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# EC CHEMISTRY

## VOLUME - I & II

# 12

This Special guide is prepared on the basis of New Syllabus



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# PREFACE

**Welcome to all teachers and students.**

Nothing succeeds like success' Loyola's EC brings that success.

Loyola Publications has immense pleasure in bringing this EC Guide for Std XII Chemistry.

- This guide is framed in such a way to fulfil the needs of the students going for Government Public Examination as well as various entrance examinations.
- This guide elaborately deals with all the exercise questions given in the text book.
- Moreover additional questions in each category (1, 2, 3 & 5 Marks) for all units are provided.
- Answers for 1 mark questions are provided with suitable explanations and reasons wherever necessary.
- Answer for 2, 3 and 5 mark questions are provided in a simple and lucid manner so as to make the learning as an enjoyable experience.
- After learning this guide thoroughly a student will understand clearly all the concepts given in the text book.
- Surely this guide will be a boon to slow learners.
- Utmost care has been taken in bringing this guide without any conceptual and spelling errors.
- A team of well experienced and dedicated teachers worked tirelessly in making this endeavour a successful one.
- Your valuable suggestions and comments are expected to improve this guide in the coming years.
- **Included PTA questions and Govt. question papers with their Answer Key.**

Loyola Publications wishes you all good luck.

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# CONTENTS

## CHEMISTRY

# UNIT 1 Metallurgy

## PART I - TEXT BOOK EVALUATION

### I. Choose the correct answer

**1. Bauxite has the composition** Hy - 2019

a) $Al_2O_3$ b) $Al_2O_3.nH_2O$ May 2022

c) $Fe_2O_3.2H_2O$ d) None of these

**Ans : b) $Al_2O_3.nH_2O$**

**2. Roasting of sulphide ore gives the gas (A). (A) is a colourless gas. Aqueous solution of (A) is acidic. The gas (A) is**

a) $CO_2$ b) $SO_3$ c) $SO_2$ d) $H_2S$

**Ans : c) $SO_2$**

**3. Which one of the following reaction represents calcinations?**

a) $2Zn + O_2 \rightarrow 2ZnO$

b) $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

c) $MgCO_3 \rightarrow MgO + CO_2$

d) Both (a) and (c)

**Ans : c) $MgCO_3 \rightarrow MgO + CO_2$**

**4. The metal oxide which cannot be reduced to metal by carbon is**

a) PbO b) $Al_2O_3$ c) ZnO d) FeO

**Ans : b) $Al_2O_3$**

**5. Which of the metal is extracted by Hall - Heroult process?** March - 2023

a) Al b) Ni c) Cu d) Zn

**Ans : a) Al**

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

a) $\Delta G_f^0$ of sulphide is greater than those for $CS_2$ and $H_2S$

b) $\Delta G_r^0$ is negative for roasting of sulphide ore to oxide

c) Roasting of the sulphide to its oxide is thermodynamically feasible.

d) Carbon and hydrogen are suitable reducing agents for metal sulphides.

**Ans : d) Carbon and hydrogen are suitable reducing agents for metal sulphides.**

**7. Match items in 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 |

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

**Ans :c) (iv) (ii) (iii) (i)**

**8. Wolframite ore is separated from tinstone by the process of** PTA - 2; MARCH 2020

a) Smelting b) Calcination c) Roasting d) Electromagnetic separation

**Ans : d) Electromagnetic separation**

**9. Which one of the following is not feasible**

a) $Zn(s) + Cu^{2+}(aq) \rightarrow Cu(s) + Zn^{2+}(aq)$
b) $Cu(s) + Zn^{2+}(aq) \rightarrow Zn(s) + Cu^{2+}(aq)$
c) $Cu(s) + 2Ag^{+}(aq) \rightarrow 2Ag(s) + Cu^{2+}(aq)$
d) $Fe(s) + Cu^{2+}(aq) \rightarrow Cu(s) + Fe^{2+}(aq)$

**Ans : b) $Cu(s) + Zn^{2+}(aq) \rightarrow Zn(s) + Cu^{2+}(aq)$**

**10. Electrochemical process is used to extract**

a) Iron b) Lead c) Sodium d) Silver

**Ans : c) Sodium**

**11. Flux is a substance which is used to convert**

a) Mineral into silicate
b) Infusible impurities to soluble impurities
c) Soluble impurities to infusible impurties
d) All of these

**Ans : b) Infusible impurities to soluble impurities**

**12. Which one of the following ores is best concentrated by froth - floatation method?**

a) Magnetite b) Haematite GMQ-2019
c) Galena d) Cassiterite

**Ans : c) Galena**

**13. In the extraction of aluminium from alumina by electrolysis, cryolite is added to**

a) Lower the melting point of alumina
b) Remove impurities from alumina
c) Decrease the electrical conductivity
d) Increase the rate of reduction

**Ans : a) Lower the melting point of alumina**

**14. Zinc is obtained from ZnO by**

a) Carbon reduction
b) Reduction using silver
c) Electrochemical process
d) Acid leaching

**Ans : a) Carbon reduction**

**15. Extraction of gold and silver involves leaching with cyanide ion. silver is later recovered by (NEET - 2017)**

a) Distillation
b) Zone refining
c) Displacement with zinc
d) liquation

**Ans : c) Displacement with zinc**

**16. Considering Ellingham diagram, which of the following metals can be used to reduce alumina? (NEET - 2018)**

a) Fe b) Cu c) Mg d) Zn

**Ans : c) Mg**

**17. The following set of reactions are used in refining Zirconium** Aug-2021

$Zr(impure) + 2I_2 \xrightarrow{523K} ZrI_4$

$ZrI_4 \xrightarrow{1800K} Zr\ (pure) + 2I_2$

**This method is known as**

a) Liquation b) Van Arkel process
c) Zone refining d) Mond's process

**Ans : b) Van Arkel process**

**18. Which of the following is used for concentrating ore in metallurgy?**

a) Leaching b) Roasting
c) Froth floatation d) Both (a) and (c)

**Ans : d) Both (a) and (c)**

**19. The incorrect statement among the following is** QY - 2019, SEP - 2020

a) Nickel is refined by Mond's process
b) Titanium is refined by Van Arkel's process
c) Zinc blende is concentrated by froth floatation
d) In the metallurgy of gold, the metal is leached with dilute sodium chloride solution

**Ans : d) In the metallurgy of gold, the metal is leached with dilute sodium chloride solution**

**20. In the electrolytic refining of copper, which one of the following is used as anode?**

a) Pure copper b) Impure copper
c) Carbon rod d) Platinum electrode

**Ans : b) Impure copper**

**21. Which of the following plot gives Ellingham diagram**

a) $\Delta S$ VsT b) $\Delta G^0$ VsT
c) $\Delta G^0$ Vs 1/T d) $\Delta G^0$ $VsT^2$

**Ans : b) $\Delta G^0$ VsT**

**22. In the Ellingham diagram, for the formation of carbon monoxide**

a) $\left(\frac{\Delta S^0}{\Delta T}\right)$ is negative b) $\left(\frac{\Delta G^0}{\Delta T}\right)$ is positive

c) $\left(\frac{\Delta G^0}{\Delta T}\right)$ is negative

d) Initially $\left(\frac{\Delta T}{\Delta G^0}\right)$ is positive, after $700^0C$ $\left(\frac{\Delta G^0}{\Delta T}\right)$ is negative

**Ans : c) $\left(\frac{\Delta G^0}{\Delta T}\right)$ is negative**

**23. Which of the following reduction is not thermodynamically feasible?** PTA - 3

a) $Cr_2O_3 + 2Al \rightarrow Al_2O_3 + 2Cr$
b) $Al_2O_3 + 2Cr \rightarrow Cr_2O_3 + 2Al$
c) $3TiO_2 + 4Al \rightarrow 2Al_2O_3 + 3Ti$
d) none of these

**Ans : b) $Al_2O_3 + 2Cr \rightarrow Cr_2O_3 + 2Al$**

**24. Which of the following is not true with respect to Ellingham diagram?**

a) Free energy changes follow a straight line. Deviation occurs when there is a phase change.
b) The graph for the formation of $CO_2$ is a straight line almost parallel to free energy axis.
c) Negative slope of CO shows that it becomes more stable with increase in temperature.
d) Positive slope of metal oxides shows that their stabilities decrease with increase in temperature.

