SURA'S

CHEMISTRY

Volume 1 & 2

12th Standard

FREE Practice Workbook with Lab Manual

Based on the New Syllabus and New Textbook

Salient Features

- Complete Solutions to Textbook Exercises.
- Exhaustive Additional MCQs, VSA, SA, LA questions with answers are given in each unit.
- NEET based questions with Answers are also given.
- Model Question Papers 1 to 6 (PTA) : Questions are incorporated in the appropriate sections.
- September - 2020 question paper **[Sep-2020]**, March - 2020 question paper **[Mar-2020],** Govt. Model Question Paper **[Govt. MQP-2019]**,Common Quarterly Exam - 2019, **[QY-2019]**, Common Half Yearly Exam - 2019 **[HY-2019]**, are incorporated at appropriate sections.
- September - 2020 Question Paper is given with Answers.

SURA PUBLICATIONS
Chennai

orders@surabooks.com
Ph:9600175757 / 8124201000

2021-22 *Edition*

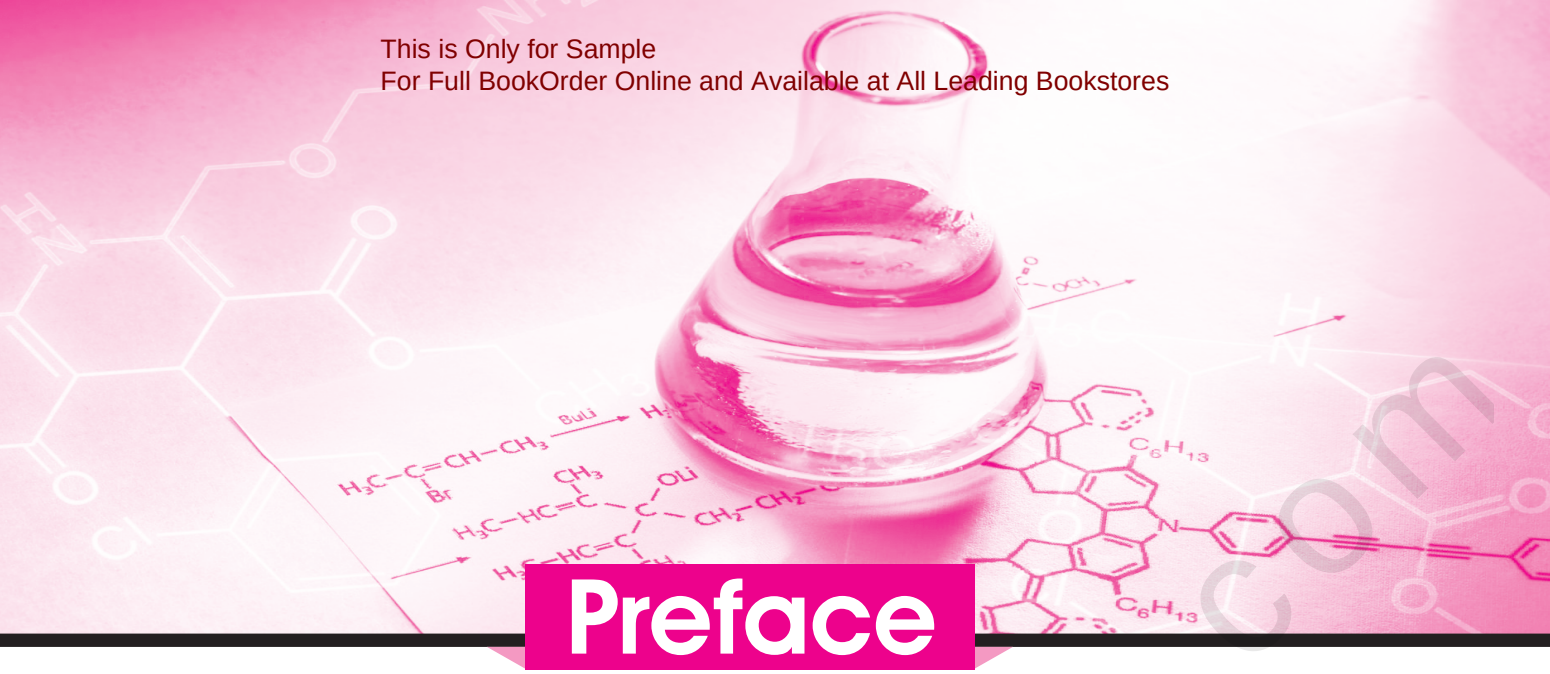
ISBN : 978-93-5330-141-5
Code No : SG 324

Authors
Dr. D. Kumarasan, M.Sc., M.Ed.,Ph.D., Chennai
Mr. V. Dakshinamoorthy, M.Sc,

Edited by
Mr. P. Vishwanathan, M.Sc., B.Ed., Nagercoil

Reviewed by
Dr. A. Dhanalakshmi M.Sc., M.Phil., Ph.D.
Head of the Department, Chennai
Mrs. H.M. Aisha M.Sc., M.Phil.,
Head of the Department, Chennai

Head Office
Sura Publications
1620, 'J' Block, 16th Main Road,
Anna Nagar, **Chennai - 600 040.**
Phones : 044-4862 9977, 044-486 27755.
Mobile : 81242 01000/ 81243 01000
e-mail : orders@surabooks.com
website : www.surabooks.com



Preface

"Nothing in life is to be feared, it is only to be understood.
Now is the time to understand more, so that we may fear less."

- Marie Curie

Respected Principals, Correspondents, Head Masters / Head Mistresses, Teachers,

From the bottom of our heart, we at SURA Publications sincerely thank you for the support and patronage that you have extended to us for more than a decade.

It is in our sincerest effort we take the pride of releasing **SURA's CHEMISTRY** Guide (Volume I & II) for +2 Standard – for this year 2021-22. This guide has been authored and edited by qualified teachers having teaching experience for over a decade in their respective subject fields. This Guide has been reviewed by reputed Professors who are currently serving as Head of the Department in esteemed Universities and Colleges.

With due respect to Teachers, I would like to mention that this guide will serve as a teaching companion to qualified teachers. Also, this guide will be an excellent learning companion to students with exhaustive exercises and in-text questions in addition to precise answers for textual questions.

In complete cognizance of the dedicated role of Teachers, I completely believe that our students will learn the subject effectively with this guide and prove their excellence in Board Examinations.

I once again sincerely thank the Teachers, Parents and Students for supporting and valuing our efforts.

God Bless all.

Subash Raj, B.E., M.S.
- Publisher
Sura Publications

All the Best

TO ORDER WITH US

SCHOOLS and TEACHERS

We are grateful for your support and patronage to **'SURA PUBLICATIONS'**
Kindly prepare your order in your School letterhead and send it to us.
For Orders contact: 80562 94222 / 80562 15222

DIRECT DEPOSIT

A/c Name	: **Sura Publications**	A/c Name	: **Sura Publications**
Our A/c No.	: **36550290536**	Our A/c No.	: **21000210001240**
Bank Name	: **STATE BANK OF INDIA**	Bank Name	: **UCO BANK**
Bank Branch	: PADI	Bank Branch	: Anna Nagar West
IFSC	: SBIN0005083	IFSC	: UCBA0002100

A/c Name	: **Sura Publications**	A/c Name	: **Sura Publications**
Our A/c No.	: **6502699356**	Our A/c No.	: **1154135000017684**
Bank Name	: **INDIAN BANK**	Bank Name	: **KVB BANK**
Bank Branch	: ASIAD COLONY	Bank Branch	: Anna Nagar
IFSC	: IDIB000A098	IFSC	: KVBL0001154

After Deposit, please send challan and order to our address.
email : orders@surabooks.com / Whatsapp : 81242 01000.

DEMAND DRAFT / CHEQUE

Please send Demand Draft / cheque in favour of **'SURA PUBLICATIONS'** payable at **Chennai**.

The Demand Draft / cheque should be sent with your order in School letterhead.

STUDENTS

Order via Money Order (M/O) to

SURA PUBLICATIONS
1620, 'J' Block, 16th Main Road, Anna Nagar,
Chennai - 600 040.
Phones : 044-4862 9977, 044-486 27755.
Mobile : 81242 01000 / 81243 01000.
E-mail : orders@surabooks.com Website : www.surabooks.com

