METALLURGY

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Syllabus

METALLURGY

Ores and minerals : Commonly occurring ores and minerals of iron, copper, tin, lead, magnesium, aluminium, zinc and silver.

Extractive metallurgy : Chemical principles and reactions only (industrial details excluded); Carbon reduction method (iron and tin); Self reduction method (copper and lead); Electrolytic reduction method (magnesium and aluminium); Cyanide process (silver and gold).

Name : _____ **Contact No.** _____

Classification Of Ores :

Type of Ore	Ore or Mineral	Composition	Metal Present
Oxide Ores	Bauxite	$Al_2O_3.2H_2O$	Al
	Cuprite	Cu_2O	Cu
	Haematite	Fe_2O_3	Fe
	Magnetite	Fe_3O_4	Fe
	Cassiterite	SnO_2	Sn
	Pyrolusite	MnO_2	Mn
	Pitch Blende	U_3O_8	U
	Zincite	ZnO	Zn
Halide Ores	Rock Salt	NaCl	Na
	Carnallite	$Kcl.MgCl_2.6H_2O$	Mg
	Horn Silver	AgCl	Ag
	Cryolite	$3NaF.AlF_3$	Al
	Sylvine	KCl	K
Sulphide Ores	Copper Pyrites	$CuFeS_2$	Cu
	Copper Glance	Cu_2S	Cu
	Cinnabar	HgS	Hg
	Galena	PbS	Pb
	Zinc Blende	ZnS	Zn
	Argentite	Ag_2S	Ag
Sulphate Ores	Epsom Salt	$MgSO_4.7H_2O$	Mg
	Gypsum	$CaSO_4.2H_2O$	Ca
	Anglesite	$PbSO_4$	Pb
	Barytes	$BaSO_4$	Ba
Silicate ores	Asbestos	$CaSiO_3.3MgSiO_3$	Mg
	Felspar	$K_2O.Al_2O_3.6SiO_2$	Al
	Mica	$K_2O.3Al_2O_3.6SiO_2.2H_2O$	Al
	Willimite	Zn_2SiO_4	Zn
Nitrate Ores	Chile Salt petre	$NaNO_3$	Na
	Bengal Salt petre	KNO_3	K
Carbonate Ores	Magnesite	$MgCO_3$	Mg
	Dolomite	$CaCO_3.MgCO_3$	Mg
	Calamine	$ZnCO_3$	Zn
	Malachite	$CuCO_3.\ Cu(OH)_2$	Cu
	Lime Stone	$CaCO_3$	Ca
	Azurite	$2CuCO_3.\ Cu(OH)_2$	Cu
	Cerussite	$PbCO_3$	Pb
	Siderite (Spathic iron ore)	$FeCO_3$	Fe
Phosphate Ores	Phosphorite	$Ca_3(PO_4)_2$	P

Some Important ores of metals

Metal	Ores	Composition
Aluminium	Bauxite	$AlO_X(OH)_{3-2X}$ [where $0 < X < 1$] Al_2O_3
	Diaspore	$Al_2O_3.H_2O$
	Corundam	Al_2O_3
	Kaolinite (a form of clay)	$[Al_2 (OH)_4 Si_2O_5]$
Iron	Haematite	Fe_2O_3
	Magnetite	Fe_3O_4
	Siderite	$FeCO_3$
	Iron pyrite	FeS_2
	Limonite	$Fe_2O_3.3H_2O$
Copper	Copper pyrite	$CuFeS_2$
	Copper glance	Cu_2S
	Cuprite	Cu_2O
	Malachite	$CuCO_3.Cu(OH)_2$
	Azurite	$2CuCO_3.Cu(OH)_2$
Zinc	Zinc blende or Sphalerite	ZnS
	Calamine	$ZnCO_3$
	Zincite	ZnO
Lead	Galena	PbS
	Anglesite	$PbSO_4$
	Cerrusite	$PbCO_3$
Magnesium	Carnallite	$KCl.MgCl_2$ $6H_2O$ (K_2MgCl_4 $.6H_2O$)
	Magnesite	$MgCO_3$
	Dolomite	$MgCO_3$ $CaCO_3$
	Epsomsalt (Epsomite)	$MgSO_4$ $7H_2O$
	Langbeinite	$K_2Mg_2(SO_4)_3$
Tin	Cassiterite (Tin stone)	SnO_2
Silver	Silver glance (Argentite)	Ag_2S
	Pyrargyrite (Ruby Silver)	Ag_3SbS_3
	Chlorargyrite (Horn silver)	AgCl.
	Stefinite	Ag_5SbS_4
	Proustite	Ag_3AsS_3

EXERCISE # 1

PART - I : OBJECTIVE QUESTIONS

*** Marked Questions are having more than one correct option.**

1. Calamine is an ore of :
(A) Zn (B) Mg (C) Ca (D) Pb

2. Which of the following is not the ore of aluminium ?
(A) Bauxite (B) Corundum (C) Langbeinite (D) Kaolinite

3. Which of the following set of metals mostly found as sulphide ores :
(A) Zn, Cu, Mg (B) Zn, Cu, Pb (C) Fe, Al, Ti (D) Cu, Ag, Au

4. Match Column-I with Column-II and select the correct answer using the codes given below :

Column-I (Metals)	**Column-II (Ores)**
(A) Tin	(p) Calamine
(B) Zinc	(q) Cassiterite
(C) Iron	(r) Cerrusite
(D) Lead	(s) Siderite

Codes :

	(A)	(B)	(C)	(D)		(A)	(B)	(C)	(D)
(A)	p	q	r	s	(B)	q	p	s	r
(C)	s	r	q	p	(D)	q	p	r	s

5. Which is not correct statement ?
(A) Cassiterite, chromite and haematite are concentrated by hydraulic washing (Tabling).
(B) Pure Al_2O_3 is obtained from the bauxite ore by leaching in the Bayer's process.
(C) Sulphide ore is concentrated by calcination method.
(D) Roasting can convert sulphide into oxide or sulphate and part of sulphide may also act as a reducing agent.

6. Which mineral has been named incorrectly ?
(A) Bauxite : $Al_2O_3.2H_2O$ (B) Corundum : Al_2O_3
(C) Cryolite : $3NaF.AlF_3$ (D) Feldspar : $Be_3Al_2Si_6O_{18}$

7. Black tin is
(A) an alloy of Sn (B) an allotrope of Sn (C) 60-70 percent SnO_2 (D) 100 percent SnO_2

8. Chemical leaching is useful in the concentration of :
(A) carnallite (B) bauxite (C) galena (D) zinc blende

9. Sulphide ores are generally concentrated by the :
(A) gravity separation process (B) calcination process
(C) leaching process (D) none of these

10. NaCN is sometimes added in the froth flotation process as a depressant when ZnS and PbS minerals are expected because :
(A) $Pb(CN)_2$ is precipitated while no effect on ZnS.
(B) ZnS forms soluble complex $Na_2[Zn(CN)_4]$ while PbS forms froth
(C) PbS forms soluble complex $Na_2[Pb(CN)_4]$ while ZnS forms froth.
(D) NaCN is never added in froth floatation process.

11. Which one of the following reactions represents a calcination reaction?
(A) $HgS + O_2 \rightarrow Hg + SO_2$ (B) $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
(C) $CuCO_3 . Cu(OH)_2 \rightarrow CuO + CO_2 + H_2O$ (D) $Al_2O_3 + NaOH \rightarrow NaAlO_2 + H_2O$

12*– Egg shell is made up of a chemical. In which of the following ores this chemical is present ?
(A) Dolomite (B) Calamine (C) Lime stone (D) Feldspar

13*– Which of the following manufactured by the electrolysis of their fused salts.
(A) Copper (B) Sodium (C) Aluminium (D) Platinum

14. Selection of temperature to carry out a reduction process depends so as to make :
(A) ΔG negative (B) ΔG positive (C) ΔH negative (D) ΔH positive

15. Select correct statement
(A) In the decomposition of an oxide into oxygen and solid/liquid metal, entropy increases.
(B) Decomposition of an oxide is an endothermic change.
(C) To make $\Delta G°$ negative, temperature should be high enough so that $T\Delta S° > \Delta H°$.
(D) All are correct statements.

16. Which of the following represents the thermite reaction?
(A) $3Mn_3O_4 + 8Al \rightarrow 9Mn + 4Al_2O_3$ (B) $MgCO_3 + SiO_2 \rightarrow MgSiO_3 + CO_2$
(C) $Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$ (D) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

17. An ore after levigation is found to have acidic impurities. Which of the following can be used as flux during smelting operation ?
(A) H_2SO_4 (B) $CaCO_3$ (C) SiO_2 (D) both (B) and (C)

18*– On the basis of ellingham diagram which of the following is/are correct.
(A) Entropy change for all metal oxides is roughly same.
(B) Below the boiling point, '$T\Delta S$' factor is same irrespective of metal.
(C) Above $\Delta G = 0$ line, oxide decomposes into metal & oxygen.
(D) If randomness increases the slope increases

19. Which of the following metals is obtained by the self reduction process?
(A) Copper (B) Iron (C) Silver (D) Magnesium

20. Self-reduction of Cu_2S to Cu can be carried out in.
(A) bessemer convertor (B) blast furnace (C) both (A) and (B) (D) none of these

21. Blister copper is :
(A) impure copper.
(B) obtained in self reduction process during bessemerisation.
(C) both (A) and (B) are correct.
(D) none is correct.

22. Main source of lead is PbS. It is converted to Pb by :

(X) : $PbS \xrightarrow[\Delta]{air} PbO + SO_2$, $PbO \xrightarrow{C} Pb + CO_2$

(Y) : $PbS \xrightarrow[\Delta]{air} PbO + PbS$, $PbO + PbS \rightarrow Pb + SO_2$

(Z) : $PbS \xrightarrow[\Delta]{air} PbO + SO_2$, $PbO \xrightarrow{CO} Pb + CO_2$

Self - reduction process is :
(A) X (B) Y (C) Z (D) none

23. Identify the metal M whose extraction is based on the following reactions :

$MS + 2O_2 \rightarrow MSO_4$

$2MS + 3O_2 \rightarrow 2MO + 2SO_2$

$MS + 2MO \rightarrow 3M + SO_2$

$MS + MSO_4 \rightarrow 2M + 2SO_2$

(A) magnesium (B) aluminium (C) lead (D) tin

24. Which of the following reactions represents the self-reduction process?

(A) $\begin{cases} HgS + O_2 \rightarrow HgO + SO_2 \\ HgO + HgS \rightarrow Hg + SO_2 \end{cases}$ (B) $\begin{cases} Cu_2S + O_2 \rightarrow Cu_2O + SO_2 \\ Cu_2S + Cu_2O \rightarrow Cu + SO_2 \end{cases}$

(C) $\begin{cases} PbS + O_2 \rightarrow PbO + SO_2 \\ PbO + PbS \rightarrow Pb + SO_2 \end{cases}$ (D) All of these

25*– The smelting of iron in a blast furnace involves, which of the following process/(es) ?
(A) Combustion (B) Reduction (C) Slag formation (D) Sublimation

26.* Addition of high proportion of manganese makes steel useful in making rails of rail roads, because manganese :
(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

27. The metal which is obtained from both sea-water and ores from the earth's solid crust is :
(A) Magnesium (B) Iron (C) Silver (D) Gold

28. Magnesium is extracted from ore carnallite by :
(A) the self-reduction process
(B) the carbon-reduction process
(C) the electrolytic process
(D) treating the ore with aqueous NaCN and then reducing the mixture

29. NaCl and $CaCl_2$ are added to fused $MgCl_2$ in the electrolysis of $MgCl_2$ since :
(A) melting point is decreased and conductivity is increased.
(B) melting point is increased and conductivity is decreased.
(C) melting point and conductivity both are decreased.
(D) melting point and conductivity both are increased.

30. In the leaching of Ag_2S with NaCN, a stream of air is also passed . It is because of :
(A) reversible nature of reaction between Ag_2S and NaCN
(B) to oxidise Na_2S formed into Na_2SO_4 and sulphur
(C) both (A) and (B)
(D) None of the above

31. Which metal is extracted using a hydrometallurgical process involving complexation?
(A) Mg (B) Ag (C) Cu (D) Zn

32. Which of the following metals cannot be extracted by the carbon reduction process ?
(A) Zn (B) Fe (C) Al (D) Sn

33. In electrolysis of Al_2O_3 by Hall-Heroult process :
(A) cryolite $Na_3[AlF_6]$ lowers the melting point of Al_2O_3 and increases its electrical conductivity.
(B) Al is obtained at cathode and probably CO_2 at anode
(C) both (A) and (B) are correct
(D) none of the above is correct

34. During the electrolytic reduction of aluminium, the carbon anodes are replaced from time to time because:
(A) the carbon anodes get decayed
(B) the carbon prevents atmospheric oxygen from coming in contact with aluminium
(C) oxygen liberated at the carbon anodes reacts with anodes to form CO and CO_2
(D) carbon converts Al_2O_3 to Al

35*– Complexes formed in the cynide process are :
(A) $[Au(CN)_2]^-$ (B) $[Ag(CN)_2]^-$ (C) $[Cu(CN)_4]^{2-}$ (D) $[Zn(CN)_4]^{2-}$

36. Poling process :
(A) reduces SnO_2 to Sn (B) oxidises impurities like iron and removes as scum
(C) uses green poles (D) all of the above are correct

37. Poling process is used for :
(A) the removal of Cu_2O from Cu (B) the removal of Al_2O_3 from Al
(C) the removal of Fe_2O_3 from Fe (D) all of these.

