TOPIC : METALLURGY
EXERCISE # 1

Section (A)

1. It is a factual.

2. Hydraulic washing or Gravity separation or Levigation method is based on the difference in the densities of the gangue and ore particles.

3. Lighter gangue particles are washed in a current of water by a process called levigation. In levigation the powdered ore is agitated with water or washed with a upward stream of running water, the lighter particles of sand, clay etc are washed away leaving behind heavier ore particles.

4. Silver occurs as free metal associated with rock / sand and as minerals (Ag_2S, AgCl, etc.,) on earth crust. Hence it is found as native ore as well as in the combined form.

5. Horn silver (chlorargyrite) is AgCl.

6. The rocky and silicious impurities associated with an ore is called matrix or gangue.

7. Cerrusite is $PbCO_3$.

8. Zinc blende, ZnS; copper glance, Cu_2S; Galena, PbS.
Therefore, (2) option is correct.

9. (4) Felspar is $K_2O.Al_2O_3.6H_2O$. $Be_3Al_2Si_6O_{18}$ is beryl.

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

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

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

11. Low grade sulphide ores are concentrated by froth floatation process and it is based on the fact that gangue and ore particles have different degree of wetability with water and pine oil.

12. $ZnS + 4NaCN \rightarrow Na_2[Zn(CN)_4] + Na_2S$

$PbS + NaCN \rightarrow$ No such complex formation.

13. Carbonate ores are calcined in absence of air to obtain the metal oxides.

14. Roasting is a process of heating the concentrated ore (generally sulphide ore) strongly in the excess of air or O_2 below its melting point. During roasting impurities of As, Sb, P and S escape as their volatile oxides.

$S(s) + O_2(g) \longrightarrow SO_2(g)$

15. Roasting removes easily oxidisable volatile impurities like arsenic (as As_2O_3) sulphur (as SO_2), phosphorus (as P_4O_{10}) and antimony (as Sb_2O_3).

$4M\ (M = As, Sb) + 3O_2 \longrightarrow 2M_2O_3\uparrow$

$S + O_2 \longrightarrow SO_2\uparrow$; $P_4 + 4O_2 \longrightarrow P_4O_{10}\uparrow$

Organic matter, moisture if present in the ore, also get expelled and the ore becomes porous.

16. Generally the sulphides of Zn, Pb, Fe, Cu etc. are subjected to roasting to convert into their oxides prior to reduction by carbon.

18. Calamine is $ZnCO_3$.

19. Haematite is Fe_2O_3 which has magnetic property.

20. Conversion of carbonate ore in to oxide on heating in absence of air is called calcination.

21. (a) Tin-cassiterite, SnO_2 (b) Zinc - zincite , ZnO
(c) Copper - cuprite, Cu_2O (d) Lead - Cerrusite, $PbCO_3$
Therefore, (2) option is correct.

22. This method is commonly used for the concentration of the low grade sulphide ores like galena, PbS (ore of Pb) ; copper iron pyrites $Cu_2S.Fe_2S_3$ or $CuFeS_2$ (ore of copper) ; zinc blende, ZnS (ore of zinc) etc., and is based on the fact that gangue and ore particles have different degree of wettability with water and pine oil; the gangue particles are preferentially wetted by water while the ore particles are wetted by oil.

23. (a) Bauxite is leached with NaOH (concentrated) to form soluble $Na[Al(OH)_4]$ complex and insoluble impurities are filtered off.
(b) Carbonate and hydroxide ores are heated in absence of air below their melting point to convert in to their oxides in reverberatory furnace. This is called calcination. So magnesite, $MgCO_3$ is subjected to calcination.
(c) This method is commonly used for the concentration of the low grade sulphide ores like galena, PbS (ore of Pb) ; copper iron pyrites $Cu_2S.Fe_2S_3$ or $CuFeS_2$ (ore of copper) ; zinc blende, ZnS (ore of zinc) etc., and is based on the fact that gangue and ore particles have different degree of wettability with water and pine oil; the gangue particles are preferentially wetted by water while the ore particles are wetted by oil.
(d) Chromite ore ($FeO.Cr_2O_3$) having magnetic properties is separated from non–magnetic silicious impurities by magnetic separator.