CONTENTS

VOLUME - I

VOLUME - II

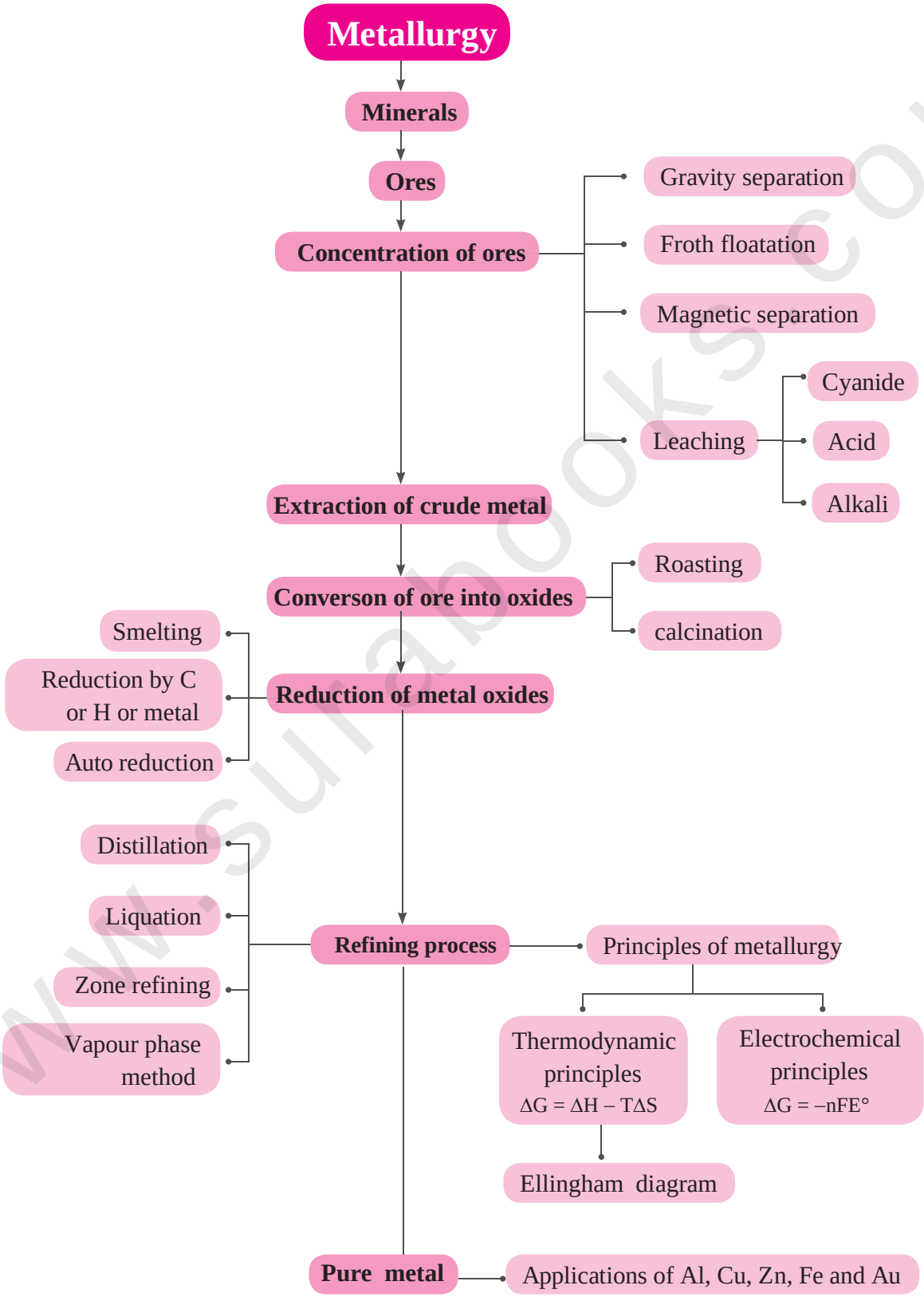
VOLUME - I

UNIT 1

METALLURGY

CHAPTER SNAPSHOT

CONCEPT MAP



orders@surabooks.com
Ph:9600175757 / 8124201000

FORMULAE TO REMEMBER

Metal	Ore	Composition	Metal	Ore	Composition
Aluminium	Bauxite	$Al_2O_3.nH_2O$	Zinc	Zinc blende or Sphalerite	ZnS
	Diaspore	$Al_2Si_2O_5(OH)_4$		Calamine	$ZnCO_3$
	Kaolinite	Al_2O_3		Zincite	ZnO
Iron	Haematite	Fe_2O_3	Lead	Galena	PbS
	Magnetite	Fe_3O_4		Anglesite	$PbSO_4$
	Siderite	$FeCO_3$		Cerrusite	$PbCO_3$
	Iron pyrite	FeS_2	Tin	Cassiterite (Tin stone)	SnO_2
	Limonite	$Fe_2O_3.3H_2O$	Silver	Silver glance (Argentite)	Ag_2S
Copper	Copper pyrite	$CuFeS_2$		Pyrargyrite (Ruby silver)	Ag_3SbS_3
	Copper glance	Cu_2S		Chlorargyrite (Horn Silver)	AgCl
	Cuprite	Cu_2O		Stefinite	Ag_5SbS_4
	Malachite	$CuCO_3.Cu(OH)_2$		Proustite	Ag_3AsS_3
	Azurite	$2CuCO_3.Cu(OH)_2$			

MUST KNOW DEFINITIONS

Mineral : A naturally occurring 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**.

Ores : Minerals that contains a high percentage of metal, from which it can be extracted conveniently and economically are called **ores**.

Concentration of Ore : The preliminary step in metallurgical process is removal of impurities. This removal process is known as **concentration of ore**.

Roasting : **Roasting** is the method, usually applied for the conversion of sulphide ores into their oxides. The concentrated ore is oxidised by heating it with excess of oxygen in a suitable furnace below the melting point of the metal.

Calcination : **Calcination** is the process in which the concentrated ore is strongly heated in the absence of air.

Refining process : Removal of unreacted oxide ore, other metals, non-metals associated with the isolated crude metal is called **refining process**.

Ellingham diagram	:	The graphical representation of variation of the standard Gibbs free energy of reaction for the formation of various metal oxides with temperature is called **Ellingham diagram.**
Application of Ellingham diagram	:	**Ellingham diagram** helps us to select a **suitable reducing agent** and **appropriate temperature** range for reduction.
Electrolytic refining	:	In electrolytic refining of the metal : **Cathode** : Pure metal **Anode** : Impure metal **Electrolyte** : Acidified aqueous solution of salt of the metal

EVALUATION

Choose The Correct Answer

1. Bauxite has the composition *[HY. 2019]*

a) Al_2O_3 b) $Al_2O_3.nH_2O$
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 calcination?

a) $2Zn + O_2 \longrightarrow 2ZnO$
b) $2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$
c) $MgCO_3 \longrightarrow MgO + CO_2$
d) Both (a) and (c)

[*Ans.* (c) $MgCO_3 \longrightarrow MgO + CO_2$]

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?

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) ΔG_f° of sulphide is greater than those for CS_2 and H_2S.
b) ΔG_r° 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; Mar-2020]*

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

[*Ans.* (d) Electromagnetic separation]

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

a) $Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Cu_{(s)} + Zn^{2+}_{(aq)}$
b) $Cu_{(s)} + Zn^{2+}_{(aq)} \longrightarrow Zn_{(s)} + Cu^{2+}_{(aq)}$
c) $Cu_{(s)} + 2Ag^{+}_{(aq)} \longrightarrow Ag_{(s)} + Cu^{2+}_{(aq)}$
d) $Fe_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Cu_{(s)} + Fe^{2+}_{(aq)}$

[*Ans.* (b) $Cu_{(s)} + Zn^{2+}_{(aq)} \longrightarrow Zn_{(s)} + Cu^{2+}_{(aq)}$]

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 impurities
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?** *[Govt.MQP_2019]*

a) Magnetite b) Hematite
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**

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

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

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) ΔS Vs T b) ΔG° Vs T

c) ΔG Vs $\frac{1}{T}$ d) ΔG° Vs T^2

[*Ans.* (b) ΔG° Vs T]

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

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

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

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

[*Ans.* (c) $\left(\frac{\Delta G^\circ}{\Delta T}\right)$ is negative]

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

a) $Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$

b) $Al_2O_3 + 2Cr \longrightarrow Cr_2O_3 + 2Al$

c) $3TiO_2 + 4Al \longrightarrow 2\,Al_2O_3 + 3Ti$

d) none of these

[*Ans.* (b) $Al_2O_3 + 2Cr \longrightarrow Cr_2O_3 + 2Al$]

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.]

Q&A Answer the Following Questions

1. What is the difference between minerals and ores? *[QY_2019; Sep-2020]*

Ans.

Minerals	Ores
A naturally occurring substance obtained by mining which contain the metal in free state or in the form of compounds.	Ore contains a high percentage of metal, from which it can be extracted conveniently and economically.
All minerals are not ores	All ores are Minerals
It contains a low percentage of metal.	It contains a high percentage of metals
Ex : Mineral of Al is bauxite and china clay	**Ex :** Ore of Al is bauxite

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

Ans. The various steps involved in the extraction of pure metals from their ores are

(i) concentration of the ore

(ii) extraction of crude metal

(iii) refining of crude metal

3. What is the role of Limestone in the extraction of Iron from its oxide Fe_2O_3?

Ans. *(i)* Lime stone acts as a Flux.

(ii) It combine with silica and get converted into Calcium silicate called as slag.

$$\underset{\text{Flux}}{CaO_{(s)}} + \underset{\text{Gangue}}{SiO_{2(s)}} \longrightarrow \underset{\text{Slag}}{CaSiO_{3(s)}}$$

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

Ans. *(i)* Sulphide ores can be concentrated by froth floatation method.

(ii) **Ex :** Lead sulphide **galena** (PbS) and zinc blende (ZnS).

5. Describe a method for refining nickel.

Ans. **Mond process for refining nickel :** *[PTA - 3]*

(i) The impure metal is heated in a stream of carbon monoxide at around 350K.

(ii) The nickel reacts with the CO to form a highly volatile nickel tetra carbonyl.

(iii) The solid impurities are left behind.

$$Ni_{(s)} + 4CO_{(g)} \xrightarrow{350\ K} [Ni(CO)_4]_{(g)}$$

(iv) On heating the nickel tetracarbonyl around 460K, the complex decomposes to give pure metal.

$$[Ni(CO_4)]_{(g)} \xrightarrow{460\ K} Ni_{(s)} + 4CO_{(g)}$$

6. Explain zone refining process with an example. *[PTA - 6; Mar-2020]*

Ans. *(i)* This method when is based on Fractional Crystallisation. The impure metal is melted are allowed to solidify, the impurities prefer to remain in the molten region.

(ii) The impure metal is taken in the form of a rod.

(iii) When the metal rod is heated with a heater the metal melts.

(iv) The heater is slowly moved from one end to the other end.

(v) The impurity dissolves in the molten zone.

(vi) When the heater moves, the molten zone also moves.

(vii) This process is repeated again and again to get pure metal.

(viii) The process is carried in an inert gas atmosphere to prevent oxidation of metal.

Example :

(i) Elements such as Germanium (Ge), Silicon (Si) and Galium (Ga) are refined using 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 1200 K.

Ans. **(A) (i)**

* Ellingham diagram for the formation of Al_2O_3 and HgO intersects around 1600 K.
* Above this temperature aluminium lines lies below the magnesium line.
* Hence we can use aluminium to reduce magnesia above 1600 K.

(ii)

* In Ellingham diagram below 1600 K magnesium line lies below aluminium line.
* Hence, below 1600 K magnesium can reduce alumina.

(B)

(i) In Ellingham diagram above 1000 K carbon line lies below the iron line.

(ii) Hence, it is possible to reduce Fe_2O_3 by coke at a temperature around 1200 K.

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

Ans. *(i)* Metallic zinc is used in **galvanising** metals such as iron and steel structures to protect them from rusting and corrosion.

(ii) Zinc is also used to produce die-castings in the automobile, electrical and hardware industries

(iii) Zinc oxide is used in the manufacture of many products such as paints, rubber, cosmetics, pharmaceuticals, plastics, inks, batteries, textiles and electrical equipment.

(iv) Zinc sulphide is used in making luminous paints, fluorescent lights and x-ray screens.

(v) Brass an alloy of zinc is used in water valves and communication equipment as it is highly resistant to corrosion.

9. Explain the electrometallurgy of aluminium. *[Govt.MQP_2019]*

Ans. **Hell - Herold Process :**

Cathode : Iron tank lined with carbon

Anode : Carbon blocks

Electrolytes : 20% solution of alumina obtained from bauxite + Molten cryolite + Calcium chloride (lowers the malting point of the mixture)

Temperature : Above 1270 K

Ionisaiton of alumina

$$Al_2O_3 \longrightarrow 2Al^{3+} + 3O^{2-}$$

Reaction at cathode

$$2Al^{3+}\ (melt) + 6e^- \longrightarrow 2Al_{(l)}$$

Reaction at anode

$$6O^{2-}\ (melt) \longrightarrow 3O_2 + 12e^-$$

(i) Since carbon acts as anode the following reaction takes place.

$$C_{(s)} + O^{2-}\ (melt) \longrightarrow CO + 2e^-$$

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

(ii) During electrolysis anodes are slowly consumed due to the above two reactions.