38. Aluminium metal is purified by :
(A) Hooper's process (B) Hall-Heroult process
(C) Serpeck's process (D) Baeyer's process

39. High purity copper metal is obtained by :
(A) carbon reduction (B) hydrogen reduction
(C) electrolytic reduction (D) thermite reduction

40. In the electrolytic refining of lead, Sb, Cu, Ag and Au are found :
(A) on anode (B) in electrolyte solution
(C) in anode mud (D) in cathode mud

41. The anode mud in the electrolytic refining of silver contains :
(A) Zn, Cu, Ag, Au (B) Zn, Ag, Au (C) Cu, Ag, Au (D) Au only

42. Silver can be separated from lead by :
(A) fractional crystallisation (B) liquation
(C) cupellation (D) addition of zinc (Parke's method)

43. In electrolytic refining of lead, electrolyte is consist of :
(A) H_2SiF_6 only (B) $PbSiF_6$ only (C) H_2SiF_6 only (D) H_2SiF_6 and $PbSiF_6$

44. The method of zone refining of metals is based on the principle of :
(A) greater mobility of the pure metal than that of impurity
(B) higher melting point of the impurity than that of the pure metal
(C) greater noble character of the solid metal than that of the impurity
(D) greater solubility of the impurity in the molten state than in the solid

45. Which does not represent correct method ?
(A) $TiCl_2 + 2Mg \longrightarrow Ti + 2MgCl_2$: Kroll
(B) $Ni(CO)_4 \longrightarrow Ni + 4CO$: Mond
(C) $Ag_2CO_3 \longrightarrow 2Ag + CO_2 + \frac{1}{2} O_2$: Van Arkel
(D) $ZrI_4 \longrightarrow Zr + 2I_2$: Van Arkel

46*– In poling process of purification of Cu, O_2 oxidises following group of elements :
(A) S, Sb, As (B) Sb, As, Fe (C) S, Sb, As (D) As, Ag, Au

47*– Parting of gold may be done with :
(A) Sulphuric acid (B) Sodium hydroxide (C) Borax (D) Chlorine (Cl_2)

48. Formation of metallic copper from the sulphide ore in the commercial thermo-metallurgical process essentially involves which one of the following reaction:

(A) $Cu_2S + \frac{3}{2}O_2 \longrightarrow Cu_2O + SO_2$; $CuO + C \longrightarrow Cu + CO$

(B) $Cu_2S + \frac{3}{2}O_2 \longrightarrow Cu_2O + SO_2$; $2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2$

(C) $Cu_2S + 2O_2 \longrightarrow CuSO_4$; $CuSO_4 + Cu_2S \longrightarrow 3Cu + 2SO_2$

(D) $Cu_2S + \frac{3}{2}O_2 \longrightarrow Cu_2O + SO_2$; $Cu_2O + CO \longrightarrow 2Cu + CO_2$

49. $Ag_2S + NaCN + Zn \longrightarrow Ag$
This method of extraction of Ag by complex formation and then its displacement is called:
(A) Parke's method (B) McArthur-Forest method
(C) Serpeck method (D) Hall's method

50. Which of the following does not contain Mg:
(A) magnetite (B) magnesite (C) asbestos (D) carnallite

51. Bessemerisation is carried out for
I : Fe, II : Cu, III : Al, IV : silver
(A) I , II (B) II, III (C) III, IV (D) I, III

52. Refining of silver is done by:
(A) liquation (B) poling (C) cupellation (D) van Arkel method

53. These are following extraction process of silver but not the step involved
(A) as a side product in electrolytic refining of copper
(B) Parke's process in which Zn is used to extract silver by solvent extraction from molten lead
(C) by reaction of silver sulphide with KCN and then reaction of soluble complex with Zn
(D) by heating $Na[Ag(CN)_2]$

54. Blister Cu is about:
(A) 60% Cu (B) 90% Cu (C) 98% Cu (D) 100% Cu

55. Which one of the following is not a method of concentration of ore?
(A) gravity separation (B) froth floating process
(C) electromagnetic separation (D) smelting

56. In which of the following isolations no reducing agent is required:
(A) iron from haematite (B) aluminium from bauxite
(C) mercury from cinnabar (D) zinc from zinc blende

57. Chemical leaching is useful in the concentration of:
(A) copper pyrites (B) bauxite (C) galena (D) cassiterite

58. The element which could be extracted by electrolytic reduction of its oxide dissolved in a high temperature melt is:
(A) sodium (B) magnesium (C) fluorine (D) aluminium

59. Consider the following statements:
Roasting is carried out to :
(i) convert sulphide to oxide and sulphate
(ii) remove water of hydration
(iii) melt the ore
(iv) remove arsenic and sulphur impurities
Of these statements:
(A) (i), (ii) and (iii) are correct (B) (i) and (iv) are correct
(C) (i), (ii) and (iv) are correct (D) (ii), (iii) and (iv) are correct

60. Iron obtained from blast furance is:
(A) wrought iron (B) cast iron (C) pig iron (D) steel

61. Which one of the following statements is not correct:
(A) Nickel forms $Ni(CO)_4$
(B) All the transition metals form monometallic carbonyls
(C) Carbonyls are formed by transition metals
(D) Transition metals form complexes

62. In the extraction of nickel by Mond process, the metal is obtained by:
(A) electrochemical reduction (B) thermal decomposition
(C) chemical reduction by aluminium (D) reduction by carbon

63. Formation of $Ni(CO)_4$ and subsequent its decomposition into Ni and CO (recycled) makes basis of Mond's process

$$Ni + 4CO \xrightarrow{T_1} Ni(CO)_4 \xrightarrow{T_2} Ni + 4CO$$

T_1 and T_2 are:
(A) 100°C, 50°C (B) 50°C, 100°C (C) 50°C, 230°C (D) 230°C, 50°C

Question No. 64 to 66 are based on following reactions

(I) $FeCr_2O_4 + NaOH + air \longrightarrow (A) + Fe_2O_3$

(II) $(A) + (B) \longrightarrow Na_2Cr_2O_7$

(III) $Na_2Cr_2O_7 + X \xrightarrow{\Delta} Cr_2O_3$

(IV) $Cr_2O_3 + Y \xrightarrow{\Delta} Cr$

64. Compounds (A) and (B) are:
(A) Na_2CrO_4, H_2SO_4 (B) $Na_2Cr_2O_7$, HCl
(C) Na_2CrO_5, H_2SO_4 (D) $Na_4[Fe(OH)_6]$, H_2SO_4

65. (X) and (Y) are:
(A) C and Al (B) Al and C (C) C in both (D) Al in both

66. Na_2CrO_4 and Fe_2O_3 are separated by
(A) dissolving in conc. H_2SO_4 (B) dissolving in NH_3
(C) dissolving in H_2O (D) dissolving in dil. HCl

67. High temperature (> 1000°C) electrolytic reduction is necessary for isolating
(A) Al (B) Cu (C) C (D) F_2

68. In froth-floatation process, palm oil functions as
(A) activator (B) frother (C) collector (D) agitator

69. Collectors are the substances which help in attachment of an ore particle to air bubble in froth. A popular collector used industrially is
(A) sodium ethyl xanthate (B) sodium xenate
(C) sodium pyrophosphate (D) sodium nitroprusside

70. Zone refining is based on the principle of
(A) fractional distillation (B) fractional crystallisation
(C) partition coefficient (D) chromatographic separation

71. Which of the following reaction does not occur in Bessemer's converter?
(A) $2Cu_2S + 5O_2 \longrightarrow 2CuSO_4 + 2CuO$ (B) $2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2\uparrow$
(C) $2CuFeS_2 + O_2 \longrightarrow Cu_2S + 2FeS + SO_2$ (D) $FeO + SiO_2 \longrightarrow FeSiO_3$

72. Dow's process
(A) involves purification of copper (B) involves extraction of magnesium
(C) gives metal chloride as product (D) gives pure metal as product

73. In the cyanide process involving extraction of silver, zinc is used industrially as a(an)
(A) oxidising agent (B) reducing agent (C) solvent (D) solvating agent

74. Carnallite does not contain
(A) K (B) Ca (C) Mg (D) Cl

75. During initial treatment, preferential wetting of ore by oil and gangue by water takes place in
(A) Levigation (gravity separation) (B) Froth floatation
(C) Leaching (D) Bessemerisation

76. Silica is added to roasted copper ores during extraction in order to remove
(A) cuprous sulphide (B) ferrous oxide (C) ferrous sulphide (D) cuprous oxide

77. Addition of high proportions of manganese makes steel useful in making rails of railroads, because manganese
(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

78. Among the following statements, the incorrect one is
(A) calamine and siderite are carbonate ores (B) argentite and cuprite are oxide ores
(C) zinc blende and pyrites are sulphide ores (D) malachite and azurite are ores of copper

79. In the commercial electrochemical process for aluminium extraction the electrolyte used is
(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 ,Na_3AlF_6 & CaF_2
(D) a molten mixture of AlO(OH) and $Al(OH)_3$

80. Blister copper is refined by stirring molten impure metal with green logs of wood because such a wood liberates hydrocarbon gases (like CH_4). This process X is called _____ and the metal contains impurities of Y is _____.
(A) X = cupellation, Y = CuO_2 (B) X = polling, Y = Cu_2O
(C) X = polling, Y = CuO (D) X = cupellation, Y = CuO

81. Select the correct statement :
(A) Magnetite is an ore of manganese (B) Pyrolusite is an ore of lead
(C) Siderite is carbonate ore of iron (D) FeS_2 is rolled gold

82. Three most occuring elements in the earth crust are
(A) O, Si, Al (B) Si, O, Fe (C) Fe, Ca, Al (D) Si, O, N

83. An ore containing the impurity of $FeCr_2O_4$ is concentrated by
(A) magnetic-separation (B) gravity separation
(C) froth-floatation method (D) electrostatic method

84. A piece of steel is heated until redness and then plugged into cold water or oil. This treatment of steel makes it
(A) soft and malleable (B) hard but not brittle (C) more brittle (D) hard and brittle

85. In the extraction of aluminium
Process X : applied for red bauxite to remove iron oxide (chief impurity)
Process Y : (Serpeck's process) : applied for white bauxite to remove Z (chief impurity) then, process X and impurity Z are
(A) X = Hall and Heroult's process and Z = SiO_2 (B) X = Baeyer's process and Z = SiO_2
(C) X = Serpeck's process and Z = iron oxide (D) X = Baeyer's process and Z = iron oxide

86. Which of the following statement(s) is / are incorrect?
(A) Liquation is applied when the metal has low melting point than that of impurities.
(B) Presence of carbon in steel makes it hard due to formation of Fe_3C called cementite.
(C) Less reactive metals like Hg, Pb and Cu are obtained by auto reduction of their sulphide or oxide ores.
(D) Amalgamation method of purification cannot be applied for Au and Ag.

87. Si and Ge used for semiconductors are required to be of high purity and hence purified by
(A) zone-refining (B) electrorefining (C) Van-Arkel's process (D) cupellation process

88. In electrorefining of metals anode and cathode are taken as thick slab of impure metal and a strip of pure-metal respectively while the electrolyte is solution of a complex metal salt. This method cannot be applied for the refining of
(A) Copper (B) Sodium (C) Aluminium (D) Zinc and Silver

89. Select the correct statement:
(A) Black jack is ZnS
(B) Sulphide ores are concentrated by floatation method
(C) Parke's process is based on distribution principle
(D) All are correct

90. The metal for which, its property of formation of volatile complex is taken in account for its extraction is
(A) Cobalt (B) Nickel (C) Vanadium (D) Iron

91. A metal has a high concentration into the earth crust and whose oxides cannot be reduced by carbon. The most suitable method for the extraction of such metal is
(A) Alumino thermite process (B) Electrolysis process
(C) Van-Arkel's process (D) Cupellation

92. The process, which does not use a catalyst is
(A) Contact process (B) Thermite process
(C) Ostwald's process (D) Haber's process

93. Refractory materials are generally used in furnaces because
(A) they are chemically inert (B) they can withstand high temperature
(C) they do not contain impurities (D) they decrease melting point of ore

94. % of silver in 'german silver' is
(A) 0 (B) 80 (C) 90 (D) 10

95. Modern method of steel manufacturing is
(A) open hearth process (B) L.D. Process
(C) Bessemerisation (D) Cupellation

96. When an impurity in a metal has greater affinity for oxygen and is more easily oxidises than the metal itself. Then, the metal is refined by
(A) cupellation (B) zone-refining (C) distillation (D) electrolytic process

97. "Fool's gold" is
(A) iron pyrites (B) horn silver (C) copper pyrites (D) bronze

98. During electrolytic reduction of alumina, two auxiliary electrolytes X and Y are added to increase the electrical conductance and lower the temperature of melt in order to making fused mixture very conducting. X and Y are
(A) cryolite and flourspar (B) cryolite and alum
(C) alum and flourspar (D) flourspar and bauxite

99. For extraction of sodium from NaCl, the electrolytic mixture NaCl + KCl + $CaCl_2$ is used. During extraction process, only sodium is deposited on cathode but K and Ca do not because
(A) Na is more reactive than K and Ca
(B) Na is less reactive than K and Ca
(C) NaCl is less stable than Na_3AlF_6 and $CaCl_2$
(D) the discharge potential of Na^+ is less than that of K^+ and Ca^{2+} ions.

100. Which of the following statements is correct regarding the slag formation during the extraction of a metal like copper or iron.
(A) The slag is lighter and lower melting than the metal
(B) The slag is heavier and lower melting than the metal
(C) The slag is lighter and higher melting than the metal
(D) The slag is heavier and higher melting than the metal.