SECTION (B)

1. (1) When the oxide undergoes a phase change, there will be an increase in the entropy of the oxide.
(2) It is true statements, $HgO \xrightarrow{\Delta} Hg + 1/2O_2$
(3) For a reduction process the change in the free energy, ΔG must be negative and to make ΔG negative temperature should be high enough so that $T\Delta S > \Delta H$.

2. Reduction of oxides of Mn, Cr etc., by electropositive aluminium metal is called as alumino thermite process.

3. $2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$; $2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$.

4. The solidified copper obtained after bessemerisation is impure and contains Fe, Ni, Zn, Ag, Au etc., as impurity. It has blistered like appearance due to the evolution of SO_2 and so it is called blister copper.

5. (Y) PbS reduces PbO to Pb ; it is called self reduction.

6. As PbS on self reduction with PbO and $PbSO_4$ gives metallic lead.

7. $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$
$CaO + SiO_2 \longrightarrow CaSiO_3$ (slag)

8. Matte mostly contains Cu_2S and a little FeS.

9. Highest temperature 2170 K is found in the lower most part of the blast furnance, where carbon burns to form CO_2. $C + O_2 \longrightarrow CO_2$

10. The free energy change that occurs when 1 mol of common reactant (in this case O_2) is used may be plotted graphically against temperature for a number of reactions. This is called an Ellingham diagram.

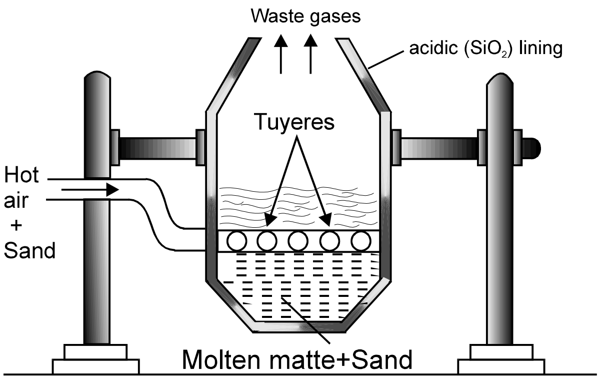
11. In Elingham diagram, the $\Delta_f G^o$ of Al_2O_3 lies below that of CO_2. If reduction is carried out at very high temperature, the Al produced will react with carbon forming Al_4C_3.

12. $PbS + 2PbO \xrightarrow{\text{self reduction}} 3Pb + SO_2$

13. For examples $SiO_2 + CaO \longrightarrow CaSiO_3$ (metal silicate) or $FeO + SiO_2 \longrightarrow FeSiO_3$.

15. Molten iron from blast furnace is taken in to sand pigs for solidification. Therefore iron obtained from blast furnace is called pig iron.

16.



Bessemer convertor

Reactions involved :

$2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2$; $FeO + SiO_2 \longrightarrow FeSiO_3$

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

17. In actual process the ore is heated in a reverberatory furnace after mixing with silica. In the furnace, iron oxide 'slags of' as iron silicate and copper is produced in the form of copper matte which contains mostly Cu_2S and some FeS.

18. $2ZnS + 3O_2 \xrightarrow{\text{roasting}} 2ZnO + 2SO_2$

$ZnO + C \xrightarrow{1100^oC} Zn + CO$.

Therefore, (2) option is correct.

SECTION (C)

1. Sea water contains 0.13% Mg as salt and extracted by Dow's process and also from ore magnesite found in earth crust.

2. It is obtained by electrolytic reduction of molten anhydrous KCl $MgCl_2$ (other methods are not economical/ feasible for the extraction of Mg metal).