(iii) Aluminium is formed at the cathode and settles at the bottom.

(iv) Net electrolysis reaction is

$$4Al^{3+}\ (melt) + 6O^{2-}\ (melt) + 3C_{(s)} \longrightarrow 4Al_{(l)} + 3CO_{2(g)}$$

10. Explain the following terms with suitable examples. *[PTA - 2; Sep-2020]*

(i) Gangue (ii) Slag

Ans. (i) **Gangue :** The non-metallic impurities, rocky materials and siliceous matter, associated with the ore is called gangue.

Example : SiO_2 is the gangue present in the iron ore.

(ii) **Slag :** Slag is the fusible product formed when flux reacts with gangue during the extraction of metal.

Example :

$$\underset{\text{Flux}}{CaO_{(s)}} + \underset{\text{Gangue}}{SiO_2} \longrightarrow \underset{\text{(slag)}}{CaSiO_3}$$

11. Give the basic requirement for vapour phase refining.

Ans. (i) The metal should form a volatile compound when treated with a suitable reagent.

(ii) Then the volatile compound is decomposed to give the pure metal.

12. Describe the role of the following in the process mentioned.

(i) Silica in the extraction of copper.

(ii) Cryolite in the extraction of aluminium. *[QY_2019]*

(iii) Iodine in the refining of Zirconium. *[QY_2019]*

(iv) Sodium cyanide in froth floatation.

Ans. (i) Silica, is used as an acidic flux is used to remove slag during the process of roasting.

(ii) Lowers the melting point to 1173K and improves the electrical conductivity of the aluminium.

(iii) To form a volatile compound which on further heating decomposes to give pure Zn.

(iv) Sodium cyanide is used as an depressing agent in froth flotation. It prevents other metal sulphides coming to the froth.

For Example, 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.

13. Explain the principle of electrolytic refining with an example. *[HY_2019]*

Ans. (i) Electrolytic refining is carried out in an electrolytic cell.

(ii) **Anode :** Impure metal

Cathode : Thin strips of pure metal

Electrolyte : Aqueous solution of the salts of the metal.

(iii) The metal of interest dissolves from the anode, pass into the solution while the same amount of metal ions from the solution will be deposited at the cathode.

(iv) During electrolysis, the less electropositive impurities in the anode, settle down at the bottom and are removed as anode mud.

(v) Electrolytic refining of silver as an example.

Cathode : Pure silver

Anode : Impure silver rods

Electrolyte : Acidified aqueous solution of silver nitrate.

(vi) When a current is passed through the electrodes the following reactions will take place

Reaction at anode

$$Ag_{(s)} \longrightarrow Ag^+_{(aq)} + 1e^-$$

Reaction at cathode

$$Ag^+_{(aq)} + 1e^- \longrightarrow Ag_{(s)}$$

(vii) During electrolysis, at the anode the silver atoms lose electrons and enter the solution.

(viii) The positively charged silver cations migrate towards the cathode and get discharged by gaining electrons and deposited on the cathode.

Unit 1

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

Ans. *(i)* A suitable reducing agent is selected based electrolyte on the thermodynamic considerations.

(ii) For a spontaneous reaction, ΔG should be negative.

(iii) Thermodynamically, the reduction of metal oxide with a given reducing agent can occur if ΔG for the coupled reaction is negative.

(iv) Hence, the reducing agent is selected in such a way that it provides a large negative ΔG value for the coupled reaction.

(v) Ellingham diagram is used to predict thermodynamic feasibility of reduction of oxides of one metal by another metal.

(vi) Any metal can reduce the oxides of other metals that are located above it in the diagram.

(vii) Ellignham diagram, for the formation of FeO and CO intersects around 1000 K.

(viii) Below this temperature the carbon line lies above the iron line.

(ix) Hence FeO is more stable than CO and the reduction is not thermodynamically feasible.

(x) However, above 1000 K carbon line lies below the iron line.

(xi) Hence, at this condition FeO is less stable than CO and the reduction is thermodynamically feasible.

(xii) So coke can be used as a reducing agent above this temperature.

15. Give the limitations of Ellingham diagram.

Ans. *(i)* Ellingham diagram is constructed based only on thermodynamic considerations.

(ii) The interpretation of ΔG is based on the assumption that the reactants are in equilibrium with the products which is not always true.

(iii) It does not tell anything about the rate of the reaction.

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

Ans. *(i)* Electrochemical principles also find applications in metallurgical process.

(ii) The reduction of oxides of active metals such as sodium, potassium etc., by carbon is thermodynamically not feasible.

(iii) Such metals are extracted from their ores by using electrochemical methods.

(iv) In this technique, the metal salts are taken in a fused form or in solution form.

(v) The metal ion present can be reduced by treating it with some suitable reducing agent or by electrolysis.

(vi) Gibbs free energy change for the electrolysis process is given by the following expression

$$\Delta G^\circ = -nFE^\circ$$

(vii) Where n is number of electrons involved in the reduction process, F is the Faraday and E^0 is the electrode potential of the redox couple.

(viii) If E^0 is positive then the ΔG is negative and the reduction is spontaneous and hence a redox reaction is planned in such a way that the e.m.f of the net redox reaction is positive.

(ix) When a more reactive metal is added to the solution containing the relatively less reactive metal ions, the more reactive metal will go into the solution.

(x) For example,

$$Cu_{(s)} + 2Ag^+_{(aq)} \longrightarrow Cu^{2+}_{(aq)} + 2Ag_{(s)}$$

$$Cu^{2+}_{(aq)} + Zn_{(s)} \longrightarrow Cu_{(s)} + Zn^{2+}_{(aq)}$$

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

$2Na[Ag(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + 2Ag$

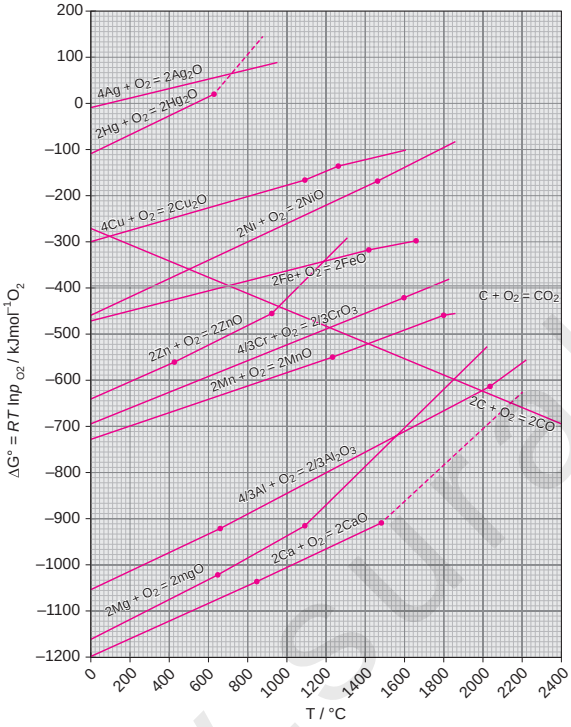
(i) Silver is leached with an aqueous solution of NaCN to form soluble sodium dicyano argentite.

(ii) Silver is recovered from dicyano argentite. Silver is reduced to its elemental state.

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

Ans. $MgCO_3 \xrightarrow{\Delta} MgO + CO_{2(g)} \uparrow$

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



Ans. *(i)* Ellingham diagram for the formation of ZnO and CO intersects around 1200 K.

(ii) Below this temperature the carbon line lies above zinc line.

(iii) Hence ZnO is more stable than CO so the reduction is thermodynamically not feasible at this temperature range.

(iv) However above 1200 K carbon line lies below the zinc line, hence carbon can be used as a reducing agent above 1200 K.

$2Zn + O_2 \longrightarrow 2ZnO$ .....(1)

$2C + O_2 \longrightarrow 2CO$ .....(2)

(v) Reversing (1) and adding with eqn. (2)

$2ZnO \longrightarrow 2\,Zn + O_2$

$2C + O_2 \longrightarrow 2\,CO$

$2ZnO + 2C \longrightarrow 2Zn + 2CO$

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. Metallic sodium is not extracted by the electrolysis of brine because hydrogen has a lower discharge potential than sodium. If it forms in aqueous solution, it would immediately react with water to produce NaOH.

At cathode : $2H^+ + 2e^- \rightleftharpoons H_{2(g)}$

At anode : $2Cl^-_{(eq)} + 2e^- \longrightarrow Cl_{2(g)}$

The negative cathode attracts the Na^+ (from sodium chloride) and H^+ ions (from water). Only the hydrogen ions are discharged at the cathode. The more reactive a metal, the less readily its ion is reduced in the electrode surface. Nothing happens to sodium ion.

PTA Model Questions And Answers

Choose the Correct Answer — 1 mark

1. Sulphide 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]

2. Which method of purification represented by the equation? *[PTA - 5]*

$$Ti(impure) + 2I_2 \xrightarrow{550K} TiI_4$$
$$\xrightarrow{1800K} Ti(pure) + 2I_2$$

a) Cupellation b) Zone refining
c) Van - Arkel method
d) Mond's process

[*Ans.* (c) Van - Arkel method]

3. 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]

Answer The Questions — 2 marks

1. What is the role of depressing agent in froath floatation process? *[PTA - 1]*

Ans. 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. Describe the underlying principle of froth floatation process. *[PTA - 3]*

Ans. Froth floatation process is based on the principle that the ore particles are wetted by oil and the gangue particles by water. This is used for the concentration of sulphide ores.

Answer The Questions — 3 marks

1. What is the role of graphite rods in the electro metallurgy of aluminium? *[PTA - 1]*

Ans. *(i)* Graphite rods act as **anode** during electrolytic reduction of alumina.
(ii) At anode, O_2 gas is produced which react with the carbon of anode (rods) to produce CO_2 gas.
(iii) So these graphite rods are consumed slowly and need to be replaced from time to time.