101. Among the following groups of oxides, the group containing oxides that cannot be reduced by C to give the respective metal is
(A) CaO and K_2O (B) Fe_2O_3 and ZnO (C) Cu_2O and SnO_2 (D) PbO and Pb_3O_4

102. The beneficiation of the sulphide ores is usually done by
(A) Electrolysis (B) Smelting process
(C) Metal displacement method (D) Froth flotation method

103. In the alumino thermite process, Al acts as
(A) An oxidising agent (B) A flux (C) A reducing agent (D) A solder

104. The process of the isolation of a metal by dissolving the ore in a suitable chemical reagent followed by precipitation of the metal by a more electropositive metal is called:
(A) hydrometallurgy (B) electrometallurgy (C) zone refining (D) electrorefining

105. Froth floatation process for concentration of ores is an illustration of the practical application of:
(A) Adsorption (B) Absorption (C) Coagulation (D) Sedimentation

106. Which process of purification is represented by the following equation :

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

(A) Cupellation (B) Poling (C) Van-Arkel Process (D) Zone refining

107. Mercury is purified by:
(A) Passing through dilute HNO_3 (B) Distillation
(C) Distribution (D) Vapour phase refining

108. Which of the following employ(s) thermal decomposition of volatile iodide compounds?
(A) Thermite process (B) Hall's process (C) Van-Arkel's process (D) Mond's process

109. The method of zone refining of metals is based on the principle of:
(A) Greater mobility of the pure metal than that of impurity.
(B) Higher melting point of the impurity than that of the pure metal.
(C) Greater noble character of the solid metal than that of the impurity
(D) Greater solubility of the impurity in the molten state than in the solid

110. Railway wagon axles are made by heating iron rods embedded in charcoal powder. This process is known as:
(A) Sherardising (B) Annealing (C) Tempering (D) Case hardening

111. 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

112. Carnallite on electrolysis gives:
(A) Ca and Cl_2 (B) Na and CO_2 (C) Al and Cl_2 (D) Mg and Cl_2

EXERCISE # 2

Single choice type

1.1 The formula of carnallite is :
(A) $LiAl(Si_2O_5)_2$ (B) $KCl.MgCl_2.6H_2O$ (C) $K_2O.Al_2O_3.6SiO_2$ (D) $KCl.MgCl_2.2H_2O$

1.2 Dolomite is mineral whose formula is :
(A) $CaMg(CO_3)_2$ (B) $MgCO_3$ (C) $CaCO_3.MgCO_3$ (D) (A) & (C) both

1.3 Magnetic separation process may be used for the concentration of :
(A) chalcopyrite (B) bauxite (C) haematite (D) calamine

1.4 Bauxite is leached with :
(A) KCl (B) NaCN (C) NaOH (D) Na_2SO_4

1.5 Froth floatation process for the concentration of sulphide ores is an illustration of the practical application of:
(A) adsorption (B) absorption (C) sedimentation (D) coagulation

1.6 Which one of the following is not a method of concentration of ore ?
(A) electromagnetic separation (B) smelting
(C) gravity separation (D) froth floatation process

1.7 Froth floatation process used for the concentration of sulphide ore :
(A) is based on the difference in wetability of different minerals.
(B) uses Xanthates and fatty acids as collector.
(C) uses NaCN as depressant in the mixture of ZnS and PbS when ZnS forms soluble complex and PbS forms froth.
(D) All are correct statements.

1.8 Haematite ore is concentrated by :
(A) gravity separation method (B) froth floatation process
(C) amalgamation (D) leaching

1.9 The metal which mainly occurs as oxide ore in nature is :
(A) gold (B) lead (C) aluminium (D) magnesium

1.10 In the extraction of aluminium
Process X : employed for red bauxite to remove iron oxide (main impurity)
Process Y : (Serpeck`s process) : used for white bauxite to remove Z (main impurity) then,
Select correct option for the process X and impurity Z.
(A) X = Hall and Heroult`s process and Z = $SiO_2$ (B) X = Bayer`s process and Z = SiO_2
(C) X = Serpeck`s process and Y = iron oxide (D) X = Bayer`s process and Y = iron oxide

1.11 Which of the following statements is correct regarding the slag obtained during the extraction of a metal like copper or iron ?
(A) The slag is lighter and has lower melting point than the metal
(B) The slag is heavier and has lower melting point than the metal
(C) The slag is lighter and has higher melting point than the metal
(D) The slag is heavier and has higher melting point than the metal

1.12 The slag consists of molten impurities, generally, in the form of :
(A) metal carbonate (B) metal silicate (C) metal oxide (D) metal nitrate

1.13 The reason, for floating of ore particles in concentration by froth floatation process is that :
(A) they are light (B) they are insoluble (C) they are charged (D) they are hydrophobic

1.14 The process of the isolation of a metal by dissolving the ore in a suitable chemical reagent followed by precipitation of the metal by a more electropositive metal is called :
(A) hydrometallurgy (B) electrometallurgy (C) zone refining (D) electro-refining

1.15 Choose the correct option using the code regarding roasting process.
(I) It is the process of heating the ore in air in a reverberatory furnace to obtain the oxide.
(II) It is an exothermic process.
(III) It is used for the concentration of sulphide ore.
(IV) It removes easily oxidisable volatile impurities present in the concentrated ore.
(A) I, II and III (B) I, II and IV (C) I, III and IV (D) I, II, III and IV

1.16 Magnesium is extracted by electrolysing fused magnesium chloride containing NaCl & $CaCl_2$ using :
(A) a nickel cathode and a graphite anode.
(B) the iron container as anode and a nickel cathode.
(C) the iron container as cathode and a graphite rod as anode.
(D) the nickel container as cathode and iron anode.

1.17 In the metallurgy of iron, the upper layer obtained in the bottom of blast furnace mainly contains :
(A) $CaSiO_3$ (B) spongy iron (C) Fe_2O_3 (D) $FeSiO_3$

1.18 During extraction of iron, which of the following act as a flux :
(A) Silica (B) Calcium silicate (C) Lime stone (D) Coke

1.19 Ellingham diagram represents :
(A) change of ΔG with temperature. (B) change of ΔH with temperature.
(C) change of ΔG with pressure. (D) change of $(\Delta G - T\Delta S)$ with temperature.

1.20 Which one of the following reactions occurs during smelting in the reduction zone at lower temperature (in iron metallurgy) ?
(A) $CaO + SiO_2 \longrightarrow CaSiO_3$ (slag) (B) $Fe_2O_3 + 3C \longrightarrow 2Fe + CO$
(C) $3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$ (D) $CO_2 + C \longrightarrow 2CO$

1.21 A sulphide ore like ZnS is first roasted into its oxide prior to reduction by carbon because :
(A) a sulphide ore cannot be reduced to metal at all
(B) no reducing agent is found suitable for reducing a sulphide ore.
(C) the Gibb's free energy of formation of most sulphides are greater than that for CS_2.
(D) a metal oxide is generally less stable than the metal sulphide.

1.22 Extraction of silver from Ag_2S by the use of sodium cyanide is an example of :
(A) roasting (B) hydrometallurgy (C) electrometallurgy (D) smelting

1.23 In the purification of aluminium by Hoope's process, impurities of silicon and copper are added to molten aluminium in order to :
(A) make the melt conducting (B) lower the melting point of the melt
(C) smooth deposit of aluminium (D) make the melt heavier

1.24 Which method of purification is represented by the equations ?

$$\underset{\text{(impure)}}{Ti + 2I_2} \xrightarrow{500\ K} TiI_4 \xrightarrow{1675\ K} \underset{\text{(Pure)}}{Ti + 2I_2}$$

(A) Cupellation (B) Poling (C) Van Arkel (D) Zone refining

1.25 Select correct statement regarding silver extraction / purification process.
(A) When the lead-silver alloy is rich in silver, lead is removed by the cupellation process.
(B) Lead is removed from argentiferous lead by Parke's process.
(C) Zinc forms an alloy with lead, from which lead is separated by distillation.
(D) Zinc forms an alloy with silver, from which zinc is separated by distillation.

1.26 Formation of volatile $Ni(CO)_4$ and then its subsequent decomposition into Ni and CO makes basis of Mond's process :

$$Ni + 4CO \xrightarrow{T_1} Ni(CO)_4 \xrightarrow{T_2} Ni + 4CO$$, T_1 and T_2 are :

(A) 100ºC, 50ºC (B) 50ºC, 100ºC (C) 50ºC, 200ºC (D) 200ºC, 50ºC

1.27 Which method is not correctly matched for refining of crude metals ?
(A) Distillation : zinc and mercury (B) Liquation : tin
(C) Van Arkel : titatnium (D) Mond process : lead

1.28 Silver ore dissolves in dilute solution of NaCN in the presence of air to form :
(A) AgCN (B) $[Ag(CN)_2]^-$ (C) AgCNO (D) $[Ag(CN)_3]^{3-}$

1.29 Which of the following metals may be present in the anode mud during electrorefining of copper?
I. Gold ; II. Iron, III. Silver ; IV Magnesium
(A) I and II (B) II and IV (C) I and III (D) III and IV

1.30 Which one of the following processes involves the principle of fractional crystallisation for the refining of impure metals ?
(A) Parke's process (B) Mond's process (C) Van Arkel process (D) Zone refining

1.31 In the electrolysis of molten alumina during the manufacture of aluminium :
(A) Al_2O_3 undergoes dissociation (B) cryolite undergoes dissociation
(C) Al_2O_3 and cryolite both undergo dissociation (D) Neither of the two undergoes dissociation

1.32 Consider the following isolation / purification processes.
(I) Heating impure metal with I_2 at 150 – 200ºC and passing the resulting volatile iodide on hot tungsten filament at 1400ºC to get the pure metal.
(II) Heating the sulphide ore in air until a part is converted to oxide and then further heating in the absence of air to let the oxide react with unchanged metal sulphide to get the metal.
(III) Electrolysis of the molten electrolyte containing metal oxide and cryolite or florspar to obtain the metal.
The processes used for obtaining aluminium, titanium and lead are respectively :
(A) (I), (II) and (III) (B) (II), (III) and (I) (C) (III), (I) and (II) (D) (II), (I) and (III)

1.33 Poling process is used for the :
(A) reduction of CuO to Cu in impure copper (B) purification of silver
(C) reduction of Al_2O_3 to Al (D) none

1.34 In Van Arkel method, if I_2 is introduced at 1800 K over impure zirconium metal, the product will be :
(A) iodide of the metal (B) pure metal
(C) impurities react with iodine (D) none of these

1.35 During the electrolysis of fused carnallite, $MgCl_2$ is decomposed to liberate Mg at cathode and not KCl to liberate the K at cathode. This is because of :
(A) lower decomposition voltage of $MgCl_2$ than that of KCl
(B) higher decomposition voltage of $MgCl_2$ than that of KCl.
(C) higher melting point of $MgCl_2$ than KCl.
(D) none of the above

1.36 Match the reactions taking place in blast furnace with temperature - range of operations

	Column - I		**Column - II**
(a)	$C + CO_2 \rightarrow 2CO$	(p)	$\approx 1000^oC$
(b)	$FeO + CO \rightarrow Fe + CO_2$	(q)	$\approx 800^oC$
(c)	$CaO + SiO_2 \rightarrow CaSiO_3$	(r)	$\approx 1800^oC$
(d)	$Fe_3O_4 + 4CO \rightarrow 3Fe + 4CO_2$	(s)	$\approx 400^oC$

Select the correct option from the given codes.

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

More than one choice type

2.1 Hoop's process of purification of aluminium involves formation of layers during electrolysis. It involves
(A) the three layers have same densities but different materials.
(B) the three layers have different densities
(C) the upper layer is of pure aluminium which acts as a cathode
(D) the bottom layer is of impure aluminium which acts as an anode and middle layer consists of cryolite and BaF_2.

2.2 Metallurgical process of zinc involves roasting of zinc sulphide followed by reduction. Metallic zinc distills over as it is volatile and impurities like Cu, Pd and Fe gets condensed. The crude metal obtained is called spelter, which may be purified by
(A) electrolysis process (B) fractional distillation
(C) polling (D) heating with iodine

2.3 Calcination and roasting processes of reduction of ores to their oxides are beneficial
(A) to convert ores into porous form so that their reduction becomes easier
(B) as volatile impurities like P, As, Sb, S are removed
(C) as organic impurities are removed.
(D) as the ores are converted into oxide form which makes the reduction easier

2.4 In the extraction of copper, the reaction which takes place in Bessemer converter is
(A) $2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2 \uparrow$ (B) $CuFeS_2 + O_2 \longrightarrow Cu_2S + 2FeS + SO_2 \uparrow$
(C) $2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2 \uparrow$ (D) $2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2$

2.5 Extraction of silver from argentiferrous lead (Pb +Ag) involves
(A) distillation method (B) cupellation
(C) froth flotation method (D) treatment with NaCl

2.6 In the manufacturing of metallic sodium by fused salt-electrolysis method (Down's process), small amount of $CaCl_2$ that added is known as auxiliary electrolyte and is used to
(A) improve the electrical conductance (B) decrease the melting point of NaCl
(C) stabilise the metallic sodium (D) increase the temperature of electrolysis

2.7 Metal(s) which does/do not form amalgam is/are
(A) Fe (B) Pt (C) Zn (D) Au

2.8 Auto reduction process is used in extraction of
(A) Cu (B) Hg (C) Al (D) Fe

2.9 Zone refining is used for purification of
(A) Ge (B) Si (C) Ga (D) Se

2.10 Which of the following process (es) are used for purification of Bauxite ore?
(A) Hall's process (B) Serpeck's process (C) Baeyer's process (D) Mond's process

2.11 Metals which can be extracted by smelting process
(A) Pb (B) Fe (C) Zn (D) Mg

2.12 Common impurities present in Bauxite are
(A) CuO (B) ZnO (C) Fe_2O_3 (D) SiO_2

2.13 Which of the following reduction reactions are actually employed in commerical extraction of metals?
(A) $Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe$ (B) $Cr_2O_3 + 2Al \rightarrow Al_2O_3 + 2Cr$
(C) $2Na[Au(CN)_2] + Zn \rightarrow Na_2[Zn(CN)_4] + 2Au$ (D) $Cu_2S + Pb \rightarrow Cu + PbS \downarrow$

2.14 Which of the following cannot be obtained by electrolytic reduction of their compounds in aqueous solution?
(A) Barium (B) Cadmium (C) Potassium (D) nickel

2.15 Which of the following ores is(are) concentrated by froth floatation?
(A) haematite (B) galena (C) copper pyrite (D) azurite

2.16 Which of the following statements is/are common between roasting and sintering?
(A) Both require heating of the ore.
(B) Both involve burning away of organic matter.
(C) Both the process cause partial fusion of ore, resulting in bigger lumps.
(D) Both are performed only for sulphide ores.

