SOLVED EXAMPLES

Ex. 1 Using data given below, predict whether the reduction of MgO with C is spontaneous or not at 1500°C.

$2C + O_2 \longrightarrow 2CO$ $\quad \Delta G^\circ \approx -530$ kJ

$2MgO \longrightarrow 2Mg + O_2$ $\quad \Delta G^\circ \approx +730$ kJ

Sol. The positive value of ΔG° indicates that the reduction of MgO with C dose not occur to a significant extent at 1500°C

$2C + O_2 \longrightarrow 2CO$ $\quad \Delta G^\circ \approx -530$ kJ

$2MgO \longrightarrow 2Mg + O_2$ $\quad \Delta G^\circ \approx +730$ kJ

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

or $MgO + C \longrightarrow Mg + CO$ $\quad \Delta G^\circ$ positive value.

Ex. 2 Sea water $\xrightarrow{(A)} Mg(OH)_2 \xrightarrow{(B)} MgCl_2.6H_2O \xrightarrow{(C)} MgCl_2 \xrightarrow{(D)} Mg + Cl_2\uparrow$

Identify the reagents and processes (A) to (D) and give the name of this process.

Sol. $MgCl_2$ (from sea water) $+ Ca(OH)_2$ (A) $\rightarrow Mg(OH)_2\downarrow + CaCl_2$; $Mg(OH)_2 + 2HCl$ (B) $\rightarrow MgCl_2$ (aq.) $+ 2H_2O$

Crystallisation of $MgCl_2$(aq) yields $MgCl_2.6H_2O$

$$MgCl_2\,6H_2O \xrightarrow[\text{Dry HCl}]{\text{Calcination (C)}} MgCl_2 + 6H_2O$$

$$MgCl_2(\bullet) \xrightarrow{\text{Electrolysis is (D)}} \underset{\downarrow +2e^-}{Mg^{2+}} + \underset{\downarrow Cl_2}{2Cl^-}$$

Mg (cathode) $\quad$ Cl_2 (anode)

Name of the process is Dow's process.

Ex. 3 Convert magnesite into anhydrous $MgCl_2$.

Sol. $MgCO_3 \xrightarrow{\Delta} MgO + CO_2$.

$MgO + C + Cl_2 \longrightarrow MgCl_2 + CO$

Ex. 4 At a site, low grade copper ores are available and zinc and iron scraps are also available. Which of the two scraps would be more suitable for reducing the leached copper ore and why?

Sol. Since zinc lies above iron in electrochemical series, it is more reactive than iron. As a result, if zinc scraps are used the reduction will be faster. However, zinc is a costlier metal than iron. Therefore, it will be advisable and advantageous to use iron scraps.

Ex. 5 A metal is extracted from its sulphide ore and the process of extraction involves the following steps.

Metal sulphide $\xrightarrow{(A)}$ Concentrated ore $\xrightarrow{(B)}$ Matte $\xrightarrow{(C)}$ Impure metal $\xrightarrow{(D)}$ Pure metal

Identify the steps (A), (B), (C) and (D).

Sol. (A) Froth floatation process. Sulphide ores are concentrated by froth-floatation process.

(B) Roasting. Metal sulphides are roasted to convert into metal oxide and to remove impurities.

In roasting ; $2CuFeS_2 + O_2 \longrightarrow Cu_2S + 2FeS + SO_2$.

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

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

$FeO + SiO_2 \longrightarrow FeSiO_3$

(C) Bessemerisation / self reduction. Reduction of metal oxide by its sulphide takes place in Bessemer converter.

In Bessemerisation ; $2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2$ (self - reduction)

(D) Electro-refining. Pure metal is obtained at cathode.

$M^{n+} + n\,e^- \longrightarrow m$

Ex. 6 Write chemical equations for metallurgical processes to represent :

(i) roasting of galena (PbS) in limited supply of air at moderate temperature.

(ii) reduction of Cu_2O using coke as a reducing agent.

(iii) deposition of pure silver from an aqueous solution of Ag^+.

Sol. (i) $2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$

$PbS + 2O_2 \longrightarrow PbSO_4$

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

(iii) $Ag^+ + e^- \xrightarrow{\text{Electrolysis}} Ag\downarrow$ (at cathode)

Ex. 7 Which is not the correct process-mineral matching in metallurgical extraction.

(A) Leaching : silver **(B)** Zone refining : lead.

(C) Liquation : tin **(D)** Van Arkel : Zr

Sol. Lead is purified by Electro-refining. Zone refining is used for the purification of Si and Ge.

Therefore, (B) option is correct.

Ex. 8 Tin stone, an oxide or of tin is amphoteric in nature. Explain.

Sol. Tin stone is cassiterite i.e. SnO_2. SnO_2 dissolves in acid and alkali both, hence amphoteric oxide.

$SnO_2 + 4HCl \longrightarrow SnCl_4 + 2H_2O$

$SnO_2 + 2NaOH \longrightarrow Na_2SnO_3 + H_2O$

Ex. 9 Select the incorrect statement.

(A) In the Bayer's Al_2O_3 goes in to solution as soluble $[Al(OH)_4]^-$ while other basic oxides as TiO_2 and Fe_2O_3 remain insoluble

(B) Extraction of zinc from zinc blende is achieved by roasting followed by reduction with carbon.

(C) The methods chiefly used for the extraction of lead and tin are respectively carbon reduction and electrolytic reduction.

(D) Extractive metallurgy of magnesium involves fused salt electrolysis.

Sol. Lead $\rightarrow$ self reduction; $2PbO + PbS \longrightarrow 3Pb + SO_2$

Tin $\rightarrow$ carbon reduction ; $SnO_2 + 2C \longrightarrow Sn + 2CO$

Therefore, (C) option is correct.

Ex. 10 **Assertion :** In froth floatation process sodium ethyl xanthate is used as collector.

Reason : Sulphide ores are water soluble.

(A) If both Assertion and Reason are true and Reason is a correct explanation of Assertion.

(B) If both Assertion and Reason are true and Reason is not a correct explanation of Assertion.

(C) If Assertion is true but Reason is false.

(D) If Assertion is false but Reason is true.

Sol. **Assertion :** Potassium or sodium ethyl xanthate is used as a collector. These get attached with the particles of the sulphide ore and thus make them water-repellant. Consequently the ore particles pass on into the froth. Collectors are always added in small quantity.

Reason : Sulphide ores are water insoluble.

Therefore, (C) option is correct.

Ex. 11 **Assertion :** In the electrolytic reduction of Al_2O_3, cryolite lowers the melting point of the mixture and brings conductivity.

Reason : Cryolite is an ore of aluminium.

(A) If both Assertion and Reason are true and Reason is a correct explanation of Assertion.

(B) If both Assertion and Reason are true and Reason is not a correct explanation of Assertion.

(C) If Assertion is true but Reason is false.

(D) If Assertion is false but Reason is true.

Sol. **Assertion :** Cryolite as impurity reduces the melting point of Al_2O_3 from 2200 K to approximately 930 K and being ionic compound dissociates to give ions which bring about the conductivity of the electrolyte.

Reason : Cryolite is Na_3AlF_6 and is ore of aluminium.

Therefore, (B) option is correct.

Ex. 12 **Assertion :** Reduction of ZnO with carbon is done at 1100°C.

Reason : ΔG° is negative at this temperature thus, process is spontaneous.

(A) If both Assertion and Reason are true and Reason is a correct explanation of Assertion.

(B) If both Assertion and Reason are true and Reason is not a correct explanation of Assertion.

(C) If Assertion is true but Reason is false.

(D) If Assertion is false but Reason is true.

Ans. 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

$$ZnO(s) + C(s) \longrightarrow Zn(g) + CO(g)$$

Therefore, (A) option is correct.