2. Define roasting. *[PTA - 4]*

Ans. In roasting, the concentrated ore is oxidised by heating it with excess of oxygen in a suitable furnace below the melting point of the metal.

$$2PbS + 3O_2 \xrightarrow{\Delta} 2PbO + 2SO_2 \uparrow$$

3. Explain calcination with an example. *[PTA - 4]*

Ans. *(i)* Calcination is the process in which the concentrated ore is strongly heated in the absence of air.
(ii) During this process, the water of crystallisation present in the hydrated oxide escapes as moisture.
(iii) Any organic matter (if present) also get expelled leaving behind a porous ore.
(iv) This method can also be carried out with a limited supply of air.
(v) During calcination of carbonate ore, carbon dioxide is expelled

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

Answer The Questions — 5 marks

1. Explain electrolytic refining of silver. *[PTA - 5]*

Ans. *(i)* Electrolytic refining of silver as an example.
Cathode : Pure silver
Anode : Impure silver rods
Electrolyte : Acidified aqueous solution of silver nitrate.
(ii) When a current is passed through the electrodes the following reactions will take place

Reaction at anode

$$Ag_{(s)} \longrightarrow Ag^{+}_{(aq)} + 1e^{-}$$

Reaction at cathode

$$Ag^{+}_{(aq)} + 1e^{-} \longrightarrow Ag_{(s)}$$

2. Explain extraction of copper from copper pyrites. *[PTA - 5]*

Ans. *(i)* In this method, a flux (a chemical substance that forms an easily fusible slag with gangue) and a reducing agent such as carbon, carbon monoxide (or) aluminium is added to the concentrated ore and the mixture is melted by heating at an elevated temperature (above the melting point of the metal) in a smelting furnace.

(ii) For example the oxide of iron can be reduced by carbon monoxide as follows.

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

(iii) In this extraction, a basic flux, limestone (CaO) is used. Since the silica gangue present in the ore is acidic in nature, the limestone combines with it to form calcium silicate (slag).

$$\underset{\text{Flux}}{CaO_{(s)}} + \underset{\text{Gangue}}{SiO_{2(s)}} \longrightarrow \underset{\text{Slag}}{CaSiO_{3(s)}}$$

(iv) In the extraction of copper from copper pyrites, the concentrated ore is heated in a reverberatory furnace after mixing with silica, an acidic flux.

(v) The ferrous oxide formed due to melting is basic in nature and it combines with silica to form ferrous silicate (slag).

(vi) The remaining metal sulphides Cu_2S and FeS are mutually soluble and form a copper matte.

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

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

$$\underset{\text{Flux}}{FeO_{(s)}} + \underset{\text{Gangue}}{SiO_{2(s)}} \longrightarrow \underset{\text{Slag}}{FeSiO_{3(s)}}$$

(vii) The matte is separated from the slag and fed to the converting furnace.

(viii) During conversion, the FeS present in the matte is first oxidised to FeO.

(ix) This is removed by slag formation with silica.

(x) The remaining copper sulphide is further oxidised to its oxide which is subsequently converted to metallic copper.

$$2Cu_2S_{(l,s)} + 3O_{2(g)} \longrightarrow 2Cu_2O_{(l,s)} + 2SO_{2(g)}$$

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

(xi) The metallic copper is solidified and it has blistered appearance due to evolution of SO_2 gas formed in this process. This copper is called blistered copper.

Government Exam Questions And Answers

Choose the Correct Answer — 1 mark

1. The metal which is used in packing metarial for food items : *[Sep-2020]*

(a) Zn (b) Zr (c) Al (d) Au

[Ans. **(c)** Al*]*

Answer The Questions — 2 marks

1. Oxides like Ag_2O and HgO undergo self reduction. Why? *[QY_2019]*

Ans. Decomposition temperature of Ag_2O and HgO are 600 and 700 K respectively.

These oxides are unstable at moderate temperature so undergo self reduction.

2. Name the collector and depressing agent used in froth flotation process. *[HY_2019]*

Ans. *(i)* Sodium ethyl xanthate acts as a collector.

(ii) Sodium cyanide, Sodium carbonate are used as depressing agents in froth flotation process.

Answer The Questions — 3 marks

1. Explain how gold ore is leached by cyanide process *[Govt.MQP_2019]*

Ans. *(i)* Gold is usually found in native state.

(ii) The leaching process is intended to concentrate the gold metal.

$$4Au_{(s)} + 8\,NaCN^-_{(aq)} + 2H_2O_{(aq)} + O_{2(g)} \longrightarrow 4\,Na\,[Au(CN)_2]^-_{(aq)} + 4NaOH^-_{(aq)}$$

$$2Na\,[Au(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + 2Au\downarrow$$

(iii) In this reaction, gold is reduced to its elemental state and the process is called cementation.

Answer The Questions — 5 marks

1. In metallurgy roasting of ore is done below its melting points whereas smelting is done above its melting point Why? *[QY_2019]*

Ans. **Roasting :** Roasting is the method the sulphide ore is converted into oxide ore below its melting only it exist in solid.

Smelting : Smelting is a chemical substance that forms an easily fusible slag with gangue.

2. What are the main observations of Ellingham diagram? *[QY_2019]*

Ans. **Observations from the Ellingham diagram.**

(i) For most of the metal oxide formation, the slope is positive. It can be explained as follows. Oxygen gas is consumed during the formation of metal oxides which results in the decrease in randomness. Hence, ΔS becomes negative and it makes the term, $T\Delta S$ positive in the straight line equation.

(ii) The graph for the formation of carbon monoxide is a straight line with negative slope. In this case ΔS is positive as 2 moles of CO gas is formed by the consumption of one mole of oxygen gas. It indicates that CO is more stable at higher temperature.

(iii) As the temperature increases, generally ΔG value for the formation of the metal oxide become less negative and becomes zero at a particular temperature. Below this temperature, ΔG is negative and the oxide is stable and above this temperature ΔG is positive. This general trend suggests that metal oxides become less stable at higher temperature and their decomposition becomes easier.

(iv) There is a sudden change in the slope at a particular temperature for some metal oxides like MgO, HgO. This is due to the phase transition (melting or evaporation).

Additional Questions and Answers

Choose the Correct Answer — 1 mark

1. Which metal is used for extraction of Au and Ag and also for galvanisation of iron objects?

a) Mg b) Zn c) Cr d) Co

[*Ans.* (b) Zn]

2. Which of the following is not a mineral of aluminium?

a) Bauxite b) Cryolite
c) China clay d) Malachite

[*Ans.* (d) Malachite]

3. Which of the following is commonly used to produce foam in froth floatation process?

a) Pine oil b) Cresol
c) NaCN d) Xanthate

[*Ans.* (a) Pine oil]

4. Name the process by which elements such as germanium, silicon and gallium are refined.

a) Vapour phase method
b) Electrolytic refining
c) Zone refining
d) Van-Arkel method **[*Ans.* (c) Zone refining]**

5. Among the following, one does not belong to calcination. Pick the odd one out.

a) $PbCO_3 \xrightarrow{\Delta} PbO + CO_2\uparrow$
b) $CaCO_3 \xrightarrow{\Delta} CaO + CO_2\uparrow$
c) $PbSO_3 \xrightarrow{\Delta} PbO + 2SO_2\uparrow$
d) $ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2\uparrow$

[*Ans.* (c) $PbSO_3 \xrightarrow{\Delta} PbO + 2SO_2\uparrow$ **]**

6. **Which of the following is incorrect with respect to metallurgy of iron in the blast furnace?**

a) Zone of combustion : $C + O_2 \rightarrow CO_2$

b) Zone of heat absorption : $CO_2 \rightarrow C + O_2$

c) Zone of slag formation : $CaO + SiO_2 \rightarrow CaSiO_3$

d) Zone of reduction : $Fe_2O_3 + 3C \rightarrow 3CO + 2Fe$

[*Ans.* (b) Zone of heat absorption : $CO_2 \rightarrow C + O_2$]

7. **Identify the metal that occurs in free state.**

a) Al b) Au c) Mg d) Ca

[*Ans.* (b) Au]

8. **Which of the following will give respective metal by self reduction?**

a) Galena (PbS) b) HgS

c) ZnS d) Both (a) & (b)

[*Ans.* (d) Both (a) & (b)]

9. **In the extraction of copper from its sulphide ore, the metal is finally obtained by the reduction of cuprous oxide with**

a) Iron sulphide (FeS)

b) Carbon monoxide (CO)

c) Copper (I) sulphide (Cu_2S)

d) Sulphur dioxide (SO_2)

[*Ans.* (c) Copper (I) sulphide (Cu_2S)]

10. **Which among the following reaction represents the formation of slag?**

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

b) $2C_{(s)} + O_{2(g)} \longrightarrow 2CO_{(g)}$

c) $Fe_2O_3 + 3CO_{(g)} \longrightarrow 2Fe_{(l)} + 3CO_{2(g)}$

d) $CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(g)}$

[*Ans.* (a) $CaO_{(s)} + SiO_{2(s)} \longrightarrow CaSiO_{3(s)}$]

11. **Which one of the following element is present as an impurity in pig iron?**

a) Phosphorus b) Manganese

c) Carbon d) Silicon

[*Ans.* (c) Carbon]

12. **Which of the following mineral contains calcium as well as magnesium?**

a) Zinc blende b) Aragonite

c) Dolomite d) Carnalite

[*Ans.* (c) Dolomite]

13. **Concentration of copper glance is done by**

a) leaching b) magnetic separation

c) froth flotation d) hydraulic washing

[*Ans.* (c) froth flotation]

14. **Identify the decreasing order of carbon content in different forms of iron.**

a) Wrought iron > Pig iron > castiron

b) Castiron > Pig iron > Wrought iron

c) Pig iron > Cast iron > Wrought iron

d) Cast iron > Wrought iron > Pig iron

[*Ans.* (c) Pig iron > Cast iron > Wrought iron]

15. **Sodium, magnesium and aluminum can be obtained from their ore by**

a) electro metallurgy b) pyro metallurgy

c) hydro metallurgy d) smelting

[*Ans.* (a) electro metallurgy]

16. **The blistered appearance of Cu obtained from the reverberatory furance is due to evolution of**

a) CO_2 gas b) SO_2 gas

c) NO_2

d) Due to evaporation of volatile materials

[*Ans.* (b) SO_2 gas]

17. **Identify the halide ore among the following.**

a) Epsom Salt b) Pyrolusite

c) Anglesite d) Rock Salt

[*Ans.* (d) Rock Salt]

18. $2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$

Name the process.

a) Roasting b) Calcination

c) Smelting d) Leaching

[*Ans.* (a) Roasting]

19. **The process of heating of copper pyrites to remove sulphur is called**

a) froth flotation b) roasting

c) calcination d) smelling

[*Ans.* (b) roasting]

Fill in the blanks :

1. **Malachite has _____ composition.**

a) $2CuCO_3.Cu(OH)_2$ b) $CuCO_3Cu(OH)_2$

c) Cu_2O d) Cu_2S

[*Ans.* (b) $CuCO_3Cu(OH)_2$]

2. **Zinc blende is _____.**
a) ZnS b) PbS c) Ag_2S d) Cu_2S
[*Ans.* (a) ZnS]

