

# Chapter - General Principles and Process of Isolation of Elements



## Topic-1: Occurrence of Metals and Metallurgical Processes



### 1 MCQs with One Correct Answer

- Calamine, malachite, magnetite and cryolite, respectively, are [Adv. 2019]
  - $\text{ZnCO}_3$ ,  $\text{CuCO}_3$ ,  $\text{Cu(OH)}_2$ ,  $\text{Fe}_3\text{O}_4$ ,  $\text{Na}_3\text{AlF}_6$
  - $\text{ZnSO}_4$ ,  $\text{Cu(OH)}_2$ ,  $\text{Fe}_3\text{O}_4$ ,  $\text{Na}_3\text{AlF}_6$
  - $\text{ZnSO}_4$ ,  $\text{CuCO}_3$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{AlF}_3$
  - $\text{ZnCO}_3$ ,  $\text{CuCO}_3$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{Na}_3\text{AlF}_6$
- In the cyanide extraction process of silver from argentite ore, the oxidising and reducing agents used are [2012]
  - $\text{O}_2$  and CO respectively
  - $\text{O}_2$  and Zn dust respectively
  - $\text{HNO}_3$  and Zn dust respectively
  - $\text{HNO}_3$  and CO respectively
- Oxidation states of the metal in the minerals haematite and magnetite, respectively, are [2011]
  - II, III in haematite and III in magnetite
  - II, III in haematite and II in magnetite
  - II in haematite and II, III in magnetite
  - III in haematite and II, III in magnetite
- Extraction of zinc from zinc blende is achieved by [2007]
  - electrolytic reduction
  - roasting followed by reduction with carbon
  - roasting followed by reduction with another metal
  - roasting followed by self-reduction
- Which ore contains both iron and copper? [2005S]
  - Cuprite
  - Chalcocite
  - Chalcopyrite
  - Malachite
- In the process of extraction of gold, [2003S]
 
$$\text{Roasted gold ore} + \text{CN}^- + \text{H}_2\text{O} \xrightarrow{\text{O}_2} [\text{X}] + \text{OH}^-$$

$$[\text{X}] + \text{Zn} \longrightarrow [\text{Y}] + \text{Au}$$
 Identify the complexes [Main X] and [Main Y]
  - $\text{X} = [\text{Main Au(CN)}_2]^-$ ,  $\text{Y} = [\text{Main Zn(CN)}_4]^{2-}$
  - $\text{X} = [\text{Main Au(CN)}_4]^{3-}$ ,  $\text{Y} = [\text{Main Zn(CN)}_4]^{2-}$
  - $\text{X} = [\text{Main Au(CN)}_2]^-$ ,  $\text{Y} = [\text{Main Zn(CN)}_6]^{4-}$
  - $\text{X} = [\text{Main Au(CN)}_4]^-$ ,  $\text{Y} = [\text{Main Zn(CN)}_4]^{2-}$
- Which of the following process is used in the extractive metallurgy of magnesium? [2002S]
  - fused salt electrolysis
  - self reduction
  - aqueous solution electrolysis
  - thermite reduction
- Electrolytic reduction of alumina to aluminium by Hall-Heroult process is carried out [2000S]
  - in the presence of NaCl
  - in the presence of fluorite
  - in the presence of cryolite which forms a melt with lower melting temperature
  - in the presence of cryolite which forms a melt with higher melting temperature
- The chemical processes in the production of steel from haematite ore involve [2000S]
  - reduction
  - oxidation
  - reduction followed by oxidation
  - oxidation followed by reduction
- The chemical composition of 'slag' formed during the smelting process in the extraction of copper is [2001S]
  - $\text{Cu}_2\text{O} + \text{FeS}$
  - $\text{FeSiO}_3$
  - $\text{CuFeS}_2$
  - $\text{Cu}_2\text{S} + \text{FeO}$
- In the commercial electrochemical process for aluminium extraction the electrolyte used is [1999 - 2 Marks]
  - $\text{Al(OH)}_3$  in NaOH solution
  - an aqueous solution of  $\text{Al}_2(\text{SO}_4)_3$
  - a molten mixture of  $\text{Al}_2\text{O}_3$  and  $\text{Na}_3\text{AlF}_6$
  - a molten mixture of  $\text{AlO(OH)}$  and  $\text{Al(OH)}_3$
- In the aluminio-thermite process, aluminium acts as [1983 - 1 Mark]
  - an oxidizing agent
  - a flux
  - a reducing agent
  - a solder



13. In the metallurgy of iron, when limestone is added to the blast furnace, the calcium ion ends up in [1982 - 1 Mark]

- (a) slag (b) gangue  
(c) metallic calcium (d) calcium carbonate

14. Copper can be extracted from [1978]

- (a) Kupfernickel (b) Dolomite  
(c) Malachite (d) Galena



#### 4 Fill in the Blanks

15. 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, calcining, roasting, sintering) [1988 - 1 Mark]

16. In the basic Bessemer process for the manufacture of steel, the lining of the converter is made of ..... The slag formed consists of ..... [1980]

17. In the thermite process ..... is used as reducing agent. [1980]

18. Cassiterite is ore of ..... [1980]



#### 6 MCQs with One or More than One Correct Answer

19. The treatment of galena with  $\text{HNO}_3$  produces a gas that is [Adv. 2022]

- (a) paramagnetic (b) bent in geometry  
(c) an acidic oxide (d) colorless

20. The correct option(s) related to the extraction of iron from its ore in the blast furnace operating in the temperature range 900 – 1500 K is(are) [Adv. 2022]

- (a) Limestone is used to remove silicate impurity.  
(b) Pig iron obtained from blast furnace contains about 4% carbon.  
(c) Coke (C) converts  $\text{CO}_2$  to CO.  
(d) Exhaust gases consist of  $\text{NO}_2$  and CO.