Ex. 13 Which of the following is not an ore of iron ?

(A) limonite **(B)** cassiterite **(C)** magnetite **(D)** none of these

Sol. SnO_2 , cassiterite is an ore of tin.

Therefore, (B) option is correct.

Ex. 14 In the extraction of copper from sulphide ore the metal is formed by reduction of Cu_2O with :

(A) FeS **(B)** CO **(C)** Cu_2S **(D)** SO_2

Sol. $2Cu_2O + Cu_2S \xrightarrow{\Delta} 6Cu + SO_2$.

Therefore, (C) option is correct.

Ex. 15 Which of the following is a carbonate ore ?

(A) pyrolusite **(B)** malachite **(C)** diaspore **(D)** cassiterite

Sol. $CuCO_3.Cu(OH)_2 \rightleftharpoons$ Malachite.

Therefore, (B) option is correct.

Ex. 16 Column-I and column-II contains four entries each. Entries of column-I are to be matched with some entries of column-II. Each entry of column-I may have the matching with one or more than one entries of column-II.

Column-I	Column-II
(A) Pb	**(p)** Bessemerisation
(B) Cu	**(q)** Roasting
(C) Zn	**(r)** Pyrometallurgy
(D) Fe (pig iron)	**(s)** Self-reduction method

Ans. (A) q, r, s; (B) p, q, r, s; (C) q, r; (D) r ;

Sol. **(A)** $2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$ (Roasting)

$PbS + PbO_2 \xrightarrow{\Delta} 2Pb + SO_2$ (Self-reduction method)

(B) $2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$ (Roasting)

$Cu_2S + 2Cu_2O \xrightarrow{\Delta} 6Cu + SO_2$ (Self-reduction takes place in Bessemer converter)

(C) $2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$ (Roasting)

$ZnO + C \xrightarrow{\Delta} Zn + CO$ (Carbon reduction)

(D) Haematite ore is calcined.

$3Fe_2O_3 + CO \xrightarrow{\Delta} 2Fe_3O_4 + CO_2$

$Fe_3O_4 + CO \xrightarrow{\Delta} 3FeO + CO_2$

$FeO + CO \xrightarrow{\Delta} Fe + CO_2$

Exercise # 1 [Single Correct Choice Type Questions]

1. 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

2. 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) Cerussite
(D) Lead	(s) Siderite

Codes :

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

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

3. 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.

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

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

6. Which of the following is not an ore ?
(A) Malachite **(B)** Calamine **(C)** Salt cake **(D)** Cerussite

7. 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 : $Be_3Al_2Si_6O_{18}$

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

9. 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.

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

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. 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 ΔG° negative, temperature should be high enough so that $T\Delta S^\circ > \Delta H^\circ$.
(D) All are correct statements.

13. 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

14. 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

15. 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) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

16. 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

17. 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

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

19. 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

20. 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.

21. 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) : $PbS \xrightarrow[\Delta]{air} PbO + PbS \longrightarrow Pb + SO_2$

(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

22. 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

23. 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

24. 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

25. Complexes formed in the cyanide process are :

(A) $[Au(CN)_2]^-$ **(B)** $[Ag(CN)_2]^-$ **(C)** $[Cu(CN)_4]^{2-}$ **(D)** $[Zn(CN)_4]^{2-}$

26. 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

27. 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.

28. Which of the following metals cannot be extracted by the carbon reduction process ?

(A) Zn **(B)** Fe **(C)** Al **(D)** Sn

29. 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

30. 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

31. Silver can be separated from lead by :
(A) fractional crystallisation **(B)** liquation
(C) cupellation **(D)** addition of zinc **(Parkes method)**

32. 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

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

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

35. 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

36. 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**

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

38. 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

39. Bauxite is leached with :
(A) KCl **(B)** NaCN **(C)** NaOH **(D)** Na_2SO_4

40. 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

41. 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

42. 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)** $KCl.MgCl_2.2H_2O$

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

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

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

46. 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

47. 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

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

49. 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

50. 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)** $FeSiO_3$

51. 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.

52. 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.

53. 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

54. 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)** $CO_2 + C \longrightarrow 2CO$

55. 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

56. 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.

57. 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

58. 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

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

60. 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

61. Which method of purification is represented by the equations ?

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

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

62. 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 Parkes 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.

63. 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

64. In the froth floatation process for the purification of minerals the particles float because :
(A) they are light. **(B)** they are insoluble.
(C) their surface is preferentially wetted by oil. **(D)** they bear an electrostatic charge.

65. An ore of tin containing $FeCr_2O_4$ is concentrated by :
(A) magnetic separation **(B)** froth floatation **(C)** leaching method **(D)** gravity separation.

66. Process of heating ore in air to remove sulphur is :
(A) calcination **(B)** roasting **(C)** smelting **(D)** none of these.

67. The rocky and silicious matter associated with an ore is called :
(A) slag **(B)** mineral **(C)** matrix or gangue **(D)** flux

68. The process of removing lighter gangue particles by washing in a current of water is called :
(A) levigation **(B)** liquation **(C)** leaching **(D)** cupellation.

69. Gravity separation method is based upon :
(A) preferential washing of ores and gangue particles.
(B) difference in densities of ore particles and impurities.
(C) difference in chemical properties of ore particles and impurities.
(D) none of these.

70. In roasting :
(A) moisture is removed. **(B)** non–metals as their volatile oxide are removed.
(C) ore becomes porous. **(D)** all the above.

71. Roasting is carried out in case of :
(A) galena **(B)** iron pyrites **(C)** copper glance **(D)** all.

72. Slag is a product of :
(A) flux and coke. **(B)** coke and metal oxide.
(C) flux and impurities. **(D)** metal and flux.

73. Which one of the following metals cannot be extracted by carbon reduction ?
(A) Pb **(B)** Fe **(C)** Zn **(D)** Al.

74. Among the following groups of oxides, the group that cannot be reduced by carbon to give the respective metals.
(A) Cu_2O, SnO_2 **(B)** Fe_2O_3 , ZnO **(C)** CuO, K_2O **(D)** PbO, FeO.

75. The process of bringing the metal or its ore into solution by the action of a suitable chemical reagent followed by extraction of the metal either by electrolysis or by a suitable precipitating agent i.e. more electropositive metal is called
(A) electrometallurgy **(B)** hydrometallurgy
(C) electro-refining **(D)** zone refining.

76. An ore after levigation is found to have basic impurities. Which of the following can be used as flux during smelting ?
(A) H_2SO_4 **(B)** $CaCO_3$ **(C)** SiO_2 **(D)** Both CaO and SiO_2 .

77. Among the following statements, the incorrect one is :
(A) calamine and siderite are carbonates **(B)** argentite and cuprite are oxides
(C) zinc blende and iron pyrites are sulphides **(D)** malachite and azurite are ores of copper

78. Electrolytic reduction method is used in the extraction of :
(A) highly electronegative elements. **(B)** highly electropositive elements.
(C) transition metals. **(D)** noble metals.

79. Cryolite is :
(A) Na_3AlF_6 and is used in the electrolysis of alumina for decreasing electrical conductivity.
(B) Na_3AlF_6 and is used in the electrolysis of alumina for lowering the melting point of alumina.
(C) Na_3AlF_6 and is used in the electrolytic purification of alumina.
(D) Na_3AlF_6 and is used in the electrolysis of alumina for increasing the melting point and electrical conductivity.

80. In the extraction of Cu the reaction takes place in Bessemer converter is :
(A) $2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$. **(B)** $2CuFeS_2 + O_2 \rightarrow Cu_2S + FeS + SO_2$.
(C) $2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$. **(D)** $2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$.