3. **In acid leaching process, the insoluble sulphide is converted into soluble sulphate and elemental _____.**
a) carbon b) lead
c) sulphur d) zinc
[*Ans.* (c) sulphur]

4. **Sulphide ore is converted to oxide form by using the process _____.**
a) Calcination b) Roasting
c) Smelting d) Leaching
[*Ans.* (b) Roasting]

5. **Magnetic separation it is based on the difference in the _____ of the ore and the impurities.**
a) magnetic properties
b) chemical properties
c) physical properties
d) melting point
[*Ans.* (a) magnetic properties]

6. **Zinc is extracted from Zinc blende by _____**
a) Carbon reduction process
b) Nitrogen reduction process
c) Oxygen reduction process
d) All of these
[*Ans.* (a) Carbon reduction process]

7. $ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2 \uparrow$ **. The above equation is an example for _____.**
a) calcination b) reduction
c) roasting d) leaching
[*Ans.* (c) roasting]

8. **Gibb's free energy is given by _____**
a) $\Delta G^\circ = -nFE^\circ$ b) $\Delta G^\circ = nF$
c) $\Delta G^\circ = nFE^\circ$ d) $\Delta E^\circ = -nFG^\circ$
[*Ans.* (a) $\Delta G^\circ = -nFE^\circ$]

9. **$Na[Ag(CN)_2]$ is _____.**
a) Sodium aurocyanide
b) Sodium meta aluminate
c) Aluminosilicate
d) Sodium dicyano argentate
[*Ans.* (d) Sodium dicyano argentate]

10. $Zn_{(s)} + 2[Au(CN)_2]^-_{(aq)} \longrightarrow [Zn(CN)_4]^{2-}_{(aq)} + 2Au_{(s)}$
In the above equation, the oxidation state of metallic gold is _____
a) 1 b) 0 c) +2 d) −2
[*Ans.* (b) 0]

11. **Semiconductors are purified by _____ method.**
a) Zone refining b) Electrolytic refining
c) Mond's process d) Beisemerisation
[*Ans.* (a) Zone refining]

12. **Magnesite is _____.**
a) Magnesium oxide
b) Magnesium carbonate
c) Magnesium sulphate
d) Magnesium chloride
[*Ans.* (b) Magnesium carbonate]

13. **The following set of reaction is used for refining titanium. This method is known as _____**

$Ti_{(s)} + 2I_{2(s)} \longrightarrow TiI_4$ (vapour)
TiI_4 (vapour) $\longrightarrow Ti_{(s)} + 2I_{2(s)}$

a) Hall Herold process
b) Mond process c) Van-Arkel process
d) Alumino thermic process
[*Ans.* (c) Van-Arkel process]

14. **In the metallurgy of iron, limestone is added to coke, which acts as a _____**
a) Reducing agent b) Oxidising agent
c) Slag d) Flux
[*Ans.* (d) Flux]

15. **A mixture containing sulphides of copper and iron is called _____**
a) mineral b) ore
c) matte d) matrix
[*Ans.* (c) matte]

16. **Cinnabar is the sulphide ore of _____ metal.**
a) Zn b) Pb c) Hg d) Ag
[*Ans.* (c) Hg]

17. **The percentage of carbon in high carbon steel is _____.**
a) 0.5 – 1% b) 0.15 – 1.5%
c) 0.15 – 1.5% d) 0.15 – 0.3%
[*Ans.* (b) 0.15 – 1.5%]

18. **Galena is _____**
a) PbS b) ZnS c) Ag_2S d) FeS_2
[*Ans.* (a) PbS]

19. **Froth floatation process is suitable for concentrating _____ ores.**
a) oxide b) carbonate
c) sulphide d) halide
[*Ans.* (c) Sulphide]

20. **Steel is an alloy of _____**
a) iron and carbon b) iron and calcium
c) copper and carbon d) copper and iron
[*Ans.* (a) iron and carbon]

21. **Sodium cyanide solution is used to extract _____ from its ores.**
a) copper b) silver
c) gold d) both (b) and (c)
[*Ans.* (d) both (b) and (c)]

22. **In the thermite process _____ is used as a reducing agent.**
a) Al b) CO c) C d) CO_2
[*Ans.* (a) Al]

23. $HgS_{(s)} + O_{2(g)} \longrightarrow Hg_{(l)} + SO_2\uparrow$
The above reaction is an example of _____ reduction.
a) metal b) hydrogen
c) carbon d) auto
[*Ans.* (d) auto]

Assertion & Reason :

Direction : In each of the following questions a statement of assertion (A) is given and a corresponding statement of reason (R) is given just below it. Mark the correct statement as.
a) (A) and (R) are true and (R) is the correct explanation of (A)
b) Both (A) and (R) are true but (R) does not explain (A)
c) (A) is true but (R) is false
d) Both (A) and (R) are false

1. **Assertion (A) :** Aluminium is used in the design of chemical reactors, medical equipments, refrigeration units and gas pipelines.
Reason (R) : Aluminium shows high resistance to corrosion.
[*Ans.* (a) Both (A) and (R) are true and (R) is the correct explanation of (A)]

2. **Assertion (A) :** Metallic zinc is used in galvanising metals such as iron and steel.
Reason (R) : Zinc is also used to produce die castings.
[*Ans.* (b) Both (A) and (R) are true and (R) is not the correct explanation of (A)]

3. **Assertion (A) :** Zone refining is carried out in an inert gas atmosphere.
Reason (R) : The metal is treated with a suitable reagent which can form a volatile compound with the metal.
[*Ans.* (c) Assertion is true, but reason is false]

4. **Assertion :** Cuprite is concentrated by froth floatation process.
Reason : Cuprite is the sulphide ore
[*Ans.* (d) Both assertion and reason are false]

5. **Assertion :** Roasting process is involved in the metallurgy of Cu from malachite ore.
Reason : Roasting is the process of heating the ore in the absence of air.
[*Ans.* (d) Both assertion and reason are false.]

6. **Assertion :** Metallurgy of Ag from argentite is known as hydro-metallurgy.
Reason : Argentite is Ag_2S.
[*Ans.* (b) Both assertion and reason are true but the reason is not the correct explanation of the assertion.]

7. **Assertion :** Wrought iron is purest form of iron with respect to other forms.
Reason : It has less than 0.5% carbon .
[*Ans.* (a) Both assertion and reason are true and the reason is the correct explanation of the assertion]

8. **Assertion :** Aluminium metal is used as a reducing agent for the extraction of metals.
Reason : Aluminium has great affinity for oxygen.
[*Ans.* (a) Both assertion and reason are true and the reason is the correct explanation of the assertion]

9. **Assertion :** Carbon is used in blast furnace for reduction of Fe_2O_3.
Reason : The gangue present is silica which is acidic in nature.
[*Ans.* (b) Both assertion and reason are true but the reason is not the correct explanation of the assertion.]

10. **Assertion :** Ti can be purifed by van arkel process
Reason : TiI_4 is a volatile compound which decomposes at a high temperature
[*Ans.* (a) Both assertion and reason are true and the reason is the correct explanation of the assertion]

11. **Assertion :** In the manufacturing of iron from hematite, silicon dioxide is added as flux.
Reason : Lime stone is used as acidic flux in many case.
[*Ans.* (d) Both assertion and reason are false]

12. **Assertion :** Aluminothermic process is the extraction of chromium from chromic oxide.
Reason : Alumina has a high melting point
[*Ans.* (b) Both assertion and reason are true but the reason is not the correct explanation of the assertion.]

13. **Assertion :** A dilute solution of NaCN is used for leaching ores of silver and gold.
Reason : Impurities present in these ores dissolve in NaCN
[*Ans.* (c) Assertion is true, but reason is false]

14. **Assertion :** Carbonate and sulphate are concentrated by froth floatation process
Reason : Pine oil wets the gangue particle
[*Ans.* (d) Both assertion and reason are false]

15. **Assertion :** Galvanising is the process of coating iron and steel with metallic zinc.
Reason : Highly resistant to rusting and corrosion.
[*Ans.* (a) Both assertion and reason are true and the reason is the correct explanation of the assertion]

CORRECT STATEMENT (S):

1. **I. All ores are minerals**
II. All minerals are not ores.
III. Aluminium can be extracted from bauxite.
IV. Aluminium can be extracted from china clay.
a) Only I b) Only II
c) III & IV d) I, II & III
[*Ans.* (d) I, II & III]

2. **I. Copper is the first metal used by the human**
II. Aluminuim is used in galvanising metals
III. Aluminium is a good conductor of electricity
IV. Magnets can be made from iron.
a) Only I b) Only II
c) I, III & IV d) III & IV
[*Ans.* (c) I, III & IV]

3. **I. Ellingham diagram helps to select a suitable reducing agent**
II. Magnesite is calcinated to obtain magnesia.
III. Calcination is a process of cooling substances.
IV. Sulphur dioxide is harmful to the environment.
a) I, II & IV b) Only II
c) Only I d) III & IV
[*Ans.* (a) I, II & IV]

4. **I. Froth flotation is used to concentrate sulphide ores.**
II. Magnetic separation is applicable for ferromagnetic ores.

III. Roasting method used to convert sulphide ores to oxides.
IV. Magnetic separation is used to concentrate heavy oxide ores.

a) III & IV b) Only II
c) Only I d) I, II & III

[*Ans.* (d) I, II & III]

5. I. Ores are associated with non-metallic impurities
II. Ores are associated with rocky materials
III. Removal of impurities is known as concentration of ore.
IV. Ellingham diagram shows the stability of different metal oxides.

a) I, II, III & IV
b) Only II
c) Only I d) III & IV

[*Ans.* (a) I, II, III & IV]

6. Identify the correct statement(s) with respect to the following reaction.

$$2Na[Al(OH)_4]_{(aq)} + CO_{2(g)} \longrightarrow Al_2O_3.xH_2O_{(s)} + 2NaHCO_{3(aq)}$$

(i) CO_2 is acting as a reducing agent.
(ii) The solution is neutralised by passing CO_2 gas to form hydrates Al_2O_3 precipitate.
(iii) Insoluble sulphate is converted into soluble sulphate.
(iv) The precipitate is filtered off and heated around 1670 K to get pure Alumina.

a) only (ii) b) only (iv)
c) both (ii) & (iv) d) both (i) and (iii)

[*Ans.* (c) both (ii) & (iv)]

Incorrect statement (s):

1. About "Electrolytic refining"

a) The crude metal is refined by electrolysis.
b) The rods of impure metal are used as cathode.
c) Thin strips of pure metal are used as cathode.
d) Less electropositive impurities removed as anode mud.

[*Ans.* (b) The rods of impure metal are used as cathode.]