3. NaCl and $CaCl_2$ both being ionic compounds ionise to give ions which lowers the melting point and increase the conductivity of the mixture.

4. $4Au + 8CN^- + 2H_2O \longrightarrow 4[Au(CN)_2]^-$ (soluble complex) ¼यथकस बिमत्रथ½ $+ 4OH^-$

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

5. $Na_3[AlF_6] \longrightarrow 3NaF + AlF_3$

NaF and AlF_3 both are ionic compounds and so ionise to give ions. This increases the electrical conductivity and lowers the melting point of Al_2O_3 .

At cathode : Al^{3+} (melt) + $3e^- \longrightarrow Al$.

At anode : $C(s) + O^{2-}$ (melt) $\longrightarrow CO\ (g) + 2e^-$; $C(s) + 2O^{2-}$ (melt) $\longrightarrow CO_2\ (g) + 4e^-$.

6. Mg being strong reducing agent cannot be obtained by any chemical reduction method.

7. $Ag_2S + 2NaCN \xrightleftharpoons{Air} 2AgCN + Na_2S$

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

8. A hydrometallurgical process for the extraction of metals from ores, concentrates, or secondary materials essentially contains three basic steps—dissolution of the valuable metal in the aqueous solution (leaching) purification of leach solution and subsequent recovery of metal from the purified solutions either by electrolysis or by adding some electropositive metal to it.

9. O^{2-} (melt) $\longrightarrow \frac{1}{2} O_2\ (g) + 2e^-$ (melt)

SECTION (D)

1. The Hoope's process is a process for the electrolytic refining of aluminium. Impure Al forms the anode and pure Al forms the cathode of the Hooper's cell which contains three liquid layers. The bottom layer is molten impure Al, the middle is a fused salt layer containing sodium fluoride, aluminum fluoride and barium fluoride, and the top layer is pure Al. At the anode (bottom layer), Al passes with solution as aluminium ion (Al^{3+}), and at the cathode (top layer), these ions are reduced to the pure metal. In operation, molten metal is added to the bottom of the cell and pure aluminium is drawn off the top.

At anode : $Al \longrightarrow Al^{3+} + 3e^-$

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

2. Cathode (reduction) Cu^{2+} (aq) + $2e^- \longrightarrow Cu(s)$.

3. Anode mud contains the impurity of Au only.

4. It is process for purification of metal.

5. Used for the purification of metals like Si, Ge etc used as semiconductor.

6. This process is used when metals are required in very high purity, for specific application. For example pure Si and Ge are used in semiconductors and hence are purified by this method. Zone refining method is based on the principle that an impure molten metal on gradual cooling will deposit crystals of the pure metal, while the impurities will be left in the remaining part of the molten metal.

7. This process is used for the purification of the metal, which itself is readily fusible, but the impurities present in it are not, i.e., the impurities are infusible. This process is used for the purification of Sn and Zn, and for removing Pb from Zn-Ag alloy, which is obtained at the end of Parke's process and contains Pb as impurity.

8. Hydrocarbons liberated by green wood which use to reduce the metallic oxide to metal.

9. Impure metal is made as anode and pure metal is made as cathode.

10. $Ti\ (impure) + 2I_2\ (g) \xrightarrow{50-250°C} TiI_4\ (g) \xrightarrow[\text{Tungsten filament}]{1400°C} Ti\ (pure) + 2I_2\ (g)$

EXERCISE # 2

1. Zinc blende or sphalerite is ZnS.

2. (1) Calamine is $ZnCO_3$ and siderite is $FeCO_3$
(2) Argentite is Ag_2S while bauxite is $Al_2O_3.2H_2O$
(3) Zinc blende is ZnS and galena is PbS
(4) Malachite is $CuCO_3\ Cu(OH)_2$ and azurite is $2CuCO_3\ Cu(OH)_2$

3. Dolomite is mixed carbonate of calcium and magnesium i.e. $CaCO_3.MgCO_3$ or $CaMg(CO_3)_2$.

4. Bauxite is concentrated by leaching. All other require magnetic separation process.

5. The process is truly adsorption as gangue particles are wetted with water and sulphide ore particles are wetted with pine oil.