2.17 Which of the following reaction(s) occur during calcination?
(A) $CaCO_3 \rightarrow CaO + CO_2$ (B) $4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$
(C) $2Al(OH)_3 \rightarrow Al_2O_3 + 3H_2O$ (D) $CuS + CuSO_4 \rightarrow 2Cu + 2SO_2$

2.18 Roasting is usually performed in
(A) blast furnace (B) reverberatory furnace
(C) Bessemer's converter (D) electric furnace

2.19 Which of the following is(are) sulphide ores?
(A) Argentite (B) Galena (C) Anglesite (D) Copper glance

2.20 Which of the following is(are) regarded as iron ores?
(A) Haematite (B) Magnetite (C) Limonite (D) Copper pyrites

2.21 Which of the following employ downward movement of ore due to gravity?
(A) Gravity separation (B) Froth floatation
(C) Blast furnace (D) Bessemer's coverter

2.22 Calcium silicate slag formed in extraction of iron
(A) prevents the reoxidation of molten iron.
(B) catalyses the combustion of carbon.
(C) reduces CO_2 toCO at the bottom of the furnace.
(D) is used in cement industry.

2.23 Amphoteric nature of aluminium is employed in which of the following process for extraction of aluminium?
(A) Baeyer's process (B) Hall's process (C) Serpek's process (D) Dow's process

2.24 Noble metal(s) which are commercially extracted by cyanide process is(are)
(A) copper (B) silver (C) gold (D) mercury

2.25 Carbon reduction method is employed for commercial extraction of
(A) haematite (B) cassiterite (C) iron pyrite (D) corundum

2.26 The chief rection(s) occuring in blast furnace during extraction of iron from haematite is(are)
(A) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ (B) $FeO + SiO_2 \rightarrow FeSiO_3$
(C) $Fe_2O_3 + C \rightarrow 2Fe + 3CO$ (D) $CaO + SiO_2 \rightarrow CaSiO_3$

2.27 Which of the following are true for electrolytic extraction of aluminium
(A) cathode material contains graphite (B) anode material contains graphite
(C) cathode reacts away forming CO_2 (D) anode reacts away forming CO_2

2.28 During extraction of copper, it is obtained in the form of molten *matte*. Which of the following is **not true**?
(A) matte is further treated in Bessemer's coverter
(B) molten *matte* is electrolysed
(C) It is treated with a blast of air and sand
(D) It is dissolved in $CuSiF_6$ and crystallised.

2.29 Which of the following ores is (are) concentrated industrially by froth floatation?
(A) Copper pyrites (B) Galena (C) Dolomite (D) Carnallite

2.30 Which of the following is true for calcination of a metal ore?
(A) It makes the ore more porous
(B) The ore is heated to a temperature when fusion just begins
(C) Hydrated salts lose their water of crystallisation
(D) Impurities of S, As and Sb are removed in the form of their volatile oxides.

2.31 The major role of fluorspar (CaF_2) which is added in small quantities in the electrolytic reduction of alumina dissolved in fused cryolite (Na_3AlF_6) is
(A) as a catalyst
(B) to make the fused mixture very conducting
(C) to lower the temperature of the melt
(D) to decrease the rate of oxidation of carbon at the anode.

2.32 The difference(s) between roasting and calcination is (are)
(A) roasting is highly endothermic while calcination is not.
(B) partial fusion occurs in calcination but not in roasting.
(C) calcination is performed in limited supply of air but roasting employs excess air.
(D) combustion reactions occur in roasting but not in calcination.

2.33 Leaching is used for the concentration of:
(A) Red bauxite (B) Haematite (C) Gold ore (D) Silver ore

2.34 The correct statements are :
(A) generally the calcination and roasting is done in blast furance
(B) the sandy and rocky materials associated with ore are called matrix
(C) froth floatation process is suitable for sulphide ores
(D) substance that reacts with gangue to form fusible mass is called slag

2.35 Poling is employed in refining of
(A) iron (B) copper (C) tin (D) lead

2.36 Which of the following reaction is not occur in blast furance during extraction of iron :

(A) $CaO + SiO_2 \longrightarrow CaSiO_3$ (B) $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

(C) $FeO + SiO_2 \longrightarrow FeSiO_3$ (D) $FeO \longrightarrow Fe + \frac{1}{2} O_2$

2.37 Which of the following process(es) occur(s) during the extraction of copper from chalcopyrites ?

(A) Froth floatation (B) Roasting (C) Bessemerisation (D) calcination

2.38 Poling process is used for the refining of :

(A) Iron (B) Copper (C) Tin (D) Lead

2.39 Calcium silicate (slag) formed in the slag formation zone in extraction of iron from haematite ore :

(A) does not dissolve in molten iron. (B) being lighter floats on the molten iron .

(C) is used in cement industry and as building material.

(D) prevents the re-oxidation of molten iron.

2.40 The major role of fluorspar (CaF_2) which is added in small quantities in the electrolytic reduction of alumina dissolved in fused cryolite (Na_3AlF_6) is :

(A) as a catalyst. (B) to make the fused mixture very conducting.

(C) to lower the temperature of the melt. (D) to decrease the rate of oxidation of carbon at anode.

2.41 Which of the following statement(s) is (are) incorrect ?

(A) In Serpeck's process silica is removed by heating the bauxite to 1800°C with coke in a current of N_2

(B) In extraction of lead from galena roasting and self reduction takes place in the same furnace but under different conditions of temperature and supply of air

(C) The tin is obtained by the carbon reduction of black tin.

(D) None

2.42 Liquation process may be applied for the purification of :

(A) copper (B) tin (C) iron (D) zinc

2.43 In alumino-thermite process, aluminium is used as :

(A) oxidising agent (B) flux (C) reducing agent (D) solder

2.44 Which of the following statement(s) is/are correct ?

(A) Cuprite and Zincite are oxide ores. (B) Magnesite and carnallite are carbonate ores.

(C) Chalcocite and azurite are ores of copper. (D) Feldspar and albite minerals contain aluminium.

2.45 Of the following reduction processes, the correct process(es) is/are :

(A) $Fe_2O_3 + CO \longrightarrow Fe + CO_2$ (B) $ZnO + C \longrightarrow Zn + CO$

(C) $Cu_2O + Cu_2S \longrightarrow Cu + SO_2$ (D) $PbO + C \longrightarrow Pb + CO$

2.46 Roasting of copper pyrites is done :

(A) to remove moisture. (B) to oxidise free sulphur and antimony.

(C) to convert pyrites completely into Cu_2O and FeO. (D) to remove volatile organic impurities.

2.47 In which of the following pairs, both the minerals are oxides?

(A) Sylvine, Saltpetre (B) Cassiterite, Litharge

(C) Siderite, Corundum (D) Cuprite, Tin stone

2.48 Select the correct statement(s) with respect to the differences between roasting and calcination.

(A) In roasting at higher temperature sulphide ores of the some metal like Cu, Pb, Hg etc. are reduced directly to metal but not in calcination.

(B) Partial fusion occurs in calcination but not in roasting.

(C) Calcination is done in limited supply of air or absence of air but in roasting supply of excess air is required.

(D) Combustion reaction occurs in roasting but not in calcination.

SUBJECTIVE

1. Name three ores which are concentrated by froth-floatation process.

2. What is meant by a depressant ?

3. Which concentration method is used for separating tungsten ore particles from cassiterite ore (SnO_2) ?

4. Which metals are obtained by self reduction of their ores ?

5. How carnallite ore is made anhydrous ?

6. What is the role of a stabiliser in froth-floatation process ?

7. Out of C and CO, which is a better reducing agent for ZnO ?

8. Why the HgO decomposes into its constituent elements on heating ?

9. The standard free energy of formation of MgO and CO at temperatures 1000ºC and 2000ºC are given below (they refer to the reaction involving one mole of oxygen at one atmospheric pressure). Calculate the free energy change to the reaction

$2MgO + 2C \longrightarrow 2Mg + 2CO$

at each of the two temperature and comment on your answer.

$2Mg + O_2 \longrightarrow 2MgO$ $\quad \Delta G_{1000°C} = -941$ kJ/mol, $\Delta G_{2000°C} = -314$ kJ/mol

$2C + O_2 \longrightarrow 2CO$ $\quad \Delta G_{1000°C} = -439$ kJ/mol, $\Delta G_{2000°C} = -628$ kJ/mol

10. CuO is less reduced by carbon but more reduced by H_2. Explain in terms of thermodynamics, given: ΔG°_f for CuO = -129.7 kJ mol^{-1}, CO = -137.2 kJ $mole^{-1}$, H_2O = -237.2 kJ mol^{-1}

11. Using the Ellingham diagram, show the lowest temperature at which MgO can be reduced to metal by carbon. What is the overall reaction at this temperature ?

12. Describe the principle of extraction of each of the following.
(i) Sn from SnO_2 , (ii) Pb from PbS , (iii) Ag from Ag_2S

13. Cinnabar (HgS) and galena (PbS) on roasting often give their respective metals but zinc blende (ZnS) does not. explain.

14. Magnesium oxide is often used as the lining in steel making furnace, Explain.

15. In the extraction of tin from tin stone addition of excess lime stone should be avoided. Why ?

16. In the extraction of lead from galena lime stone is added, why ?

17. Why excess of carbon is added in the zinc metallurgy ?

18. In the extractive metallurgy of iron from haematite ore, lime stone is added during smelting. Explain why.

19. State the role of silica in the metallurgy of copper.

20. Why air is continuously passed through the suspension of the concentrated ore of silver, the argentite during leaching with the aqueous solution of sodium cyanide ?

21. Alkali metals and alkaline earth metals can only be extracted by electrolytic reduction of their fused salts, why?

22. What is the role of cryolite in the metallurgy of aluminium?

23. Estimate the minimum potential difference needed to reduce Al_2O_3 at 500ºC.

The reaction for decomposition is $\frac{2}{3} Al_2O_3 \longrightarrow \frac{4}{3} Al + O_2$

ΔG = + 960 kJ at 500ºC.

24. Use the relationship $\Delta G^\circ = -nF E^\circ_{cell}$ to estimate the minimum voltage required to electrolyse Al_2O_3 in the Hall-Heroult process.

$\Delta G^\circ_f (Al_2O_3) = -1520$ kJ mol^{-1} ; $\Delta G^\circ_f (CO_2) = -394$ kJ mol^{-1}

Show that the oxidation of the graphite anode to CO_2 permits the electrolysis to occur at a lower voltage than if the electrolysis reactions were $Al_2O_3 \longrightarrow 2Al + 3O_2$.

25. Name the physical processes which are used for the purification of impure metals ?

26. Which impure metals are purified by Poling process ?

27. Give the name of the metals which are purified using vapour phase thermal decomposition method.

28. Name the elements which are obtained as anode mud in the electrolytic refining of copper.

29. Why are sulphide ores generally roasted to oxide for the extraction of metals instead of being directly reduced ?

30. Why sulphide ores usually concentrated by froth floatation process ?

31. Why is the extraction of copper from pyrites more difficult than that from its oxide ore through reduction?

32. Name two metals which are used for the reduction in metallurgical process. Give one chemical equation for each.

33. Coke and flux are used in smelting in the extraction of iron from haematite. Explain giving the relevant chemical reactions.

34. Name the chemical process and also write the chemical reactions involved in the removal of impurities of copper and silver from impure gold.

35. How can you separate alumina from silica in a bauxite ore associated with silica? Give equations, if any.

36. What is the role of graphite rod in the electrometallurgy of aluminium?

37. Lead can also be obtained by reduction of roasted ore with coke. Out line the process.

38. Mond's process involves formation of $Ni(CO)_4$ and subsequent decomposition into Ni and CO.
$Ni + 4CO \xrightarrow{T_1} Ni(CO)_4 \xrightarrow{T_2} Ni + 4CO$. What are the values of temperatures, T_1 and T_2?

39. The following reactions take place during the extraction of copper from copper ore:
(a) $2Cu_2S(\ell) + 3O_2(g) \longrightarrow 2Cu_2O(\ell) + 2SO_2(g)$
(b) $2Cu_2O(\ell) + Cu_2S(\ell) \longrightarrow 6Cu(\ell) + SO_2(g)$
Identify the oxidising and reducing agents.

40. Explain the oxidative process used for the purificaiton of impure metals.

41. Write down the chemical reactions involved in the extraction of magnesium from Sea water.

42. Copper can be extracted by hydrometallurgy but not zinc. Explain.

43. The value of $\Delta_f G^\circ$ for formation of Cr_2O_3 is 540 kJ/mol and that of Al_2O_3 is –827 kJ/mol. Is the reduction of Cr_2O_3 possible with Al ?

