

# General Principles and Processes of Isolation of Elements

## 6.1 Occurrence of Metals

- Which one is malachite from the following?  
(a)  $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$  (b)  $\text{CuFeS}_2$   
(c)  $\text{Cu(OH)}_2$  (d)  $\text{Fe}_3\text{O}_4$  (NEET 2019)
- Identify the incorrect statement.  
(a) The scientific and technological process used for isolation of the metal from its ore is known as metallurgy.  
(b) Minerals are naturally occurring chemical substances in the earth's crust.  
(c) Ores are minerals that may contain a metal.  
(d) Gangue is an ore contaminated with undesired materials. (Odisha NEET 2019)
- "Metals are usually not found as nitrates in their ores." Out of the following two (I and II) reasons which is/are true for the above observation?  
I. Metal nitrates are highly unstable.  
II. Metal nitrates are highly soluble in water.  
(a) I is false but II is true.  
(b) I is true but II is false.  
(c) I and II are true.  
(d) I and II are false (2015, Cancelled)
- Which one of the following is a mineral of iron?  
(a) Malachite (b) Cassiterite  
(c) Pyrolusite (d) Magnetite (2012)
- Cassiterite is an ore of  
(a) Sb (b) Ni  
(c) Mn (d) Sn (1999)

## 6.2 Concentration of Ores

- Sulphide ores of metals are usually concentrated by froth floatation process. Which one of the following sulphide ores offer an exception and is concentrated by chemical leaching?  
(a) Galena (b) Copper pyrite  
(c) Sphalerite (d) Argentite (2007)

## 6.3 Extraction of Crude Metal from Concentrated Ore

- Roasting of sulphides gives the gas X as a byproduct. This is a colourless gas with choking smell of burnt sulphur and causes great damage to respiratory organs as a result of acid rain. Its aqueous solution is acidic, acts as a reducing agent and its acid has never been isolated. The gas X is  
(a)  $\text{CO}_2$  (b)  $\text{SO}_3$   
(c)  $\text{H}_2\text{S}$  (d)  $\text{SO}_2$  (NEET 2013)

## 6.4 Thermodynamic Principles of Metallurgy

- Considering Ellingham diagram, which of the following metals can be used to reduce alumina?  
(a) Fe (b) Zn  
(c) Mg (d) Cu (NEET 2018)
- In the extraction of copper from its sulphide ore, the metal is finally obtained by the reduction of cuprous oxide with  
(a) carbon monoxide (b) copper (I) sulphide  
(c) sulphur dioxide (d) iron (II) sulphide. (2015, 2012)
- The metal oxide which cannot be reduced to metal by carbon is  
(a)  $\text{Al}_2\text{O}_3$  (b)  $\text{PbO}$  (c)  $\text{ZnO}$  (d)  $\text{Fe}_2\text{O}_3$  (Karnataka NEET 2013)
- Which of the following elements is present as the impurity to the maximum extent in the pig iron?  
(a) Manganese (b) Carbon  
(c) Silicon (d) Phosphorus (2011, 1998)
- The following reactions take place in the blast furnace in the preparation of impure iron. Identify the reaction pertaining to the formation of the slag.  
(a)  $\text{Fe}_2\text{O}_{3(s)} + 3\text{CO}_{(g)} \rightarrow 2\text{Fe}_{(l)} + 3\text{CO}_{2(g)}$   
(b)  $\text{CaCO}_{3(s)} \rightarrow \text{CaO}_{(s)} + \text{CO}_{2(g)}$   
(c)  $\text{CaO}_{(s)} + \text{SiO}_{2(s)} \rightarrow \text{CaSiO}_{3(s)}$   
(d)  $2\text{C}_{(s)} + \text{O}_{2(g)} \rightarrow 2\text{CO}_{(g)}$  (Mains 2011)

13. Which of the following statements, about the advantage of roasting of sulphide ore before reduction is not true?

- (a) The  $\Delta G_f^\circ$  of the sulphide is greater than those for  $\text{CS}_2$  and  $\text{H}_2\text{S}$ .
- (b) The  $\Delta G_f^\circ$  is negative for roasting of sulphide ore to oxide.
- (c) Roasting of the sulphide to the oxide is thermodynamically feasible.
- (d) Carbon and hydrogen are suitable reducing agents for metal sulphides. (2007)

14. Nitriding is the process of surface hardening of steel by treating it in an atmosphere of

- (a)  $\text{NH}_3$  (b)  $\text{O}_3$
- (c)  $\text{N}_2$  (d)  $\text{H}_2\text{S}$  (1989)