21. The correct statement(s) related to the metal extraction processes is(are) [Adv. 2021]

- (a) A mixture of PbS and PbO undergoes self-reduction to produce Pb and  $\text{SO}_2$ .  
(b) In the extraction process of copper from copper pyrites, silica is added to produce copper silicate.  
(c) Partial oxidation of sulphide ore of copper by roasting, followed by self-reduction produces blister copper.  
(d) In cyanide process, zinc powder is utilized to precipitate gold from  $\text{Na}[\text{Main Au}(\text{CN})_2]$

22. Which among the following statement(s) is(are) true for the extraction of aluminium from bauxite? [Adv. 2020]

- (a) Hydrated  $\text{Al}_2\text{O}_3$  precipitates, when  $\text{CO}_2$  is bubbled through a solution of sodium aluminate.  
(b) Addition of  $\text{Na}_3\text{AlF}_6$  lowers the melting point of alumina.  
(c)  $\text{CO}_2$  is evolved at the anode during electrolysis.  
(d) The cathode is a steel vessel with a lining of carbon.

23. The cyanide process of gold extraction involves leaching out gold from its ore with  $\text{CN}^-$  in the presence of Q in water to form R. Subsequently, R is treated with T to obtain Au and Z. Choose the correct option(s) [Adv. 2019]

- (a) Q is  $\text{O}_2$  (b) T is Zn  
(c) Z is  $[\text{Main Zn}(\text{CN})_4]^{2-}$  (d) R is  $[\text{Main Au}(\text{CN})_4]^-$

24. Extraction of copper from copper pyrite ( $\text{CuFeS}_2$ ) involves [Adv. 2016]

- (a) crushing followed by concentration of the ore by froth-flotation  
(b) removal of iron as slag  
(c) self-reduction step to produce 'blister copper' following evolution of  $\text{SO}_2$   
(d) refining of 'blister copper' by carbon reduction

25. Upon heating with  $\text{Cu}_2\text{S}$ , the reagent(s) that give copper metal is/are [Adv. 2014]

- (a)  $\text{CuFeS}_2$  (b) CuO (c)  $\text{Cu}_2\text{O}$  (d)  $\text{CuSO}_4$

26. The carbon-based reduction method is NOT used for the extraction of [Adv. 2013]

- (a) Tin from  $\text{SnO}_2$   
(b) Iron from  $\text{Fe}_2\text{O}_3$   
(c) Aluminium from  $\text{Al}_2\text{O}_3$   
(d) Magnesium from  $\text{MgCO}_3 \cdot \text{CaCO}_3$

27. Extraction of metal from the ore cassiterite involves

- (a) carbon reduction of an oxide ore [2011]  
(b) self-reduction of a sulphide ore  
(c) removal of copper impurity  
(d) removal of iron impurity

28. The major role of fluorspar ( $\text{CaF}_2$ ), which is added in small quantities in the electrolytic reduction of alumina dissolved in fused cryolite ( $\text{Na}_3\text{AlF}_6$ ), is [1993 - 1 Mark]

- (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.

29. Of the following, the metals that cannot be obtained by electrolysis of the aqueous solution of their salts are :

- [1990 - 1 Mark]  
(a) Ag (b) Mg (c) Cu (d) Al  
(e) Cr.

30. In the electrolysis of alumina, cryolite is added to : [1986 - 1 Mark]

- (a) lower the melting point of alumina  
(b) increase the electrical conductivity  
(c) minimise the anode effect  
(d) remove impurities from alumina



#### 7 Match the Following

31. Match the anionic species given in Column I that are present in the ore(s) given in Column II. [Adv. 2015]

- | Column-I      | Column-II     |
|---------------|---------------|
| (A) Carbonate | (p) Siderite  |
| (B) Sulphide  | (q) Malachite |
| (C) Hydroxide | (r) Bauxite   |
| (D) Oxide     | (s) Calamine  |
|               | (t) Argentite |



32. Match the conversions in **Column I** with the type(s) of reaction(s) given in **Column II**. [2008 - 6M]

Column I	Column II
(A) $\text{PbS} \rightarrow \text{PbO}$	(p) roasting
(B) $\text{CaCO}_3 \rightarrow \text{CaO}$	(q) calcination
(C) $\text{ZnS} \rightarrow \text{Zn}$	(r) carbon reduction
(D) $\text{Cu}_2\text{S} \rightarrow \text{Cu}$	(s) self reduction

33. Match the extraction processes listed in **Column I** with metals listed in **Column II**: [2006 - 6M]

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

34. Match the following choosing one item from column X and the appropriate item from column Y:

[Multiple concept, 1986 -  $\frac{1}{2} \times 8 = 4$  Marks]