EXERCISE # 3

PART - I : MATCH THE COLUMN

1.1 Match the method of concentration of the ore in column I with the ore in column II and select the correct alternate:

Column- I		**Column - II**	
(A)	magnetic separation	(P)	Ag_2S
(B)	froth floation	(Q)	$FeCr_2O_4$
(C)	gravity separation	(R)	$Al_2(SiO_3)_3$

1.2 Match column (I) (process) with column (II) (electrolyte)

Column (I) (process)		**Column (II) (electrolyte)**	
(A)	Downs cell	(P)	fused $MgCl_2$
(B)	Dow sea water process	(Q)	fused ($Al_2O_3 + Na_3AlF_6 + CaF_2$)
(C)	Hall-Heroult	(R)	fused (40% NaCl + 60% $CaCl_2$)
		(S)	($A\ell N + C + N_2$)

1.3 Match column - I with column - II and select the correct answer using the codes given below the lists:

Column - I		**Column - II**	
(A)	Van Arkel method	(P)	Manufacture of caustic soda
(B)	Solvay process	(Q)	Purification of titanium
(C)	Cupellation	(R)	Manufacture of Na_2CO_3
(D)	Poling	(S)	Purification of copper
		(T)	Refining of silver

1.4 Match column - I with column - II

Column - I (Property)		**Column - II (Element/compound)**	
(A)	Explosive	(P)	Cu
(B)	Self-reduction	(Q)	Fe_3O_4
(C)	Magnetic material	(R)	$Cu(CH_3COO)_2.Cu(OH)_2$
(D)	Verdigris	(S)	$Pb(NO_3)_2$

1.5 Match column - I and column - II and select the correct answer using the codes given below the lists:

Column - I		**Column - II**	
(A)	Cyanide process	(P)	Ultrapure Ge
(B)	Floatation process	(Q)	Dressing of HgS
(C)	Electrolytic reduction	(R)	Extraction of Al
(D)	Zone refining	(S)	Extraction of Au

1.6 Match **Column-I** with **Column-II** and select the correct answer using the codes given below .

Column-I (Metals)		**Column-II (Method used for refining)**	
(A)	Iron & copper	(P)	Poling
(B)	Zirconium & Titanium	(Q)	Bessemerisation
(C)	Lead & Tin	(R)	Van-Arkel
(D)	Copper & Tin	(S)	Liquation

1.7 Which of the following ore and metal are correctly matched:

Column-I (Ore)		**Column-II (Metal)**	
(A)	Carnallite	(P)	Zinc
(B)	Calamine	(Q)	Titanium
(C)	Ilmenite	(R)	Magnesium
(D)	Chalcopyrite	(S)	Copper

1.8 Which of the following metal is correctly matched with its ore:

Column-I (Metal)		**Column-II (Ore)**	
(A)	Iron	(P)	Siderite
(B)	Tin	(Q)	Silver glance
(C)	Magnesium	(R)	Cassiterite
(D)	Silver	(S)	Dolomite

1.9 Match the following choosing one item from column I and the appropriate item from column II.

Column-I		**Column-II**
(A)	Fe_2O_3 ore	(P) Calcination
(B)	PbS ore	(Q) Roasting
(C)	$CuFeS_2$	(R) Froth floatation process
		(S) Poling

1.10 Match the reactions listed in column (I) with processes listed in column (II).

Column – I (reactions)	**Column – II (processes)**
(A) $4\,Au + 8\,NaCN + 2\,H_2O + O_2\,(air) \longrightarrow 4\,Na\,[Au\,(CN)_2] + 4\,NaOH$	(p) Leaching
(B) $CuFeS_2 + 2\,H_2SO_4 \longrightarrow CuSO_4 + FeSO_4 + 2H_2S$	(q) Smelting
(C) $CaO + SiO_2 \xrightarrow{\Delta} CaSiO_3$	(r) Hydrometallurgy
(D) $MgCl_2.\,6\,H_2O \xrightarrow[\text{Dry HCl(g)}]{\Delta} MgCl_2 + 6\,H_2O$	(s) Calcination

1.11

Column – I (Reaction)		Column – II (Process)	
(A)	$FeO + SiO_2 \longrightarrow FeSiO_3$	(p)	Calcination
(B)	$3Mn_3O_4 + 8Al \longrightarrow 4Al_2O_3 + 9Mn$	(q)	Displacement method
(C)	$Cu_2S + 2Cu_2O \xrightarrow{\Delta} 6\,Cu + SO_2$	(r)	Smelting
(D)	$2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$	(s)	Thermite process
(E)	$2Na[Ag(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + 2Ag$	(t)	Bessemerisation

1.12 Match the purification processes given in **Column-I** with the metal(s) given in **Column-II.**

Column-I		Column-II	
(A)	Poling	(p)	Titanium
(B)	Cupellation	(q)	Copper
(C)	Liquation	(r)	Silver
(D)	Van Arkel method	(s)	Tin

PART - II : COMPREHENSION

Read the following passage carefully and answer the questions.

Comprehension # 1

The following "cycle of copper" experiment is performed in some general chemistry laboratories. The series of reactions starts with copper and ends with metallic copper. The steps are as follows : (1) A piece of copper wire of known mass is allowed to react with concentrated nitric acid [The products are copper (II) nitrate, nitrogen dioxide, and water]. (2) The copper (II) nitrate is treated with a sodium hydroxide solution to form copper (II) hydroxide precipitate. (3) On heating copper (II) hydroxide decomposes to yield copper (II) oxide. (4) The copper (II) oxide is reacted with concentrated sulphuric acid to yield copper (II) sulphate. (5) Copper (II) sulphate is treated with an excess of zinc metal to form metallic copper. (6) the remaining zinc metal is removed by treatment with hydrochloric acid and metallic copper is filtered, dried, and weighted.

2.1 Assuming that a student started with 65.6 g of copper, calculate the theoretical yield of copper sulphate.
(A) 165 g (B) 82.4 g (C) 90 g (D) 100.2 g

2.2 Copper obtained at the end of the cycle is..... amount originally taken.
(A) less than (B) greater than
(C) nearly equal (D) only copper salts are obtained.

2.3 $CuSO_4$ solution thus formed is subjected to electrolysis. To deposit all the copper formed at the end, a current of 50 A will have to be used for approximately :
(A) 10 hours (B) 1 hour (C) 5 hours (D) 0.5 hours

Comprehension # 2

At high temperature carbon reacts with water to produce a mixture of carbon monoxide, CO and hydrogen, H_2.

$$C + H_2O \xrightarrow{\text{red heat}} CO + H_2$$

CO is separated from H_2 and then used to separate nickel from cobalt by forming a volatile compound, nickel tetracarbonyl, $Ni(CO)_4$.

$$Ni + 4\,CO \rightarrow Ni(CO)_4$$

2.4 How many moles of $Ni(CO)_4$ could be obtained from the CO produced by the reaction of 75.0 g of carbon ? Assume 100% reaction and 100% recovery in both steps.
(A) 6.25 (B) 1.563 (C) 3.125 (D) 25.0

2.5 Formation of volatile $NI(CO)_4$ and its subsequent heating gives pure Ni. process is called :
(A) Hall (B) Dow (C) Serpeck (D) Mond

Comprehension # 3

Magnesium is a valuable, light weight metal used as a structural material as well as in alloys, in batteries, and in chemical synthesis. Although magnesium is plentiful in Earth's crust, it is cheaper to "mine" the metal from seawater. Magnesium forms the second most abundant cation in the sea (after sodium); there are about 1.3 g of magnesium in a kilogram of sea-water. The process from obtaining magnesium from sea - water employs all three types of reactions precipitation, acid-base, and redox reactions.

2.6 Precipitation reaction involves formation of :

(A) insoluble $MgCO_3$ by adding Na_2CO_3 (B) insoluble $Mg(OH)_2$ by adding $Ca(OH)_2$

(C) insoluble $MgSO_4$ by adding Na_2SO_4 (D) insoluble $MgCl_2$ by adding NaCl

2.7 Acid-base reaction involves reaction between:

(A) $MgCO_3$ and HCl (B) $Mg(OH)_2$ and H_2SO_4

(C) $Mg(OH)_2$ and HCl (D) $MgCO_3$ and H_2SO_4

2.8 Redox reaction involves reaction between :

(A) in the electrolytic cell when fused $MgCl_2$ is subjected to electrolysis.

(B) when fused $MgCl_2$ is heated.

(C) when fused $MgCO_3$ is strongly heated

(D) in none of the above.

2.9 Instead of calcium hydroxide, why don't we simply add sodium hydroxide to seawater to precipitate magnesium hydroxide ?

(A) Solubility of $Ca(OH)_2$ is smaller than that of NaOH so that $Mg(OH)_2$ is precipitated.

(B) NaOH may dissolve $Mg(OH)_2$ formed.

(C) NaOH may also precipitate other species, being a strong electrolyte

(D) NaOH, being a weak electrolyte will not coagulate $Mg(OH)_2$

2.10 Which is the best source of the given process in the metallurgical process ?

(A) Magnesite (B) Kieserite (C) Epsomite (D) Dolomite

Comprehension # 4

The chief ore of zinc is the sulphide, ZnS. The ore is concentrated by flotation process and then heated in air, which converts the ZnS to ZnO.

$$2ZnS + 3O_2 \xrightarrow{90.6\%} 2ZnO + 2SO_2 \quad .....(1)$$

The ZnO is then treated with dilute H_2SO_4

$$ZnO + H_2SO_4 \xrightarrow{100\%} 2ZnSO_4 + H_2O \quad .....(2)$$

to produce $ZnSO_4$(aq.) which produces Zn metal on electrolysis.

$$2\,ZnSO_4 + 2H_2O \xrightarrow{98.2\%} 2Zn + 2H_2SO_4 + O_2 \quad .....(3)$$

2.11 What mass of Zn will be obtained from an ore containing 225 kg of ZnS ? Efficiencies of the process have been indicated above the arrow mark. (Zn = 65, S = 32, O=16, H=1)

(A) 134 kg (B) 112 kg (C) 102 kg (D) 130 kg

2.12 What amount of current is required (with 100% efficiency) in step (3) if it takes one month ?

(A) 10.2 A (B) 15.4 A (C) 17.0 A (D) 154.0 A

2.13 ZnO is step (i) can also be dissolved in NaOH forming :

(A) $Zn(OH)_2$ (B) Na_2ZnO_2 (C) Na_2O_3 (D) $NaZn(OH)_4$

2.14 How many kilomoles of NaOH are required to dissolve all the ZnO of step (1) assuming 100% yield ?

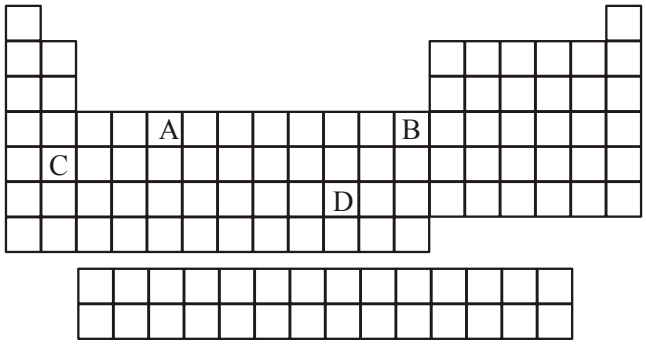
(A) 2.32 (B) 1.16 (C) 4.64 (D) 9.28

2.15 What valume of 98% H_2SO_4 (by weight, density 1.8 g/mL) is required in step (2) ?

(A) 130 L (B) 140 L (C) 120 L (D) 150 L

Comprehension # 5

Look at the location of elements A,B,C and D in the following periodic table and answer the questions given below :



2.16 Which of the elements indicated by A,B, C and D is expected to be found in native state
(A) A (B) B (C) C (D) D

2.17 Which is found as its sulphide ?
(A) A (B) B (C) C (D) D

2.18 Which is found as its carbonate ?
(A) A (B) B (C) C (D) D

2.19 Imagine a planet with an atmosphere that contains O_2 and SO_2 but no CO_2 and no moisture. What is the chemical composition of the mineral you would expect to find for the alkaline earth metals (M) on such a planet ?
(A) MO_2, M_2O_2 (B) MSO_3, MSO_4 (C) $M(HSO_3)_2\ M(HSO_4)_2$ (D) All of the above

Comprehension # 6

Metallic gold frequently is found in aluminosilicate rocks and it is finely dispersed among other minerals. It may be extracted by treating the crushed rock with aerated sodium cyanide solution. During this process metallic gold is slowly converted to $[Au(CN)_2]^-$, which is soluble in water. After equilibrium has been reached, the aqueous phase is pumped off and the metallic gold is recovered from it by reacting the gold complex with zinc, which is converted to $[Zn(CN)_4]^{2-}$. Gold in nature is frequently alloyed with silver which is also oxidised by aerated sodium cyanide solution.

2.20 The correct ionic reaction for the process are
(A) $4Au + 8CN^- + 2H_2O + O_2(air) \rightarrow 4[Au(CN)_2]^-$ (soluble) $+ 4OH^-$
(B) $Au + 2CN^- \longrightarrow Au[(CN)_2]^-$
(C) $Zn + 2CN^- \longrightarrow Zn[(CN)_2]^-$
(D) $Zn + 4CN^- \longrightarrow Zn[(CN)_4]^{2-}$

2.21 There have been several efforts to develop alternative gold extraction processes which could replace this one. Why ?
(A) Sodium cyanide solutions corrode mining machinery
(B) Sodium cyanide escapes into ground water and produces hydrogen cyanide which is toxic to many animals.
(C) Gold obtained by this process is not pure.
(D) The amount of gold in aluminosilicate rocks is very less.

