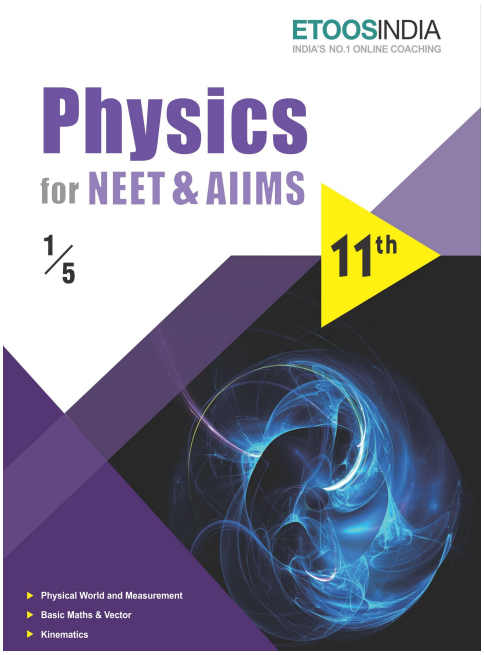
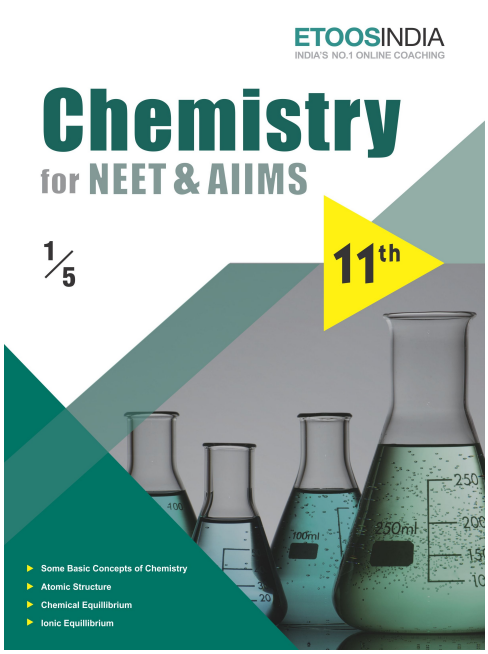
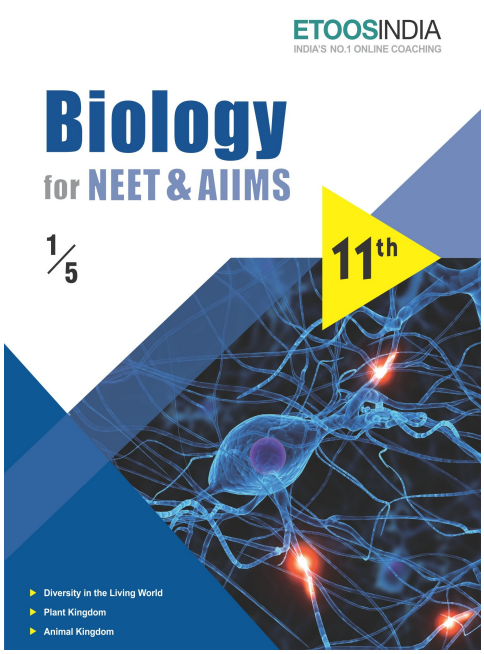
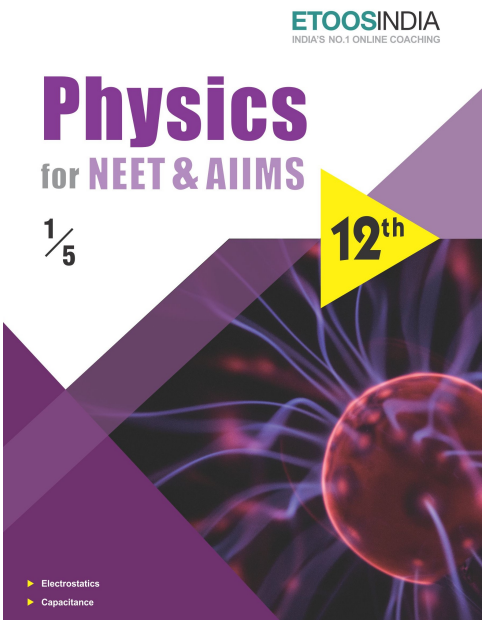
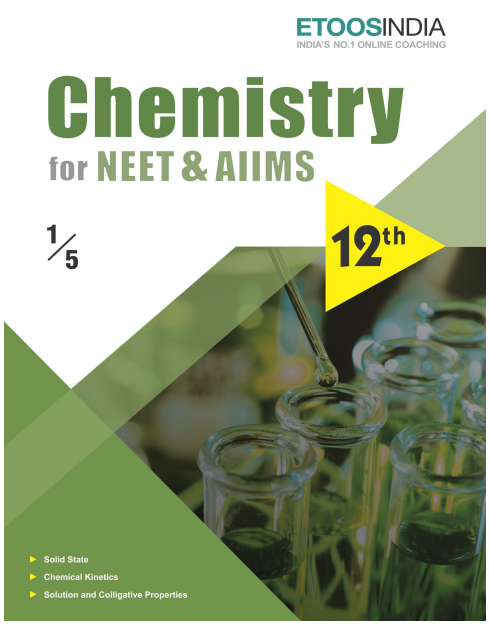
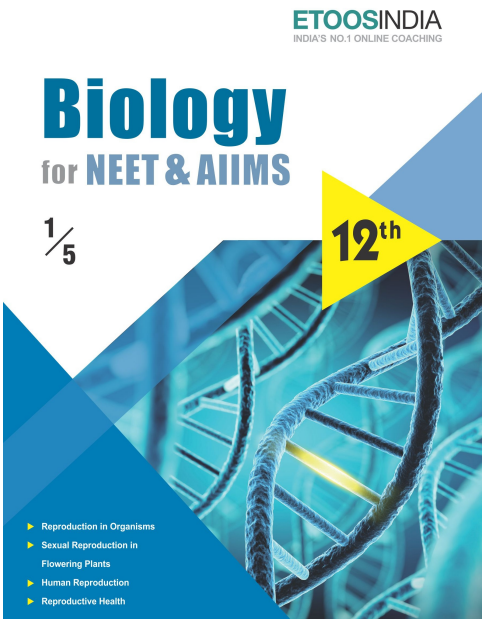