6. In smelting the concentrated oxide ores like haematite, tin stone even after concentration, is heated with flux to remove the acidic or basic impurities forming the slag. All other processes are used for removing the earthy/silicious impurities.

7. Options (1), (2) and (3) comprise the froth floatation process.

8. Potassium or sodium ethyl xanthate get attached with the particle of the sulphide ore and thus make them water repellant i.e. hydrophobic.

9. (1) $Al_2O_3\ (s) + 2NaOH\ (aq) + 2H_2O\ (\ell) \xrightarrow{\Delta} 2NaAlO_2\ (aq) + 3H_2O\ (\ell)$
(2) $Ag_2S\ (s) + 4CN^-\ (aq) \longrightarrow [Ag(CN)_2]^-\ (aq) + S^{2-}\ (aq)$
(3) $MgCl_2$ (anhydrous) – No leaching is required.
(4) $Cu_2O\ (s) + 4H_2SO_4 + O_2 \longrightarrow 4CuSO_4 + 4H_2O$

10. It is extracted by the electrolysis of aluminia mixed with molten cryolite.

11. $MgCl_2 \rightleftharpoons Mg^{2+} + 2Cl^-$
At cathode : $Mg^{2+} + 2e^- \longrightarrow Mg$
At anode : $2Cl^- \longrightarrow Cl_2 + 2e^-$
$4Ag + 8CN^- + 2H_2O + O_2 \longrightarrow 4[Ag(CN)_2]^- + 4OH^-$
$2[Ag(CN)_2]^- + Zn \longrightarrow 2Ag\downarrow + [Zn(CN)_4]^{2-}$

12. Extraction of Fe from haematite ore :

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$; $CaO + SiO_2$ $CaSiO_3$

Extraction of Cu from copper pyrites :

$2CuFeS_2 + 4O_2 \xrightarrow{\Delta} Cu_2S + 2FeO + 3SO_2$; $FeO + SiO_2$ $FeSiO_3$

13. $Al_2O_3 + 3C + N_2 \xrightarrow{1800°C} 2AlN + 3CO$

14. Al_2O_3 (bauxite) + 2NaOH (aq) + H_2O (l) $\xrightarrow{\text{leaching}}$ $2Na[Al(OH)_4]$ (aq).

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

16. Goldschmidt aluminothermite process is ; $2Al + Cr_2O_3 \longrightarrow 2Cr + Al_2O_3$.

17. Statement (2) is correct.

18. (X) Red bauxite contains the impurities of oxides of iron and silicates. In Bayer process, alumina us dissolved by reacting sodium hydroxide solution leaving behind the insoluble oxide of iron.

(Y) White bauxite contains the impurity of silica which is removed by Serpeck's method.

$Al_2O_3 + N_2 + 3C \xrightarrow{1800°C} 2AlN + 3CO$; $SiO_2 + 2C \xrightarrow{1800°C} Si + 2CO$

$AlN + 3H_2O \longrightarrow Al(OH)_3 + NH_3$; $2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$.

19. Slag is fusible mass having lower melting point; not miscible with molten metal and lighter than molten metal.

20. Ore is heated below its melting point in a reverberatory furnace in the presence of air to convert it into its oxides. It removes easily oxidisable volatile impurities like arsenic as As_2O_3, antimony as Sb_2O_3 and sulphur as SO_2. Roasting is an exothermic process; once started it does not require additional heating.

21. $CaO + SiO_2 \longrightarrow CaSiO_3$ (slag) (Haematite ore contains silica as impurities).