**Ans : b) The graph for the formation of $CO_2$ is a straight line almost parallel to free energy axis.**

## II. Answer the following questions

**1. What are the difference between minerals and ores?** QY - 2019, SEP - 2020 May 2022

- Naturally occuring substances obtained by mining which contain the metals in free state or in the form of compounds like oxides, sulphides etc. are called minerals.
- Minerals that contain high percentage of metal from which it can be extracted conveniently and economically are called ores.
- All ores are minerals but all minerals are not ores.

**2. What are the various steps involved in extraction of pure metals from their ores?**

- Steps involved in extraction of pure metals from their ores are

i) Concentration of the ore
ii) Extraction of the crude metal.
iii) Refining of the crude metal.

**3. What is the role of quick lime in the extraction of Iron from its oxide $Fe_2O_3$?**

- Lime stone (CaO) is used as a flux in the extraction of iron from its oxide $Fe_2O_3$.
- A flux is a chemical substance that forms an easily fusible slag with gaugue.
- Oxide of iron can be reduced by carbon monoxide as follows

$Fe_2O_{3(s)} + 3CO_{(g)} \rightarrow 2Fe_{(s)} + 3CO_{2(g)}\uparrow$

- In this extraction a basic flux quick lime (or) lime (CaO) reacts with acidic gaugue silica to form the slag calcium silicate.

$CaO_{(s)}$ + $SiO_{2(s)}$ → $CaSiO_{3(s)}$
Flux Gaugue Slag

**4. Which type of ores can be concentrated by froth floatation method? Give two examples for such ores.**

- Sulphide ores can be concentrated by froth floatation method.
- (eg) Galena (PbS), Zinc blende (ZnS)

**5. Describe a method for refining nickel.** PTA - 3 May 2022

**Mond process for refining nickel :**

- Impure nickel is heated in a stream of carbon monoxide at around 350K. Nickel reacts with CO to form a highly volatile nickel tetracarbonyl. The solid impurities are left behind.

  $Ni_{(S)} + 4CO_{(g)} \rightarrow Ni(CO)_{4(g)}$
- On heating nickel tetra carbonyl around 460K, the complex decomposes to give pure nickel.

  $Ni(CO)_{4(g)} \rightarrow Ni_{(S)} + 4CO_{(g)}$

**6. Explain zone refining process with an example.** PTA - 6; MARCH 2020 March - 2023

**Zone refining :**

- The principle is fractional crystallisation.
- When an impure metal is melted and allowed to solidify, the impurities will prefer to remain in the melten region. ie; impurities are more soluble in the melt than in the solid state metal.
- In this process the impure metal is taken in the form of a rod. One end of the rod is heated using a mobile induction heater, melting the metal on that portion of the rod.
- When the heater is slowly moved to the other end pure metal crystallises while impurities will move on to the adjacent molten zone formed due to the movement of the heater.
- As the heater moves further away, the molten zone containing impurities also moves along with it.
- This process is repeated several times by moving the heater in the same direction again and again to achieve the desired purity level.
- This process is carried out in an inert gas atmosphere to prevent the oxidation of metals.
- Germanium, Silicon and gallium which are used as semiconductor are refined by this process.

**7. Using the Ellingham diagram.**

**(A) Predict the conditions under which**

**i) Aluminium might be expected to reduce magnesia.**

**ii) Magnesium could reduce alumina.**

**B) It is possible to reduce $Fe_2O_3$ by coke at a temperature around 1200K**

A) i) Ellingham diagram for the formation of $Al_2O_3$ and MgO intersects around 1600K. Above this temperature aluminium line lies below the magnesium line. Hence we can use aluminium to reduce magnesia above 1600K.

ii) In Ellingham diagram below 1600K magnesium line lies below aluminium line. Hence below 1600K magnesium can reduce alumina.

B) In Ellingham diagram above 1000K carbon line lies below the iron line. Hence it is possible to reduce $Fe_2O_3$ by coke at a temperature around 1200K.

**8. Give the uses of zinc.** PTA - 4

- Metallic zinc is used in galvanisation to protect iron and steel structures from rusting and corrosion.
- Zinc is used to produce die - castings in the automobile, electrical and hardware industries.
- Zinc oxide is used in the manufacture of paints, rubber, cosmetics, pharmaceuticals, plastics, inks, batteries, textiles and electrical equipment.
- Zinc sulphide is used in making luminous paints, fluorescent lights and x - ray screens.
- Brass an alloy of zinc which is highly resistant to corrosion is used in water valves and communication equipment.

**9. Explain the electrometallurgy of aluminium.**

Hall - Herold Process GMQ - 2019

Cathode : Iron tanked lined with carbon

Anode : Carbon blocks

Electrolyte : 20% solution of alumina obtained from bauxite + Molten Cryolite + 10% calcium chloride (lowers the melting point of the mixture)

Temperature : Above 1270K

Ionisation of Alumina $Al_2O_3 \rightarrow 2Al^{3+} + 3O^{2-}$
Reaction at cathode : $2Al^{3+}(melt) + 6e^- \rightarrow 2Al_{(l)}$
Reaction at anode : $2O^{2-}(melt) \rightarrow O_2 + 4e^-$
Since carbon acts as anode the following reaction also takes place on it.
$C_{(s)} + O^{2-}(melt) \rightarrow CO + 2e^-$
$C_{(s)} + 2O^{2-}(melt) \rightarrow CO_2 + 4e^-$
During electrolysis anodes are slowly consumed due to the above two reactions. Pure aluminium is formed at the cathode and settles at the bottom.
Net electrolysis reaction is
$4Al^{3+}(melt) + 6O^{2}(melt) + 3C(s) \rightarrow 4Al_{(l)} + 3CO_{2(g)}$

**10. Explain the following terms with suitable examples. i) Gangue ii) Slag**

**i) Gangue :** PTA - 2; SEP - 2020

- The non metallic impurities, rocky materials and siliceous matter present in the ores are called gangue.
(eg) : $SiO_2$ is the gangue present in the iron ore $Fe_2O_3$.

**ii) Slag :**

- Slag is a fusible chemical substance formed by the reaction of gangue with a flux.
$CaO_{(s)} + SiO_{2(s)} \rightarrow CaSiO_{3(s)}$
Flux gangue slag

**11. Give the basic requirement for vapour phase refining.**

- The metal is treated with a suitable reagent to form a volatile compound.
- Then the volatile compound is decomposed to give the pure metal.

**12. Describe the role of the following in the process mentioned.** QY - 2019

**i) Silica in the extraction of copper.**
**ii) Cryolite in the extraction of aluminium.**
**iii) Iodine in the refining of Zirconium.**
**iv) Sodium cyanide in froth floatation.**

**i) Silica in the extraction of copper.**
In the extraction of copper silica acts as an acidic flux to remove FeO as slag $FeSiO_3$.
$FeO_{(s)} + SiO_{2(s)} \rightarrow FeSiO_{3(s)}$
Flux Slag

**ii) Cryolite in the extraction of aluminium.**
As $Al_2O_3$ is a poor conductor cryolite improves the electrical conductivity.
In addition, cryolite serves as an added impurity and lowers the melting point of the electrolyte.

**iii) Iodine in the refining of Zirconium.**
First Iodine forms a Volatile tetraiodide with impure metal, which decomposes to give pure metal. Impure zirconium metal is heated in an evacuated vessel with iodine to form the volatile zirconium tetraiodide ($ZrI_4$). The impurities are left behind, as they do not react with iodine.
$Zr_{(s)} + 2I_{2(s)} \rightarrow ZrI_{4(Vapour)}$
On passing volatile zirconium tetraiodide vapour over a tungsten filament, it is decomposed to give pure zirconium.
$ZrI_{4(Vapour)} \rightarrow Zr_{(s)} + 2I_{2(s)}$

**iv) Sodium cyanide in froth floatation.**
Sodium cyanide acts as a depressing agent in froth floatation process. When a sulphide ore of a metal of interest contains other metal sulphides the depressing agent sodium cyanide selectively prevent other metal sulphides from coming to the froth.
eg: NaCN depresses the floatation property ZnS present in Galena (PbS) by forming a layer of Zinc complex $Na_2[Zn(CN)_4]$on the surface of Zinc sulphide.