81. Which of the following statement is incorrect about the extractive metallurgy of copper ?
(A) Matte chiefly consists of iron sulphide and some ferrous oxide.
(B) The impurity of iron sulphide is removed as fusible slag, $FeSiO_3$ during roasting.
(C) The copper pyrite is concentrated by froth floatation process.
(D) Copper is obtained by self reduction in bessemer converter.

82. Tin and zinc can be refined by :
(A) cupellation **(B)** liquation **(C)** poling **(D)** bessemerisation.

83. Which one of the following reactions is an example of calcination process ?
(A) $2Ag + 2HCl + [O] \rightarrow 2AgCl + H_2O$ **(B)** $2Zn + O_2 \rightarrow 2ZnO$.
(C) $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$ **(D)** $MgCO_3 \rightarrow MgO + CO_2$.

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

Column I	Column II
I. Cyanide process.	**(a)** Ultra pure Ge
II. Froth floatation process.	**(b)** Pine oil.
III. Electrolytic reduction.	**(c)** Extraction of Al.
IV. Zone refining.	**(d)** Extraction of Au.

(A) I–(C), II–(A), III–(D), IV-(B) **(B)** I–(D), II–(B), III–(C), IV–(A)
(C) I–(C), II–(B), III–(D), IV-(A) **(D)** I–(D), II–(A), III–(C), IV-(B)

85. Van Arkel method of purification of metals involves converting the metal to :
(A) volatile stable compound. **(B)** volatile unstable compound.
(C) non-volatile stable compound. **(D)** none of these.

86. Copper and tin are refined by :
(A) liquation **(B)** cupellation **(C)** bessemerisation **(D)** poling.

87. The process of zone refining is used for :
(A) silicon **(B)** germanium **(C)** gallium **(D)** all the above.

88. Match the ores listed in column I with the type of ores listed in column II and select the correct alternate.

Column I	Column II
(a) Limonite.	**(p)** Carbonate ore.
(b) Argentite.	**(q)** Halide ore.
(c) Carnallite	**(r)** Sulphide ore.
(d) Calamine.	**(s)** Oxide ore.

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

89. 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) Leaching.	**(p)** Copper pyrite.
(b) Calcination.	**(q)** Siderite.
(c) Froth floatation.	**(r)** Bauxite.
(d) Magnetic separation.	**(s)** Chromite.

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

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

90. Match the extraction process listed in column I with metals listed in column II and choose the correct option.

Column I	Column II
(a) Self reduction.	**(p)** Copper from copper glance
(b) Carbon and carbon monoxide reduction.	**(q)** Silver from argentite.
(c) Electrolytic reduction in fused state.	**(r)** Aluminium from bauxite.
(d) Complex formation and displacement by metal.	**(s)** Iron from haematite.

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

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

91. Give the correct order of initials **T** or **F** for following statements. Use **T** if statement is true and **F** if it is false.

(i) In Gold Schmidt thermite process aluminium acts as a reducing agent.

(ii) Mg is extracted by electrolysis of aqueous solution of $MgCl_2$

(iii) Extraction of Pb is possible by carbon reduction of PbO in smelting.

(iv) Red bauxite is purified by Serpeck`s process

(A) T T T F **(B)** T F F T **(C)** F T T T **(D)** T F T F

92. Leaching of Ag_2S is carried out by heating it with a dilute solution of :

(A) NaCN only **(B)** HCl **(C)** NaOH **(D)** NaCN in presence of O_2

93. In which of the following pair of metals, both are commercially extracted from their respective ores by self reduction method ?

(A) Zn, Cu **(B)** Pb, Cu **(C)** Sn, Zn **(D)** Al, Ag

94. The iron obtained from the blast furnace is called :

(A) pig iron **(B)** cast iron **(C)** wrought iron **(D)** steel

95. The extraction of zinc from zinc blende involves :

(A) the electrolytic reduction.

(B) the roasting followed by reduction with carbon.

(C) the calcination followed by reduction with another metal.

(D) the roasting at molten temperature.

96. Carbon cannot be used in the reduction of Al_2O_3 because :

(A) it is non-metal

(B) the heat of formation of CO_2 is more than that of Al_2O_3

(C) pure carbon is not easily available

(D) the heat of formation of Al_2O_3 is too high

97. 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 fluorspar 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)

98. Consider the following statements

S1 : In extraction of iron from haematite ore, the reduction reactions take place only in the lower temperature range in the blast furnace.

S2 : Calamine is an carbonate ore of zinc.

S3 : The principal ore of aluminium, bauxite, usually contains silica, iron oxides and titanium oxide as impurities.

S4 : Solidified copper obtained from silica lined convertor (Bessemer converter) has blistered appearance due to the evolution of SO_2.

and arrange in the order of true/false.

(A) F T T T **(B)** F T F F **(C)** F F T T **(D)** T F F T

99. Consider the following statements

S1 : In electrolytic refining, the impurities from the blister copper deposits anode mud which contains antimony, selenium, tellurium, silver , gold and platinum. (From copper pyrites)

S2 : In Serpeck's process silica is removed by heating the bauxite to 1800ºC with coke in a current of N_2 .

S3 : Chalcocite and azurite are ores of copper.

S4 : The tin is obtained by the carbon reduction of black tin.

and arrange in the order of true/false.

(A) T F T T **(B)** F T F F **(C)** F F T T **(D)** T T T T

100. Consider the following statements

S1 : Extraction of zinc from sphalerite involves roasting followed by carbon reduction.

S2 : In bessemer convertor, along with copper $FeSiO_3$ is also obtained.

S3 : In extraction of lead, CaO prevents the formation of $PbSiO_3$.

S4 : Copper is extracted by hydrometallurgy from low grade ores and scraps.

and arrange in the order of true/false.

(A) T T T F **(B)** F T T F **(C)** T T T T **(D)** F F F T

101. Consider the following statements

S1 : Poling process is used for the refining of copper and lead.

S2 : The scavenger which is used in the manufacture of steel is manganese.

S3 : The chemical composition of matte is $Cu_2O + Cu_2S$.

S4 : In the extraction of aluminium from alumina Al_2O_3 undergoes dissociation.

and arrange in the order of true/false.

(A) F T F F **(B)** T T F F **(C)** F F T T **(D)** T T F T

Exercise # 2 Part # I [Multiple Correct Choice Type Questions]

1. Liquation process may be applied for the purification of :
(A) copper **(B)** tin **(C)** iron **(D)** zinc

2. 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)** $PbO + C \longrightarrow Pb + CO$

3. 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.

4. Which of the following process(es) occur(s) during the extraction of copper from chalcopyrites ?
(A) Froth floatation **(B)** Roasting **(C)** Bessemerisation **(D)** calcination

5. 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.

6. 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

7. 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.

8. In which of the following extraction no reducing agent is required ?
(A) Iron from haematite. **(B)** Aluminium from bauxite.
(C) Magnesium from carnallite. **(D)** Zinc from zinc blende.

9. The smelting of iron in a blast furnace involves the following processes :
(A) combustion **(B)** reduction **(C)** slag formation **(D)** fusion

10. Out of Cu_2S, HgS, Ag_2S, PbS and ZnS, roasting will convert the minerals into metal in case of :
(A) Cu_2S, PbS **(B)** HgS,ZnS **(C)** Cu_2S, Ag_2S **(D)** HgS,Cu_2S.

11. Select the correct statement :
(A) Dolomite contains both magnesium and calcium.
(B) Extraction of lead from galena involves roasting in limited supply of air at moderate temperature followed by self reduction at higher temperature (to melt the charge).
(C) Extraction of zinc from zinc blende involves roasting followed by reduction with carbon.
(D) The chemical composition of 'slag' formed during the extraction of iron and copper is $FeSiO_3$.