Slag being lighter and insoluble in molten metal floats over and thus forms upper layer.

22. All lower temperature following reactions occur in blast furnace.

$3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$; $Fe_3O_4 + CO \longrightarrow 3Fe + 4CO_2$; $Fe_2O_3 + CO \longrightarrow 2FeO + CO_2$

23. Ag_2S (concentrated ore) + 2NaCN (aq) $\overset{\text{Air}}{\rightleftharpoons}$ 2AgCN (s) + Na_2S (aq).

$4Na_2S$ (aq) + $5O_2$ (g) + $2H_2O$ (ℓ) $\longrightarrow$ $2Na_2SO_4$ (aq) + 4NaOH (aq) + 2S (s)

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

$2Na[Ag(CN)_2]$ (aq) + Zn (dust) $\longrightarrow$ 2Ag (s) + $Na_2[Zn(CN)_4]$ (aq). Hence these reactions suggest that extraction of silver from Ag_2S by the use of sodium cyanide is an example of hydrometallurgy.

24. H_2O + C(red hot) $\longrightarrow$ CO (g) + H_2 (g) ; Ni(s) + 4CO (g) $\xrightarrow{50°C}$ $[Ni(CO)_4]$ (g) ;

$[Ni(CO)_4]$ (g) $\xrightarrow{200°C}$ Ni(s) + 4CO (g). So Mond process is used for the purification of nickel.

25. $4NaCN + Ag_2S \xrightarrow{O_2} 2Na[Ag(CN)_2] + Na_2S$.

26. Anode mud contains Ag, Au as impurities.

27. **(I)** $4Au / Ag (s) + 8CN^{-}(aq) + 2H_2O(aq) + O_2(g) \longrightarrow 4[Au / Ag (CN)_2]^{-}(aq) + 4OH^{-}(aq)$

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

(II) This method is based on the fact that gangue and ore particles have different degree of wettability with water and pine oil; the gangue particles are preferentially wetted by water while the ore particles are wetted by oil.

(III) Electrolytic reduction (Hall-Heroult process) :

The purified Al_2O_3 is mixed with Na_3AlF_6 (cryolite) or CaF_2 (fluorspar)) which lowers the melting point of the mixture and brings conductivity. The fused matrix is electrolysed. The electrolytic reactions are :

Cathode : Al^{3+} (melt) + $3e^{-} \longrightarrow Al(l)$

Anode : $C(s) + O^{2-}$ (melt) $\longrightarrow CO(g) + 2e^{-}$

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

(IV) This process is used when metals are required in very high purity, for specific application. For example pure Si and Ge are used in semiconductors and hence are purified by this method. Zone refining method is based on the principle that an impure molten metal on gradual cooling will deposit crystals of the pure metal, while the impurities will be left in the remaining part of the molten metal.

28. Ge, Si and Ga used as semi-conductors are refined by the zone refining method.

EXERCISE # 3

PART - I

1. The use of Na_3AlF_6 (cryolite) in the electrolysis of alumina for lowering the melting point of alumina.

2. The method of zone refining of metals is based on the principle of greater solubility of the impurity in the molten state than in the solid. Elements which are used as semiconductors like Si, Ge, Ga etc are refined by this method.

3. $2Na[Ag (CN)_2] (aq) + Zn(s) \rightarrow Na_2 [Zn (CN)_4]_{(aq)} + 2Ag (s)$

4. Greater solubility of the impurity in the molten state than in the solid.

5. Argentite is Ag_2S.

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

$Ag_2S + 2NaCN \longrightarrow Na[Ag(CN)_2] + NaCl$

6. Blister copper contains almost 1% impurity

7. Carbon and hydrogen are not suitable reducing agents for metal sulphides.

8. Galena (PbS), copper pyrites ($CuFeS_2$) and argentite (Ag_2S) are concentrated by froth flotation process but sphalerite (ZnS) is concentrated by chemical leaching.