CHAPTER 09

METALLURGY

All parts of the material universe are in constant motion and though some of the changes may appear to be cyclical, nothing ever exactly returns, so far as human experience extends, to precisely the same condition.

"JOSEPH HENRY"

INTRODUCTION

The branch of chemistry which deals with the method of extraction of metals from their ores. A few elements like carbon, sulphur, gold and noble gases, occur in free state while others in combined forms in the earth's crust. The extraction and isolation of an element from its combined form involves various principles of chemistry. A particular element may occur in a variety of compounds. The process of metallurgy and isolation should be such that it is chemically feasible and commericially viable. Still, some general principles are common to all the extraction processes of metals. For obtaining a particular metal, first we look for minerals which are naturally occurring chemical substances in the earth's crust obtainable by mining. Out of many minerals in which a metal may be found, only a few are viable to be used as sources of that metal. Such minerals are known as ores.

Rarely, an ore contains only a desired substance. It is usually contaminated with earthly or undesired materials known as gangue. The extractin and isolation of metals from ores involve the following major steps:

- Concentration of the ore,
- Isolation of the metal from its concentrated ore, and
- Purification of the metal.

The entire scientific and technological process used for isolation of the metal from its ores is known as metallurgy.

Advantages of Roasting

- Excess of sulphur is removed as volatile oxide.

  $S + O_2 \rightarrow SO_2 \uparrow$
  (air)

- The metal sulphide is converted into metal oxide.
- Impurities of arsenic and antimony are removed as their volatile oxides.

  $Sb_4 + 3O_2 \rightarrow 2Sb_2O_3$

  $As_4 + 3O_2 \rightarrow 2As_2O_3$

(III) Reduction of Ore to the Metal

The calcined or roasted ore is then reduced to the metallic state in either of the following ways.

(A) Reduction by Carbon (Smelting) : (This is common method of reduction)

"Reduction of the oxide with carbon at high temperature is known as smelting".

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

Slag : Fusible metarial during reduction process.

Slag : Gangue + substance (for remove gangue)

Flux : Substance used to convert non fusible impurities into fusible one.

ETOOS KEY POINTS

Three types of flux :

(a) Acidic Flux : Substance used to remove basic impurities (metal oxide)

For example $\underset{\text{(basic impurity)}}{CaO} + \underset{\text{(acidic flux)}}{SiO_2} \rightarrow \underset{\text{(Slag)}}{CaSiO_3}$

Acidic flux are non metal oxide (SiO_2, P_2O_5 etc.)

(b) Basic flux : Substance used to remove acidic impurities (non metal oxide)

From example

CaO	+	SiO_2	$\longrightarrow$	$CaSiO_3$
↓		↓		↓
(basic flux)		(acidic impurities)		Slag

Basic flux are metal oxide. (CaO, MgO, etc.)

