. (*d*) Each plot is a straight line except when some change in phase (solid-liquid or liquid-solid) takes place.

96. (*d*) C and H are suitable reducing agents for metal oxides.

97. (*c*) The electrorefining method of metals is useful for Al, Ag and Cu.

98. (*d*) Heating with 1/2 and with stream of CO.

99. (*b*) For vapour phase refining, the volatile compound should be easily decomposable so that the recovery is easy.

100. (*c*) Chromatography in general, involves a mobile phase and a stationary phase. The mobile phase may be a gas, a liquid or a super critical fluid. The stationary phase is immobile and immiscible.

101. (*b*) Minerals are naturally occurring chemical substances in the earth's crust obtained by mining. But a mineral is called an ore only when the metal can be extracted from it conveniently and economically. Thus, all ores are minerals but all minerals are not ores.

102. (*c*) The cyanide dissolves gold by forming a complex.

103. (*a*) In the metallurgy of aluminium, purified Al_2O_3 is mixed with Na_3AlF_6 or CaF_2 which lowers the melting point of the mix and brings conductivity.

104. (*a*) For iron, generally the oxide ores which are abundant and do not produce polluting gases (like SO_2 is produced in case of iron pyrites).

105. (*a*) Usually the sulphide ore is converted to oxide before reduction as oxides are easier to reduce.

106. (*c*) The Cu^{2+} ion in both the compounds gets reduced while sulphur gets oxidised.

107. (*a*) Large amount of heat is evolved which melts iron and can be used for welding.

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

109. (*c*) Malachite is $CuCO_3 \cdot Cu(OH)_2$, calamine is $ZnCO_3$, siderite is $FeCO_3$ and bauxite is $Al_2O_3 \cdot 2H_2O$

Thus, correct match is A → 4, B → 3, C → 1, D → 2

110. (*a*) Bauxite is soluble in suitable solvent, so concentrated by leaching.Haematite being heavier is concentrated by hydraulic washing. Copper pyrites is concentrated by froth floatation method and cassiterite by magnetic separation

A → 4, B → 3, C → 1, D → 2.

111. (*c*) A → 3, B → 1, C → 2, D → 4

112. (*c*) Malachite — $CuCO_3 \cdot Cu(CO)_2$ (Carbonate ore)

Azurite — $2CuCO_3 \cdot Cu(OH)_2$ (Carbonate ore)

Coper pyrites — $CuFeS_2$ (Sulphide ore so roasted)

Copper glance — Cu_2S (Sulphide ore so roasted)

Thus, A → q, B → q, C → p,s, D → p,s

113. (*b*) A $\rightarrow$ p,q,s , B $\rightarrow$ p,q,s , C $\rightarrow$ q,s , D $\rightarrow$ r

Iron pyrites or fool's gold is FeS_2. Being sulphide ore it is concentrated by froth floatation process.

Galena is PbS. It is also a sulphide ore so concentrated by froth floatation froces.

Haematite is Fe_2O_3.

114. (*c*) A $\rightarrow$ p,s B $\rightarrow$ p,s C $\rightarrow$ q,r D $\rightarrow$ q,r

Magnesite ($MgCO_3$), Dalomite ($CaCO_3 \cdot MgCO_3$)

Corundum (Al_2O_3), Bauxite ($Al_2O_3 \cdot 2H_2O$).

115. (*a*) A $\rightarrow$ p B $\rightarrow$ p,q C $\rightarrow$ q,s D $\rightarrow$ r

116. (*d*) A $\rightarrow$ p, B $\rightarrow$ q, C $\rightarrow$ q, D $\rightarrow$ r,s

118. (*c*) A mixture of two sulphides can be separated by adjusting the proportion of oil to water or by using some depressant like NaCN.

119. (*c*) NaCN selectively prevents ZnS from coming to the froth but allows PbS to come with the froth.

123. (*a*) $E°$ value of $Zn^{2+}/Zn = -0.76$ V is less than that of $Cu^{2+}/Cu = +0.34$ V. It means that zinc is a stronger reducing agent and can easily displace the Cu^{2+} ions present in the complex.

$$\underset{\text{Soluble complex}}{[Cu(CN)_2]} + Zn \longrightarrow [Zn(CN)_2] + \underset{\text{ppt.}}{Cu\downarrow}$$

So, zinc can be isolated by hydrometallurgy only when stronger reducing agents than zinc (Ca, Mg, Al etc.) are present. But these react with water to evolve hydrogen gas. Thus, these metals also do not solve the purpose and zinc cannot be extracted by hydrometallurgy.

124. (*d*) The standard free energy of formation ($\Delta_f G°$) of Cu_2S is greater than those of CS_2 and H_2S. So, Cu_2S (pyrites) cannot be reduced by carbon or hydrogen.

$$2Cu_2S + C \longrightarrow 4Cu + CS_2 \text{ (Not feasible)}$$

$$Cu_2S + H_2 \longrightarrow 2Cu + H_2S \text{ (Not feasible)}$$

However, the $\Delta_f G°$ of copper oxide is less than that of CO_2. Therefore, the sulphide ore is first converted to oxide by roasting and then reduced.

$$2Cu_2S + 3O_2 \xrightarrow{\text{Roasting}} 2Cu_2O + 2SO_2$$

$$2Cu_2O + C \xrightarrow{\text{Heat}} 4Cu + CO_2 \text{ [Feasible]}$$

125. (*d*) Metals which are less reactive and valuable as silver, gold, platinum, etc., are found in anode mud. The reason is that being less reactive, they do not lose electrons at anode and collect under the anode as anode mud. Copper metal at anode loses electrons in a usual manner to form Cu^{2+} ions.