2.22 The process described above in the passage is represents :
(A) ore concentration (B) pyrometallurgical extraction
(C) hydrometallurgical extraction (D) purification of metal

Comprehension # 7

Amongst the various ores of a metal (M) (sulphide, carbonates, oxides, hydrated or hydroxides) two ores [X] and [Y] show the following reactivity.
(i) [X] on calcination gives a black solid (S), water and a colourless gas which produces milkyness when passed through lime water. But this colourless gas does not decolourise the acidified $KMNO_4$.
(ii) [X] dissolved in dilute HCl on reaction with KI gives a white precipitate (P) and iodine gas.
(iii) [Y] on roasting at high temperature gives metal (M) and a gas (G_1) which turns starch iodate solution blue.
(iv) [Y] on reaction with dilute HCl gives a white precipitate (MS) and another gas (G_2) which turns lead acetate solution black and also reacts with gas (G_1) to precipitate colloidal sulphur in presence of moisture.
The M, S, [X] and [Y] gives greenish blue flame.

2.23 The metal ores [X] and [Y] are respectively :
(A) Carbonate and sulphide ores (B) Sulphide and carbonate ores
(C) Carbonate and hydroxide ores (D) Carbonate and oxide ores

2.24 Which of the following statements is correct about [Y] ?
(A) [Y] is converted to metal (M) by self reduction.
(B) Carbonate extract of [Y] gives yellow precipitate with suspension of $CdCO_3$.
(C) [Y] is copper glance or copper pyrite
(D) All of these

2.25 The gas (G_1) acts as
(A) oxidising agent (B) reducing agent
(C) oxidising and reducing agent (D) fluxing agent

2.26 The white precipitate (P) is of :
(A) Cu_2I_2 (B) CuI_2 (C) $K_2[CuI_4]$ (D) none

2.27 Identify the correct statement about [X].
(A) It is malachite or azurite ore (B) Its solution in dil. HCl gives white ppt of Cu_2I_2 with KI
(C) It on calcination gives black cupric oxide (D) All of these

PART - III : ASSERTION / REASONING

DIRECTIONS :

Each question has 5 choices (A), (B), (C), (D) and (E) out of which ONLY ONE is correct.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(C) Statement-1 is True, Statement-2 is False.
(D) Statement-1 is False, Statement-2 is True.
(E) Statement-1 and Statement-2 both are False.

3.1 **Statement-1 :** Sulphide ores are concentrated by froth floatation process.
Statement-2 : Pine oil acts as a frothing agent in froth floatation process.

3.2 **Statement-1 :** Platinum and gold occur in native state in nature.
Statement-2 : Platinum and gold are noble metals.

3.3 **Statement-1 :** Wolframite impurities are separated from cassiterite by electromagnetic separation.
Statement-2 : Cassiterite being magnetic is attacted by the magnet and forms a separate heap.

3.4 **Statement-1 :** In smelting, roasted ore is heated with powdered coke in presence of a flux.
Statement-2 : Oxides are reduced to metals by C or CO. Impurities are removed as slag.

3.5 **Statement-1 :** Al is used as a reducing agent in aluminothermy.
Statement-2 : Al has a lower melting point than Fe, Cr and Mn.

3.6 **Statement-1 :** Lead, tin and bismuth are purified by liquation method.
Statement-2 : Lead, tin and bismuth have low m.p. as compared to impurities.

3.7 **Statement-1 :** Wolframite impurity is separated from SnO_2 by magnetic separation
Statement-2 : Tin stone is ferromagnetic, therefore attracted by magnet.

3.8 **Statement-1 :** Titanium is purified by Van-Arkel method.
Statement-2 : Ti reacts with I_2 to form TiI_4 which decomposes at 1700 K to give pure Ti.

3.9 **Statement-1 :** CuO can be reduced by C, H_2 as well as CO
Statement-2 : CuO is basic oxide.

3.10 **Statement-1 :** Alkali metals can not be prepared by the electrolysis of their chlorides in aqueous solution
Statement-2 : Reduction potentials of alkali metals cations is much lower than that of H^+.

3.11 **Statement-1 :** Magnesium can be prepared by the electrolysis of aq. $MgCl_2$.
Statement-2 : The reduction potential of Mg^{2+} is much lower than that of H^+.

3.12 **Statement-1 :** Titanium can be purified by Van-Arkel process.
Statement-2 : TiI_4 is a volatile, stable compound.

3.13 **Statement-1 :** Magnesia and quick lime are used as basic flux.
Statement-2 : MgO and CaO can withstand very high temperatures.

3.14 **Statement-1 :** Nickel is purified `by the thermal decomposition of nickel tetracarbonyl.
Statement-2 : Nickel is a transitional element.

3.15 **Statement-1 :** During calcination the ore is heated well below its melting point in the limited supply of air or absence of air.
Statement-2 : The process of calcination is carried out for sulphide ores.

3.16 **Statement-1 :** Electropositive metals like Mg, Al are extracted by electrolysis of their salt solutions.
Statement-2 : Highly electropositive metals cannot be reduced by chemical reduction methods.

3.17 **Statement-1 :** In Hall - Heroult process aluminium is extracted by the electrolytic reduction of alumina dissolved in molten cryolite or fluorspar.
Statement-2 : The cryolite or fluorspar lower the melting point of melt and make it more conducting

3.18 **Statement-1 :** In extraction of copper from chalcopyrite after roasting in supply of air at moderate temperature, the temperature of the roasting ore is increased above the fusion temperature and then silica is added in reverberatory furnace .
Statement-2 : In the extraction of copper from chalcopyrites during smelting, the impurity of iron oxide is removed as fusible slag ($FeSiO_3$) in blast furnace or reverberatory furnace.

3.19 **Statement-1 :** Galena on heating in a reverberatory furnace above the melting point of metal gives metallic lead.
Statement-2 : Galena is partially converted to PbO and $PbSO_4$ which are reduced by excess galena to metallic lead.

3.20 **Statement-1 :** The reduction of a metal oxide is easier if the metal formed is in liquid state at the temperature of reduction.
Statement-2 : The value of entropy change ΔS of the reduction process is more on + ve side when the metal formed is in liquid state and the metal oxide being reduced is in solid state. Thus the value of ΔG becomes more on negative side.

3.21 **Statement-1 :** Extraction of zinc from sphalerite ore involves the roasting followed by reduction with coke.
Statement-2 : Zinc can be extracted by hydrometallurgy.

3.22 **Statement-1 :** Silica is added as a flux in reverberatory furnace, in the extraction of copper from copper pyrites.
Statement-2 : Silica decreases the melting point of the ore and increases the conductivity.

3.23 **Statement-1 :** Oxide ores of iron are concentrated through calcination/roasting in a reverberatory furnace.
Statement-2 : The water of crystalisation of hydrated oxide ore get lost as moisture, carbonate ore get deomposed to form oxide and sulphide if present is oxidised.

3.24 **Statement-1 :** In the Hoop's process of aluminium purification, the fused materials remains in three different layers. These layers remain intact even in electrolytic reduction, because
Statement-2 : All the layers have different densities

3.25 **Statement-1 :** In froth floatation process sodium ethyl xanthate is used as collector.
Statement-2 : Sulphide ores are water soluble.

PART - IV : TRUE / FALSE

4.1 Both copper glance and cuprite ores of copper cannot be concentrated by froth floatation process.

4.2 Liquation process is used for removing Pb from Zn-Ag mixture.

4.3 Any Fe_2O_3 which escapes reduction in the zone of reduction is reduced in zone of heat absorption by carbon in the extractive metallurgy of iron.

4.4 Anhydrous magnesium chloride from hydrated magnesium chloride can be obtained by calcination in presence of dry HCl gas.

4.5 Cassiterite, cerrusite and cuprite are oxide ores.

4.6 In extraction of iron from haematite ore, the reduction reactions take place in the lower temperature range and in the higher temperature range, in the blast furnace

4.7 The principal ore of aluminium, bauxite, usually contains silica, iron oxides and titanium oxide as impurities.

4.8 Solid copper obtained from bessemer converter is called as blister copper.

4.9 In electrolytic refining, the impurities from the blister copper deposits anode mud which contains antimony, selenium, tellurium, silver , gold and platinum. (From copper pyrites)

4.10 The low grade ore of copper is leached with acid and is then treated with scrap iron to get copper

PART - V : FILL IN THE BLANKS

5.1 During the extraction, metallic silver is precipitated by the addition of _____ to _____ solution.

5.2 The most important ore of iron is _____.

5.3 CaO acts as _____ flux.

5.4 Aluminium is obtained from Al_2O_3 by _____ reduction.

5.5 Poling is used for the purification of _____.

5.6 In the basic bessemer process for the manufacture of steel, the lining of the convertor is made of _____. The slag formed consists of _____ with P_2O_5.

5.7 In the zone of heat-absorption the _____is reduced by _____to _____in the extraction of iron from haematite ore.

5.8 Anhydrous $MgCl_2$ is obtained from ore magnesite by _____and then _____ with _____ in a current of chlorine gas.

5.9 In the purification of tin stone, the impurities of wolframite are removed by_____.

5.10 In extractive metallurgy of zinc partial fusion of ZnO with coke is called ..... and reduction of the ore to the molten metal is called ..... . (smelting, calcination, roasting, sintering)

EXERCISE # 4

IIT-JEE PROBLEMS (PREVIOUS YEARS)

*** Marked Questions are having more than one correct option.**

1.1 Electrolytic reduction of alumina to aluminium by Hall-Heroult process is carried out : **[JEE - 2000, 1/35]**
(A) in the presence of NaCl.
(B) in the presenc 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.

1.2 The chemical processes in the production of steel from haematite ore involve : **[JEE - 2000, 1/35]**
(A) reduction (B) oxidation
(C) reduction followed by oxidation (D) oxidation followed by reduction

1.3 Write the chemical reactions involved in the extraction of metallic silver from argentite. **[JEE - 2000, 2/100]**

1.4 The chemical composition of slag formed during the smelting process in the extraction of copper is : **[JEE - 2001, 1/35]**
(A) $Cu_2O + FeS$ (B) $FeSiO_3$ (C) $CuFeS_2$ (D) $Cu_2S + FeO$

1.5 Which of the following process is used in the extractive metallurgy of magnesium ? **[JEE - 2002, 3/90]**
(A) Fused salt electrolysis (B) Self reduction
(C) Aqueous solution electrolysis (D) Thermite reduction

1.6 In the process of extraction of gold,

$$\text{Roasted gold ore} + CN^- + H_2O \xrightarrow{O_2} [X] + OH^-$$

$$[X] + Zn \longrightarrow [Y] + Au$$

Identify the complexes [X] and [Y]. **[JEE - 2003, 3/84]**
(A) $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_4]^{2-}$ (B) $X = [Au(CN)_4]^{3-}$, $Y = [Zn(CN)_4]^{2-}$
(C) $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_5]^{4-}$ (D) $X = [Au(CN)_4]^-$, $Y = [Zn(CN)_4]^{2-}$

1.7 Write down the reaction involved in the extraction of lead. What is the oxidation number of lead in litharge ? **[JEE - 2003, 2/60]**

1.8 Pb and Sn are extracted from their chief ores by : **[JEE - 2004, 3/84]**
(A) carbon reduction and self reduction. (B) self reduction and carbon reduction.
(C) electrolytic reduction and self reduction. (D) self reduction and electrolysis.

1.9 Two ores A1 and A2 of a metal M show the following reactivity : **[JEE - 2004, 4/60]**

A1 —Calcination→ S (black solid) + CO_2 + H_2O

A1 —(i) dil. HCl, (ii) KI→ P (precipitate) + I_2

A2 —Roasting→ G (gas) + M (metal)

G —Acidified $K_2Cr_2O_7$ solution→ green solution

Write the chemical formulae of A1, A2, S, P and G. Explain using required chemical reactions.

1.10 Which of the following ore contains both Fe and Cu ? **[JEE - 2005, 3/84]**
(A) Chalcopyrite (B) Malachite (C) Cuprite (D) Azurite

1.11 Match the extraction processes listed in column-I with metals listed in column-II. **[JEE - 2006, 6/184]**

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

1.12 Extraction of zinc from zinc blende is achieved by : **[JEE - 2007, 3/162]**
(A) electrolytic reduction
(B) roasting followed by reduction with carbon
(C) roasting followed by reduction with another metal
(D) roasting followed by self-reduction

1.13 Native silver metal forms a water soluble complex with a dilute aqueous solution of NaCN in the presence of: **[JEE - 2008, 3/163]**
(A) nitrogen (B) oxygen (C) carbon dioxide (D) argon

1.14 Match the conversions in Column-I with the type(s) of reaction(s) given in Column-II. **[JEE - 2008, 6/163]**

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

Comprehension : (Q. No. 1.15 to 1.17)

Copper is the most noble of the first row transition metals and occurs in small deposits in several countries, Ores of copper include chalcanthite ($CuSO_4.5H_2O$), 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.