X	Y
(i) Lewis acid	(a) K electron capture
(ii) Philosopher's wool	(b) Zinc ore
(iii) Electrophile	(c) HCHO
(iv) Preservative	(d) $\text{NH}_4^+$
(v) Electron emission	(e) Small proton to neutron ratio
(vi) Bronsted acid	(f) $\text{SO}_3$
(vii) Black jack	(g) $\text{BF}_3$
(viii) X-ray emission	(h) ZnO

35. Match the following, choosing one item from column X and the appropriate item from column Y. [1983 - 2 Marks]

X	Y
(i) Al	(a) Calamine
(ii) Cu	(b) Cryolite
(iii) Mg	(c) Malachite
(iv) Zn	(d) Carnallite



### 8 Comprehension/Passage Based Questions

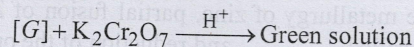
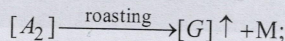
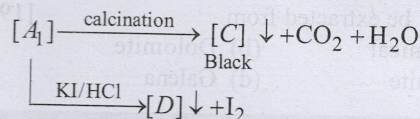
Copper is the most noble of the first row transition metals and occurs in small deposits in several countries. Ores of copper include chalcantite ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ), atacamite ( $\text{Cu}_2\text{Cl}(\text{OH})_3$ ), cuprite ( $\text{Cu}_2\text{O}$ ), copper glance ( $\text{Cu}_2\text{S}$ ) and malachite ( $\text{Cu}_2(\text{OH})_2\text{CO}_3$ ). However, 80% of the world copper production comes from the ore chalcopyrite ( $\text{CuFeS}_2$ ). The extraction of copper from chalcopyrite involves partial roasting, removal of iron and self-reduction. [2010]

36. Partial roasting of chalcopyrite produces  
 (a)  $\text{Cu}_2\text{S}$  and  $\text{FeO}$  (b)  $\text{Cu}_2\text{O}$  and  $\text{FeO}$   
 (c)  $\text{CuS}$  and  $\text{Fe}_2\text{O}_3$  (d)  $\text{Cu}_2\text{O}$  and  $\text{Fe}_2\text{O}_3$
37. Iron is removed from chalcopyrite as  
 (a)  $\text{FeO}$  (b)  $\text{FeS}$  (c)  $\text{Fe}_2\text{O}_3$  (d)  $\text{FeSiO}_3$
38. In self-reduction, the reducing species is  
 (a) S (b)  $\text{O}^{2-}$  (c)  $\text{S}^{2-}$  (d)  $\text{SO}_2$



### 10 Subjective Problems

39. Some reactions of two ores,  $A_1$  and  $A_2$  of the metal  $M$  are given below. [2004 - 4 Marks]



Identify  $A_1$ ,  $A_2$ ,  $M$ ,  $C$ ,  $D$ , and  $G$ , and explain using the required chemical reactions.

40. Write down reactions involved in the extraction of Pb. What is the oxidation number of lead in litharge? [2003 - 2 Marks]

41. When the ore haematite is burnt in air with coke around  $2000^\circ\text{C}$  along with lime, the process not only produces steel but also produces a silicate slag that is useful in making building materials such as cement. Discuss the same and show through balanced chemical equations. [1998 - 4 Marks]

42. State with balanced equations what happens when :  
 (i) Write balanced equations for the extraction of copper from copper pyrites by self-reduction. [1990 - 2 Marks]  
 (ii) Write balanced equations for the extraction of silver from silver glance by cyanide process. [1988 - 1 Mark]

43. Give the equations for the recovery of lead from Galena by air reduction. [1987 - 1 Mark]

44. What is the actual reducing agent of haematite in blast furnace? [1987 - 1 Mark]

45. Give reasons for the following :  
 (i) Why is chalcocite roasted and not calcinated during recovery of copper? [1987 - 1 Mark]  
 (ii) Metals can be recovered from their ores by chemical methods. [1984 - 1 Mark]

46. Give balanced equations for extraction of silver from its sulphide ore [1982 - 2 Marks]

47. Give balanced equations for the extraction of aluminium from bauxite by electrolysis. [1982 - 2 Marks]

48. Write the matching pairs: [1980]

Bleaching agent	Aluminium
Smelling salt	Carbon
Cryolite	Tin
Bell metal	Ammonium carbonate
Fluorspar	Ammonium phosphate
Fertilizer	Calcium
Anthraxite	Chlorine

#### Examples :

Bleaching agent	—	Chlorine
Smelling salt	—	Ammonium carbonate



49. (a) Write the chemical equations involved in the extraction of lead from galena by self reduction process.  
 (b) Match the following extraction processes with the appropriate metals listed below :
- |              |                               |
|--------------|-------------------------------|
| (i) Silver   | (A) Fused salt electrolysis   |
| (ii) Calcium | (B) Carbon reduction          |
| (iii) Zinc   | (C) Carbon monoxide reduction |
| (iv) Iron    | (D) Amalgamation              |
| (v) Copper   | (E) Selfreduction             |
- [1979]