9. Pig gron contain about 4% carbon and many impurity in smaller amount (S, P, Si, Mn ......)

10. Van arkel method is used to purification Ti, & Zr

11. Na_3AlF_6, CaF_2 increase conductance and decrease M.P. of Al_2O_3.

12. [$Fe_3O_4 \Rightarrow$ Magnetite]

13. $2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2(g)$

14. Steel : It always have few% of carbon.

15. Nitrates are less found in earth crust because they are highly water soluble and very stable because do not decompose easily on heating so the answer is (2)

17. Cyanide process $\longrightarrow$ Leaching process of Au

$$\underset{}{Au} + \underset{aq.}{2NaCN} \xrightleftharpoons{O_2} Au(CN)_2^- + Na^+$$

Froth floatation process $\longrightarrow$ Pressing of ZnS (It is applicable for concentration of sulphide are)
Electrolytic reduction $\longrightarrow$ Extraction of Al
Zone refining $\longrightarrow$ Purification of Si, Ge

18. Gold and silver forms a complex $[M(CN)_2]^-$ with CN^- in leaching process.

M(Ag or Au) can be displaced from the complex with a more reactive metal like Zn.

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

20. $2NaN_3 \xrightarrow{\Delta} 2Na + 3N_2$
$Ba(N_3)_2 \xrightarrow{\Delta} 2NH_3(g)$
Pure N_2 obtained (NCERT XII Page 174)
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
[Haber process] [NCERT XII] Page 176
Contact Process :
$2SO_2(g) + O_2(g) \xrightarrow{V_2O_5} 2SO_3(g)$
$SO_3 + H_2SO_4 \longrightarrow H_2S_2O_7$(Oleum)
$H_2S_2O_7 + H_2O \longrightarrow 2H_2SO_4$ (96 – 98% pure)
[NCERT XII page 195]
Deacon process
$4HCl + O_2 \xrightarrow{CuCl_2} 2Cl_2 + 2H_2O$
[NCERT Class XII page 202]

21. Malachite ore = $CuCO_3 . Cu(OH)_2$
NCERT XII, Page 152, Metallurgy.

22. All ores are having many metals compounds not have a single metal.

PART - II

1. Thermite is a mixture of Fe_2O_3 and Al. This reaction involves reduction of Fe_2O_3 to Fe by Al and the reaction is highly exothermic due to which Fe obtained is in molten form. Thus this reaction can be used for welding purposes. In this Fe_2O_3 and Al are mixed in 3 : 1 ratio.

$$Fe_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Fe(\ell) + \Delta$$

(thermite process).

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

3. Iron is obtained from Fe_2O_3 by heating Fe with a mixture of coke and $CaCO_3$ in a blast furnace in which CO formed reduce Fe_2O_3 to Fe.

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

The reason is false as the reaction :

$Fe_2O_3(s) \longrightarrow Fe(s) + \frac{3}{2}O_2(g)$ is not spontaneous as for this reaction both ΔH and ΔS are negative so ΔG will be positive.

4. Zone refining process is based upon the fact that impurities are more soluble in melt than in the original metal. Hence, molten zone contains more impurities than the original metal.

5. The process of conversion of a concentrated ore into its oxide by heating in absence of or in limited supply of air is called calcination. It is usually done for hydroxide, hydrated oxides and carbonate ores.

Thus, $MgCO_3 \xrightarrow{\Delta} MgO + CO_2$ is an example of calcination process.

6. (4) : Ferrous sulphate $\rightarrow FeSO_4.7H_2O$

Copper sulphate $\rightarrow CuSO_4.5H_2O$

Magnesium sulphate $\rightarrow MgSO_4.7H_2O$

Sodium Chloride $\rightarrow NaCl$

7. Ellingham diagrams are based on thermodynamic concepts. It does not tell anything about the kinetics of the reduction process.