At anode $Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$

Noble metals $\longrightarrow$ No reaction

126. (*b*) In general, an adsorbent is used as a stationary phase during the process of chromatography. It should have following characteristics :

1. It should have high but selective adsorption capacity.
2. The stationary phase should not react with the mobile phase or with the components of the mixture to be separated.
3. It should be easily available.

127. (*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.

128. (*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.

129. (*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.

130. (*b, c*) Haematite (Fe_2O_3) and magnetite (Fe_3O_4) are oxide ores while galena (PbS) and copper pyrites ($Cu\,FeS_2$) are sulphide ores. As we know sulphide ores are extracted by using froth floatation method.

131. (*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. Following reactions occur during calcination.

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2\uparrow$$

$$Al_2O_3 \cdot xH_2O \xrightarrow{\Delta} Al_2O_3 + xH_2O$$

132. (*a, b*) In the metallurgical process, the oxide ores are reduced by carbon. Sulphide ore cannot be reduced by carbon. Here, haematite (Fe_2O_3) and calamine (ZnO) are oxide ores of iron and zinc respectively while iron pyrites (FeS_2) and sphalerite (ZnS) are sulphide ores of iron and zinc respectively.

Therefore, haematite and calamine can be reduced by carbon.

133. (*b, d*) Below point *B* and *E*, FeO will be reduced to Fe by all the three reactions shown above in the question. $\Delta G°_{(C, CO_2)}$, $\Delta G°_{(C, CO)}$, $\Delta G°_{(CO, CO_2)}$ lie below $\Delta_f G°_{(Fe, FeO)}$ curve at point *B* and *E*. Therefore, FeO will be reduced by all three reactions. Hence, options (b) and (d) are correct choice.

134. (*a, d*) In extraction of iron from haematite ore, following reactions take place.

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

This reaction represents reduction of Fe_2O_3 to Fe.

(ii) $CaO + SiO_2 \longrightarrow CaSiO_3$ (Slag)

135. (*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).

Copper matte $\longrightarrow Cu_2S$ and FeS

136. (*c*) In the extraction of copper from its sulphide ore, the metal is formed by the reduction of Cu_2O with Cu_2S. This reaction completes with the process of auto-reduction.

Chemical reaction occurring in this reaction is as follows

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

In this process, copper appears as blister copper.

137. (*c, d*) Bauxite is an ore of aluminium which contain Fe_2O_3 and SiO_2 as common impurities.

138. (*a, b*) In the metallurgy of aluminium Al_2O_3 is mixed with Na_3AlF_6 or CaF_2 which causes following affects:

(i) Lower the melting point of Al_2O_3

(ii) Increase the conductivity of molten mixture

139. (*b, c*) Electrolysis of brine solution is used to extract chlorine. Overall chemical reaction occurring in this process and value of $\Delta G°$ can be shown as

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

For the given reaction, value of $\Delta G°$ is + 422 kJ

Using $\Delta G° = -nFE°$, the value of $E° = -2.2V$.

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

140. (*a*) Extraction of gold and silver involves leaching the metal with CN^- ion. The metal is recovered by displacement of metal by some other metal from the complex ion.

This is an oxidation reaction.

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

$$4[Au(CN)_2]^-(aq) + Zn(s) \longrightarrow 2Au(s) + [Zn(CN)_4]^{2-}(aq)$$

Here, Zn acts as a reducing agent.

141. (*a, d*) Correct statements are

(a) Cast iron is obtained by remelting pig iron with scrap iron and coke using hot air blast.

(d) Zr and Ti are purified by van-Arkel method as

$$\underset{\text{Impure}}{Zr} + 2I_2 \longrightarrow \underset{\text{Volatile}}{ZrI_4} \xrightarrow{\Delta} \underset{\text{Pure}}{Zr} + 2I_2$$

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

(b) In extraction of silver, silver is extracted as anionic complex $[Ag(CN)_2]^-$

(c) Nickel is purified by vapour phase refining method.

$$Ni + 4CO \xrightarrow{330\text{-}350\ K} Ni(CO)_4 \xrightarrow{450\text{-}470\ K} Ni + 4CO$$

142. (*a, c*) Correct statements are

(a) A depressant prevents certain type of particle to come to the froth. e.g. NaCN is added as a depressant during separation of PbS and ZnS.

(b) The solidified copper obtained from reverberatory furnace has blistered appearance due to evolution of SO_2 during the extraction.

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

(c) Copper matte contains Cu_2S and FeS.

(d) Zinc can be extracted by reduction of ZnO with carbon.

143. (*a, b*) Vapour phase refining method includes

(a) Heating of metal with stream of CO

$$Ni + 4CO \xrightarrow{330\text{–}350\ K} Ni(CO)_4 \xrightarrow{450\text{–}470\ K} Ni + 4CO$$

(Mond's process)

(b) Heating with iodine

$$Zr + 2\,I_2 \xrightarrow{870\ K} ZrI_4 \xrightarrow[\text{Tungsten filament}]{2075\ K} Zr + 2\,I_2$$

(van-Arkel method)

144. (*b*) 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.

145. (*b*) Hydrometallurgy involves dissolving the ore in suitable reagent followed by precipitation with the help of more electropositive metal in which pure metal gets replaced by more electropositive metal.

146. (*b*) 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.

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

148. (*a*) Zirconium can be purified by van-Arkel method which include formation of volatile ZrI_4 which decomposes at 1800 K to Zr.

149. (*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 Al_2O_3.

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

A. Cyanide process is used for extraction of Au through formation of anionic complex $[Au\,CN)_2]^-$.

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.

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

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

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

B. Iron is extracted by using blast furnace.

C. In reverberatory furnace formation of slag occurs as

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

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

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

153. (*c*) A. → (4) B. → (3) C. → (1) D. → (2)