## Topic-2: Purification and Uses of Metals



### 6 MCQs with One or More than One Correct Answer

- The correct statement(s) related to processes involved in the extraction of metals is(are) [Adv. 2023]
  - Roasting of malachite produces cuprite.
  - Calcination of calamine produces zincite.
  - Copper pyrites is heated with silica in a reverberatory furnace to remove iron.
  - Impure silver is treated with aqueous KCN in the presence of oxygen followed by reduction with zinc metal.
- The electrochemical extraction of aluminum from bauxite ore involves [Adv. 2022]
  - the reaction of  $\text{Al}_2\text{O}_3$  with coke (C) at a temperature  $> 2500^\circ\text{C}$ .
  - the neutralization of aluminate solution by passing  $\text{CO}_2$  gas to precipitate hydrated alumina ( $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ ).
  - the dissolution of  $\text{Al}_2\text{O}_3$  in hot aqueous NaOH.
  - the electrolysis of  $\text{Al}_2\text{O}_3$  mixed with  $\text{Na}_3\text{AlF}_6$  to give Al and  $\text{CO}_2$ .
- Copper is purified by electrolytic refining of blister copper. The correct statement(s) about this process is(are) [Adv. 2015]
  - Impure Cu strip is used as cathode
  - Acidified aqueous  $\text{CuSO}_4$  is used as electrolyte
  - Pure Cu deposits at cathode
  - Impurities settle as anode-mud



### 10 Subjective Problems

- Magnesium oxide is used for the lining of steel making furnace. [1987 - 1 Mark]
- High purity metals can be obtained by zone refining method. [1984 - 1 Mark]



## Answer Key

### Topic-1 : Occurrence of Metals and Metallurgical Processes

- |   |  |  |               |                           |   |               |               |        |         |
|---|--|--|---------------|---------------------------|---|---------------|---------------|--------|---------|
| 1. (a)                                  | 2. (b)                                       | 3. (d)                                       | 4. (b)        | 5. (c)                    | 6. (a)                                    | 7. (a)        | 8. (c)        | 9. (c) | 10. (b) |
| 11. (c)                                 | 12. (c)                                      | 13. (a)                                      | 14. (c)       | 15. (sintering, smelting) | 16. (Magnesia and lime; calcium silicate) |               |               |        |         |
| 17. (Aluminium)                         | 18. (Tin)                                    | 19. (a, d)                                   | 20. (a, b, c) | 21. (a, c, d)             | 22. (a, b, c, d)                          | 23. (a, b, c) | 24. (a, b, c) |        |         |
| 25. (b, c, d)                           | 26. (c, d)                                   | 27. (a, c, d)                                | 28. (b, c)    | 29. (b, d)                | 30. (a, b)                                |               |               |        |         |
| 31. A-(p, q, s), B-(t), C-(q, r), D-(r) | 32. (A) - p; (B) - q; (C) - p, r; (D) - p, s | 33. (A) - p, r; (B) - p, r; (C) - q; (D) - s |               |                           |   |               |               |        |         |
| 35. (c)                                 | 36. (b)                                      | 37. (d)                                      | 38. (c)       |                           |   |               |               |        |         |

### Topic-2 : Purification and Uses of Metals

1. (b, c, d) 2. (b, c, d) 3. (b, c, d)



# Hints & Solutions



## Topic-1: Occurrence of Metals and Metallurgical Processes

- (a) Calamine  $\rightarrow \text{ZnCO}_3$   
Malachite  $\rightarrow \text{CuCO}_3 \cdot \text{Cu(OH)}_2$   
Magnetite  $\rightarrow \text{Fe}_3\text{O}_4$   
Cryolite  $\rightarrow \text{Na}_3\text{AlF}_6$
- (b) The reactions involved in cyanide extraction process are :  
$$\text{Ag}_2\text{S} + 4\text{NaCN} \rightarrow 2\text{Na}[\text{Ag}(\text{CN})_2] + \text{Na}_2\text{S}$$

(argentite)

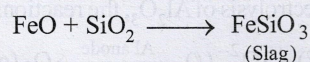
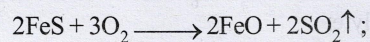
$$4\text{Na}_2\text{S} + \underset{\substack{\text{Oxidizing} \\ \text{agent}}}{5\text{O}_2} + 2\text{H}_2\text{O} \rightarrow 2\text{Na}_2\text{SO}_4 + 4\text{NaOH} + 2\text{S}$$
$$2\text{Na}[\text{Ag}(\text{CN})_2] + \underset{\substack{\text{(reducing} \\ \text{agent})}}{\text{Zn}} \rightarrow \text{Na}_2[\text{Zn}(\text{CN})_4] + 2\text{Ag} \downarrow$$
- (d) (i) Haematite is  $\text{Fe}_2\text{O}_3$  in which Fe is present in III oxidation state.  
(ii) Magnetite ( $\text{Fe}_3\text{O}_4$ ) is an equimolar mixture of FeO and  $\text{Fe}_2\text{O}_3$ .  
Oxidation state of Fe in FeO is II.  
Oxidation state of Fe in  $\text{Fe}_2\text{O}_3$  is III.
- (b) Extraction of Zn from ZnS (Zinc blende) is achieved by roasting followed by reduction with carbon.  
$$2\text{ZnS} + 3\text{O}_2 \rightarrow 2\text{ZnO} + 2\text{SO}_2$$
$$\text{ZnO} + \text{C} \rightarrow \text{Zn} + \text{CO}$$
- (c) Cuprite :  $\text{Cu}_2\text{O}$ ; Chalcocite :  $\text{Cu}_2\text{S}$ ; Chalcopyrite :  $\text{CuFeS}_2$ ; Malachite:  $\text{Cu(OH)}_2 \cdot \text{CuCO}_3$ . We see that  $\text{CuFeS}_2$  contains both Cu and Fe.
- (a)  $2\text{Au} + 4\text{CN}^- + \text{H}_2\text{O} + \frac{1}{2}\text{O}_2 \rightarrow$   
$$2[\text{Au}(\text{CN})_2]^- + 2\text{OH}^-$$