### 6.5 Electrochemical Principles of Metallurgy

15. Aluminium is extracted from alumina ( $\text{Al}_2\text{O}_3$ ) by electrolysis of a molten mixture of

- (a)  $\text{Al}_2\text{O}_3 + \text{HF} + \text{NaAlF}_4$
- (b)  $\text{Al}_2\text{O}_3 + \text{CaF}_2 + \text{NaAlF}_4$
- (c)  $\text{Al}_2\text{O}_3 + \text{Na}_3\text{AlF}_6 + \text{CaF}_2$
- (d)  $\text{Al}_2\text{O}_3 + \text{KF} + \text{Na}_3\text{AlF}_6$  (2012)

16. Purification of aluminium, by electrolytic refining, is known as

- (a) Hoope's process
- (b) Baeyer's process
- (c) Hall's process
- (d) Serpeck's process. (1999)

17. Calcium is obtained by

- (a) reduction of calcium chloride with carbon
- (b) electrolysis of molten anhydrous calcium chloride
- (c) roasting of limestone
- (d) electrolysis of solution of calcium chloride in  $\text{H}_2\text{O}$ . (1997)

### 6.6 Oxidation Reduction

18. Extraction of gold and silver involves leaching with  $\text{CN}^-$  ion. Silver is later recovered by

- (a) distillation (b) zone refining

(c) displacement with Zn

(d) liquation. (NEET 2017)

### 6.7 Refining

19. Identify the correct statement from the following :

- (a) Wrought iron is impure iron with 4% carbon.
- (b) Blister copper has blistered appearance due to evolution of  $\text{CO}_2$ .
- (c) Vapour phase refining is carried out for Nickel by van Arkel method.
- (d) Pig iron can be moulded into a variety of shapes. (NEET 2020)

20. Match items of Column I with the items of Column II and assign the correct code :

#### Column I

#### Column II

- |                              |                        |
|------------------------------|------------------------|
| (A) Cyanide process          | (i) Ultrapure Ge       |
| (B) Froth floatation process | (ii) Dressing of ZnS   |
| (C) Electrolytic reduction   | (iii) Extraction of Al |
| (D) Zone refining            | (iv) Extraction of Au  |
|                              | (v) Purification of Ni |

Code :

- |     | A     | B     | C     | D    |
|-----|-------|-------|-------|------|
| (a) | (i)   | (ii)  | (iii) | (iv) |
| (b) | (iii) | (iv)  | (v)   | (i)  |
| (c) | (iv)  | (ii)  | (iii) | (i)  |
| (d) | (ii)  | (iii) | (i)   | (v)  |
- (NEET-I 2016)

21. Which of the following pairs of metals is purified by van Arkel method?

- (a) Ga and In (b) Zr and Ti
- (c) Ag and Au (d) Ni and Fe (2011)

22. The method of zone refining of metals is based on the principle of

- (a) greater mobility of the pure metal than that of the 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. (2003)

### ANSWER KEY

- |         |         |         |         |         |         |         |         |         |         |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 1. (a)  | 2. (d)  | 3. (a)  | 4. (d)  | 5. (d)  | 6. (d)  | 7. (d)  | 8. (c)  | 9. (b)  | 10. (a) |
| 11. (b) | 12. (c) | 13. (d) | 14. (a) | 15. (c) | 16. (a) | 17. (b) | 18. (c) | 19. (d) | 20. (c) |
| 21. (b) | 22. (d) |         |         |         |         |         |         |         |         |

## Hints & Explanations

1. (a) : Malachite :  $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$
2. (d) : An ore rarely contains only a desired substance. It is usually contaminated with earthly or undesired materials known as gangue.
3. (a) : All nitrates are soluble in water and are quite stable as they do not decompose easily on heating.
4. (d) : Magnetite is  $\text{Fe}_3\text{O}_4$  and contains upto 70% of iron metal.
5. (d) : Cassiterite is also known as tin stone ( $\text{SnO}_2$ ), an ore of tin (Sn).
6. (d) : Leaching process involves the treatment of the ore with a suitable reagent as to make it soluble while impurities remain insoluble. The ore is recovered from the solution by suitable chemical method. Argentite or silver glance,  $\text{Ag}_2\text{S}$  is an ore of silver. Silver is extracted from argentite by the Mac-Arthur and Forest cyanide process (leaching process).  