(c) Neutral flux : Substance used in electrolytic reduction to decrease the fusion temperature and to increase the conductivity of the solution by providing free ions.

For example $(\underset{\text{Cryolite}}{Na_3AlF_6} + \underset{\text{Flourspar}}{CaF_2})$, $CaCl_2$ etc.

Smelting :

- Concentrate ore (ore + gangue) + RA (carbon) + Flux (RA ⇒ Reducing agent)

  ↓

  Metal + Slag + gases

- Cr_2O_3, Mn_3O_4, MnO_2 } ⟶ Carbon is not used for reduction
- Coke is not used for reduction of s-block oxide Al_2O_3 (due to formation of metal carbides)

  $CaO + 2C \longrightarrow CaC_2 + CO$

Etoos Tips & Formulas

Mettallurgy at a Glance

FLOW SHEET FOR THE EXTRACTION OF ALUMINIUM

Aluminium ore, $Al_2O_3 \cdot 2H_2O$ (Bauxite)

↓

REFINING OF BAUXITE

(a) Baeyer's process :

$$\text{Bauxite ore} \xrightarrow{\text{Roasted}} \text{as to convert FeO into } Fe_2O_3$$

$$\underset{\text{ore}}{\text{Roasted}} + \underset{\text{Solution}}{\text{NaOH}} \xrightarrow[80\text{ atm.}]{150^\circ C} NaAlO_2 \xrightarrow[\text{of little } Al(OH)_3]{\text{Hydrolysis in presence}} \underset{\text{ppt.}}{Al(OH)_3} + NaOH$$

(b) Hall's Process :

$$\underset{\text{ore}}{\text{Bauxite}} + Na_2CO_3 \xrightarrow{\text{Fused}} NaAlO_2$$

↓ extracted with water

Solution

↓ warmed 50°–60°C

CO_2 is circulated

↓

$$\underset{\text{ppt.}}{Al(OH)_3} + Na_2CO_3$$

(c) Serpeck's process :

$$\underset{\text{nitrogen}}{\text{Bauxite ore + Coke}} \xrightarrow{1800^\circ C} AlN \xrightarrow{H_2O} \underset{\text{ppt.}}{Al(OH)_3} + \underset{\text{by product}}{NH_3}$$

↓

CALCINATION

$$Al(OH)_3 \xrightarrow{1500^\circ C} \underset{\text{Anhydrous alumina}}{Al_2O_3}$$

↓

ELECTROLYTIC REDUCTION

Electrolyte Al_2O_3 dissolved in Na_3AlF_6 and CaF_2

Cathode—Carbon lining **Anode**—Graphite rods

$$Al_2O_3 \xrightarrow[950^\circ C]{\text{Electrolysis}} \underset{99.8\%\text{ pure}}{Al} + O_2$$

↓

ELECTROLYTIC REFINING

(Hoope's process)

↓

Pure Al (99.98% pure)

SOLVED EXAMPLE

Ex. 1 Using data given below, predict whether the reduction of MgO with C is spontaneous or not at 1500°C.

$2C + O_2 \longrightarrow 2CO \quad \Delta G^o \approx -530\ kJ$

$2MgO \longrightarrow 2Mg + O_2 \quad \Delta G^o \approx +730\ kJ$

Sol. The positive value of ΔG^o indicates that the reduction of MgO with C dose not occur to a significant extent at 1500°C

$2C + O_2 \longrightarrow 2CO \qquad \Delta G^o \approx -530\ kJ$

$2MgO \longrightarrow 2Mg + O_2 \qquad \Delta G^o \approx +730\ kJ$

$2MgO + 2C \longrightarrow 2Mg + 2CO$

or $MgO + C \longrightarrow Mg + CO \qquad \Delta G^o$ positive value.

Ex. 2 Sea water $\xrightarrow{(A)} Mg(OH)_2 \xrightarrow{(B)} MgCl_2.6H_2O \xrightarrow{(C)} MgCl_2 \xrightarrow{(D)} Mg + Cl_2\uparrow$

Identify the reagents and processes (A) to (D) and give the name of this process.

Sol. $MgCl_2$ (from sea water) $+ Ca(OH)_2$ (A) $\rightarrow Mg(OH)_2\downarrow + CaCl_2$; $Mg(OH)_2 + 2HCl$ (B) $\rightarrow MgCl_2$ (aq.) $+ 2H_2O$

Crystallisation of $MgCl_2$(aq) yields $MgCl_2.6H_2O$

$$MgCl_2\,6H_2O \xrightarrow[\text{Dry HCl}]{\text{Calcination (C)}} MgCl_2 + 6H_2O$$

$$MgCl_2(\ell) \xrightarrow{\text{Electrolysis is (D)}} \underset{\downarrow +2e^-}{Mg^{2+}} + \underset{\downarrow Cl_2}{2Cl^-}$$

Mg (cathode) $\quad$ Cl_2 (anode)

Name of the process is Dow's process.