'X'

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

'Y'
- (a)  $\text{MgCl}_2 \rightarrow \text{Mg}^{+2} + 2\text{Cl}^-$   
(fused anhydrous)  
At cathode :  $\text{Mg}^{+2} + 2\text{e}^- \rightarrow \text{Mg}$ ;  
At anode :  $2\text{Cl}^- - 2\text{e}^- \rightarrow \text{Cl}_2 \uparrow$
- (c)  $\text{Al}_2\text{O}_3$  is mixed with cryolite ( $\text{Na}_3\text{AlF}_6$ ) which lowers the melting point of the mixture and brings conductivity.
- (c) Haematite ore ( $\text{Fe}_2\text{O}_3$ ) is first reduced to cast iron which is then oxidised for removing carbon (impurity) as  $\text{CO}_2$ .

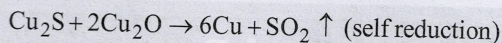
- (b) During the extraction of copper, iron is present in the ore as impurity ( $\text{FeS}$ ).  
The ore together with a little coke and silica is smelted;  $\text{FeS}$  present as impurity in the ore is oxidized to iron oxide, which then reacts with silica to form fusible ferrous silicate which is removed as slag.



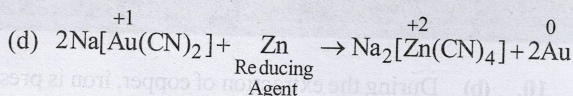
- (c)  $\text{Al}_2\text{O}_3$  is electrolyte, while  $\text{Na}_3\text{AlF}_6$  is used to decrease the melting point of  $\text{Al}_2\text{O}_3$  and to increase the conductivity.
- (c) Al reduces  $\text{Fe}_2\text{O}_3$  or  $\text{Cr}_2\text{O}_3$  to respective metals and acts as a reducing agent.  
$$\text{Fe}_2\text{O}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + 2\text{Fe}$$
- (a)  $\text{CaCO}_3 \xrightarrow{\text{Heat}} \text{CaO} + \text{CO}_2$ ;  
$$\underset{\text{Flux}}{\text{CaO}} + \underset{\text{impurity}}{\text{SiO}_2} \rightarrow \text{CaSiO}_3 \text{ (slag)}.$$
- (c) Malachite is  $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$  which is ore of copper.
- sintering, smelting.**
- Magnesia and lime; calcium silicate**  
The lining of converter is made of magnesia & lime. Slag formed consists of  $\text{CaSiO}_3$ .
- Aluminium**  
$$\text{Fe}_2\text{O}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + 2\text{Fe} + \text{Heat}$$

[Thermite reaction]
- Tin.** It is  $\text{SnO}_2$ .
- (a, d)  
The treatment of galena with  $\text{HNO}_3$  produces nitric oxide gas which is paramagnetic.  
$$\text{PbS} + \text{HNO}_3 \rightarrow \text{Pb(NO}_3)_2 + \text{S} \downarrow + \text{NO} \uparrow + 4\text{H}_2\text{O}$$
  
NO is colourless, neutral, paramagnetic gas.  
NO is of linear geometry :  $\cdot\text{N} = \ddot{\text{O}} : \longleftrightarrow : \ddot{\text{O}} = \text{N} \cdot$
- (a, b, c)  
Exhaust gases do not contain  $\text{NO}_2$ .
- (a, c, d)  
(a)  $\text{PbS} + 2\text{PbO} \rightarrow 3\text{Pb} + \text{SO}_2$  (self reduction)  
(b) Silica is added to remove impurity of Fe in the form of slag  $\text{FeSiO}_3$ . Hence, this statement is wrong.  
(c) Sulphide ore is partially oxidized first by roasting and then self reduction of Cu takes place to produce blister copper.  
$$\text{Cu}_2\text{S} + \frac{3}{2}\text{O}_2 \rightarrow \text{Cu}_2\text{O} + \text{SO}_2 \uparrow$$

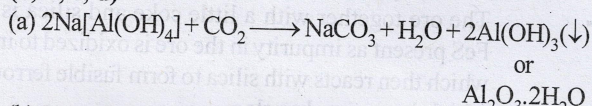




The molten copper obtained is poured into large container and allowed to cool and during cooling the dissolved  $\text{SO}_2$  comes up to the surface and forms blisters. It is known as blister copper.