12. Which of the following statement(s) is/are true for the extraction of tin from ore cassiterite ?
(A) Impurity of wolframite is removed by magnetic separation.
(B) The concentrated ore containing 60-70% SnO_2 is called as black tin.
(C) Tin is obtained by the carbon reduction of SnO_2.
(D) Anglesite is an another ore of tin.

13. Of the following reduction processes, the correct process(es) is/are :
(A) $B_2O_3 + Al \xrightarrow{\Delta} B.$ **(B)** $Cr_2O_3 + 2Al \xrightarrow{\Delta} Cr.$
(C) $TiCl_4 + Mg \xrightarrow{\Delta} Ti.$ **(D)** $PbS + PbO \xrightarrow{\Delta} Pb.$

14. Why lime stone is added In the extraction of lead from galena ?
(A) It prevents the formation of $PbSO_4$.
(B) It remove the impurity of silica as fusible slag.
(C) It converts lead silicate to lead oxide.
(D) It remove the impurity of iron oxide as fusible slag.

15. Which of the following is / are correctly matched ?
(A) Copper - Bessemer converter. **(B)** Iron - Blast furnace
(C) Chromium - Aluminothermic process **(D)** Tin - Electrolytic reduction

16. The reaction(s) which does (do) not occur in the reduction zone in the extraction of iron from haematite ore is (are)
(A) $Fe_2O_3 + CO \rightarrow 2\,FeO + CO_2$ **(B)** $FeO + CO \rightarrow Fe + CO_2$
(C) $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$ **(D)** $CaO + SiO_2 \rightarrow CaSiO_3$

17. Froth floatation :
(A) is a physical method of separating mineral from the gangue
(B) is a method of concentration of ore depending on the difference in wet ability of gangue and the ore particles.
(C) is used for the concentration of sulphide ores
(D) is a method in which impurities sink to the bottom and ore particles pass on to the surface with froth.

18. Which of the following pair consists of ore of the same metal?
(A) Bauxite, Limonite **(B)** Haematite, Siderite
(C) Cinnabar, Cassiterite **(D)** Galena, Cerrusite

19. Which of the following reduction reactions are actually employed in commercial 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)** $Cu_2S + 2CuO \rightarrow 6Cu + SO_2$

20. Which of the following statement(s) is (are) true ?
(A) In the process of precipitation of silver from sodium dicyanidoargentate (I), the zinc acts as reducing agent as well as complexing agent.
(B) In process of the roasting, the copper pyrite is converted into a mixture of Cu_2S & FeS which, in turn, are partially oxidised
(C) Limonite, haematite and magnesite are ores of iron.
(D) Tin and lead both are extracted from their ores by self-reduction.

21. Which of the following is a correct statement ?
(A) Calamine is the ore of zinc. **(B)** Proustite is the ore of silver.
(C) Cassiterite is the ore of tin. **(D)** Diaspore is the ore of aluminium.

22. The chemical treatment of the ore for concentration is done in the case of :
(A) aluminium **(B)** silver **(C)** copper **(D)** gold

23. Which of the following reaction (s) occurs 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)** $CuS + CuSO_4 \rightarrow 2Cu + 2SO_2$

Part # II [Assertion & Reason Type Questions]

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 and Statement-2 is correct explanation for Statement-1.

(B) Statement-1 is true, Statement-2 is true and Statement-2 is not correct explanation for Statement-1.

(C) Statement-1 is true, Statement-2 is false.

(D) Statement-1 is false, Statement-2 is true.

(E) Both Statements are false.

1. **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.

2. **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. **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.

4. **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.

5. **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.

6. **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

7. **Statement-1 :** Wolframite impurity is separated from tin stone (SnO_2) by magnetic separation.
   Statement-2 : Tin stone is ferromagnetic and is attracted by the magnet.

8. **Statement-1 :** Wrought iron is prepared from cast iron by oxidising impurities in a reverberatory furnace lined with haematite.
   Statement-2 : Haematite oxidises carbon to carbon monoxide.

9. **Statement-1 :** Sulphide ores of Zn and Pb are generally converted into their respective oxides, prior to reduction.
   Statement-2 : The zinc oxide and lead oxide are reduced by carbon to their respective free metals.

10. **Statement-1 :** $CuFeS_2$ is concentrated by froth floatation method
    Statement-2 : $CuFeS_2$ is main ore of copper

11. **Statement-1 :** In the smelting of copper ore coke is added in the blast furnace.
Statement-2 : Coke reduces, CuO into Cu.

12. **Statement-1 :** Extraction of iron metal from iron oxide ore is carried out by heating with coke.
Statement-2 : The reaction $Fe_2O_3(s) \xrightarrow{\Delta} Fe(s) + 3/2O_2(g)$ is a spontaneous process at standard condition.

13. **Statement-1 :** All the ores are mineral
Statement-2 : Most of the ores contains metals in combined state

14. **Statement-1 :** In the extraction of Ag the complex $Na[Ag(CN)_2]$ is reacted with Zn
Statement-2 : Zn is transition metal according to electronic theory

15. **Statement-1 :** Thermite mixture Fe_2O_3+Al (powder) is used in the welding.
Statement-2 : Al is a good reductant

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

17. **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.

Exercise # 3 Part # I [Matrix Match Type Questions]

1.

Column-I (Ore)	Column-II (Created formula & properties)
(A) Iron pyrites	(p) FeS_2
(B) Fool's gold	(q) Sulphide ore
(C) Galena	(r) Fe_2O_3
(D) Haematite	(s) Concentrated by froth

2.

Column-I (Metal)	Column-II
(A) Magnesite	(p) Ore of magnesium
(B) Siderite	(q) Ore of aluminium
(C) Corundum	(r) Oxide ore
(D) Bauxite	(s) Carbonate ore

3.

Column-I (Ore)	Column-II
(A) Iron	(p) Carbon reduction method
(B) Lead	(q) Self reduction
(C) Copper	(r) Thermite process
(D) Chromium	(s) Hydrometallurgical process

4. Match the ores given in column-I with typ(s) of processes given in column-II.

Column – I	Column – II
(A) Haematite	(p) Slag formation during roasting/smelting and bessemerisation.
(B) Copper pyrites	(q) Reduction by carbon monoxide / carbon at different temperatures.
(C) Carnallite	(r) Electrolytic reduction.
(D) Bauxite	(s) Calcination.

5. Match the type of processes involved in the extraction of metal given in column-I with the given ores in column-II.

Column – I	Column – II
(A) Slag formation	(p) Extraction of copper from copper pyrites.
(B) Froth – floatation	(q) Extraction of aluminium form bauxite.
(C) Leaching	(r) Extraction of iron from haematite.
(D) Roasting	(s) Extraction of tin from cassiterite
	(t) Extraction of lead from galena.

6. Match the name of the processes given in column-I with type(s) of metallurgical methods given in column-II.

Column – I	Column – II
(A) Hall – Heroult process	(p) Molten $Al_2O_3 + Na_3AlF_6$ electrolysis.
(B) Dow's sea water process	(q) Molten $MgCl_2 + CaCl_2 + NaCl$ electrolysis.
(C) Hoop's process	(r) Molten impure aluminium + fluorides of Na^+, Ba^{2+} and Al^{3+} electrolysis.
(D) Mac-Arthur Forrest process	(s) Complex formation and displacement method.

7. 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

8.

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

9. 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 Type Questions]

Comprehension # 1

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.

1. 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. 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

3. The gas (G_1) acts as

(A) oxidising agent **(B)** reducing agent **(C)** oxidising and reducing agent **(D)** fluxing agent

4. The white precipitate (P) is of :

(A) Cu_2I_2 **(B)** CuI_2 **(C)** $K_2[CuI_4]$ **(D)** none

5. 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

Comprehension # 2

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.