Ex. 3 Convert magnesite into anhydrous $MgCl_2$.

Sol. $MgCO_3 \xrightarrow{\Delta} MgO + CO_2$.

$MgO + C + Cl_2 \longrightarrow MgCl_2 + CO$

Ex. 4 At a site, low grade copper ores are available and zinc and iron scraps are also available. Which of the two scraps would be more suitable for reducing the leached copper ore and why?

Sol. Since zinc lies above iron in electrochemical series, it is more reactive than iron. As a result, if zinc scraps are used the reduction will be faster. However, zinc is a costlier metal than iron. Therefore, it will be advisable and advantageous to use iron scraps.

Ex. 5 A metal is extracted from its sulphide ore and the process of extraction involves the following steps.

Metal sulphide $\xrightarrow{(A)}$ Concentrated ore $\xrightarrow{(B)}$ Matte $\xrightarrow{(C)}$ Impure metal $\xrightarrow{(D)}$ Pure metal

Identify the steps (A), (B), (C) and (D).

Sol. (A) Froth floatation process. Sulphide ores are concentrated by froth-floatation process.

(B) Roasting. Metal sulphides are roasted to convert into metal oxide and to remove impurities.

In roasting ; $2CuFeS_2 + O_2 \longrightarrow Cu_2S + 2FeS + SO_2$.

$2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2$.

$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$.

$FeO + SiO_2 \longrightarrow FeSiO_3$

(C) Bessemerisation / self reduction. Reduction of metal oxide by its sulphide takes place in Bessemer converter.

In Bessemerisation ; $2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2$ (self - reduction)

(D) Electro-refining. Pure metal is obtained at cathode.

$M^{n+} + n\,e^- \longrightarrow m$

Ex. 6 Write chemical equations for metallurgical processes to represent :

(i) roasting of galena (PbS) in limited supply of air at moderate temperature.

(ii) reduction of Cu_2O using coke as a reducing agent.

(iii) deposition of pure silver from an aqueous solution of Ag^+.

Sol. (i) $2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$

$PbS + 2O_2 \longrightarrow PbSO_4$

(ii) $Cu_2O + C \longrightarrow 2Cu + CO$

(iii) $Ag^+ + e^- \xrightarrow{\text{Electrolysis}} Ag\downarrow$ (at cathode)

Ex. 7 Which is not the correct process-mineral matching in metallurgical extraction.

(A) Leaching	:	silver
(B) Zone refining	:	lead.
(C) Liquation	:	tin
(D) Van Arkel	:	Zr

Sol. Lead is purified by Electro-refining. Zone refining is used for the purification of Si and Ge.

Therefore, (B) option is correct.

Exercise # 1 SINGLE OBJECTIVE NEET LEVEL

1. The most abundant element on earth crust is
(A) Hydrogen (B) Oxygen
(C) Silicon (D) Carbon

2. Naturally occurring substances from which a metal can be profitably (or economically) extracted are called
(A) Minerals (B) Ores
(C) Gangue (D) Salts

3. Titanium containing mineral found in our country is
(A) Bauxite (B) Dolomite
(C) Chalcopyrites (D) Elmanite

4. Silicon is main constituent of
(A) Alloys (B) Rocks
(C) Animals (D) Vegetables

5. Which of ore is metalloid
(A) As (B) Na
(C) Au (D) Fe

6. A mineral is called an ore if
(A) Metal present in mineral is precious
(B) Metal can be extracted from it
(C) Metal can be extracted profitably from it
(D) Metal cannot be extracted from it

7. The highest quantity present in the atmosphere is of
(A) Oxygen (B) Hydrogen
(C) Nitrogen (D) Ozone

8. Which of the following statement is correct
(A) Bauxite is an ore of aluminium
(B) Magnetite is an ore of manganese
(C) Haematite is an ore of mercury
(D) Pyrites is an ore of phosphorus

9. Carnellite is a mineral of
(A) Ca (B) Na
(C) Mg (D) Zn

10. The salt which is least likely to be found in minerals is
(A) Chloride (B) Sulphate
(C) Sulphide (D) Nitrate

11. Metal which can be extracted from all the three dolomite, magnesite and carnallite is
(A) Na (B) K
(C) Mg (D) Ca

12. Cinnabar is an ore of
(A) Hg (B) Cu
(C) Pb (D) Zn

13. Metallurgy is the process of
(A) Concentrating the ore
(B) Roasting the ore
(C) Extracting the metal from the ore
(D) Adding carbon to the ore in blast furnace