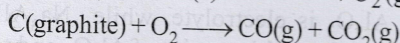
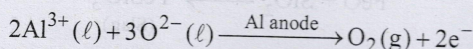


22. (a, b, c, d)



(b) Function of  $\text{Na}_3\text{AlF}_6$  is to lower the melting point of electrolyte.

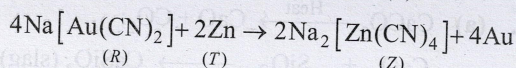
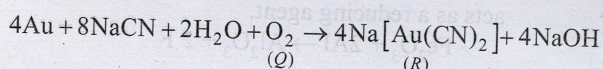
(c) During electrolysis of  $\text{Al}_2\text{O}_3$ , the reactions at anode are:



(d) The steel vessel with a lining of carbon acts as cathode.

23. (a, b, c)

Gold extraction:



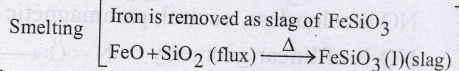
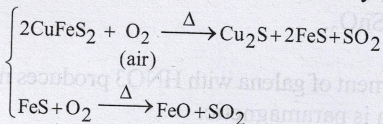
24. (a, b, c)

Copper pyrite [ $\text{CuFeS}_2$ ]

Crushing into fine powder

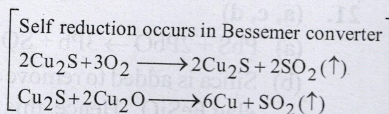
Concentrated by froth floatation process

Roasting take place in reverberatory furnace



Copper matte ( $\text{Cu}_2\text{S} + \text{FeS}$ )

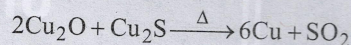
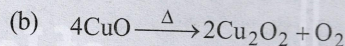
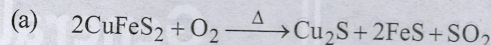
Self reduction



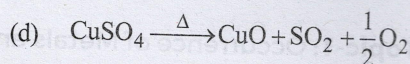
(Blister copper)

Refining of blister copper is done by poling followed by electrorefining but not by carbon reduction method.

25. (b, c, d)



(c) From above,  $\text{Cu}_2\text{O}$  gives copper metal.



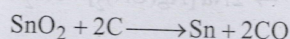
From above,  $\text{CuO}$  also gives copper metal.

26. (c, d) Al from  $\text{Al}_2\text{O}_3$  and Mg from  $\text{MgCO}_3 \cdot \text{CaCO}_3$  are separately extracted by electrolytic reduction.

27. (a, c, d) Cassiterite ( $\text{SnO}_2$ ) contains impurity of S, As, Fe, Cu etc.

Roasting: Concentrated ore is heated in a current of air impurities of iron and copper changed to their oxides and sulphates.

$\text{SnO}_2$  is treated with coke to reduce it to Sn.

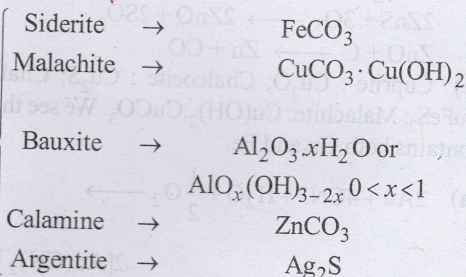


28. (b, c) To make the fused mixture very conducting and to reduce the temperature of the melt.

29. (b, d) Both Mg and Al have their reduction potentials less than that of water [ $E^\circ = -0.83 \text{ V}$ ]. Hence, their ions in the aqueous solution can not be reduced. Instead water will be reduced:  $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$

30. (a, b) Because of high melting point ( $2050^\circ\text{C}$ ), pure alumina cannot be electrolysed. Hence a mixture of alumina, cryolite (m.p.  $1000^\circ\text{C}$ ) and calcium fluoride (to lower the temperature of the melt) is electrolysed at about  $900^\circ\text{C}$ . The function of cryolite is to increase the electrical conductivity of the electrolyte, and to lower the temperature of the melt.

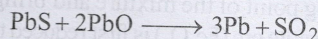
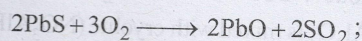
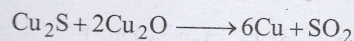
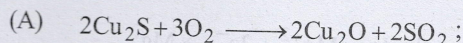
31. A-(p, q, s), B-(t), C-(q, r), D-(r)



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

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

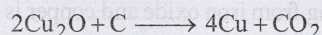
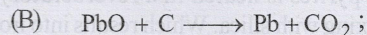
The oxides and sulphides of less active metals like Hg, Cu & Pb are unstable to heat and hence no reducing agent is required. They undergo self reduction.



Hence, (A)  $\rightarrow$  (p), (r)

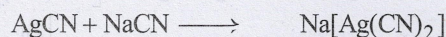
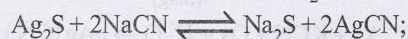


The oxides of less electropositive metals like Pb, Zn, Fe, Sn, Cu, etc. are reduced by strongly heating them with coke or coal.



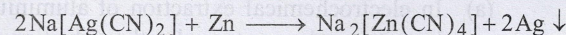
Hence, (B)  $\rightarrow$  (p), (r)

(C) Extraction from argentite ( $\text{Ag}_2\text{S}$ )



Sod. argentocyanide (soluble)

Zn, being more electropositive than Ag, displaces Ag from the complex.