8. **(2)** Cyanide process is for gold (I– D) ; floatation process – pine oil (II–B) ; Electrolytic reduction – Al(III –C) ; Zone refining – Ge (IV – A).

9. **(1)** Both assertion and reason are correct and reason is the correct explanation of assertion.

12. The zone refining process of metals is based on greater solubility of impurity in the molten state than in the solid.

14. Smelting of Cu result in slag formation and matle formation

$FeS + Cu_2O \longrightarrow FeO + Cu_2S$

$FCO + SiO_2 \longrightarrow FeSiO_3$ (slage)

PART - III

1. Pure metal always deposits at cathode according to the following reactions.

Anode (oxidation) : $M(s) \longrightarrow M^{2+}(aq) + 2e^-$ (M = Cu, Zn, Fe)

Cathode (reduction) : $Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$

Thus, the net cell reaction simply involves transfer of Cu metal from the impure anode to the pure cathode, Cu obtained by this process is 99.95% pure.

2. Electrolyte consists of molten Al_2O_3, Na_3AlF_6 or CaF_2. Cryolite or fluorspar lowers the melting point and increase the conductivity of electrolyte. So option (4) is correct.

3. Silver ore forms a soluble complex when leached with NaCN solution and from which silver is precipitated using scrap zinc.

Ag_2S (conc. ore) + $2NaCN \xrightleftharpoons{Air} 2AgCN + Na_2S$.

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

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

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

4. Froth-floatation method is used for the concentration of sulphide ores. The method is based on the preferential wetting properties with the frothing agent and water. Here galena (PbS) is the only sulphide ore.

5. $2Cu_2O + Cu_2S \xrightarrow{\Delta} 6Cu + SO_2$. (self reduction)

6. Anode mud contains Ag, Pt, Sb, Se, Te and Au as impurities. (NCERT)

7. (3) It is true that this statement has no significance for roasting sulphide ores to the oxides.
The Gibb's energies of formation of most sulphides are greater than that for CS_2. In fact, CS_2 is an endothermic compound. There, the $\Delta_f G^{\ominus}$ of M_xS is not compensated. So reduction of M_xS is difficult. Hence it is common practice to roast sulphide ores to corresponding oxides prior to reduction.

8. The process is known as Van Arkel method.

9. (1) In this process, carbon anode is oxidised to CO and CO_2.
(2) It is a fact
(3) At cathode, Al^{3+} from Al_2O_3 is reduced to Al.
(4) Al_2O_3 is the electrolyte, which is undergoing the redox process. So, Al_2O_3 serves as electrolyte and Na_3AlF_6, although an electrolyte, serves as solvent.

11. $(A\ell)M + NaOH \longrightarrow \underset{\text{Gelatinous white ppt}}{(X)A\ell(OH)_3\downarrow} \xrightarrow{\Delta} \underset{\text{Silica Gel. used as adsorbent in chromatography}}{A\ell_2O_{3(s)}}$

$(X)A\ell(OH)_3 \xrightarrow[\text{Excess}]{NaOH} \underset{\text{soluble in water}}{Na[Al(OH)_4]_{aq}}$

12. $CuCO_3 .Cu(OH)_2$ malachite
$2CuCO_3 .Cu(OH)_2$ Azurite
$CuFeS_2$ copper pyrite
Dolomite $CaCO_3.MgCO_3$

13. $\frac{4}{3}Al + 2ZnO \longrightarrow 2Zn + \frac{2}{3}Al_2O_3$
ΔG for the above reaction is (–)ve.

14. Al_2O_3 (molten) + C (anode) $\rightarrow$ Al + CO + CO_2

15.

Malachite	-	$CuCO_3.Cu(OH)_2$
Calamine	-	$ZnCO_3$
Kaolin	-	$Al_2Si_2O_5(OH)_4$
Siderite	-	$FeCO_3$

16. Cathode is made up of carbon.

17. Calcination is required for hydroxide, carbonate and hydrated oxide ores.