1. 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. 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.

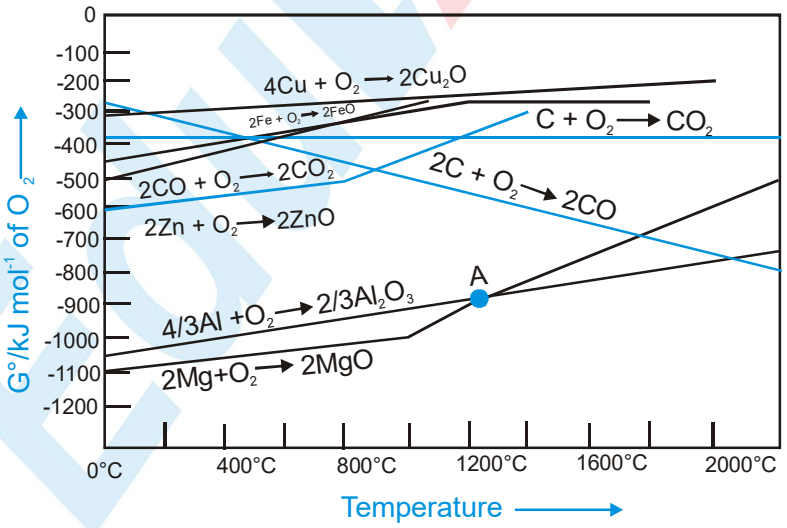
3. The process described above in the passage is represents :

(A) ore concentration **(B)** pyrometallurgical extraction

(C) hydrometallurgical extraction **(D)** purification of metal

Comprehension # 3

Read the following graph and answer the following questions.



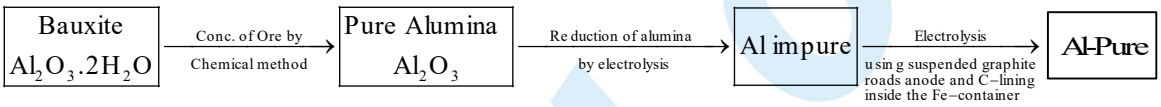
1. At what approximate temperature, zinc and carbon have equal affinity for oxygen.
(A) 1000ºC **(B)** 1500ºC **(C)** 500ºC **(D)** 1200ºC

2. To make the following reduction process spontaneous, temperature should be :
$ZnO + C \longrightarrow Zn + CO$
(A) < 1000ºC **(B)** > 1000ºC **(C)** < 500ºC **(D)** > 500ºC but < 1000ºC

3. Which of the following statement is true ?
(A) In the extractive metallurgy of iron, the reduction of calcined / roasted haematite ore in blast furnace takes place in the lower temperature range as well as in the higher temperature range by carbon monoxide and carbon respectively.
(B) The reduction of zinc oxide by carbon takes place at higher temperature than that in case of copper.
(C) It is quite easy to reduce oxide ores of copper directly to the metal by heating with coke after 500 - 600K.
(D) All of these

Comprehension # 4

Extraction of Aluminium can be understand by :



electrolytic reduction of Al_2O_3

Electrolyte	:	(Al_2O_3 + Cryolite)
Cathode	:	Graphite inside the Fe container
Anode	:	Graphite rods

1. The purpose of adding cryolite is :
(A) to increase the electrical conductivity of pure aluminium
(B) to lower the melting point of Al_2O_3
(C) to remove the impurities as slag
(D) to increase the Al% in the yield

2. Coke powder is spreaded over the molten electrolyte due to :
(A) prevent the heat radiation from the surface
(B) prevent the corrosion of graphite anode
(C) prevent oxidation of molten aluminium by air
(D) both (A) & (B)

3. The function of fluorspar (CaF_2) is :
(A) to decrease the melting point of electrolyte
(B) to increase electrolytic conductivity power
(C) to remove the impurities as slag
(D) all of the above

4. The molten electrolytes contains Na^+, Al^{3+}, Ca^{2+} but only Al gets deposited at cathode because :
(A) Standard reduction potential of Al is more than those of Na & Ca
(B) Standard oxidation potential of Al is more than those of Na & Ca
(C) Discharge potential of Al^{3+} is higher than Na^+ & Ca^{2+}
(D) Graphite reacts only with Al^{3+} and not with Na^+ & Ca^{2+}

5. What is wrong if anode is made of nickel instead of graphite?

(A) Ni is costly

(B) Anode will be affected by produced Cl_2

(C) Graphite remain unaffected by produced Cl_2

(D) Ni may be affected by high temp.

Comprehension # 5

Dow's process of extraction of Mg involves extraction of Mg from sea water. Sea water is concentrated in sun light and is then treated with slaked lime. Magnesium hydroxide is heated in a stream of HCl to give $MgCl_2$ which is electrolysed to discharge Mg. The mixture is in the ratio 35% $MgCl_2$ + 50% NaCl + 15% $CaCl_2$. NaCl and $CaCl_2$ are added to lower the fusion temperature and to increase the conductance.

$$Mg^{2+} + Ca(OH)_2 \longrightarrow Mg(OH)_2 + Ca^{2+}$$

$$Mg(OH)_2 + 2HCl \longrightarrow MgCl_2 + 2H_2O \text{ (liquid)}$$

Electrolysis of fused $MgCl_2$ $\xrightarrow{\text{Anode}}$ $2Cl^- \longrightarrow Cl_2 + 2_{-1}e^\circ$

$\xrightarrow{\text{Cathode}}$ $Mg^{2+} + 2_{-1}e^\circ \longrightarrow Mg$

Mg electrolysed is protected from atmospheric oxidation by a blanket of inert gases.

1. $Mg^{2+} + Ca(OH)_2 \longrightarrow Mg(OH)_2 \downarrow + Ca^{2+}$

This reaction indicates :

(A) $Mg(OH)_2$ is weaker base than $Ca(OH)_2$

(B) Solubility products of $Mg(OH)_2$ is less than that of $Ca(OH)_2$

(C) Polarising power of Mg^{2+} is more than that of Ca^{2+} ion

(D) Both (B) and (C).

2. In the hydrated chloride of Mg the value of of x is

(A) 6 **(B)** 4 **(C)** 8 **(D)** 10

3. Molten mixture contains Mg^{2+}, Na^+ and Ca^{2+} but at cathode only Mg is discharged because :

(A) Standard reduction potential of Mg is least among the three

(B) Standard oxidation potential of Mg is least among the three

(C) Discharge potential of Mg is highest

(D) None of these

4. Molten mixture of NaCl of $CaCl_2$ is added to the heated $MgCl_2.xH_2O$ with dry HCl gas because :

(A) $MgCl_2.xH_2O$ + dry HCl $\xrightarrow{973-1023\ K}$ Partially dehydrated $MgCl_2$ and molten (NaCl + $CaCl_2$) makes it fully dehydrated

(B) $CaCl_2$ is dehydrating agent

(C) ($CaCl_2$ + NaCl) lowers the m.pt. of $MgCl_2$

(D) None of the above

Exercise # 4 [Subjective Type Questions]

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

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

3. 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 ?

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

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

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

7. 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.

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

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

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

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

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

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

$\Delta G = +960$ kJ at 500ºC.

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

12. 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?

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

14. Explain the difference between **hydro-metallurgy** and **pyro-metallurgy**.

15. Gold is also extracted by cyanide process as in case of silver. Outline the reactions.

16. How is Ag extracted from silver coin ?

17. In the purification of bauxite ore as preliminary step in the production of AI, $[AI(OH)_4]^-$ can be converted to $AI(OH)_3$ by passing $CO_2(g)$ through it. Write an equation for the reaction that occurs.