**13. Explain the principle of electrolytic refining with an example.** HY-2019; PTA-5 Aug-2022

- Crude metal is refined by electrolysis carried out in an electrolytic cell.
- **Cathode :** Thin strips of pure metal.
**Anode :** Impure metal to be refined.
**Electrolyte :** Aqueous solution of the salt of the metal with dilute acid.
- As current is passed, the metal of interest dissolves from the anode and pass into the electrolytic solution.
- At the same time same amount of metal ions from the electrolytic solution will be deposited at the cathode.
- Less electro positive impurities in the anode settle down as anode mud.

- eg : Electro refining of silver :
  Cathode : Pure silver
  Anode : Impure silver rods.
  Electrolyte : Acidified aqueous solution of silver nitrate.
- On passing current the following reactions will take place.
  Reaction at anode : $Ag_{(s)} \rightarrow Ag^{+}_{(aq)} + e^{-}$
  Reaction at cathode : $Ag^{+}_{(aq)} + e^{-} \rightarrow Ag_{(s)}$
- At anode silver atoms lose electrons and enter the solution. From the solution silver ions migrate towards the cathode. At cathode silver ions get discharged by gaining electrons and deposited on the cathode.

**14. The selection of reducing agent depends on the thermodynamic factor : Explain with an example.**

- A suitable reducing agent is selected based on the thermodynamic considerations.
- For a spontaneous reaction $\Delta G$ should be negative.
- Thermodynamically, the reduction of metal oxide with a given reducing agent can occur if $\Delta G$ for the coupled reaction is negative.
- Hence the reducing agent is selected in such a way that it provides a large negative $\Delta G$ value for the coupled reaction.
- Ellingham diagram is used to predict thremodynamic feasibility of reduction of oxides of one metal by another metal.
- Any metal can reduce the oxides of other metals that are located above it in the diagram.
- Ellingham diagram for the formation of FeO and CO intersects around 1000K. Below this temperature the carbon line lies above the iron line.
- Hence FeO is more stable than CO and the reduction is not thermodynamically feasible.
- However above 1000K carbon line lies below the iron line. Hence at this condition FeO is less stable than CO and the reduction is thermodynamically feasible. So coke can be used as a reducing agent above this temperature.
- Following free energy calculation also confirm that the reduction is thermodynamically favoured.
- From the Ellingham diagram at 1500K

$2Fe_{(s)} + O_{2(g)} \rightarrow 2FeO_{(g)} = -350\ KJmol^{-1}$ .....1

$2C_{(s)} + O_{2(g)} \rightarrow 2CO_{(g)} = -480\ KJmol^{-1}$ .....2

Reverse the reaction 1

$2FeO_{(s)} \rightarrow 2Fe_{(s)} + O_{2(g)} = 350\ KJmol^{-1}$ ..... 3

Couple the reactions 2 and 3

$2FeO_{(s)} + 2C_{(s)} \rightarrow 2Fe_{(s)} + 2CO_{(g)} = 130\ KJmol^{-1}$ .....4

- The standard free energy change for the reduction of one mole of FeO is

$$\frac{\Delta G_3}{2} = -65\ KJmol^{-1}$$

**15. Give the limitations of Ellingham diagram.**

- Ellingham diagram is constructed based only on thermodynamic considerations.
- It gives information about the thermodynamic feasibility of a reaction.
- It does not tell anything about the rate of the reaction.
- More over it does not give any idea about the possibility of other reactions that might be taking place.
- The interpreparation of G is based on the assumption that the reactants are in equilibrium with the product which is not always true.

**16. Write a short note on electrochemical principles of metallurgy.**

- Reduction of oxides of active metals such as sodium, potassium etc. by carbon is thermodynamically not feasible.
- Such metals are extracted from their ores by using electrochemical methods.
- In this method the metal salts are taken in fused form or in solution form.

- The metal ion present can be reduced by treating the solution with suitable reducing agent or by electrolysis.
- Gibbs free energy change for the electrolysis is $\Delta G^0 = - nFE^0$
  n = number of electrons involved in the reduction
  F = Faraday = 96500 coulombs
  $E^0$ = electrode potential of the redox couple.
- If $E^0$ is positive, $\Delta G^0$ is negative and the reduction is spontaneous.
- Hence a redox reaction is planned in such a way that the e.m.f of the net redox reaction is positive.
  A more reactive metal displaces a less reactive metal from its salt solution.
  eg : $Cu^{2+}_{(aq)} + Zn_{(s)} \rightarrow Cu_{(s)} + Zn^{2+}_{(aq)}$
- Zinc is more reactive than copper and displaces copper from its salt solution.

## III. Evaluate yourself

**1. Write the equation for the extraction of silver by leaching with sodium cyanide and show that the leaching process is a redox reaction.**

**Ans :** $Ag \rightarrow Ag^+$ (O.N increases from 0 to +1, hence oxidation)
$O_2 \rightarrow$ OH- (O.N decreases from 0 to -2, hence reduction)

- Leaching of silver is a redox reaction.

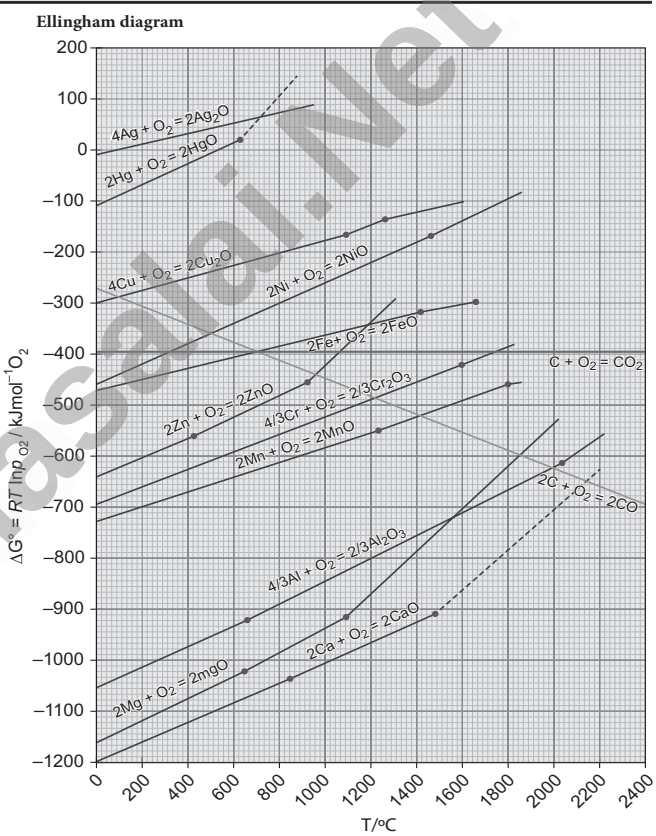
**2. Magnesite (Magnesium carbonate) is calcined to obtain magnesia, which is used to make refractory bricks. Write the decomposition reaction**

$MgCO_3 \xrightarrow{\Delta} MgO + CO_2 \uparrow$

**3. Using Ellingham diagram indicate the lowest temperature at which ZnO can be reduced to Zinc metal by carbon. Write the overall reduction reaction at this temperature**

**Ans :** Ellingham diagram for the formation of ZnO and CO intersects around 1200K Below this temperature, Carbon line lies above Zinc line. Hence ZnO is more stable than CO so the reduction is thermodynamically not feasible at this temperature range. However above 1200K carbon line lies below the zinc line, hence carbon can be used as a reducing agent above 1200K.