$$\text{Ag}_2\text{S} + 4\text{NaCN} \longrightarrow 2\text{Na}[\text{Ag}(\text{CN})_2] + \text{Na}_2\text{S}$$

$$2\text{Na}[\text{Ag}(\text{CN})_2] + \text{Zn} \longrightarrow \text{Na}_2[\text{Zn}(\text{CN})_4] + 2\text{Ag}$$
7. (d)
8. (c) : Any metal oxide with lower value of  $\Delta G^\circ$  is more stable than a metal oxide with higher  $\Delta G^\circ$ . This implies that the metal oxide placed higher in the Ellingham diagram can be reduced by the metal involved in the formation of the oxide placed lower in the diagram. The relative tendency of the various metals to act as reducing agents is :  

$$\text{Ca} > \text{Mg} > \text{Al} > \text{Zn} > \text{Fe} > \text{Cu}.$$
 Thus, Mg being more reducing in nature, can reduce aluminium oxide (alumina) to aluminium.
9. (b) : It is an example of auto reduction.  

$$2\text{Cu}_2\text{O} + \text{Cu}_2\text{S} \longrightarrow 6\text{Cu} + \text{SO}_2$$
10. (a) : Oxides of less reactive metals (like  $\text{PbO}$ ,  $\text{ZnO}$ ,  $\text{Fe}_2\text{O}_3$ ) can be reduced by carbon. While oxides of very reactive metals (like  $\text{Al}_2\text{O}_3$ ) can be reduced only by the electrolytic method.
11. (b) : Pig iron contains about 4% carbon and many impurities such as S, Mn, P, Si, etc. in smaller amount.
12. (c) : Slag is formed by the reaction  

$$\text{CaO} + \text{SiO}_2 \longrightarrow \text{CaSiO}_3$$
13. (d) : The standard free energies of formation ( $\Delta G_f^\circ$ ) of most of the sulphides are greater than those of  $\text{CS}_2$  and  $\text{H}_2\text{S}$ . Hence, neither carbon nor hydrogen can reduce metal sulphides to metal. The standard free energies of

formation of oxides are much lower than those of  $\text{SO}_2$ . Therefore, oxidation of metal sulphides to metal oxides is thermodynamically favourable. Hence, sulphide ore is roasted to the oxide before reduction.

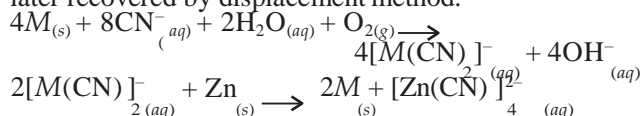
14. (a) : When steel is heated in presence of  $\text{NH}_3$ , iron nitride on the surface of steel is formed which imparts a hard coating. This process is called nitriding.

15. (c) : Electrolytic mixture contains alumina ( $\text{Al}_2\text{O}_3$ ), cryolite ( $\text{Na}_3\text{AlF}_6$ ) and fluorspar ( $\text{CaF}_2$ ) in the ratio of 20 : 40 : 20. Due to presence of these, conductivity of alumina increases and fusion temperature decreases from  $2000^\circ\text{C}$  to  $900^\circ\text{C}$ .

16. (a) : Aluminium metal obtained from Hoopes' electrolytic refining process is about 99.9% pure. The cell used for this process consists of three layers. The upper layer is pure 'Al', acts as cathode, the middle layer is mixture of fluorides of Al and Ba, which acts as electrolyte. The lowest layer is impure 'Al', which acts as anode. On electrolysis pure 'Al' is transferred from the bottom to the top layer, through the middle layer.

17. (b) : Calcium is obtained by the electrolysis of a fused mixture of anhydrous  $\text{CaCl}_2$  and  $\text{CaF}_2$  in a graphite lined tank which serves as anode. The cathode is a hollow movable iron rod which is kept cool. During electrolysis, calcium is deposited at cathode while  $\text{Cl}_2$  is liberated at anode.

18. (c) : Extraction of gold and silver involves leaching the metal with  $\text{CN}^-$  and the metals silver and gold are later recovered by displacement method.



19. (d) : (a) Pig iron is impure iron with 4% carbon.

(b) Blister copper has blistered appearance due to evolution of  $\text{SO}_2$ .

(c) Vapour phase refining is carried out for nickel by Mond's process.

(d) Pig iron can be moulded into a variety of shapes.

20. (c)

21. (b) : van Arkel method is used for purification of Zr and Ti.

22. (d) : Elements which are used as semiconductors such as Si, Ge, Ga, etc. are refined by this method, which is based on the difference in solubility of impurities in molten and solid state of the metal.