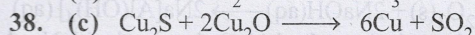
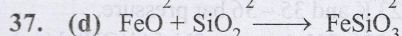
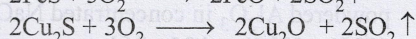
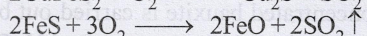
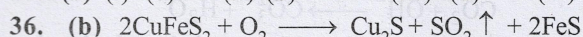
Hence, (C)  $\rightarrow$  (q)

(D) Among the halides of boron,  $\text{BI}_3$  is unstable because of the large size of Iodine and small size of boron atom.

Hence, it decomposes to give boron. Thus, (D)  $\rightarrow$  (s).

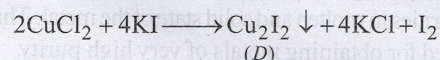
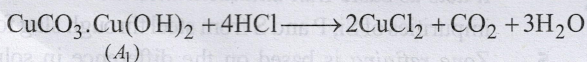
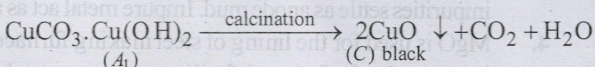
34. (i) (g) (ii) (h) (iii) (f) (iv) (c)  
(v) (e) (vi) (d) (vii) (b) (viii) (a)

35. (c) (i) (b) (ii) (c) (iii) (d) (iv) (a)

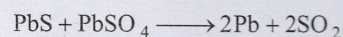
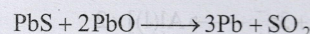
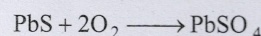
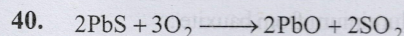
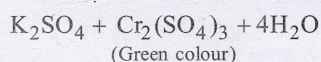
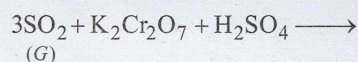
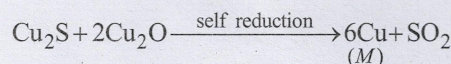
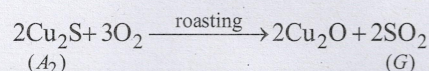


The reducing species is the one which gets oxidised. So, it is  $\text{S}^{2-}$  ion getting oxidised to  $\text{S}^{4+}$ .

39. Calcination of the ore  $A_1$  to form  $\text{CO}_2$  indicates that  $A_1$  should be a carbonate. Further, reaction of  $A_1$  with HCl and KI to evolve  $\text{I}_2$  indicates that  $A_1$  would also be hydroxide. So the possible formula for the ore, should be  $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$  which explains all the given reactions

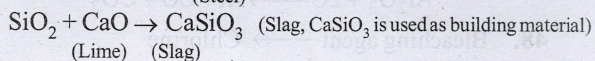
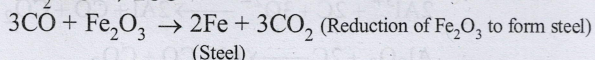
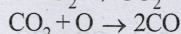
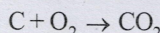


Roasting of  $A_2$  gives gas  $G$  whose nature is identified as  $\text{SO}_2$  as it gives green colour with acidified  $\text{K}_2\text{Cr}_2\text{O}_7$ . So  $A_2$  should be sulphide of copper.

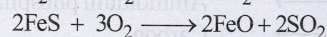
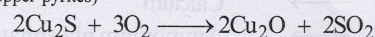
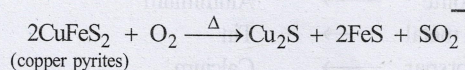


Oxidation number of Pb in litharge ( $\text{PbO}$ ) is +2

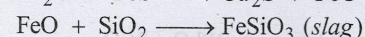
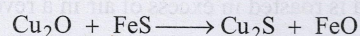
41. Haematite ( $\text{Fe}_2\text{O}_3$ ) on burning with coke and lime at  $2000^\circ\text{C}$  results in the following reactions.



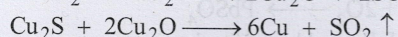
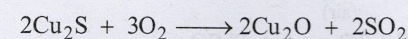
42. (i)



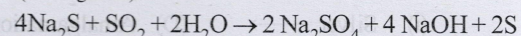
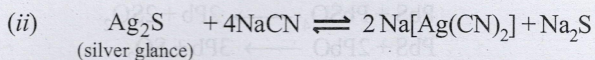
Roasting



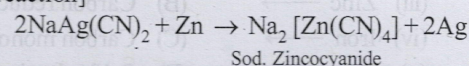
Smelting with coke and sand



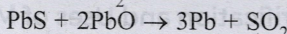
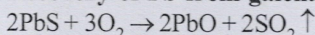
Bessemerization



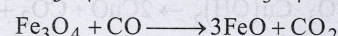
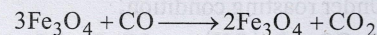
[ $\text{Na}_2\text{S}$  is converted into  $\text{Na}_2\text{SO}_4$  to avoid reversibility of first reaction]



43. Recovery of Pb from galena :



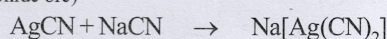
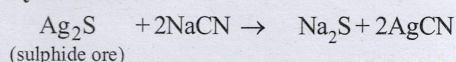
44. Carbon monoxide is the actual reducing agent of haematite in blast furnace.