$2Zn + O_2 \rightarrow 2ZnO$ .....1
$2C + O_2 \rightarrow 2CO$ .....2
Reversing 1 and adding with equation 2
$2ZnO \rightarrow 2Zn + O_2$
$2C + O_2 \rightarrow 2CO$
$2ZnO + 2C \rightarrow 2Zn + 2CO$



Ellingham diagram

**4. Metallic Sodium is extracted by the electrolysis of brine (aq.NaCl). After electrolysis the electrolytic solution becomes basic in nature. Write the possible electrode reactions.**

**Ans:** $2NaCl_{(aq)} \rightarrow 2Na^+_{(aq)} + 2Cl^-_{(aq)}$

**Anode :** $2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e^-$

**Cathode :** $2H_2O_{(l)} + 2e^- \rightarrow H_{2(g)} + 2OH^-_{(aq)}$

Nothing happens to sodium ion but it is still important. $Na^+$ ions are spectator ions

and combine with $OH^-$ ions to form NaOH
Three products are $H_2$, $Cl_2$ and NaOH
Over all equation is

$$2NaCl_{(aq)} + 2H_2O_{(l)} \rightarrow H_{2(g)} + Cl_{2(g)} + 2NaOH_{(aq)}$$

Ionic equation is

$$2H_2O_{(l)} + 2Cl^-_{(aq)} + 2Na^+_{(aq)} \rightarrow 2Na^+_{(aq)} + 2OH^-_{(aq)} + H_{2(g)} + Cl_{2(g)}$$

(or)

$$2H_2O_{(l)} + 2Cl^-_{(aq)} \rightarrow 2OH^-_{(aq)} + H_{2(g)} + Cl_{2(g)}$$

## PART II - GMQ, PTA, GOVT. EXAM QUESTIONS AND ANSWERS

### I. Choose the correct answer

**1. Elements like Silicon and Germanium to be used as a semiconductor is purified by**
a) heating under vaccum **PTA - 1**
b) Van-arkel method
c) Zone refining d) Electrolysis
**Ans : c) Zone refining**

**2. Sulphite ores of metals are usually concentrated by froath floatation process. Which one of the following sulphide ore offers an exception and is concentrated by chemical leaching.** **PTA - 4**
a) Argentite b) galena
c) Copper pyrites d) Sphalerite
**Ans : a) Argentite**

**3. Which method of purification represented by the equation?** **PTA - 5**
**Ti (Impure)** $+ 2I_2 \xrightarrow{550\ K} TiI_4 \xrightarrow{1800\ K} Ti\ (Pure) + 2I_2$
a) Cupellation b) Zone refining
c) Van-Arkel method d) Mond's process
**Ans : c) Van-Arkel method**

**4. The process of converting hydrated aluminia into anhydrous alumina is called** **PTA - 6**
a) Roasting b) Smelting
c) Auto-reduction d) Calcination
**Ans : d) Calcination**

**5. The metal which is used in packing material for food items :** **Sep - 2020**
a) Zn b) Zr c) Al d) Au
**Ans : c) Al**

**6. Zinc is obtained from ZnO by :** **Aug - 2022**
a) Carbon reduction
b) Reduction using silver
c) Electrochemical process
d) Acid leaching
**Ans : a) Carbon reduction**

### II. Short Answer Questions (2 & 3 Marks)

**1. What is the role of depressing agent in froth flotation process?** **PTA - 1; Hy - 2019**

➢ When impurities such as ZnS is present in galena (PbS), sodium cyanide (NaCN) is added to depresses the flotation property of ZnS by forming a layer of zinc complex $Na_2[Zn(CN)_4]$ on the surface of zinc sulphide.

**2. What is the role of graphite rods in the electro metallurgy of Aluminium?** **PTA - 1**

➢ Electrolysis is carried in an iron tank lined with carbon which acts as a cathode. The carbon blocks immersed in the electrolyte acts as a anode.

**3. Describe the underlying principle of froth floation process.** **PTA - 3**

➢ This method is commonly used to concentrate sulphide ores such as galena (pbs) Zinc blende (Zns)

➢ In this method the metalic ore particles which are preferentially wetted by oil can be separated from gangue.

**4. Write about roasting.** **PTA - 4**

➢ Roasting is applied for the conversion of sulphide ores into their oxides.

➢ Concentrated ore is oxidised by heating with excess of oxygen below the melting point of the metal in a suitable furnace.

$$2PbS + 3O_2 \rightarrow 2PbO + 2SO_2 \uparrow$$

➢ Roasting also removes impurities like aresenic, sulphur, phosphorous into their volatile oxides.

$$4As + 3O_2 \rightarrow 2AS_2$$

**5. Write about calcination.** PTA - 4

- Calcination is the process in which the concentrated ore is strongly heated in the absence of air.
- During this process water of crystallisation present in the hydrated oxide escapes as moisture.
- Any organic matter present also get expelled leaving the ore porous.
- This method can also be carried out with a limited supply of air.
- During calcination of carbonate ore carbondioxide is liberated.

$PbCO_3 \xrightarrow{\Delta} PbO + CO_2\uparrow$

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2\uparrow$

$Al_2O_3.2H_2O \xrightarrow{\Delta} Al_2O_{3(s)} + 2H_2O_{(g)}\uparrow$

**6. How $Cr_2O_3$ is reduced to Cr by Al powder?** PTA - 6

- In this method a metal oxide is reduced to metal by aluminium.
- It is an exothermic process where heat is liberated.
- $Cr_2O_3$ is mixed with aluminium powder in a fire clay crucible.
- Ignition mixture is magnesium and barium peroxide.

$BaO_2 + Mg \rightarrow BaO + MgO$

- Temperature = 2400°C Heat liberated = 852KJmol$^{-1}$ This heat helps the reduction of $Cr_2O_3$ by Al.

$Cr_2O_3 + 2Al \xrightarrow{\Delta} 2Cr + Al_2O_3$

**7. Oxides like $Ag_2O$ and HgO undergo self reduction why?** QY - 2019

- Decomposition temperature of $Ag_2O$ and HgO are 600 and 700K respectively.
- These oxides are unstable at moderate temperature so undergo self reduction.

**8. In metallurgy roasting of ore is done below its melting points where as smelting is done above its melting point Why?** QY - 2019

- Temperature below the melting point of metal is enough to bring the oxidation of metallic sulphides into their oxides.
- Hence roasting is done at a temperature below the melting point of metal.
- High temperature is needed to melt the metal leaving behind the insoluble slag.
- Hence smelting is done at a temperature above the melting point of metal.

**9. Write a short note on gravity separation method.** May 2022

- Ore with high specific gravity is separated from gangue with low specific gravity by simply washing with running water.
- Finely powdered ore is treated with rapidly flowing current of water.
- Lighter gangue particles are washed away by the running water.
- This method is used for concentrating native ore such as gold and oxide ores such as haematite, tin stone.

**10. What is acid leaching?** Aug 2022

- Sulphide ores ZnS, PbS can be leached with hot aqueous sulphuric acid.
- In this process the insoluble sulphide is converted into soluble sulphate and elemental sulphur.

$2ZnS_{(s)} + 2H_2SO_{4(aq)} + O_{2(g)} \rightarrow 2ZnSO_{4(aq)} + 2S_{(s)} + 2H_2O$

## III. Long Answer Questions (5 Marks)

**1. Explain how gold ore is leached by cyanide process.** GMQ - 2019

- Crushed ore of gold is leached with aerated dilute solution of sodium cyanide.
- Gold is converted into a soluble cyanide complex.
- The gangue alumino silicate remains insoluble.

$4Au_{(s)} + 8CN^-_{(aq)} + O_{2(g)} + 2H_2O_{(l)} \rightarrow 4[Au(CN)_2]^-_{(aq)} + 4OH^-_{(aq)}$

- Gold can be recovered by reacting the deoxygenated leached solution with Zinc.
- Gold is reduced to its elemental state (zero oxidation state.)
- This process is called cementation.

$Zn_{(s)} + 2[Au(CN)_2]^-_{(aq)} \rightarrow [Zn(CN)_4]^{2-}_{(aq)} + 2Au_{(s)}$

**2. Out of coke and CO, which is better reducing agent for the reduction of ZnO? why?** PTA - 2

- Out of coke and CO, coke is better reducing agent than CO for the reduction of ZnO.
- Reduction by carbon can be applied to zinc which does not form carbide with carbon at the reduction temperature.

$ZnO_{(s)} + C \rightarrow Zn_{(S)} + CO_{(g)} \uparrow$

- ZnO lies above CO in Ellingham diagram meaning that CO is more stable than ZnO. Hence carbon can be used as a reducing agent for the reduction of ZnO. During reduction oxygen from ZnO combines with carbon used for reduction.

**3. How is copper extracted from is ore.**

- **Principle ore :** Copper pyrites. PTA - 5
- **Concentration :** Froth floatation
- Concentrated ore is heated in a reverberatory furnace with an acidic flux silica.
- The basic ferrous oxide formed reacts with silica to form the slag ferrous silicate.
- Mutually soluble metal sulphides $Cu_2S$ and FeS known as copper matte is formed.

$2CuFeS_{2(s)} + O_{2(g)} \rightarrow 2FeS_{(l)} + Cu_2S_{(l)} + 2SO_{2(g)}$

$2FeS_{(l)} + 3O_{2(g)} \rightarrow 2FeO_{(l)} + 2SO_{2(g)}$

$FeO_{(s)} + SiO_{2(s)} \rightarrow FeSiO_{3(s)}$

Gangue Flux Slag

- Matte is removed from the slag and fed to the converting furnace.
- FeS present in the matte is first converted to FeO.
- FeO is removed as slag with silica.
- Remaining copper sulphide is oxidised to cuprous oxide.
- Cuprous oxide and copper sulphide react to form metallic copper.