2. About "Van-Arkel"

a) Van-Arkel method used for refining Zirconium.
b) Aluminium is a bad conductor of heat.
c) Aluminium shows high resistance to corrosion.
d) Aluminium is a good conductor of heat

[*Ans.* (b) Aluminium is a bad conductor of heat.]

3. a) Aluminium is used to produce die-castings
b) Gold nanoparticles used as an catalysts
c) Copper is the first metal used by the human
d) Brass is an alloy of zinc and copper

[*Ans.* (a) Aluminium is used to produce die-castings]

4. a) Germanium is used as a semi conductor
b) Stainless steel is an important alloy of Aluminum
c) Zinc sulphide is used in making luminous paints.
d) Brass an alloy of zinc is used in water valves.

[*Ans.* (b) Stainless steel is an important alloy of Aluminum]

5. a) Metallic oxides can be reduced by an alumino thermite process.
b) Flux + gangue → slag
c) Silica gangue present in the ore is basic in nature
d) Cu_2S + FeS →Copper matter

[*Ans.* (c) Silica gangue present in the ore is basic in nature]

Match the following :

1.

	Ores		Formulae
1	Copper pyrite	a	$CuCO_3.Cu(OH)_2$
2	Malachite	b	$CuFeS_2$
3	Azurite	c	Cu_2O
4	Cuprite	d	$2CuCO_3.Cu(OH)_2$

	1	2	3	4
(a)	a	b	c	d
(b)	b	a	c	d
(c)	b	a	d	c
(d)	d	c	b	a

[Ans. (c) b a d c]

2.

	Metal		Ores
1	Calamine	a	Fe
2	Azurite	b	Zn
3	Limonite	c	Pb
4	Cerrusite	d	Cu

	1	2	3	4
(a)	a	b	c	d
(b)	b	d	a	c
(c)	c	d	a	b
(d)	d	a	b	c

[Ans. (b) b d a c]

3.

	LIST – I		LIST – II
1	Gravity separation	a	Tinstone
2	Froth floatation	b	Bauxite
3	Chemical method	c	Zinc Blende
4	Electro magnetic separation	d	Hematite

	1	2	3	4
(a)	a	d	b	c
(b)	a	b	c	d
(c)	c	a	d	b
(d)	d	c	b	a

[Ans. (d) d c b a]

4.

	LIST – I		LIST – II
1	Oxide ore	a	Copper pyrite
2	Sulphide ore	b	Angelsite
3	Sulphate ore	c	Calamine
4	Carbonate ore	d	Diaspore

	1	2	3	4
(a)	a	b	c	d
(b)	b	c	d	a
(c)	c	d	b	a
(d)	d	a	b	c

[Ans. (d) d a b c]

5.

	LIST – I		LIST – II
1	Liquation	a	Nickel
2	Mond's process	b	Copper
3	Zone refining	c	Tin
4	Electrolytic refining	d	Silicon

	1	2	3	4
(a)	d	b	c	a
(b)	b	a	d	c
(c)	c	a	d	b
(d)	d	c	b	a

[Ans. (c) c a d b]

VERY SHORT ANSWER 2 MARKS

1. What is metallurgy?

Ans. The various steps involved in the extraction of metals from their ores as well as refining of crude metals are collectively known as metallurgy.

2. Why should we have a ecofriendly metallurgical process?

Ans. *(i)* It is essential to design an eco friendly metallurgical process that would minimize waste, maximize energy efficiency.

(ii) Such advances in metallurgy is vital for the economic and technical progress in the current era.

3. What is meant by concentration?

Ans. *(i)* The preliminary step in metallurgical process is removal of the impurities from the ore.

(ii) This process is known as concentration of ore.

4. Name some common methods of ore concentration.

Ans. *(i)* Gravity separation,
(ii) froth flotation,
(iii) leaching,
(iv) magnetic separation.

5. Name the two steps involved in the extraction of crude metal.

Ans. *(i)* Conversion of ores into oxides.
(ii) Reduction of metal oxides.

6. Name the various refining process.

Ans. *(i)* Distillation,
(ii) liquation,
(iii) electrolytic refining,
(iv) zone refining,
(v) vapour phase method,
(vi) van-Arkel method.

7. Discuss the use of an acidic flux in metallurgy.

Ans. SiO_2 is used in the metallurgy of copper to remove FeO as $FeSiO_3$ (slag) (i.e) acidic flux is used to remove basic impurities.

$$FeO + SiO_2 \longrightarrow FeSiO_3$$

8. Why are sulphide ores converted to oxide form before reduction to metal?

Ans. *(i)* Sulphide ores are **thermodynamically more stable** than CS_2 and hence cannot be converted by using coke as reducing agent.

(ii) Moreover CO_2 is more volatile and thermodynamically more stable than CS_2.

(iii) Thus ΔG° of a metal sulphide is not compensated by the energy of reaction of metal sulphide with coke.

(iv) Hence, it is better to convert the sulphide ore to oxide form and then subject to smelting (i.e) carbon reduction method.

9. Discuss the process of roasting with suitable example.

Ans. *(i)* Sulphide ores are generally roasted in reverberatory furnace in free supply of air below its melting point.

(ii) Ore changes to oxide with larger surface area and volatile impurities are removed.

$$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2$$

$$2PbS + 3O_2 \xrightarrow{\Delta} PbO + 2SO_2$$

10. Write the two similarities between calcination and roasting.

Ans. *(i)* The **end product** of both the processes is **oxide of metal**.

(ii) **Volatile impurities are removed** from the ore and surface area for the further reaction increases.

11. Name the ore that can be concentrated by magnetic separation method.

Ans. *(i)* Magnetite (Fe_3O_4), haematite (Fe_2O_3) are the ores which can be separated by the magnetic separation method.

(ii) In these ores, one component is magnetic in nature.

12. What is Ellingham diagram? (or) What does Ellingham diagram represent?

Ans. *(i)* The graphical representation of variation of the standard Gibbs free energy of reaction for the formation of various metal oxides with temperature is called Ellingham diagram.

(ii) Ellingham diagram helps us to select a suitable reducing agent and appropriate temperature range for reduction.

13. Name some depressing agents.

Ans. *(i)* Sodium cyanide and

(ii) sodium carbonate.

14. What are the various leaching processes?

Ans. The various leaching processes are

(i) Cyanide leaching,

(ii) Ammonia leaching,

(iii) Alkali leaching and

(iv) Acid leaching.

15. What is leaching?

Ans. *(i)* Leaching is based on the solubility of the ore in a suitable solvent and there reactions in aqueous solution.

(ii) In this method, the crushed ore is allowed to dissolve in a suitable solvent, the metal present in the ore is converted to its soluble salt or complex while the gangue remains insoluble.

16. What is distillation?

Ans. *(i)* Distillation is employed for low boiling volatile metals like zinc (boiling point 1180 K) and mercury (630 K).

(ii) In this method, the impure metal is heated to evaporate and the vapours are condensed to get pure metal.

17. What is the role of silica in the extraction of copper? (OR) Describe the role of SiO_2 in the extraction of Cu from Copper matte.

Ans. *(i)* Copper is extracted form copper matte which contains iron as impurity.

(ii) Silica is added to remove this impurity as iron silicate in the form of **Fusible slag**.

$$\underset{\text{Impurity}}{FeO} + SiO_2 \longrightarrow \underset{\text{Iron silicate (slag)}}{FeSiO_3}$$

Unit 1

18. Name and discuss the principle involved in obtaining silicon of high purity.

Ans. *(i)* Silicon is refined by **zone refining method**.

(ii) It is based on the principle that melting point of a substance is lowered by the presence of impurities.

(iii) Consequently when an impure molten metal is cooled, crystals of the pure metal are solidified and the impurities remain behind the remaining metal.

19. Give reason : Extraction of copper directly from sulphide ores is less favourable than that from its oxide ores through reduction.

Ans. *(i)* The standard free energy for the formation of $CuFeS_2$ (copper pyrites) is greater than those of CS_2 and H_2S.

(ii) Hence, $CuFeS_2$ cannot be reduced by carbon or hydrogen.

(iii) However, the free energy of copper oxide is less than that of CO_2.

(iv) That is the reason, extraction of copper is easier from its oxide ores through reduction.

SHORT ANSWER 3 MARKS

1. What is gravity separation? (or) Explain hydraulic washing?

Ans. *(i)* In gravity separation method, the ore having high specific gravity is separated from the gangue that has low specific gravity by washing with running water.

(ii) Ore is crushed to a finely powdered form and treated with rapidly flowing current of water.

(iii) During this process the lighter gangue particles are washed away by the running water.

(iv) This method is generally applied to concentrate the native ore such as gold and oxide ores such as haematite (Fe_2O_3), tin stone (SnO_2) etc.

2. Explain alkali leaching in the extraction of aluminum.

Ans. *(i)* In this method, the ore is treated with aqueous alkali to form a soluble complex.

(ii) Bauxite, an important ore of aluminum is heated with a solution of sodium hydroxde or sodium carbonate in the temperature range 470 - 520 K at 35 atm to form soluble sodium meta-aluminate leaving behind the impurities, iron oxide and titanium oxide.

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

(iii) The hot solution is decanted, cooled, and diluted. This solution is neutralised by passing CO_2 gas, to the form hydrated Al_2O_3 precipitate.

$$2Na[Al(OH)_4]_{(aq)} + 2CO_{2(g)} \longrightarrow Al_2O_3.3H_2O_{(s)} + 2NaHCO_{3(aq)}$$

(iv) The precipitate is filtered off and heated around 1670 K to get pure alumina Al_2O_3.

3. What is cementation?

Ans. *(i)* Gold can be recovered by reacting the deoxygenated leached solution with zinc.

(ii) In this process the gold is reduced to its elemental state (zero oxidation sate) and the process is called **cementation**.

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

4. What is meant by ammonia leaching?

Ans. *(i)* When a crushed ore containing nickel, copper and cobalt is treated with aqueous ammonia under suitable pressure.

(ii) Ammonia selectively leaches these metals by forming their soluble complexes viz. $[Ni(NH_3)_6]^{2+}$, $[Cu(NH_3)_4]^{2+}$, and $[Co(NH_3)_5H_2O]^{3+}$ respectively from the ore leaving behind the gangue, iron(III) oxides/hydroxides and aluminosilicate.

5. How is acid leaching done for the sulphide ores?

Ans. *(i)* Leaching of sulphide ores such as ZnS, PbS etc., can be done by treating them with hot aqueous sulphuric acid.

$$2ZnS_{(s)} + 2H_2SO_{4(aq)} + 2O_2 \longrightarrow 2ZnSO_{4(aq)} + 2S_{(s)} + 4H_2O$$

(ii) In this process the insoluble sulphide is converted into soluble sulphate and elemental sulphur.