1.15 Partial roasting of Chalcopyrite produces : **[JEE - 2010, 3/163]**
(A) Cu_2S and FeO (B) Cu_2O and FeO (C) CuS and Fe_2O_2 (D) Cu_2O and Fe_2O_2

1.16 Iron is removed from chalcopyrite as : **[JEE - 2010, 3/163]**
(A) FeO (B) FeS (C) Fe_2O_3 (D) $FeSiO_3$

1.17 In self-reduction, the reducing species is : **[JEE - 2010, 3/163]**
(A) S (B) O^{2-} (C) S^{2-} (D) SO_2

1.18 Extraction of metal from the ore **cassiterite** involves : **[JEE - 2011, 4/160]**
(A) Carbon reduction of an oxide ore (B) self-reduction of a sulphide ore
(C) removal of copper impurity (D) removal of iron impurity

1.19 Oxidation state of the metal in the minerals haematite and magnetite, respectively, are : **[JEE - 2011, 3/160]**
(A) II, III in haematite and III in magnetite (B) II, III in haematite and II in magnetite
(C) II in hamatite and II, III in magnetite (D) III in a haematite and II, III in magnetite

1.20 Sulfide ores are common for the metals : **[JEE Advanced 2013, P-1]**
(A) Ag, Cu and Pb (B) Ag, Cu and Sn (C) Ag, Mg and Pb (D) Al, Cu and Pb

1.21* The carbon-based reduction method is **NOT** used for the extraction of : **[JEE Advanced 2013, P-2]**
(A) tin from SnO_2 (B) iron from Fe_2O_3
(C) aluminium from Al_2O_3 (D) Magnesium from $MgCO_3.CaCO_3$

Paragraph for Question Nos. 1.22 to 1.23

An aqueous solution of a mixture of two inorganic salts, when treated with dilute HCl, gave a precipitate (**P**) and a filtrate (**Q**). The precipitate **P** was found to dissolve in hot water. The filtrate (Q) remained unchanged, when treated with H_2S in a dilute mineral acid medium. However, it gave a precipitate (**R**) with H_2S in an ammoniacal medium. The precipitate **R** gave a coloured solution (**S**), when treated with H_2O_2 in an aqueous NaOH medium.

122. The coloured solution **S** contains : **[JEE Advanced 2013, P-2]**
(A) $Fe_2(SO_4)_3$ (B) $CuSO_4$ (C) $ZnSO_4$ (D) Na_2CrO_4

123. The precipitate **P** contains : **[JEE Advanced 2013, P-2]**
(A) Pb^{2+} (B) Hg_2^{2+} (C) Ag^+ (D) Hg^{2+}

AIEEE PROBLEMS (PREVIOUS YEARS)

2.1 Refining of impure copper with zinc impurity is to be done by electrolysis using electrodes as : **[AIEEE - 2002]**

Cathode	Anode	Cathode	Anode
(1) pure copper	pure zinc	(2) pure zinc	pure copper
(3) pure copper	impure copper	(4) pure zinc	impure zinc

2.2 Aluminium is extracted by the electrolysis of : **[AIEEE - 2002]**
(1) alumina (2) bauxite
(3) molten cryolite (4) alumina mixed with molten cryolite

2.3 The metal extracted by leaching with a cyanide is : **[AIEEE - 2002]**
(1) Mg (2) Ag (3) Cu (4) Na

2.4 Which one of the following ores is best concentrated by froth floatation method ? **[AIEEE - 2004]**
(1) magnetite (2) cassiterite (3) galena (4) malachite.

2.5 Heating mixture of Cu_2O and Cu_2S will give : **[AIEEE - 2005]**
(1) Cu_2SO_3 (2) CuO + CuS (3) Cu + SO_3 (4) Cu + SO_2

2.6 During the process of electro-refining of copper some metals present as impurity settle as anode mud. These are : **[AIEEE - 2005]**
(1) Sn and Ag (2) Pb and Zn (3) Ag and Au (4) Fe and Ni

2.7 Which of the following factors is of no significance for roasting sulphide ores to the oxides and not subjecting the sulphide ores to carbon reduction directly ? **[AIEEE - 2008]**
(1) CO_2 is thermodynamically more stable than CS_2
(2) Metal sulphides are less stable than the corresponding oxides
(3) CO_2 is more volatile than CS_2
(4) Metal sulphides are thermodynamically more stable than CS_2

EXERCISE # 5

NCERT QUESTIONS

1. Copper can be extracted by hydrometallurgy but not zinc. Explain.

2. What is the role of depressant in froth floatation process?

3. Why is the extraction of copper from pyrites more difficult than that from its oxide ore through reduction?

4. Explain: (i) Zone refining (ii) Column chromatography.

5. Out of C and CO, which is a better reducing agent at 673 K ?

6. Name the common elements present in the anode mud in electrolytic refining of copper. Why are they so present ?

7. Write down the reactions taking place in different zones in the blast furnace during the extraction of iron.

8. Write chemical reactions taking place in the extraction of zinc from zinc blende.

9. State the role of silica in the metallurgy of copper.

10. What is meant by the term "chromatography"?

11. What criterion is followed for the selection of the stationary phase in chromatography?

12. Describe a method for refining nickel.

13. How can you separate alumina from silica in a bauxite ore associated with silica? Give equations, if any.

14. Giving examples, differentiate between 'roasting' and 'calcination'.

15. How is 'cast iron' different from 'pig iron"?

16. Differentiate between "minerals" and "ores".

17. Why copper matte is put in silica lined converter?

18. What is the role of cryolite in the metallurgy of aluminium?

19. How is leaching carried out in case of low grade copper ores?

20. Why is zinc not extracted from zinc oxide through reduction using CO?

21. The value of $\Delta_f G^{\ominus}$ for formation of Cr_2O_3 is – 540 kJmol^{-1} and that of Al_2O_3 is – 827 kJmol^{-1}. Is the reduction of Cr_2O_3 possible with Al ?

22. Out of C and CO, which is a better reducing agent for ZnO ?

23. The choice of a reducing agent in a particular case depends on thermodynamic factor. How far do you agree with this statement? Support your opinion with two examples.

24. Name the processes from which chlorine is obtained as a by-product. What will happen if an aqueous solution of NaCl is subjected to electrolysis?

25. What is the role of graphite rod in the electrometallurgy of aluminium?

6.26 Outline the principles of refining of metals by the following methods :
(i) Zone refining
(ii) Electrolytic refining
(iii) Vapour phase refining

ANSWER KEY

EXERCISE # 1

1.	(A)	**2.**	(C)	**3.**	(B)	**4.**	(B)	**5.**	(C)	**6.**	(D)	**7.**	(C)
8.	(B)	**9.**	(D)	**10.**	(B)	**11.**	(C)	**12*–**	(A)	**13*–**	(B), (C)	**14.**	(A)
15.	(D)	**16.**	(A)	**17.**	(B)	**18*–**	(B), (C), (D)			**19.**	(A)	**20.**	(A)
21.	(C)	**22.**	(B)	**23.**	(C)	**24.**	(D)	**25*–**	(A), (B), (C)			**26.***	(A), (C)
27.	(A)	**28.**	(C)	**29.**	(A)	**30.**	(C)	**31.**	(B)	**32.**	(C)	**33.**	(C)
34.	(C)	**35*–**	(A), (B), (D)	**36.**	(D)	**37.**	(A)	**38.**	(A)	**39.**	(C)		
40.	(C)	**41.**	(D)	**42.**	(D)	**43.**	(D)	**44.**	(D)	**45.**	(C)	**46*–**	(A),(B),(C)
47*–	(A), (D)	**48.**	(B)	**49.**	(B)	**50.**	(A)	**51.**	(A)	**52.**	(C)	**53.**	(D)
54.	(C)	**55.**	(D)	**56.**	(C)	**57.**	(B)	**58.**	(D)	**59.**	(C)	**60.**	(C)
61.	(B)	**62.**	(B)	**63.**	(C)	**64.**	(A)	**65.**	(A)	**66.**	(C)	**67.**	(A)
68.	(B)	**69.**	(A)	**70.**	(B)	**71.**	(C)	**72.**	(B)	**73.**	(B)	**74.**	(B)
75.	(B)	**76.**	(B)	**77.**	(A)	**78.**	(B)	**79.**	(C)	**80.**	(B)	**81.**	(C)
82.	(A)	**83.**	(A)	**84.**	(D)	**85.**	(B)	**86.**	(D)	**87.**	(A)	**88.**	(B)
89.	(D)	**90.**	(B)	**91.**	(B)	**92.**	(B)	**93.**	(B)	**94.**	(A)	**95.**	(B)
96.	(A)	**97.**	(A)	**98.**	(A)	**99.**	(D)	**100.**	(A)	**101.**	(A)	**102.**	(D)
103.	(C)	**104.**	(A)	**105.**	(A)	**106.**	(C)	**107.**	(B)	**108.**	(C)	**109.**	(D)
110.	(D)	**111.**	(C)	**112.**	(D)								

EXERCISE # 2

1.1	(B)	**1.2**	(D)	**1.3**	(C)	**1.4**	(C)	**1.5**	(A)	**1.6**	(B)	**1.7**	(D)
1.8	(A)	**1.9**	(C)	**1.10**	(B)	**1.11**	(A)	**1.12**	(B)	**1.13**	(D)	**1.14**	(A)
1.15	(D)	**1.16**	(C)	**1.17**	(A)	**1.18**	(C)	**1.19**	(A)	**1.20**	(C)	**1.21**	(C)
1.22	(B)	**1.23**	(D)	**1.24**	(C)	**1.25**	(D)	**1.26**	(C)	**1.27**	(D)	**1.28**	(B)
1.29	(C)	**1.30**	(D)	**1.31**	(B)	**1.32**	(C)	**1.33**	(A)	**1.34**	(D)	**1.35**	(A)
1.36	(A)	**2.1**	(B), (C), (D)	**2.2**	(A), (B)	**2.3**	(A), (B), (C), (D)			**2.4**	(A), (C), (D)		
2.5	(A), (B)	**2.6**	(A), (B)	**2.7**	(A)	**2.8**	(A), (B)	**2.9**	(A), (C)	**2.10**	(A), (B), (C)		
2.11	(A), (B), (C)	**2.12**	(C), (D)	**2.13**	(B), (C)	**2.14**	(A), (C)	**2.15**	(B), (C)	**2.16**	(A), (B)		
2.17	(A), (C)	**2.18**	(A), (B)	**2.19**	(A), (B), (D)	**2.20**	(A), (B), (C)			**2.21**	(A), (C)	**2.22**	(A), (D)
2.23	(A), (B)	**2.24**	(B), (C)	**2.25**	(A), (B)	**2.26**	(A), (D)	**2.27**	(A), (B), (D)			**2.28**	(B), (D)
2.29	(A), (B)	**2.30**	(A), (C)	**2.31**	(B), (C)	**2.32**	(A)	**2.33**	(C), (D)	**2.34**	(B), (C)	**2.35**	(B), (C)
2.36	(C), (D)	**2.37**	(A), (B), (C)	**2.38**	(B), (C)	**2.39**	(A), (B), (C), (D)			**2.40**	(B), (C)	**2.41**	(D)
2.42	(B), (D)	**2.43**	(C)	**2.44**	(A), (C), (D)	**2.45**	(A), (B), (C), (D)			**2.46**	(A), (B), (D)		
2.47	(B), (D)	**2.48**	(A), (C)										

SUBJECTIVE

1. This method is commonly used for the concentration of low grade sulphide ores like. ZnS, Cu_2S, PbS.

2. Substances which are used to prevent certain type of particles, from forming the froth with the bubbles by complexation.

3. By magnetic separation as wolframite ($FeWO_4 + MnWO_4$) has magnetic property.

4. Copper, Lead, Mercury etc.

5. By heating in a current of dry hydrogen chloride gas.

6. Stabiliser like cresol and aniline tend to stabilise the froth (i.e. the froth last for longer period).

7. All three oxidation curves for the carbon system lie above that for oxidation of zinc, until a temperature of approximately 1000ºC is reached. At this point, C is thermodynamically capable of reducing ZnO to Zn. Since this temperature is greater than the boiling point of Zn (907ºC), it will be formed as a vapour. The overall equation for reduction is, $ZnO(s) + C(s) \longrightarrow Zn(g) + CO(g)$.

8. When the temperature is raised a point will be reached where the graph crossed the $\Delta G = 0$ line. Below this temperature the free energy of formation of oxide is negative, so the oxide is stable. Above this temperature the free energy of formation of the oxide is positive, and the oxide becomes unstable and should decompose into metal and oxygen. This explains why HgO, for instance, decomposes spontaneously into its elements when heated.

9. For reaction at 1000ºC $\Delta G_{overall} = \Delta G_{(C)} - \Delta G_{(M)}$

$= -439 - (-941)$

$= +502$ kJ/mol

For reaction at 2000ºC $\Delta G = \Delta G_{(C)} - \Delta G_{(M)}$

$= -628 - (-314)$

$= -314$ kJ/mol

Reduction of MgO with C can occur at 2000ºC and not at 1000ºC.

10. $CuO + H_2 \longrightarrow Cu + H_2O$ $\qquad$ $CuO + C \longrightarrow Cu + CO$

$\Delta G^o_f = -237.2 - (-129.7)$ $\qquad$ $\Delta G^o_f = -137.2 - (-129.7)$

$\Delta G^o_f = -107.9$ kJ $\qquad$ $\Delta G^o_f = -7.5$ kJ

So, reduction of CuO is quite feasible with H_2 than C.