18. Coke does not cause reduction of AI_2O_3.
Explain. ΔG_f^o (in kJ mol^{-1}) for

AI_2O_3	:	–1582
CO	:	–137.2

19. Following method of extracting Zn is based on thermodynamics:

(A) $2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$

(B) $ZnO + C \longrightarrow Zn + CO$

ΔG^o_f (standard free energies of formation, in kJ mol^{-1}) of

$ZnS = -205.4$; $ZnO = -318.2$

$SO_2 = -300.4$; $CO = -137.3$

Calculate free energy changes of the reactions and comment on the result.

20. Describe the principle of extraction of each of the following.

(i) Sn from SnO_2 , **(ii)** Pb from PbS , **(iii)** Ag from Ag_2S

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

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

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 $Al_2O_3 \longrightarrow 2Al + 3O_2$.

22. Lead metal is purified by electrolysis similar to that for copper; the electrolyte is lead (II) hexafluorosilicate $PbSiF_6$. Describe the process.

23. **(a)** Pure iron is prepared for special purposes by precipitating iron (III) oxide and reducing the dry oxide with H_2 gas. Write the balanced equation.

(b) HCI can't be used to precipitate $AI(OH)_3$ from soluble $Na[AI(OH)_4]$ but addition of NH_4CI can cause precipitation. Explain by reactions.

(c) AgCI (Horn silver) is converted into Ag by pyrometallurgical method. Describe reactions.

24. When an inert atmosphere is needed for a metallurgical process, nitrogen is frequently used. However, in the reduction of $TiCI_4$ by by magnesium, helium is used. Explain why nitrogen is not suitable for this process.

Exercise # 5 Part # I [Previous Year Questions] [AIEEE/JEE-MAIN]

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

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

3. 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

4. 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

5. Which method of purification is represented by the following equation : **[AIEEE - 2012]**
$Ti(s) + 2I_2(g) \xrightarrow{523K} TiI_4(g) \xrightarrow{1700K} Ti(s) + 2I_2(g)$
(1) Zone refining **(2)** Cupellation **(3)** Polling **(4)** Van Arkel

6. The distillation technique most suited for separating glycerol from spent-lye in the soap industry is: **[JEE (Mains) 2016]**
(1) Fractional distillation **(2)** Steam distillation
(3) Distillation under reduced pressure **(4)** Simple distillation

7. Which one of the following ores is best concentrated by froth floation method? **[JEE (Mains) 2016]**
(1) Siderite **(2)** Galena **(3)** Malachite **(4)** Magnetite

8. Galvanization is applying a coating of: **[JEE (Mains) 2016]**
(1) Cr **(2)** Cu **(3)** Zn **(4)** Pb

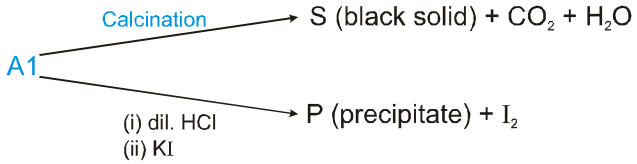
9. When metal 'M' is treated wiht NaOH, a white gelatinous precipitate 'X' is obtained, which is soluble in excess of NaOH. Compound 'X' when heated strongly gives an oxide which is used in chromatography as an adsorbent. The metal 'M' is : **[JEE (Mains) 2018]**
(1) Ca **(2)** Al **(3)** Fe **(4)** Zn

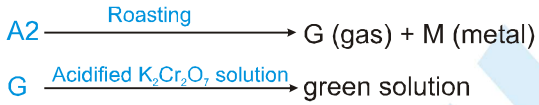
Part # II [Previous Year Questions][IIT-JEE ADVANCED]

1. Pb and Sn are extracted from their chief ores by : **[JEE-2004]**

(A) carbon reduction and self reduction.
(B) self reduction and carbon reduction.
(C) electrolytic reduction and self reduction.
(D) self reduction and electrolysis.

2. Two ores A1 and A2 of a metal M show the following reactivity :





Write the chemical formulae of A1, A2, S, P and G. Explain using required chemical reactions. **[JEE-2004]**

3. Which of the following ore contains both Fe and Cu ? **[JEE - 2005]**

(A) Chalcopyrite **(B)** Malachite **(C)** Cuprite **(D)** Azurite

4. Match the extraction processes listed in column-I with metals listed in column-II. **[JEE-2006]**

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

5. Extraction of zinc from zinc blende is achieved by : **[JEE-2007]**

(A) electrolytic reduction **(B)** roasting followed by reduction with carbon
(C) roasting followed by reduction with another metal **(D)** roasting followed by self-reduction

6. Native silver metal forms a water soluble complex with a dilute aqueous solution of NaCN in the presence of: **[JEE-2008]**

(A) nitrogen **(B)** oxygen **(C)** carbon dioxide **(D)** argon

7. Match the conversions in Column-I with the type(s) of reaction(s) given in Column-II. **[JEE-2008]**

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

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.

8. Partial roasting of Chalcopyrite produces : **[JEE-2010]**

(A) Cu_2S and FeO **(B)** Cu_2O and FeO **(C)** CuS and Fe_2O_2 **(D)** Cu_2O and Fe_2O_2

9. Iron is removed from chalcopyrite as : **[JEE-2010]**

(A) FeO **(B)** FeS **(C)** Fe_2O_3 **(D)** $FeSiO_3$

10. In self-reduction, the reducing species is : **[JEE - 2010]**

(A) S **(B)** O^{2-} **(C)** S^{2-} **(D)** SO_2

11. Extraction of metal from the ore **cassiterite** involves **[JEE - 2011]**

(A) carbon reduction of an oxide ore **(B)** self-reduction of a sulphide ore

(C) removal of copper impurity **(D)** removal of iron impurity

12. Oxidation states of the metal in the minerals haematite and magnetite, respectively, are : **[JEE - 2011]**

(A) II, III in haematite and III in magnetite

(B) II, III in haematite and II in magnetite

(C) II in haematite and II, III in magnetite

(D) III in haematite and II, III in magnetite

13. In the cyanide extraction process of silver from argentite ore, the oxidizing and reducing agents used are

(A) O_2 and CO respectively

(B) O_2 and Zn dust respectively

(C) HNO_3 and Zn dust respectively.

(D) HNO_3 and CO respectively **[JEE - 2012]**

14. Sulfide ores are common for the metals : **[JEE(Advanced) 2013]**

(A) Ag, Cu and Pb **(B)** Ag, Cu and Sn

(C) Ag, Mg and Pb **(D)** Al, Cu and Pb

15. The carbon-based reduction method is **NOT** used for the extraction of : **[JEE(Advanced) 2013]**

(A) tin from SnO_2 **(B)** iron from Fe_2O_3

(C) aluminium from Al_2O_3 **(D)** magnesium from $MgCO_3$, $CaCO_3$

16. The compound (s) which generate (s) N_2 gas upon thermal decomposition below 300°C is (are)

[JEE(Advanced) 2018]

(A) NH_4NO_3 **(B)** $(NH_4)_2Cr_2O_7$ **(C)** $Ba(N_3)_2$ **(D)** Mg_3N_2

MOCK TEST

SECTION - I : STRAIGHT OBJECTIVE TYPE

1. Match the column (I) and (II) and select the correct answer using the codes given below.

Column - I	Column - II
(a) Argentite	**(1)** Halide ore
(b) Cuprite	**(2)** Carbonate one
(c) Siderite	**(3)** Oxide ore
(d) Carnallite	**(4)** Sulphide ore

Codes :–

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

2. NaCN is sometimes added in the froth floatation process as a depressant when mineral contains ZnS and PbS because,

(A) $Pb(CN)_2$ is precipitated while there is no effect on ZnS.