6. Before reduction, the ore is first converted into the oxide of metal of interest. Give reason.

Ans. *(i)* In the concentrated ore, the metal exists in positive oxidation state and hence it is to be reduced to its elemental state.

(ii) From the principles of thermodynamics, that the reduction of oxide is easier when compared to reduction of other compounds of metal and hence, before reduction, the ore is first converted into the oxide of metal of interest.

7. Explain roasting with an example.

Ans. *(i)* Roasting is the method, usually applied for the conversion of sulphide ores into their oxides.

(ii) In this method, the concentrated ore is oxidised by heating it with excess of oxygen in a suitable furnace below the melting point of the metal.

(iii) $2PbS + 3O_2 \xrightarrow{\Delta} 2PbO + 2SO_2\uparrow$

$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2\uparrow$

$2Cu_2S + 3O_2 \xrightarrow{\Delta} 2Cu_2O + 2SO_2\uparrow$

(iv) Roasting also removes impurities such as arsenic, sulphur, phosphorous by converting them into their volatile oxides.

(v) **Ex :** $4As + 3O_2 \longrightarrow 2As_2O_3\uparrow$

$S_8 + 8O_2 \longrightarrow 8SO_2\uparrow$

$P_4 + 5O_2 \longrightarrow P_4O_{10}\uparrow$

8. Distinguish Roasting and Calcination.

Ans.

Roasting	Calcination
Roasting is a process in which ore is heated in the presence of excess of air.	Calcination is a process in which ore is heated in the absence of air.
As a result of roasting the sulphide ores are converted into their oxides.	As a result of calcination, the carbonate ore is converted into its oxide.
$2PbS + 3O_2 \xrightarrow{\Delta} 2PbO + 2SO_2\uparrow$	$PbCO_3 \xrightarrow{\Delta} PbO + CO_2\uparrow$
Roasting removes impurities such as arsenic, sulphur, phosphorous by converting them into their volatile oxides. $4As + 3O_2 \longrightarrow 2As_2O_3$	During calcination of hydrated ore, the water of hydration is expelled as vapour.

9. What is vapour phase method?

Ans. *(i)* In vapour phase method, the metal is treated with a suitable reagent which can form a volatile compound with the metal.

(ii) Then the volatile compound is decomposed to give the pure metal.

(iii) Vapour phase method is used for refining nickel.

10. Write the complete set of reactions occurring in the zone of reduction in the blast furnace in the metallurgy of iron.

Ans. In Ellingham diagram, the graph of $CO \rightarrow CO_2$ conversion remains below $Fe \rightarrow Fe_2O_3$ upto 1073 K

(for $Fe \longrightarrow FeO$). SO, CO(g) act as reducing agent upto this temperature.

$3\,Fe_2O_3 + CO \longrightarrow 2Fe_3O_4$ (ie. $FeO.Fe_2O_3$) $+ CO_2$

$Fe_3O_4 + CO \longrightarrow 3\,FeO + CO_2$

$FeO + CO \longrightarrow Fe + CO_2$

Also, graph of $C \longrightarrow CO$ is below the graph of $Fe \longrightarrow Fe_2O_3$ after 1123 K. So, carbon acts as reducing agent above this temperature.

$Fe_2O_3 + C \longrightarrow 3\,CO + 2\,Fe.$

11. What is coupling of reaction? How is it useful in metallurgy?

Ans. *(i)* If value of **ΔG is positive** for any reaction, then to make such reaction spontaneous, it is coupled with another reaction of large negative ΔG value, so that the sum of two ΔG becomes negative. This is known as coupling of reaction.

(ii) In the metallurgy, thermodynamically infeasible reaction is coupled with a reaction which has more negative ΔG, so that net **ΔG becomes negative**.

Unit 1

12. Explain how the metal oxide is converted into metal using carbon as a reducing agent.

Ans. *(i)* In this method the oxide ore of the metal is mixed with coal (coke) and heated strongly in a furnace (usually in a blast furnace).

(ii) This process can be applied to the metals which do not form carbides with carbon at the reduction temperature.

Eg : $ZnO_{(s)} + C_{(s)} \longrightarrow Zn_{(s)} + CO_{(g)}\uparrow$

13. How oxides of metals are reduced by hydrogen?

Ans. *(i)* This method can be applied to the oxides of the metals (Fe, Pb, Cu) having less electropositive character than hydrogen.

$$Ag_2O_{(s)} + H_{2(g)} \longrightarrow 2Ag_{(s)} + H_2O_{(l)}$$

(ii) Nickel oxide can be reduced to nickel by using a mixture of hydrogen and carbon monoxide (water gas)

(iii) $2NiO_{(s)} + CO_{(g)} + H_{2(g)} \longrightarrow 2Ni_{(s)} + CO_{2(g)} + H_2O_{(l)}$

14. What is meant by aluminothermite process?

Ans. *(i)* Metallic oxides such as Cr_2O_3 can be reduced by an aluminothermite process.

(ii) In this process, the metal oxide is mixed with aluminum powder and placed in a fire clay crucible.

(iii) To initiate the reduction process, an ignition mixture (usually magnesium and barium peroxide) is used.

$$BaO_2 + Mg \longrightarrow BaO + MgO$$

(iv) During the above reaction a large amount of heat is evolved (temperature up to 2400°C, is generated and the reaction enthalpy is : 852 kJ mol^{-1}) which facilitates the reduction of Cr_2O_3 by aluminium power.

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

15. What is liquation?

Ans. *(i)* Liquation is employed to remove the impurities with high melting points from metals having relatively low melting points.

(ii) In this process, the crude metal is heated to form fusible liquid and allowed to flow on a sloping surface.

(iii) The impure metal is placed on sloping hearth of a reverberatory furnace and it is heated just above the melting point of the metal in the absence of air, the molten pure metal flows down and the impurities are left behind.

(iv) The molten metal is collected and solidified.

16. List the applications of gold.

Ans. *(i)* Gold, is used for coinage, and has been used as standard for monetary systems in some countries.

(ii) It is used extensively in jewellery in its alloy form with copper.

(iii) It is also used in electroplating to cover other metals with a thin layer of gold which are used in watches, artificial limb joints, cheap jewellery, dental fillings and electrical connectors.

(iv) Gold nanoparticles are also used for increasing the efficiency of solar cells and also used a catalysts.

17. Mention the uses of copper.

Ans. *(i)* Copper is used for making coins and ornaments along with gold and other metals.

(ii) Copper and its alloys are used for making wires, water pipes and other electrical parts.

18. Copper and silver lie low in the electrochemical series and yet they are found in the combined state as sulphides in nature. Comment.

Ans. *(i)* At higher temperature, the reaction between copper and sulphur becomes feasible.

(ii) So they combine together and copper exists as copper sulphides in nature.

(iii) Besides this due to high polarising power of copper and silver ions, their sulphides are more stable.

19. Support the statement given below with relevant examples.
"The choice of a reducing agent in a particular case depends on the thermodynamic factor".

Ans. The statement is correct. We consider both relations,

$\Delta G = \Delta H - T\Delta S$ (or) $\Delta G^\circ = -RT \ln K$

For a particular reducing agent to work with a metallic oxide,

(i) the value of ΔG should be **negative**.

(ii) ΔS should be **positive**.

20. Why is zinc not extracted from zinc oxide through reduction using CO?

Ans. ΔG° for the conversion of Zn into ZnO is approximately – 650 kJ and for the conversion of CO into CO_2 is approximately – 450kJ (ie).

$2Zn + O_2 \longrightarrow 2\,ZnO$; $\Delta G^\circ = -650$ kJ

$2CO + O_2 \longrightarrow 2\,CO_2$; $\Delta G^\circ = -450$ kJ

For the reaction,

$2ZnO + 2\,CO \longrightarrow 2\,Zn + 2\,CO_2$; $\Delta G^\circ = +200$ kJ

Positive value of shows that the reaction is not feasible. That is why, CO cannot be used for the reduction of ZnO into Zn.

21. (i) Which of the following metals cannot be extracted by the smelting process : Al, Zn, Fe and Pb. Give reasons.

(ii) Which one is a good reducing agent (C or CO) for Fe_2O_3, below 1073 K?

Ans. (i) Aluminium cannot be extracted by smelting process due to the following reasons.

(a) Aluminium (Al) being highly electropositive element has very strong affinity for oxygen. So, Al_2O_3 is very stable compound and cannot be reduced by C.

(b) On heating Al_2O_3 with C, aluminium carbide is formed

$2Al_2O_3 + 9C \longrightarrow Al_4C_3 + 6CO.$

(ii) Below 1073 K, CO is more effective, because the ΔG° value for the conversion of CO into CO_2 is more negative.

22. What are the applications of the Ellingham diagram?

Ans. (i) Ellingham diagram helps us to select a suitable reducing agent and appropriate temperature range for reduction.

(ii) From the Ellingham diagram, we can infer the relative stability of different metal oxides at a given temperature.

(iii) Ellingham diagram is used to predict thermodynamic feasibility of reduction of oxides of one metal by another metal.

Long Answer 5 marks

1. Explain froth flotation, with diagram.

Ans. (i) Froth flotation method is commonly used to concentrate sulphide ores such as galena (PbS), zinc blende (ZnS) etc.

(ii) In this method, the metallic ore particles which are preferentially wetted by oil can be separated from gangue.

(iii) In this method, the crushed ore is suspended in water and mixed with frothing agent such as pine oil, eucalyptus oil etc.

(iv) A small quantity of sodium ethyl xanthate which acts as a collector is also added.

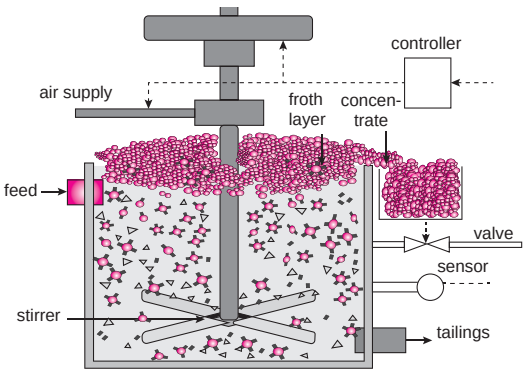
(v) A froth is generated by blowing air through this mixture.

(vi) The collector molecules attach to the ore particle and make them water repellent.

(vii) As a result, ore particles, wetted by the oil, rise to the surface along with the froth.

(viii) The froth is skimmed off and dried to recover the concentrated ore.

(ix) The gangue particles that are preferentially wetted by water settle at the bottom.



Froth Flotation

2. Explain refining of titanium by Van-Arkel method.

Ans. (i) Van-Arkel method is based on the thermal decomposition of metal compounds which lead to the formation of pure metals.