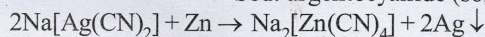
45. (i) Excess of Air (used during roasting) is necessary for converting chalcocite (a sulphide ore) to oxide. Calcination does not convert it to oxide.

(ii) Metals can be recovered by chemical methods because they occur as oxides, carbonates, sulphides which have to be calcined or roasted.

46. Equations for extraction of silver from its sulphide ore. Cyanide Process :



Sod. argentocyanide (soluble)

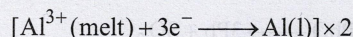


[Zn is more electropositive than Ag.]

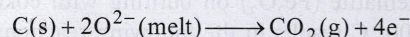
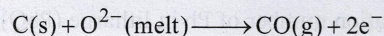


47. Extraction of aluminium from bauxite :

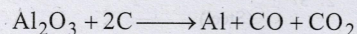
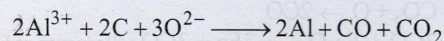
At cathode :



At anode :



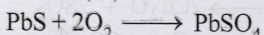
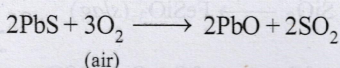
Net reaction :



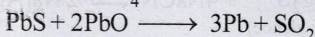
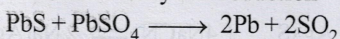
48. Bleaching agent
- $\longrightarrow$
- Chlorine

Smelling salt  $\longrightarrow$  Ammonium carbonateCryolite  $\longrightarrow$  AluminiumBell metal  $\longrightarrow$  TinFluorspar  $\longrightarrow$  CalciumFertilizer  $\longrightarrow$  Ammonium phosphateAnthracite  $\longrightarrow$  Carbon

49. (a) Galena is roasted in excess of air in a reverberatory furnace



- (b) It is followed by self reduction



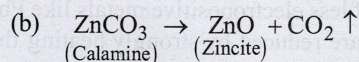
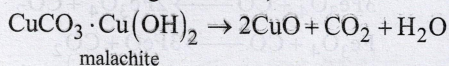
- (i) Silver  $\longrightarrow$  (D) Amalgamation  
 (ii) Calcium  $\longrightarrow$  (A) Fused salt electrolysis  
 (iii) Zinc  $\longrightarrow$  (B) Carbon reduction  
 (iv) Iron  $\longrightarrow$  (C) Carbon monoxide reduction  
 (v) Copper  $\longrightarrow$  (E) Self reduction



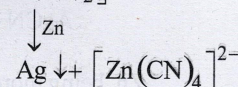
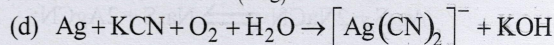
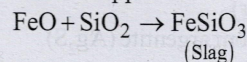
## Topic-2: Purification and Uses of Metals

1. (b, c, d)

- (a) Under roasting condition,



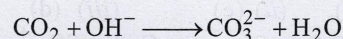
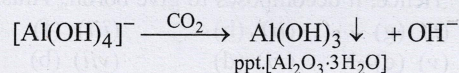
- (c) Copper pyrites is heated in a reverberatory furnace after mixing with silica. Which results into iron silicate as slag from iron oxide and copper is produced in the form of copper matte.



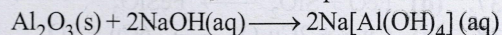
2. (b, c, d)

- (a) In electrochemical extraction of aluminium from bauxite ore does not involve the reduction of
- $\text{Al}_2\text{O}_3$
- with (C)

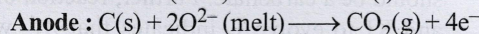
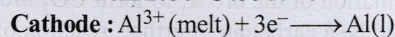
- (b) The neutralization of aluminate
- $[\text{Al}(\text{OH})_4]^-$
- solution is performed by passing
- $\text{CO}_2$
- gas –



- (c) Concentrated bauxite is carried out by heating the powdered
- $\text{Al}_2\text{O}_3$
- in concentrated
- $\text{NaOH}$
- solution at 473 K – 523 K and 35 – 36 bar pressure.



- (d) In electrolysis method
- $\text{Al}_2\text{O}_3$
- is mixed with
- $\text{Na}_3\text{AlF}_6$
- or
- $\text{CaF}_2$
- to reduce the melting temperature of the mixture from 2050 °C to 900 °C.



3. (b, c, d) In electrolytic refining of blister Cu, acidified  $\text{CuSO}_4$  is used as electrolyte, pure Cu deposits at cathode and impurities settle as anode mud. Impure metal act as an anode.
4.  $\text{MgO}$  is used for the lining of steel making furnace because it acts as basic flux and facilitates the removal of acidic impurities of Si, P and S from steel through slag formation.
5. *Zone refining* is based on the difference in solubility of impurities in molten and solid state of the metal. This method is used for obtaining metals of very high purity.
- Ge, Si and Ga used as semi-conductors are refined in this manner. These metals can be easily melted and can easily crystallise out from the melt form.