(B) ZnS forms soluble complex $Na_2[Sn(CN)_4]$ while PbS forms froth

(C) PbS forms soluble complex $Na_2[Pb(CN)_4]$ while ZnS forms froth.

(D) silicious impurities settle down on the bottom.

3. Main source of lead is galena (PbS). It is converted to Pb by :

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

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

Self-reduction process is :

(A) A **(B)** B **(C)** both **(D)** none

4. The chemical composition of "slag" formed during the smelting process in the extraction of copper is :

(A) $Cu_2O + FeS$ **(B)** $FeSiO_3$ **(C)** $CuFS_2$ **(D)** $Cu_2S + FeO$

5. Which of the following statement is incorrect about the extractive metallurgy of copper?

(A) Matte chiefly consists of cuprous sulphide and some ferrous sulphide

(B) Most of the impurity of iron sulphide is removed as fusible slag during roasting.

(C) The copper pyrites is concentrated by froth floatation process.

(D) The copper obtained from Bessemer converter is called as blister copper

6. Roasted silver ore + $CN^-_{(aq)}$ + $O_2 \rightarrow [X]_{(aq)} + OH^-_{(aq)}$; $[X]_{(aq)} + Zn \rightarrow [Y]_{(aq)} + Ag \downarrow$

The [X] and [Y] are respectively :

(A) $[Ag(CN)_2]^-$, $[Zn(CN)_6]^{-4}$ **(B)** AgCN, $[Zn(CN)_4]^{-2}$

(C) $[Ag(CN)_4]^{-3}$, $[Zn(CN)_4]^{-2}$ **(D)** $[Ag(CN)_2]^-$, $[Zn(CN)_4]^{-2}$

7. Match column (I) with column (II) and select the correct answer using codes given below in the lists.

Column - I	Column - II
(i) Cyanide process	**(a)** Extraction of Al
(ii) Self reduction	**(b)** Extraction of Ag
(iii) Electrolytic reduction	**(c)** Extraction of Cu
(iv) Carbon reduction	**(d)** Extraction of Sn

(A) (i) - (b), (ii) - (c), (iii) - (a), (iv) - (d) **(B)** (i) - (b), (ii) - (d), (iii) - (a), (iv) - (c)

(C) (i) - (d), (ii) - (a), (iii) - (c), (iv) - (b) **(D)** (i) - (c), (b) - (ii) - (d), (iv) - (a)

8. Select the group of oxides that can not be reduced by carbon to give the respective metals.

(A) CaO, K_2O **(B)** Fe_2O, ZnO **(C)** Cu_2O, SnO_3 **(D)** Fe_2O_3, PbO

SECTION - II : MULTIPLE CORRECT ANSWER TYPE

9. The reaction(s) which does (do) not occur in the reduction zone in the extraction of iron from haematite ore is (are):

(A) $Fe_2O + CO \rightarrow 2\,FeO + CO_2$ **(B)** $FeO + CO \rightarrow Fe + CO_2$

(C) $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$ **(D)** $CaO + SiO_2 \rightarrow CaSiO_3$

10. Cassiterite ore (SnO_2) is purified by :

(A) magnetic separator **(B)** roasting

(C) leaching **(D)** calcination

11. Why lime stone is added in the extraction of lead from galena?

(A) It prevents the formation of $PbSO_4$ **(B)** It remove the impurity of silica as fusible slag

(C) It converts lead silicate to lead oxide **(D)** It remove the impurity of iron oxide as fusible slag

12. Which of the following statement(s) is/are correct about slag?

(A) The chemical composition of slag obtained in the extraction of copper from copper pyrites is $PbSiO_3$.

(B) The calcium silicate, $CaSiO_3$ is obtained in slag formation zone in the extraction of iron from haematite ore.

(C) In blast furnace /Bessemer converter, the upper layer of molten liquid (i.e. molten metal) is of slag.

(D) The slag is fusible matter.

13. S_1 : Cuprite, Limonite and Zincite are oxide ores

S_2 : Magnesite and carnallite are magnesium ores

S_3 : Chalcocite and azurite are ores of copper

S_4: Felspar and mice minerals contain aluminium.

(A) T T T T **(B)** F T F F **(C)** F F T T **(D)** T T F T

14. S_1 : In the aluminothermite process, aluminium acts as reducing agent.

S_2 : Amongst the following Mg and Al can not be obtained by the electrolysis of the aqueous solution of their salts.

(I) Ag **(II)** Mg **(III)** Cu **(IV)** Al.

S_3: In the extractive metallurgy of zinc, partial fusino of ZnO with coke is called sintering and reduction of ore to the molten metal is called smelting.

S_4: Extractive metallurgy of silver from its ore argenite involves complex formation and displacement by more electropositive metal.

(A) T F F T **(B)** T T T T **(C)** T T F T **(D)** T F T F

SECTION - III : ASSERTION AND REASON TYPE

15. **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 remove the impurity of lead sulphide as $PbSiO_3$.
(A) Statement - 1 is True, Statement-2 is True, Statement-2 is a correct explanation for Statement-1.
(B) Statement-2 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.

16. **Statement - 1**: Cast iron is different from pig iron.
Statement - 2 : Cast iron is made by melting pig iron with scrap iron and coke using hot air blast and has about 3% carbon content.
(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 - 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.

17. **Statement-1** : Sodium chloride is added during electrolysis of fused anhydrous magnesium chloride.
Statement-2 : Anhydrous magnesium chloride is obtained by heating hydrate magnesium chloride, $MgCl_2.6H_2O$.
(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.

SECTION - IV : COMPREHENSION TYPE

Read the following comprehensions carefully and answer the questions.

Comprehension # 1

Minerals from which metals can be extracted economically and easily are called ores. The extraction of metals from theirs ores involves the following processes.
(i) Concentration
(ii) Calcination | roasting | leaching
(iii) Reduction
It is carried out by one of the following methods.
(a) Carbon | carbon monoxide reduction
(b) Self reduction
(c) Electrolytic reduction
(d) Reduction by more electropositve metal (i.e. displacement method).

18. Which of the following reaction does not occur in Bessemer converter in the extraction of copper from chalcopyrites.
(A) $2\ Cu\ FeS_2 + O_2 \longrightarrow Cu_2S + 2FeS + SO_2$
(B) $FeO + SiO_2 \longrightarrow FeSiO_3$
(C) $2FeS + 3O_3 \longrightarrow 2FeO + 2SO_2$
(D) $Cu_2S + 2Cu_2O \longrightarrow 6\ Cu + SO_2$

19. Silver is extracted from its native ore by :

(A) formation of soluble complex by dilute solution of NaCN in presence of air followed by the reduction with zinc.

(B) formation of soluble complex by dilute solution of NaCN in absence of air followed by the reduction with zinc.

(C) roasting followed by the self reduction.

(D) roasting followed by electrolytic reduction.

20. Which of the following is not correctly matched ?

(A)	Red bauxite	–	Purification by Serpeck's method
(B)	Iron from haematite	–	Carbon monoxide reduction
(C)	Calamine	–	Carbonate ore
(D)	$FeSiO_3$	–	Slag obtained in the extraction of copper

Comprehension # 3

Metallic gold frequently is found in aluminosilicate rocks and its is finely dispersed among other minerals. It may be extracted by trating the crushed rock with aerated potassium 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. Silver occurs as native as well as sulphurised ore.

21. The correct reaction involved in the leaching of gold with dilute solution of NaCN is :

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

(B) $Au + 2CN^- \longrightarrow Au[(Cn)_2]^-$

(C) $Zn + 2CN^- \longrightarrow Zn[(Cn)_2]^-$

(D) $Zn + 4CN^- \longrightarrow Zn[(Cn)_4]^{2-}$

22. Which of the following statement is correct ?

(A) Leaching of gold with CN^- is an oxidation reaction.

