# METALLURGY

## Contents

## 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.** ____________________

**ETOOS ACADEMY Pvt. Ltd**

F-106, Road No.2 Indraprastha Industrial Area, End of Evergreen Motor, BSNL Lane,
Jhalawar Road, Kota, Rajasthan (324005)

Tel. : +91-744-242-5022, 92-14-233303

# 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) | $[Al_2(OH)_4Si_2O_5]$ |
| 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) $\Delta G$ negative (B) $\Delta G$ positive (C) $\Delta H$ negative (D) $\Delta H$ 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) : $\mathrm{PbS} \xrightarrow[\Delta]{\text{air}} \mathrm{PbO} + \mathrm{SO_2}$

$\qquad\qquad \llcorner\xrightarrow{\mathrm{C}} \mathrm{Pb} + \mathrm{CO_2}$

(Y) : $\mathrm{PbS} \xrightarrow[\Delta]{\text{air}} \mathrm{PbO} + \mathrm{PbS}$

$\qquad\qquad \llcorner\xrightarrow{} \mathrm{Pb} + \mathrm{SO_2}$

(Z) : $\mathrm{PbS} \xrightarrow[\Delta]{\text{air}} \mathrm{PbO} + \mathrm{SO_2}$

$\qquad\qquad \llcorner\xrightarrow{\mathrm{CO}} \mathrm{Pb} + \mathrm{CO_2}$

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) $TiCl_2 + 2Mg \xrightarrow{\quad} Ti + 2MgCl_2$ : Kroll
(B) $Ni(CO)_4 \xrightarrow{\quad} Ni + 4CO$ : Mond
(C) $Ag_2CO_3 \xrightarrow{\quad} 2Ag + CO_2 + \frac{1}{2} O_2$ : Van Arkel
(D) $ZrI_4 \xrightarrow{\quad} Zr + 2I_2$ : 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 :

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

(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 $\Delta G$ with temperature. (B) change of $\Delta H$ with temperature.
(C) change of $\Delta G$ 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 :

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

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

**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 – 200°C and passing the resulting volatile iodide on hot tungsten filament at 1400°C 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) | $\approx 1000^\circ C$ |
| (b) | $FeO + CO \rightarrow Fe + CO_2$ | (q) | $\approx 800^\circ C$ |
| (c) | $CaO + SiO_2 \rightarrow CaSiO_3$ | (r) | $\approx 1800^\circ C$ |
| (d) | $Fe_3O_4 + 4CO \rightarrow 3Fe + 4CO_2$ | (s) | $\approx 400^\circ C$ |

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.

# 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**<br>**(Reaction)** | **Column – II**<br>**(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 ?

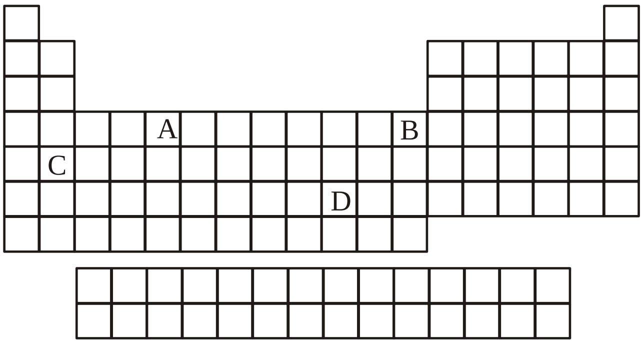
(A) 2.32 (B) 1.16 (C) 4.64 (D) 9.28

**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 attracted 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 $\Delta S$ 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 $\Delta G$ 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,

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

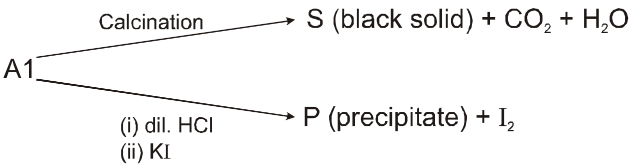
$$[X] + Zn \longrightarrow [Y] + Au$$

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]**



$$A2 \xrightarrow{\text{Roasting}} G\text{ (gas)} + M\text{ (metal)}$$

$$G \xrightarrow{\text{Acidified } K_2Cr_2O_7 \text{ solution}} \text{green solution}$$

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) | | | | | | | | | | |

# 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)