$2Cu_2S_{(l,s)} + 3O_{2(g)} \rightarrow 2Cu_2S_{(l,s)} + 2SO_{2(g)}$

$2Cu_2O_{(l)} + Cu_2S_{(l)} \rightarrow 6Cu_{(l)} + SO_{2(g)}$

- $SO_2$ is liberated through molten copper and on solidification it has blistered appearance. This is copper is called blister copper.

**Electro refining :**

**Cathode :** Thin pure sheet of copper.

**Anode :** Impure Copper

**Electrolyte :** $CuSO_4$ solution + dil $H_2SO_4$.

On passing current pure copper is deposited at the cathode.

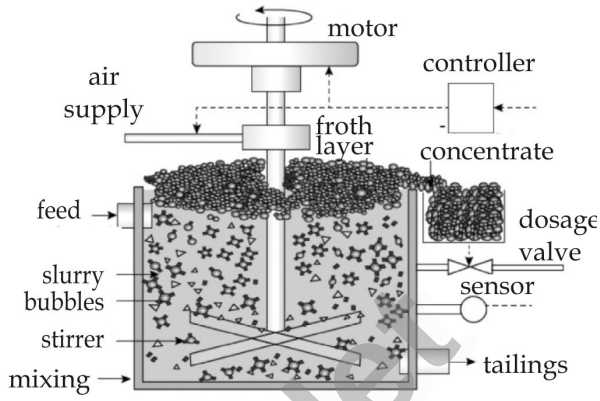
**4. Write the observations from the Ellingham diagram.** Qy - 2019

- For most of the metal oxide formation the slope is positive. This can be explained as follows. Oxygen gas is consumed during the formation of metal oxides resulting in the decrease of randomness. Hence $\Delta S$ becomes negative, $T\Delta S$ is positive in the straight line equation.
- For the formation of carbon monoxide the graph is a straight line with negative slope. In this case $\Delta S$ is positive because 2 moles of CO gas is formed by consuming 1 mole of oxygen gas. This shows CO is more stable at higher temperature.
- As temperature increases $\Delta G$ for the formation of metal oxide becomes less negative and becomes zero at a particular temperature. Below this temperature $\Delta G$ is negative and the oxide is stable. Above this temperature $\Delta G$ is positive and the oxide is less stable. Metal oxides become less stable at higher temperature and their decomposition becomes easier.
- Due to phase transition (melting or evaporation) there is a sudden change in the slope at a particular temperature for some metal oxides like MgO, HgO.

**5. Explain froth floatation method.** Aug - 2021 March - 2023

- This is used to concentrate sulphide ores such as galena (PbS) Zinc blende (ZnS) etc.
- Metallic ore particles preferentially wetted by oil can be separated from gangue.
- Crushed ore is mixed with water and a frothing agent like pine oil or eucalyptus oil.
- A small amount of sodium ethyl xanthate is added as a collector.
- A froth is formed by blowing air through the mixture.

- The collector molecules attach to the ore particles and make them water repellent.
- As a result ore particles wetted by the oil rise to the surface along with the froth.
- The froth is skimmed off and dried to recover the concentrated ore.
- Gangue particles preferentially wetted by water settle at the bottom.
- If the sulphide ore contains other metal sulphides as impurities, they are selectively prevented from coming to the froth by using depressing agents like sodium cyanide, sodium carbonate etc.
- Sodium cyanide depresses the floatation property of the impurity ZnS present in galena (PbS) by forming a layer of zinc complex $Na_2[Zn(CN)_4]$ on the surface of ZnS.




## PART III - ADDITIONAL QUESTIONS

### I. Match the following

**1.**

| | Ore of metal | | Name | Answer |
|---|---|---|---|---|
| i) | Ore of copper | a) | Diaspore | **Malachite** |
| ii) | Ore of aluminium | b) | Chlorargyrite | **Diaspore** |
| iii) | Ore of iron | c) | Malachite | **Limonite** |
| iv) | Ore of lead | d) | Limonite | **Anglesite** |
| v) | Ore of silver | e) | Anglesite | **Chlorargyrite** |

**2.**

| | Purification | | Metal | Answer |
|---|---|---|---|---|
| i) | Distillation | a) | Silicon | **Zinc** |
| ii) | Liquation | b) | Zinc | **Tin** |
| iii) | Electrolytic refining | c) | Nickel | **Silver** |
| iv) | Zone refining | d) | Tin | **Silicon** |
| v) | Mond process | e) | Silver | **Nickel** |

### II. Choose the best Answer

**1. Which of the following is an oxide ore?**
a) Sphaelerite b) Calamine
c) Cassiterite d) Stefinite
**Ans : c) Cassiterite**

**2. Which of the following is a sulphide ore?**
a) Pyrargyrite b) Malachite
c) Limonite d) Kaolinite
**Ans : a) Pyrargyrite**

**3. Which of the following is a carbonate ore?**
a) Limonite b) Siderite
c) Magnetite d) Haematite
**Ans : b) Siderite**

**4. Which of the following is the ore of iron?**
a) Limonite b) Azurite
c) Stefinite d) Cerrusite
**Ans : a) Limonite**

**5. Gravity separation is suitable for**
a) Oxide ore b) Sulphide ore
c) Carbonate ore d) Sulphate ore
**Ans : a) Oxide ore**

**6. Froth floatation is suitable for**
a) Oxide ore b) Sulphide ore
c) Carbonate ore d) Sulphate ore
**Ans : b) Sulphide ore**

7. **In froth floatation, pine oil is used as a**
a) Collector b) depressing agent
c) Frothing agent d) Flux
**Ans : c) Frothing agent**

8. **In froth floatation sodium ethyl Xanthate is used as a**
a) Collector b) depressing agent
c) frothing agent d) Flux
**Ans : a) Collector**

9. **In froth floatation sodium cyanide is used as a**
a) Collector b) depressing agent
c) frothing agent d) Flux
**Ans : b) depressing agent**

10. **Concentration of gold ore is done by**
a) Cyanide leaching
b) Ammonia leaching
c) Alkali leaching d) Acid leaching
**Ans : a) Cyanide leaching**

11. **During roasting sulphide ores are converted into their**
a) Metals b) Oxides
c) Carbonates d) nitrates
**Ans : b) Oxides**

12. **During calcination of carbonate ore the expelled gas is**
a) Carbon monoxide
b) Carbon dioxide
c) Sulphur dioxide
d) Nitrogen dioxide **Ans : b) Carbon dioxide**

13. **Cinnabar is converted into mercury by**
a) Reduction by metal
b) Reduction by hydrogen
c) Reduction by carbon
d) Auto reduction
**Ans : d) Auto reduction**

14. **Which of the following metal is refined by distillation?**
a) Tin b) Lead
c) Zinc d) Bismuth
**Ans : c) Zinc**

15. **Which of the following is not refined by zone refining?**
a) Germanium b) Zirconium
c) Silicon d) Gallium
**Ans : b) Zirconium**

16. **Which of the following is refined by Mond process?**
a) Silicon b) Copper
c) Nickel d) Zinc
**Ans : c) Nickel**

17. **Which of the following is refined by Van Arkel method?**
a) Gallium b) Titanium
c) Germanium d) Silicon
**Ans : b) Titanium**

18. **Which of the following metal is used in galvanisation?**
a) Copper b) Aluminium
c) Zinc d) Gold
**Ans : c) Zinc**

19. **Which is used for increasing the efficiency of solar cells?**
a) Brass b) Zinc sulphide
c) Cast iron d) Gold nano particles
**Ans : d) Gold nano particles**

20. **Cupellation is a process used for the refining of**
a) Silver b) Lead
c) Copper d) Iron
**Ans : a) Silver**

21. **The ore which contains copper and iron both**
a) Malachite b) Chalcopyrite
c) Chalocite d) Azurite
**Ans : b) Chalcopyrite**

22. **Heating of Iron pyrites in air to remove sulphur is called**
a) Fusion b) Calcination
c) Smelting d) Roasting
**Ans : d) Roasting**

23. **Which of the following metal is leached by cyanide process?**
a) Sliver b) Sodium
c) Aluminium d) Copper
**Ans : a) Silver**

## III. Choose the correct statement

1. a) In froth floatation sodium ethyl xanthate acts as a collector.
b) In leaching the ore is converted into insoluble salt or complex and the gangue remains in the solution.

c) Ammonia leaching is suitable for gold and silver.
d) Bauxite ore is subjected to acid leaching .