(B) Argentite is oxide ore of silver.

(C) In the precipitation of gold from the soluble complex, zinc acts as complexing and reducing agent.

(D) (A) and (C) both

23. The process described above in the passage is regarding :

(A) ore dressing **(B)** pyrometallurgical extraction

(C) hydrometallurgical extraction **(D)** purification of metal

Comprehnsion # 4

Amongst the various ores of a metal (M) (sulphide, carbonates, oxides, hydrated or hydroxide(s) two ores [X] and [Y] show the following reactively.

(i) [X] on calcination gives a black solid (S), carbon dioxide and water.

(ii) [X] Dissolved in dil. HCl on reaction with Kl gives a white precipitate (P) and iodine.

(iii) [Y] on roasting gives metal (M) and a gas (G_1), which turns acidified K_2Cr_2O, solution green.

(iv) [Y] on reaction with dil. HCl gives a white precipitate (Q) 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.

24. 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

25. 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 chalcocites or chalcopyrites

(D) All of these

26. The gas (G_1) acts as

(A) Oxidising agent **(B)** reducing agent

(C) oxidising and reducing agent **(D)** fluxing agent

27. The white precipitate (P) is of :

(A) Cu_2I_2 **(B)** CuI_2 **(C)** $K_2[CuI_4]$ **(D)** None

SECTION - V : MATRIX - MATCH TYPE

28. Match the ores listed in column (I) with type of ore/extraction process(es) listed in column (II).

Column - I	Column - II
(A) Chalcopyrites	**(p)** Self- reduction
(B) Galena	**(q)** Sulphurised ore
(C) Argentite	**(r)** Carbon reduction
(D) Malachite	**(s)** Leaching followed by displacement method.

29. Match the reactions given in column (I) with the appropriate method(s) listed in column (II).

Column - I	Column - II
(A) $4\,Au + 8\,NaCN + 2\,H_2O + O_2\,(air) \longrightarrow 4\,Na\,[Au\,(CN)_2] + 4\,NaOH$	**(p)** Leaching
(B) $CuFeS_2 + 2\,H_2SO_4 \longrightarrow CuSO_4 + FeSO_4 + 2\,H_2S$	**(q)** Smelting
(C) $Fe_3O_4 + 4CO \xrightarrow{823K} 3\,Fe + CO$	**(r)** Roasting
(D) $MgCl_2 + 6\,H_2O \xrightarrow[\text{Dry HCl(g)}]{\Delta} MgCl_2 + 6\,H_2O$	**(s)** Calcination

30. Match the following metals given in column I with the appropriate metal extraction process(es) listed below in column II.

Column - I	Column-II
(A) Silver	**(p)** Fused salt electrolysis
(B) Lead	**(q)** Cyanide process
(C) Iron	**(r)** Carbon monoxide reduction
(D) Magnesium	**(s)** Self reduction

SECTION - VI : SUBJECTIVE TYPE

31. Elaborate the metallurgy of :

(A) Silver

(B) Gold

(C) Iron

ANSWER KEY

EXERCISE - 1

1. B **2.** B **3.** C **4.** A **5.** C **6.** C **7.** D **8.** C **9.** B **10.** B,C **11.** C **12.** D **13.** A

14. B,C,D **15.** A **16.** C **17.** D **18.** A,B,C **19.** A **20.** C **21.** B **22.** A,C **23.** C **24.** C

25. A,B,D **26.** C **27.** A **28.** C **29.** C **30.** D **31.** D **32.** D **33.** A **34.** C **35.** D **36.** C **37.** A,D

38. A,B,C **39.** C **40.** A **41.** B **42.** B **43.** D **44.** C **45.** C **46.** D **47.** D **48.** B **49.** A **50.** A

51. A **52.** C **53.** A **54.** C **55.** B **56.** C **57.** C **58.** C **59.** D **60.** B **61.** C **62.** D **63.** D

64. C **65.** A **66.** B **67.** C **68.** A **69.** B **70.** D **71.** D **72.** C **73.** D **74.** C **75.** B **76.** C

77. B **78.** B **79.** B **80.** A **81.** A **82.** B **83.** D **84.** B **85.** B **86.** D **87.** D **88.** A **89.** B

90. A **91.** D **92.** D **93.** B **94.** A **95.** B **96.** D **97** C **98.** A **99.** D **100.** A **101.** A

EXERCISE - 2 : PART # I

1. B,D **2.** A,B,C,D **3.** A,B,D **4.** A,B,C **5.** A,B,C,D **6.** D

7. A,C **8.** B,C **9.** A,B,C,D **10.** A,D **11.** A,B,C **12.** A,B,C

13. A,B,C,D **14.** A,B,C **15.** A,B,C **16.** C,D **17.** A,B,C,D **18.** B,D

19. B,C,D **20.** A,B **21.** A,B,C,D **22.** A,B,D **23.** A,C

PART # II

1. D **2.** C **3.** C **4.** C **5.** D **6.** B **7.** C **8.** B **9.** A **10.** B **11.** C **12.** C **13.** B

14. C **15.** B **16.** C **17.** A

EXERCISE - 3 : PART # I

1. A → p, q, s, B → p, q, s, C → q, s, D → r

2. A → p, s, B → s, C → q, r, D → q, r

3. A → p, B → p, q, C → q, s, D → r

4. A → q, s, B → p, C → r, s, D → r, s

5. A → p, r, s, t, B → p, t, C → q, s, D → p, s, t

6. A → p, B → q, C → r, D → s

7. A → p, r, B → p, r, C → q, D → s

8. A → r, t, B → s, C → t, D → p, E → q

9. A → q, s, B → r, C → s, D → p

PART # II

Comprehension # 1 : **1.** A **2.** D **3.** C **4.** A **5.** D

Comprehension # 2 : **1.** A **2.** B **3.** C

Comprehension # 3 : **1.** A **2.** B **3.** D

Comprehension # 4 : **1.** B **2.** D **3.** B **4.** A **5.** B

Comprehension # 5 : **1.** D **2.** A **3.** B **4.** C

EXERCISE - 5 : PART # I

1. 3 **2.** 4 **3.** 3 **4.** 3 **5.** 4 **6.** 3 **7.** 2 **8.** 3 **9.** 2

PART # II

2. A1 = $CuCO_3.Cu(OH)_2$ or $2CuCO_3.Cu(OH)_2$; A2 = Cu_2S ; S = CuO; P = Cu_2I_2 ; G = SO_2

3. A **4.** A $\rightarrow$ p, r ; B $\rightarrow$ p; C $\rightarrow$ q ; D $\rightarrow$ s. **5.** B **6.** B **7.** A $\rightarrow$ p; B $\rightarrow$ q; C $\rightarrow$ p,r ; D $\rightarrow$ p, s **8.** A

9. D **10.** C **11.** A,D **12.** D **13.** B **14.** A **15.** C,D **16.** B,C

MOCK - TEST

1. A **2.** B **3.** B **4.** B **5.** B **6.** D **7.** A **8.** A **9.** C, D **10.** A, B, C **11.** A, B, **12.** B, C, D

13. A **14.** B **15.** C **16.** A **17.** C **18.** A **19.** A **20.** A **21.** A **22.** D **23.** C **24.** A **25.** D

26. C **27.** A **28.** A $\rightarrow$ p, q ; B $\rightarrow$ p, q, r ; C $\rightarrow$ q, s ; D $\rightarrow$ r **29.** A $\rightarrow$ p ; B $\rightarrow$ p ; C $\rightarrow$ q ; D $\rightarrow$ s

30. A $\rightarrow$ q ; B $\rightarrow$ s ; C $\rightarrow$ r ; D $\rightarrow$ p