11. (1) Below 1600ºC the free energy difference is positive and no reaction occurs.
(2) At 1600ºC the lines intersect and the free energy difference is zero.
(3) Above 1600ºC the free energy difference becomes negative, and the thermodynamically

Overall reaction is $2C(s) + O_2(g) \longrightarrow 2CO(g)$

$2Mg(\ell) + O_2(g) \longrightarrow 2MgO(s)$

Overall reaction $2C(s) + 2MgO \longrightarrow 2Mg(\ell) + 2CO$

$C + MgO \longrightarrow Mg(\ell) + CO$

12. (i) Carbon reduction of SnO_2

$SnO_2 + 2C \rightarrow Sn + 2CO\uparrow$; $SnO_2 + C \rightarrow SnO + CO\uparrow$

$SnO + SiO_2 \rightarrow SnSiO_3$; $CaO + SiO_2 \rightarrow CaSiO_3$

$SnSiO_3 + CaO + C \rightarrow Sn + CaSiO_3 + CO\uparrow$ or use scrap iron

$SnSiO_3 + Fe \rightarrow Sn + FeSiO_3$

(ii) Self-reduction (i.e air reduction) of PbS

$PbS + 2O_2 \longrightarrow PbSO_4$; $\qquad$ $PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$

$PbS + 2PbO \longrightarrow 3Pb + SO_2$; $\qquad$ $PbS + PbSO_4 \longrightarrow 2Pb + 2SO_2$

$SiO_2 + CaO$ (flux) $\longrightarrow CaSiO_3$ (slag) ; $PbSiO_3 + CaO \longrightarrow PbO + CaSiO_3$ (slag)

CaO, prevents the formation of $PbSiO_3$.

(iii) Cyanide process.

Ag_2S (concentrated ore) + 2NaCN $\underset{}{\overset{Air}{\rightleftharpoons}}$ 2AgCN + Na_2S.

$4Na_2S + 5O_2 + 2H_2O \longrightarrow 2Na_2SO_4 + 4NaOH + 2S$

Na_2S is converted in to Na_2SO_4. Hence equilibrium shifts towards right side.

$AgCN + NaCN \longrightarrow Na[Ag(CN)_2]$ (soluble complex)

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

13. Oxide of Pb and Hg are unstable while that of zinc is stable towards heat, therefore, oxides of mercury and lead are reduced by their respective sulphides to the corresponding metals but zinc oxide does not. Explain.

14. MgO acts as a basic flux and removes certain acidic impurities present in steel in the form of slag.

$MgO + SiO_2 \longrightarrow MgSiO_3$; $3MgO + P_2O_5 \longrightarrow Mg_3(PO_4)_2$

15. It will combine with tin to form calcium stannate.

16. $CaO + SiO_2 \longrightarrow CaSiO_3$ (slag) ; $PbO + SiO_2 \longrightarrow PbSiO_3$

CaO converts the $PbSiO_3$ to PbO, $PbSiO_3 + CaO \longrightarrow PbO + CaSiO_3$, and also prevents the formation of $PbSO_4$.

17. It reduces ZnO to Zn and also reduces CO_2 to CO which is used as a fuel.

18. Remove the infusible impurities of silica as slag

$CaCO_3 \longrightarrow CaO + CO_2$; $CaO + SiO_2 \longrightarrow CaSiO_3$ (slag)

19. Silica removes iron oxide impurity remaining in the matte by forming silicate, $FeSiO_3$.

20. Na_2S is oxidised to Na_2SO_4 in the presence of air and thus equilibrium is shifted in the forward direction according to the following reactions.

$Ag_2S + 2NaCN \underset{}{\overset{air}{\rightleftharpoons}} 2AgCN + Na_2S$; $4Na_2S + 5O_2 + 2H_2O \longrightarrow 2Na_2SO_4 + 4NaOH + 2S\downarrow$

$Ag_2S + 4\ NaCN \rightleftharpoons 2Na\ [Ag(CN)_2] + Na_2S$;

21. As they have low ionisation energies and are more electropositive elements, they themselves act as strong reducing agent.

22. To lower the melting point and increase conductivity of the mixture.

23. Hence, the change in oxidation number of aluminium is 3 per mole. Since 4/3 moles of Al are produced n = 3 × 4/3 = 4

$$E_{ext} = \frac{960\,000}{4 \times 96490} = 2.5\ V$$

A potential difference of at least 2.5 V must be applied to the oxide to bring about reduction.

24. 1.6 V in Hall-Heroult process.

25. (A) liquation process, (B) fractional distillation process, (C) zone refining method and (D) chromatographic methods.

26. This method is used for the purification of those impure metals which contain their own oxides as one of the impurities. This process is used for the purification of copper and tin.

27. Ni, Zr, Ti etc.

28. Ag, Au, Pt, Sb, Se, Te.

29. If sulphide ores are reduced by carbon, carbondisulphide is formed which is difficult to get rid off. So sulphide ores are first roasted to get metal oxides which are then reduced by carbon.

30. Sulphide ores being lighter are easily wetted by oil to come on the surface of solution with froths during froth floatation process, leaving behind heavier gangue wetted by water.

31. The Gibbs energies of formation of most sulphides are greater than that for CS_2. In fact, CS_2 is an endothermic compound. Hence it is common practice to roast sulphide ores to corresponding oxides prior to reduction.

32. $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$; $CuSO_4 + Fe \longrightarrow FeSO_4 + Cu\downarrow$

33. $C + O_2 \longrightarrow CO_2$; $C + CO_2 \longrightarrow 2CO$
$3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$; $Fe_3O_4 + CO \longrightarrow 3FeO + CO_2$; $FeO + CO \longrightarrow Fe + CO_2$
$CaO + SiO_2$ (flux) $\longrightarrow CaSiO_3$(slag)
So coke & lime stone are added during smelting in extraction of iron.

34. Parting process $Cu + 2H_2SO_4$ (or conc. HNO_3) $\xrightarrow{Boil} CuSO_4 + SO_2 + 2H_2O$
$2\,Ag + 2H_2SO_4$ (or conc. HNO_3) $\xrightarrow{Boil} Ag_2SO_4 + SO_2 + 2H_2O$
% of Au in impure sample should not be more than 25%

35. $Al_2O_3 + N_2 + 3C \xrightarrow{1800°C} 2AlN + 3CO$; $SiO_2 + 2C \xrightarrow{1800°C} Si\uparrow + 2CO\uparrow$
$AlN + 3H_2O \longrightarrow Al(OH)_3\downarrow + NH_3$; $2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$

36. Graphite rods act as anode and get burnt away as CO and CO_2 during the process of electrolysis.

37. $2PbS + 3O_2 \xrightarrow{\Delta} 2PbO + 2SO_2$; $PbO + C \xrightarrow{\Delta} Pb + CO$

38. $Ni\,(s) + 4CO\,(g) \xrightarrow{50°C} Ni(CO)_4\,(g) \xrightarrow{200°C} Ni\,(s) + 4CO\,(g)$

39. (a) $2Cu_2S(\ell) + 3O_2(g) \longrightarrow 2Cu_2O(\ell) + 2SO_2(g)$
R.A. O.A.
(b) $2Cu_2O(\ell) + Cu_2S(\ell) \longrightarrow 6Cu(\ell) + SO_2(g)$
O.A. R.A.
R.A. = Reducing Agent, O.A. = Oxidising Agent

40. This process is used for removing the metallic (e.g., Mn, Cu, Pb, Sn, Fe, Ag etc.,) as well as non-metallic (e.g., C, P, S, Si etc.,) elements present as impurities. This process is based on the fact that when O_2 or air is passed through the impure molten metal, the impurities are easily oxidised into their oxides and then these oxides may be removed by one of the following suitable methods.
(i) cupellation process, (ii) bessemer's process, (iii) softening process and (iv) pudding process.

41. $MgCl_2$ (from sea water) + $Ca(OH)_2 \longrightarrow Mg(OH)_2\downarrow + CaCl_2$
$Mg(OH)_2 + 2HCl(aq) \longrightarrow MgCl_2 + 2H_2O$
$MgCl_2.6H_2O \xrightarrow[\text{Dry HCl(g)}]{\Delta} MgCl_2 + 6H_2O$
$MgCl_2 \rightleftharpoons Mg^{2+} + 2Cl^-$
At cathode : $Mg^{2+} + 2e^- \longrightarrow Mg$(99% pure) ;
At anode : $2Cl^- \longrightarrow Cl_2 + 2e^-$

42. Zinc is highly reactive metal. It may not be possible to replace it from a solution of $ZnSO_4$ easily.

43. $2Al + \frac{3}{2}O_2 \longrightarrow Al_2O_3$; $\Delta_fG^o = -827$ kJ/mol ; $2Cr + \frac{3}{2}O_2 \longrightarrow Cr_2O_3$; $\Delta_fG^o = -540$ kJ/mol
So, $\Delta G_{overall} = -827 - (-540) = -287$ kJ/mol
Hence $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$.

EXERCISE # 3

1.1 (A) → Q ; (B) → P ; (C) → R **1.2** (A)→ R, (B) → P, (C) → Q **1.3** (A) → Q ; (B) → R ; (C) → T ; (D) → S

1.4 (A) → S ; (B) → P ; (C) → Q ; (D) → R **1.5** (A) → S ; (B) → Q ; (C) → R ; (D) → P

1.6 (A) → Q ; (B) → R ; (C) → S ; (D) → P **1.7** (A) → R, (B) → P, (C) → Q, (D) → S

1.8 (A) → P, (B) → R, (C) → S, (D) → Q **1.9** (A) → P,Q ; (B) → Q,R ; (C) → Q,R,S

1.10 (A) → p, r ; (B) → p, r ; (C) → q ; (D) → s **1.11** (A) → r, t ; (B) → s ; (C) → t ; (D) → p ; (E) → q.

1.12 (A) → q,s ; (B) → r ; (C) → s ; (D) → p **2.1** (A) **2.2** (C) **2.3** (B) **2.4** (B) **2.5** (D) **2.6** (B) **2.7** (C)

2.8 (A) **2.9** (C) **2.10** (D) **2.11** (A) **2.12** (D) **2.13** (B) **2.14** (C) **2.15** (A) **2.16** (D) **2.17** (B)

2.18 (C) **2.19** (B) **2.20** (A) **2.21** (B) **2.22** (C) **2.23** (A) **2.24** (D) **2.25** (C) **2.26** (A)

2.27 (D) **3.1** (B) **3.2** (A) **3.3** (C) **3.4** (A) **3.5** (B) **3.6** (A) **3.7** (C) **3.8** (A) **3.9** (B) **3.10** (A) **3.11** (D)

3.12 (A) **3.13** (B) **3.14** (B) **3.15** (C) **3.16** (D) **3.17** (B) **3.18** (D) **3.19** (A) **3.20** (A)

3.21 (C) **3.22** (C) **3.23** (A) **3.24** (A) **3.25** (C) **4.1** True **4.2** False **4.3** True **4.4** True

4.5 False **4.6** True **4.7** True **4.8** True **4.9** True **4.10** True **5.1** Zn, Sodium argentocyanide

5.2 haematite (Fe_2O_3) **5.3** Basic, CaO (basic) + SiO_2 (acidic) $\longrightarrow$ $CaSiO_3$ (slag).

5.4 electrolytic, aluminium can not be extracted by any chemical methods because it lies above hydrogen in electrochemical series.

5.5 Tin / copper, green wood $\longrightarrow$ Hydrocarbons $\longrightarrow$ CH_4
$CuO + CH_4 \longrightarrow 4Cu$ (pure metal) + $CO_2 + 2H_2O$.

5.6 lime, calcium phosphate
$3CaO$ (basic oxide) + P_2O_5 (acidic oxide) $\longrightarrow$ $Ca_3(PO_4)_2$ (slag)

5.7 Carbon dioxide, carbon, carbonmonooxide. **5.8** Calcination, Reduction, carbon.
5.9 Electromagnetic seperator.

5.10 sintering, smelting
Partial fusion is called as sintering. When roasted ore, coke and flux is heated in blast furnace, the process is called smelting.

EXERCISE # 4

1.1 (C) **1.2** (C)

1.3 $Ag_2S + 4\,NaCN \overset{air}{\rightleftharpoons} 2Na[Ag(CN)_2] + Na_2S$

$4Na_2S + 5O_2 + 2H_2O \longrightarrow 2Na_2SO_4 + 4NaOH + 2S \downarrow$

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

1.4 $2CuFeS_2 + O_2 \rightarrow Cu_2S + 2FeS + SO_2$; $2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$
$FeO + SiO_2 \rightarrow FeSiO_3$.

1.5 (A) **1.6** (A) **1.7** O.N. is +2, litharge is PbO **1.8** (B)

1.9 Formation of CO_2 and H_2O indicates that ore A1 is hydrated carbonate ore.

A1 when treated with HCl and then KI gives white precipitate and iodine gas indicates that it is the ore of copper.

(A1) $CuCO_3.Cu(OH)_2 \xrightarrow{\Delta} CuO \downarrow$ (black) + CO_2 + H_2O.

$CuCO_3.Cu(OH)_2 + HCl \rightarrow CuCl_2 + H_2O + CO_2$.

$2Cu^{2+} + 4I^- \longrightarrow Cu_2I_2 \downarrow + I_2$.

The precipitation of metal (by self reduction) and evolution of a gas (on roasting) which turns acidified $Cr_2O_7^{2-}$ green indicates that A_2 is sulphide ore of copper.

(A2) $2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$; $Cu_2S + 2Cu_2O \longrightarrow 6Cu + SO_2$

$3SO_2 + Cr_2O_7^{2-} + 2H^+ \longrightarrow 2Cr^{3+}$ (green solution) + $3SO_2$ + H_2O.

So, A1 = $CuCO_3.Cu(OH)_2$ or $2CuCO_3.Cu(OH)_2$;

A2 = Cu_2S ; S = CuO; P = Cu_2I_2 ; G = SO_2

1.10 (A) **1.11** (A - p, r), (B - p), (C - q), (D - s). **1.12** (B) **1.13** (B) **1.14** (A) – p (B) – q (C) – p,r (D) p, s

1.15 (A) **1.16** (D) **1.17** (C) **1.18** (A), (C), (D) **1.19** (D) **1.20.** (A)

1.21* (CD) **1.22** (D) **1.23** (A) **2.1** (3) **2.2** (4) **2.3** (2) **2.4** (3)

2.5 (4) **2.6** (3) **2.7** (3)