**Ans : a) In froth floatation sodium ethyl xanthate acts as a collector.**

**2.** a) Calcination is the process in which concentrated ore is strongly heated in the presence of air.
b) Flux is a chemical substance that forms an easily fusible slag with gangue.
c) In aluminothermite process the ignition mixture used is magnesium peroxide and barium.
d) Any metal can reduce the oxides of other metals that are located below it in Ellingham diagram.

**Ans : b) Flux is a chemical substance that forms an easily fusible slag with gangue.**

## IV. Choose incorrect statement

**1.** i) In Ellingham diagram for most of the metal oxide formation the slope is negative.
ii) Oxygen gas is consumed during the formation of metal oxides resulting in the increase of randomness.
iii) As temperature increases ΔG value for the formation of the metal oxide become more negative

a) i & ii b) i & iii
c) ii & iii d) i, ii, & iii

**Ans : c) ii & iii**

**2.** i) The reduction of oxides of active metals such as sodium, potassium etc. by carbon is thermodynamically feasible
ii) When a more reactive metal is added to the solution containing less reactive metal, the less reactive metal will go into the solution.
iii) Copper displaces zinc from zinc salt solution.

a) i & ii b) i & iii
c) ii & iii d) i, ii, iii

**Ans : d) i, ii & iii**

## V. Assertion and Reason

**1.** **Assertion (A) :** Tinstone ore is concentrated by magnetic separation.
**Reason (R) :** Wolframite impurities are magnetic
i) A and R are correct, R explains A.
ii) A is correct, R is wrong
iii) A is wrong, R is correct
iv) A and R are correct but R does not explain A.

**Ans : i) A and R are correct, R explains A.**

**2.** **Assertion (A) :** Aluminium can be commercially extracted from china clay which is a profitable one
**Reason (R) :** China clay is a mineral of aluminium.
i) A and R are correct, R explains A.
ii) A is correct, R is wrong
iii) A is wrong, R is correct
iv) A and R are correct but R does not explain A.

**Ans : iii) A is wrong, R is correct**
**Correct Assertion : Aluminium can be commercially extracted from bauxite which is a profitable ore**

**3.** **Assertion (A) :** Zinc blende can be concentrated by froth floatation method.
**Reason (R) :** Metallic ore particles are preferentially wetted by water and settle at the bottom.
i) A and R are correct, R explains A.
ii) A is correct, R is wrong
iii) A is wrong, R is correct
iv) A and R are correct but R does not explain A.

**Ans : ii) A is correct, R is wrong**
**Correct (R) : Metallic particles are preferentially wetted by oil and rise to the surface.**

## VI. Two Mark Questions

**1.** **What is a mineral?**
A naturally occuring substance obtained by mining, which contains the metal in free state or in the form of compounds like oxides, sulphides etc ; is called a mineral.

**2.** **What is an ore?**
A mineral which contains high percentage of metal, from which it can be extracted conveniently and economically is called as an ore.

**3.** **What is concentration of ores?**
The removal of non metallic impurities, rocky materials and siliceous matter (called as gangue) from the ores is known as concentration of ores.

**4. What is leaching?**

The process of dissolving metal present in an ore in a suitable solvent to form a soluble metal salt or complex leaving the gangue undissolved is called leaching.

**5. In the extraction of metal ore is first converted into metal oxide before reduction into metal. why?**

- In the concentrated ore the metal exists in positive oxidation state and hence it is to be reduced to elemental state.
- From the principles of thermodynamics the reduction of oxide is easier compared to the reduction of other compounds of metal.
- Hence before reduction the ore is first converted into metal oxide.

**6. Write about the extraction of metal by the process of reduction by carbon.**

- In this method oxide ore of the metal is mixed with coal (coke) and heated strongly in a blast furnace.
- This method can be applied to metals which do not form carbides with carbon at the reduction temperature.

$ZnO_{(S)} + C \rightarrow Zn_{(S)} + CO_{(g)} \uparrow$

**7. Write about the extraction of metal by the process of reduction by hydrogen.**

- This method can be applied to the oxides of the metals (Fe, Pb,Cu) which are less electropositive than hydrogen.

$Ag_2O_{(S)} + H_{2(g)} \rightarrow 2Ag_{(S)} + H_2O_{(l)} \uparrow$

- Nickel oxide is reduced to nickel by a mixture of hydrogen and carbon monoxide (water gas)

$2NiO_{(S)} + CO_{(g)} + H_{2(g)} \rightarrow 2Ni_{(S)} + CO_{2(g)} + H_2O_{(l)} \uparrow$

**8. Write about the extraction of metal by the process of reduction by metal.**

- In this process a metal oxide is reduced to metal by some active metals. like sodium, potassium and calcium.

$Rb_2O_3 + 3Mg \rightarrow 2Rb + 3MgO$

$TiO_2 + 2Mg \rightarrow Ti + 2MgO$

$ThO_2 + 2Ca \xrightarrow{1250K} Th + 2CaO$

- Alumino thermite process is also an example of reduction by metal.

**9. What is auto reduction of metallic ores?**

- Simple roasting of some of the metallic ores give the crude metal.
- Use of reducing agent is not necessary.
- (eg) Cinnabar is roasted to give mercury.

$HgS_{(S)} + O_{2(g)} + \rightarrow Hg_{(l)} + SO_{2(g)} \uparrow$

**10. Write about distillation process of refining a metal?**

- In this method impure metal is heated to evaporate and the vapours are condensed to get pure metal.
- This method is used for low boiling volatile metals like zinc and mercury.

**11. Write about liquation process of refining a metal?**

- This method is used to remove the impurities with high melting points from metals having relatively low melting points.
- (eg) Tin, lead, mercury, bismuth.
- Crude metal is heated to form fusible liquid and allowed to flow on a sloping surface.
- Impure metal is placed on sloping health of a reverberatory furnace.
- Impure metal is heated just above the melting point of the metal in the absence of air.
- The molten pure metal flows down.
- Impurities are left behind.
- Molten metal is collected and solidified.

**12. What are Depressing agents? Give examples.**

- When a sulphide ore of a metal contains other metal sulphides as impurities, depressing agents are used to selectively prevent other metal sulphide from coming to the froth.

e.g. NaCN, $Na_2CO_3$.

**13. Write the applications or uses of copper.**

- Copper is the first metal used by humans and extended use of its alloy bronze resulted in a new era, 'Bronze age'.
- Used for making coins and ornaments along with gold and other metals.
- Copper and its alloys are used for making wires, water pipes and other electrical parts.

**14. Write the applications or uses of gold.**

- Gold is one of the expensive and precious metals.
- Used for coinage and has been used as standard for monetary systems in some countries.
- Extensively used in jewellery in its alloy form with copper.
- Used in electroplating to cover other metals with a thin layer of gold in watches, artificial limb joints, cheap jewellery, dental fillings and electrical connectors.
- Gold nanoparticles are used for increasing the efficiency of solar cells.
- Used as catalyst.

**15. What is Blistered copper?**

- When molten metallic copper is solidified and it has blistered appearance due to evolution of $SO_2$ is called Blistered copper.

**16. Write the Principle of gravity separtation.**

- Ore with high specific gravity is separated from gangue with low specific gravity by simply washing with running water.