(ii) Titanium and zirconium can be purified using this method.

(iii) For example, the impure titanium metal is heated in an evacuated vessel with iodine at a temperature of 550 K to form the volatile titanium tetra-iodide.(TiI_4).

(iv) The impurities are left behind, as they do not react with iodine.

$$Ti_{(s)} + 2I_{2(s)} \xrightarrow[\Delta]{550K} TiI_4 \text{ (vapour)}$$

(v) The volatile titanium tetraiodide vapour is passed over a tungsten filament at a temperature aroud 1800 K.

(vi) The titanium tetraiodide is decomposed and pure titanium is deposited on the filament.

(vii) The iodine is reused.

$$TiI_4\text{(vapour)} \xrightarrow[\Delta]{1800K} Ti_{(s)} + 2I_{2(s)}$$

3. Explain concentration by magnetic separation with diagram.

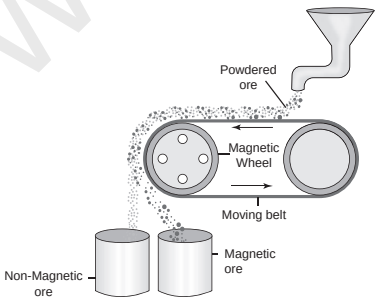
Ans. *(i)* Magnetic separation is applicable to ferromagnetic ores and it is based on the difference in the magnetic properties of the ore and the impurities.

(ii) For example tin stone can be separated from the wolframite impurities which is magnetic.

(iii) Similarly, ores such as chromite, pyrolusite having magnetic property can be removed from the non magnetic siliceous impurities.

(iv) The crushed ore is poured on to an electromagnetic separator consisting of a belt moving over two rollers of which one is magnetic.

(v) The magnetic part of the ore is attracted towards the magnet and falls as a heap close to the magnetic region while the nonmagnetic part falls away from it as shown in the figure.



Magnetic separation

4. List out the application of aluminum.

Ans. *(i)* Many heat exchangers/sinks and cooking vessels are made of aluminum.

(ii) It is used as wraps (aluminum foils) and is used in packing materials for food items,

(iii) Aluminum alloys with copper, manganese, magnesium and silicon are light weight and strong and they are used in design of aeroplanes and other forms of transport.

(iv) Aluminum shows high resistance to corrosion, so it is used in the design of chemical reactors, medical equipments,refrigeration units and gas pipelines.

(v) Aluminium is a good electrical conductor and cheap, hence used in electrical overhead electric cables with steel core for strength.

5. List the applications of iron.

Ans. *(i)* Iron and its alloys are used everywhere including bridges, electricity pylons, bicycle chains, cutting tools and rifle barrels.

(ii) Cast iron is used to make pipes, valves and pumps stoves etc.

(iii) Magnets can be made from iron and its alloys and compounds.

(iv) An important alloy of iron is stainless steel, and it is very resistant to corrosion. It is used in architecture, bearings, cutlery, surgical instruments and jewellery.

(v) Nickel steel is used for making cables, automobiles and aeroplane parts.

(vi) Chrome steels are used for manufacturing cutting tools and crushing machines.

UNIT TEST

Time : 40 min | Marks : 25

I. Choose the Correct Answer (5 × 1 = 5)

1. The chemical name of Horn silver is _____.

a) Chlorargyrite b) Silver glance
c) Prousitite d) Pyrargyrite

2. During the cyanide leaching of gold, the insoluble gangue formed is

a) gold cyanide b) aluminosilicate
c) gold silicate d) gold aluminosilicate

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

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

4. Removal of unreacted oxide ore, other metals, non metals associated with isolated crude metal is called _____

a) leaching b) bleaching
c) refining d) liquation

5. Match the following Metal with their Melting points.

Metals		Melting points	
1	Lead	a	545 K
2	Mercury	b	904 K
3	Tin	c	234 K
4	Bismuth	d	600 K

	1	2	3	4
(a)	d	c	b	a
(b)	a	b	c	d
(c)	b	c	a	d
(d)	c	b	a	d

II. Short Answer (2 × 2 = 4)

1. Give the basic requirement for vapour phase refining.
2. What is the role of Silica in the extraction of copper.

III. Answer In Paragraph (2 × 3 = 6)

1. Out of coke and CO, which is better reducing agent for the reduction of ZnO? Why?
2. Is it possible to reduce Fe_2O_3 by coke at a temperature around 1200K?

IV. Long Answer (2 × 5 = 10)

1. Give the limitations of Ellingham diagram.
2. Write a short note on electrochemical principles of metallurgy.

☆ ☆ ☆

Answer Key

I.
1. a) Chlorargyrite
2. b) aluminosilicate
3. b) Al_2O_3
4. c) refining
5. a) d c b a

II.
1. *Refer Sura's Guide Book Back, Q.No. 12.*
2. *Refer Sura's Guide Additional 2 Marks, Q.No. 17.*

III.
1. *Refer Sura's Guide Book Back, Q.No. 5.*
2. *Refer Sura's Guide Book Back, Q.No. 8 (C).*

IV.
1. *Refer Sura's Guide Book Back, Q.No. 16.*
2. *Refer Sura's Guide Book Back, Q.No. 17.*

☆ ☆ ☆

UNIT 2

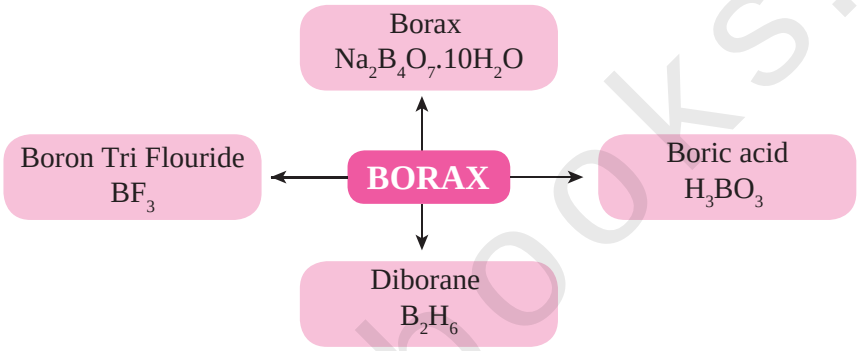
p-Block Elements - I

CHAPTER SNAPSHOT

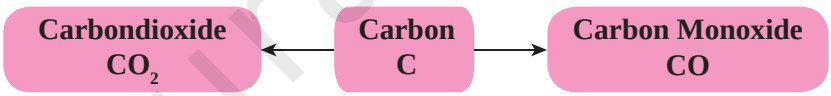
CONCEPT MAP

General trends in properties of p-block elements

- Electronic configuration and oxidation state
- Metallic nature
- Ionisation Enthalpy
- Electro negativity
- Inert pair effect
- Anomalous properties
- Allotropism



Preparation, Properties, Structure and uses of the above compounds.



Preparation, Properties, Structure and uses.

FORMULAE TO REMEMBER

Borax	:	$Na_2B_4O_7.10H_2O$
Boric acid	:	H_3BO_3 or $B(OH)_3$
Di Borane	:	B_2H_6
Boron Fluoride	:	BF_3
Aluminium Chloride	:	$AlCl_3$
Silicon tetrachloride	:	$SiCl_4$
Silicones	:	R_2SiO
Potash Alum	:	$K_2SO_4.Al_2(SO_4)_3.\ 24H_2O$

Sodium Alum	:	$Na_2SO_4.Al_2(SO_4)_3.24H_2O$
Ammonium Alum	:	$(NH_4)_2SO_4.Al_2(SO_4)_3.24H_2O$
Chrome Alum	:	$K_2SO_4.Cr_2(SO_4)_3.24H_2O$
Nickel Tetra Carbonyl	:	$[Ni(CO)_4]$
Iron Penta Carbonyl	:	$[Fe(CO)_5]$
Chromium Hexa Carbonyl	:	$[Cr(CO)_6]$
Thortveitite	:	$Sc_2Si_2O_7$
Spodumene	:	$LiAl(SiO_3)_2$

MUST KNOW DEFINITIONS

Metallic Character	:	The tendency of an element to form a cation by loosing electrons is known as **electropositive** or **metallic character.**
Allotropism	:	Some elements exist in more than one crystalline or molecular forms in the same physical state. This property is called **allotropism**.
Hydroboration	:	Diborane adds on to alkenes and alkynes in ether solvent at room temperature. This reaction is called **hydroboration**.
Catenation	:	**Catenation** is an ability of an element to form chain of atoms.
Silcones	:	**Silicones or poly siloxanes** are organo silicon polymers with general empirical formula (R_2SiO).
Silicates	:	The mineral which contains silicon and oxygen in tetrahedral $[SiO_4]^{4-}$ units linked together in different patterns are called **silicates**.
Zeolites	:	Zeolites are three dimensional crystalline solids containing aluminium, silicon, and oxygen in their regular three dimensional framework.
Inert pair effect	:	In heavier post-transition metals, the outer s electrons (ns) have a tendency to remain inert and show reluctance to take part in the bonding, which is known as inert pair effect.

EVALUATION

Choose The Correct Answer

1. An aqueous solution of borax is

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

[Ans. (c) basic]

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]

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]

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

a) Aluminium b) Calcium
c) 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]

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

a) Carbon b) silicon
c) Lead d) germanium

[Ans. (c) Lead]

7. Carbon atoms in fullerene with formula C_{60} have

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]

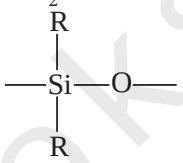
9. The basic structural unit of silicates is *(NEET) [PTA-1]*

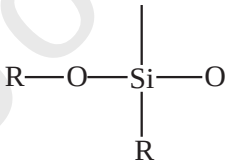
a) $(SiO_3)^{2-}$ b) $(SiO_4)^{2-}$
c) $(SiO)^-$ d) $(SiO_4)^{4-}$

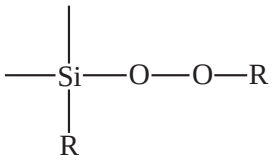
[Ans. (d) $(SiO_4)^{4-}$]

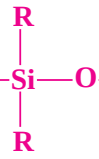
10. The repeating unit in silicone is

a) SiO_2

b)


c)


d)


[Ans. (b)

]

11. Which of these is not a monomer for a high molecular mass silicone polymer?

a) Me_3SiCl b) $PhSiCl_3$
c) $MeSiCl_3$ d) Me_2SiCl_2

[Ans. (a) Me_3SiCl]

12. Which of the following is not sp^2 hybridised?

a) Graphite b) graphene
c) Fullerene d) dry ice

[Ans. (d) dry ice]

orders@surabooks.com Ph:9600175757 / 8124201000