## VII. Three Mark Questions

**1. Write the important ores of Iron, Lead and Silver.**

**Ores of Iron**

1. Haematite - $Fe_2O_3$
2. Magnetite - $Fe_3O_4$
3. Iron pyrite - $FeS_2$

**Ores of Lead**

1. Galena - $PbS$
2. Anglesite - $PbSO_4$
3. Cerrusite - $PbCO_3$

**Ores of Silver**

1. Silver glance (Argentite) - $Ag_2S$
2. Pyrargyrite (Ruby silver) - $Ag_3SbS_3$
3. Chlorargyrite (Horn silver) - $AgCl$

**2. Write about alkali leaching?**

- In this method the ore is heated with aqueous alkali to form a soluble complex.
- Bauxite is heated with a solution of sodium hydroxide or sodium carbonate at 470K - 520K and 35 atm to form soluble sodium meta aluminate.
- The impurities iron oxide and titanium oxide are left behind.

$$Al_2O_{3(s)} + 2NaOH_{(aq)} + 3H_2O_{(l)} \rightarrow 2Na\,[Al(OH)_4]_{(aq)}$$

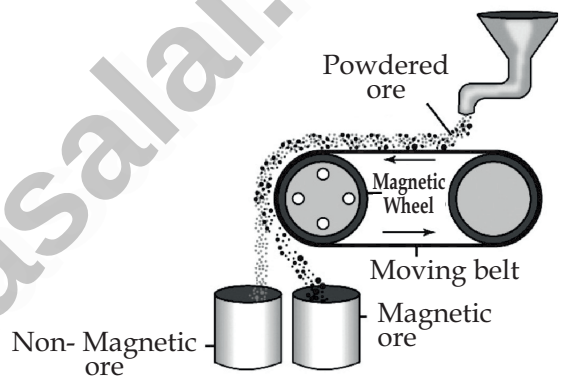
- The hot solution is decanted, cooled and diluted.
- This solution is neutralised by passing $CO_2$ gas to form hydrated $Al_2O_3$ precipitate.

$$2Na[Al(OH)_4]_{(aq)} + CO_{2(g)} \rightarrow Al_2O_3.XH_2O_{(s)} + 2NaHCO_{3(aq)}$$

- The precipitate is filtered off and heated around 1670K to get pure Alumina $Al_2O_3$.

**3. Write about magnetic separation.**

- This method is applicable to ferromagnetic ores.
- It is based on the difference in the magnetic properties of the ore and the impurities.




**Magnetic separation**

- Non magnetic tin stone can be separated from the magnetic impurities wolframite.
- Similarly magnetic ores chromite, pyrolusite can be removed from non magnetic siliceous impurities.
- Crushed ore is poured on to an electromagnetic separator with a belt moving over two rollers of which one is magnetic.
- Magnetic part of the ore is attracted towards the magnet and falls as a heap close to the magnetic region.
- Non magnetic part falls away from it.

**4. Write note on Ammonia leaching.**

When a crushed ore containing nickel, copper and cobalt is treated with agueous ammonia, it leaches these metals by forming their soluble complexes while the gangue remains insoluble as iron (III) oxides and aluminosilicate.

**5. Write about smelting.**

- Smelting is a process in which the concentrated ore is mixed with a mixture of a flux and reducing agent in a smelting furnace.
- Flux is a chemical substance which forms an easily fusible slag with gangue.
- Carbon, carbon monoxide and aluminium are used as reducing agents.
- Iron oxide can be reduced by carbon monoxide.

$$Fe_2O_{3(s)} + 3CO_{(g)} \rightarrow 2Fe_{(s)} + 3CO_{2(g)} \uparrow$$

- Silica gangue present in the ore is acidic, hence a basic flux lime combines with it forming slag calcium silicate.

$$CaO_{(s)} + SiO_{2(s)} \rightarrow CaSiO_{3(s)}$$

Slag

**6. Write about Ellingham diagram.**

- The graphical representation of variation of the standard Gibbs free energy for the formation of various metal oxides with temperature is called Ellingham diagram.
- Change in Gibbs free energy $\Delta G$ is given as $\Delta G = \Delta H - T\Delta S$
  $\Delta H$ = Enthalpy change T = Temperature in Kelvin $\Delta S$ = Entropy change.
- For an equilibrium $\Delta G^o$ can be calculated using the equilibrium constant by the equation.
  $\Delta G^o = -RT \ln K_p$
- By treating the reduction of metal oxides as an equilibrium process Harold Ellingham used the above relationship to calculate $\Delta G^o$ values at various temperatures.
- He Plotted T in the x axis and $\Delta G^o$ for the formation of metal oxides in the y axis.
- He obtained straight line graph with $\Delta S$ as slope and $\Delta H$ as y - intercept.

**7. Write about Van - Arkel method for refining zirconium/titanium?**

- This method is based on the thermal decomposition of metal compounds to metals.
- (eg) Titanium and Zirconium.
- Impure titanium is heated in an evacuated vessel with iodine at 550K to form volatile titanium tetraiodide.
- The impurities do not react with iodine.

$$Ti_{(s)} + 2I_{2(s)} \rightarrow TiI_{4(vapour)}$$

- Volatile titanium tetraiodide is passed over a tungsten filament at 1800K.
- Titanium tetraiodide is decomposed to pure titanium which is deposited over the filament.
- Iodine is reused.

$$TiI_{4(vapour)} \rightarrow Ti_{(s)} + 2I_{2(s)}$$

**8. Write the applications or uses of aluminium.**

- For making heat exchangers/sinks.
- For making our day to day vessels.
- For making aluminium foils for packing, food items.
- Alloys of aluminium with copper, manganese, magnesium, silicon are light weight and strong hence used in design of aeroplanes and other forms of transport.
- Due to its high resistance to corrosion, it is used in the design of chemical reactors, medical equipments, refrigeration units and gas pipelines.
- It is a good electrical conductor and cheap, hence used in electrical over head cables with steel core for strength.

**9. Write the applications or uses of iron.**

- Iron is one the most useful metals and its alloys are used everywhere including bridges, electricity pylons, bicycle chains, cutting tools and rifle barrels.
- Cast iron is used to make pipes, valves and pumb stoves etc.
- Magnets can be made of iron and its alloys and compounds.
- Important alloy of iron is stainless steel which is very resistant to corrosion.
- It is used in architecture, bearings, cutlery, surgical instruments and jewellery.
- Nickel steel is used for making cables, automobiles, and aeroplane parts.
- Chrome steels are used for manufacturing cutting tools and crushing machines.

## VIII. Five Marks Questions.

**1. Explain the thermodynamic principle of metallurgy.**

- Extraction of metals can be carried out by using different reducing agents.
- Consider the reduction of a metal oxide $M_xO_y$

$$\frac{2}{Y} M_xO_{y\,(s)} \rightarrow \frac{2}{Y} M_{(s)} + O_{2(g)} \quad \ldots\ldots\ldots\ldots 1$$

- Above reduction may be carried out with carbon.
- In this case the reducing agent carbon may be oxidised to CO or $CO_2$

$C + O_2 \rightarrow CO_{2(g)}$ .....2

$2C + O_2 \rightarrow 2CO_{(g)}$ .....3

- If carbon monoxide is used as a reducing agent, it is oxidised to $CO_2$

$2CO + O_2 \rightarrow 2CO_2$ .....4

- A suitable reducing agent is selected based on thermodynamic considerations.
- For a spontaneous reaction, the change in free energy ($\Delta G$) should be negative.
- Thermodynamically the reduction of metal oxide equation (1)] with a given reducing agent [equation 2,3,or 4] can occur if the free energy change for the coupled reaction [equation 1&2, 1&3or 1&4] is negative.
- Hence the reducing agent which gives large negative $\Delta G$ value for the coupled reaction is selected.

**2. Write the applications of Ellingham diagram.**

- Ellingham diagram helps us to select a suitable reducing agent and appropriate temperature range for reduction.
- Reduction of metal oxide to metal is considered as a competition between the element used for reduction and the metal to combine with oxygen.
- If metal oxide is more stable, oxygen remains with the metal.
- If oxide of the element used for reduction is more stable, oxygen from metal oxide combines with the element used for reduction.
- From Ellingham diagram the relative stablility of different metal oxides at a given temperature can be inferred.
- Ellingham diagram for the formation of $Ag_2O$ and HgO is at the upper part and their decomposition temperatures are 600 and 700K respectively. This shows that these oxides are unstable at moderate temperatures and will decompose on heating even in the absence of a reducing agent.
- Ellingham diagram is used predict thermodynamic feasibility of reduction of oxides of one metal by another metal.
- Any metal can reduce the oxides of other metals that are located above it in the diagram.
- Carbon line cuts across the lines of many metal oxides and hence it can reduce all these metal oxides at sufficently hig temperature.

***

UNIT 2

# p-Block Elements - I

## PART I - TEXT BOOK EVALUATION

### I. Choose the correct answer

**1. An aqueous solution of borax is _____.** May 2022

a) neutral b) acidic
c) basic d) amphoteric

**Ans : c. basic**

*Sol :*

$Na_2B_4O_7 + 7H_2O \rightleftharpoons \underset{\text{Strong base}}{2NaOH} + \underset{\text{Weak acid}}{4H_3BO_3}$

**2. Boric acid is an acid because its molecule (NEET)**

a) contains replaceable $H^+$ ion
b) gives up a proton
c) combines with proton to form water molecule
d) accepts $OH^-$ from water, releasing proton

**Ans : d. accepts $OH^-$ from water, releasing proton**

*Sol :*

$B(OH)_3 + H_2O \rightleftharpoons [B(OH)_4]^- + H^+$

**3. Which among the following is not a borane?**

a) $B_2H_6$ b) $B_3H_6$
c) $B_4H_{10}$ d) none of these

**Ans : b. $B_3H_6$**

*Sol :*

nido borane : $B_nH_{4+n}$
aracno borane : $B_nH_{6+n}$
$B_3H_6$ is not a borane

**4. Which of the following metals has the largest abundance in the earth's crust?**

a) Aluminium b) Calcium
b) Magnesium d) Sodium

**Ans : a. Aluminium**

**5. In diborane, the number of electrons that accounts for banana bonds is**

a) six b) two c) four d) three

**Ans : c. four**

*Sol :*

There are two 3c - 2e bonds i.e., the bonding in the bridges account for 4 electrons.

**6. The element that does not show catenation among the following p-block elements is** Aug 2022

a) Carbon b) Silicon
c) Lead d) Germanium

**Ans : c. Lead**

**7. Carbon atoms in fullerene with formula $C_{60}$ have** March - 2023

a) $sp^3$ hybridised
b) sp hybridised
c) $sp^2$ hybridised
d) partially $sp^2$ and partially $sp^3$ hybridised

**Ans : c. $sp^2$ hybridised**

**8. Oxidation state of carbon in its hydrides**

a) +4 b) –4 c) +3 d) +2

**Ans : a. +4**

**Example : $CH_{4+}$ in which the oxidation state of carbon is +4**

**9. The basic structural unit of silicates is (NEET)** PTA - 1

a) $(SiO_3)^{2-}$ b) $(SiO_4)^{2-}$
c) $(SiO)^-$ d) $(SiO_4)^{4-}$

**Ans : d. $(SiO_4)^{4-}$**

## GOVT. QUESTION PAPER - MARCH 2023

### 12 - CHEMISTRY

Time Allowed : 3.00 Hours Maximum Marks : 70

### PART - I

**Note : i) Answer All the questions.** **15 x 1 = 15**

**ii) Choose the most appropriate answer from the given four alternatives and write the option code and the corresponding answer.**

1. The crystal with metal excess defect is:
   **a) NaCl** b) AgBr c) AgCl d) FeO
2. Which of the following base is **not** present in DNA?
   **a) Uracil** b) Adenine c) Cytosine d) Guanine
3. Milk of Magnesia is used as _____.
   a) Tranquilizer b) Analgesic **c) Antacid** d) Anaesthetic
4. The most common oxidation state of Actinoids is:
   a) + 4 b) + 2 c) + 6 **d) + 3**
5. Which of the following compound is used as an anti-freeze in automobile radiator?
   a) Methanol **b) Ethane-1, 2-diol**
   c) Ethanol d) Glycerol
6. Carbon atoms in Fullerene with formula $C_{60}$ have _____ hybridisation.
   **a) $sp^2$** b) $sp^3$ c) $sp^3d$ d) sp
7. The metal extracted by Hall-Heroult process is:
   a) Cu **b) Al** c) Zn d) Ni
8. The product formed by the reaction of an Aromatic aldehyde with primary amines is:
   **a) Schiff's base** b) Carboxylic acid
   c) Ketone d) Aromatic acid
9. The emf of Standard Hydrogen Electrode (SHE) is _____.
   a) – 1.0 **b) 0** c) 1.1 d) + 1.0
10. A magnetic moment of 1.73 BM will be shown by one among the following:
    a) $[CoCl_6]^{4-}$ b) $TiCl_4$
    **c) $[Cu(NH_3)_4]^{2+}$** d) $[Ni(CN)_4]^{2-}$
11. The addition of a catalyst during a chemical reaction alters, which of the following quantities?
    a) Entropy b) Internal energy
    **c) Activation energy** d) Enthalpy
12. Which one of the following will cause common-ion-effect when added to the following dissociation equilibrium reaction?
    $CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$
    a) $CH_3COCl$ b) AgCl c) $CH_3Cl$ **d) HCl**
13. **Assertion:** Hex-4-ennitrile on reaction with Di-isobutyl aluminium hydride followed by Hydrolysis gives Hex-4-enal.

**Reason:** Di-isobutyl aluminium hydride is a selective reducing agent.

a) Assertion is true but Reason is false.

b) Both Assertion and Reason are true, but reason is not the correct explanation of assertion.

c) Both Assertion and Reason are false.

**d) Both Assertion and Reason are true and reason is the correct explanation of assertion.**

14. Which of the following is used as the source of gamma rays?

a) Xe b) Ar **c) Rn** d) Kr

15. Which one is correctly matched?

a) Foam - mist

b) Emulsion - smoke

c) Sol - whipped cream

**d) Gel - butter**

## PART - II

**Answer any six questions. Question No. 24 is Compulsory.** **6 x 2 = 12**

16. Which type of ores can be concentrated by froth floatation method? Give two examples for such ores. UNIT - 1
17. Write the uses of Silicones. UNIT - 2
18. Define the term central atom in co-ordination compounds. UNIT - 5
19. Calculate the number of atoms in an FCC unit cell. UNIT - 6
20. What is conjugate Acid-Base pairs? UNIT - 6
21. What are catalytic poisons? UNIT - 10
22. How will you convert acetone into propane? UNIT - 12
23. What are Hormones? Give example. UNIT - 14
24. Identify the compounds A and B in the following sequence of reactions. UNIT - 13

$$CH_3CH_2NO_2 \xrightarrow{Sn / HCl} A \xrightarrow{CH_3COCl} B.$$

## PART - III

**Answer any six questions. Question No. 33 is Compulsory.** **6x3=18**

25. Write a note on Fischer tropsch synthesis. UNIT - 2
26. Write any three differences between Lanthanoids and Actinoids. UNIT - 4
27. For the complex, $[Pt(NO_2)(H_2O)(NH_3)_2]Br$ identify the following. UNIT - 5
    a) Central metal atom / ion
    b) Co-ordination number
    c) Oxidation number of central metal ion
28. Write a note on Helmholtz electrical double layer. UNIT - 10
29. State Faraday's Laws of Electrolysis. UNIT - 9
30. Give the structure of a Zwitter ion. UNIT - 14
31. How will you convert Ethylacetate into Ethylaceto acetate? UNIT - 12
32. What are food preservatives? Give two examples. UNIT - 15
33. Show that in case of first order reaction the time required for the completion of 99 % is twice the time required for the completion of 90 % of the reaction. UNIT - 7

## PART - IV

**Answer all the questions.** **5 x 5 = 25**

34. a) Explain zone refining process with an example. UNIT - 1

**(OR)**

b) i) Find the oxidation state of Halogen in the following compounds. UNIT - 3
1) $OF_2$ 2) $I_2O_4$

ii) Complete the following reactions. UNIT - 3
1) $P_4 + NaOH + H_2O \rightarrow$
2) $XeF_6 + H_2O \rightarrow$
3) $Cu + \text{conc. } H_2SO_4 \rightarrow$

35. a) i) Describe the structure of Diborane. UNIT - 2
ii) Write ethylborate test. UNIT - 2

**(OR)**

b) Describe the nature of bonding in metallic carbonyls. UNIT - 5

36. a) Explain Schottky and Frenkel defects. UNIT - 6

**(OR)**

b) i) Give two examples for zero order reaction. UNIT - 7
ii) How colloids are used in tanning of leather and in Rubber industry? UNIT - 10

37. a) Derive an expression for Ostwalds's Dilution Law. UNIT - 8

**(OR)**

b) i) Why aniline does not undergo Friedel Craft's reaction? UNIT - 13
ii) How nylon-2-nylon-6 is prepared? UNIT - 15

38. a) i) How Malachitegreen is prepared from Benzaldehyde? UNIT - 12
ii) Write short note on Thorpe nitrile Condensation reaction. UNIT - 13

**(OR)**

b) Compound (A) of molecular formula $C_6H_6O$ gives purple colouration with neutral $FeCl_3$. Compound (A) reacts with ammonia to give Compound (B) and it also reacts with Zn dust to give Compound (C). Identify the Compounds A, B and C and write down the equations. UNIT - 11