14. What is believed to be the second most common element in the universe
(A) Helium (B) Hydrogen
(C) Nitrogen (D) Silicon

15. Which of the following substances consists of only one element
(A) Marble (B) Sand
(C) Diamond (D) Glass

16. Which of the following minerals is not an ore of aluminum
(A) Bauxite (B) Gypsum
(C) Cryolite (D) Corundum

17. An example of halide ore is
(A) Galena (B) Bauxite
(C) Cinnabar (D) Cryolite

18. Which of the following is not an ore
(A) Bauxite (B) Malachite
(C) Zinc blende (D) Pig iron

19. "Chile saltpetre" is an ore of
(A) Iodine (B) Sodium
(C) Bromine (D) Magnesium

20. Sulphide ores are generally concentrated by
(A) Froth floatation process
(B) Magnetic separation
(C) Gravity separation
(D) By hand picking

21. Froth floatation process is used for the concentration of
(A) Oxide ores (B) Sulphide ores
(C) Chloride ores (D) Amalgams

22. A process used for the concentration of ore is
(A) Froth floatation (B) Roasting
(C) Electrolysis (D) Bessemerization

Exercise # 2 SINGLE OBJECTIVE AIIMS LEVEL

1. Bauxite is leached with :
(A) KCl (B) NaCN
(C) NaOH (D) Na_2SO_4

2. Froth floatation process for the concentration of sulphide ores is an illustration of the practical application of:
(A) adsorption (B) absorption
(C) sedimentation (D) coagulation

3. Which one of the following is not a method of concentration of ore ?
(A) electromagnetic separation
(B) smelting
(C) gravity separation
(D) froth floatation process

4. The formula of carnallite is :
(A) $LiAl(Si_2O_5)_2$ (B) $KCl.MgCl_2.6H_2O$
(C) $K_2O.Al_2O_3.6SiO_2$ (D) $KCl.MgCl_2.2H_2O$

5. Dolomite is mineral whose formula is :
(A) $CaMg(CO_3)_2$ (B) $MgCO_3$
(C) $CaCO_3.MgCO_3$ (D) (A) & (C) both

6. Magnetic separation process may be used for the concentration of :
(A) chalcopyrite (B) bauxite
(C) haematite (D) calamine

7. The metal which mainly occurs as oxide ore in nature is :
(A) gold (B) lead
(C) aluminium (D) magnesium

8. The reason, for floating of ore particles in concentration by froth floatation process is that :
(A) they are light
(B) they are insoluble
(C) they are charged
(D) they are hydrophobic

9. Choose the correct option using the code regarding roasting process.
(I) It is the process of heating the ore in air in a reverberatory furnace to obtain the oxide.
(II) It is an exothermic process.
(III) It is used for the concentration of sulphide ore.
(IV) It removes easily oxidisable volatile impurities present in the concentrated ore.
(A) I, II and III (B) I, II and IV
(C) I, III and IV (D) I, II, III and IV

10. The slag consists of molten impurities, generally, in the form of :
(A) metal carbonate (B) metal silicate
(C) metal oxide (D) metal nitrate

11. The process of the isolation of a metal by dissolving the ore in a suitable chemical reagent followed by precipitation of the metal by a more electropositive metal is called :
(A) hydrometallurgy (B) electrometallurgy
(C) zone refining (D) electro-refining

12. In the metallurgy of iron, the upper layer obtained in the bottom of blast furnace mainly contains :
(A) $CaSiO_3$ (B) spongy iron
(C) Fe_2O_3 (D) $FeSiO_3$

13. Ellingham diagram represents :
(A) change of ΔG with temperature.
(B) change of ΔH with temperature.
(C) change of ΔG with pressure.
(D) change of $(\Delta G - T\Delta S)$ with temperature.

14. A sulphide ore like ZnS is first roasted into its oxide prior to reduction by carbon because :
(A) a sulphide ore cannot be reduced to metal at all
(B) no reducing agent is found suitable for reducing a sulphide ore.
(C) the Gibb's free energy of formation of most sulphides are greater than that for CS_2.
(D) a metal oxide is generally less stable than the metal sulphide.

15. Which of the following statements is correct regarding the slag obtained during the extraction of a metal like copper or iron ?
(A) The slag is lighter and has lower melting point than the metal
(B) The slag is heavier and has lower melting point than the metal
(C) The slag is lighter and has higher melting point than the metal
(D) The slag is heavier and has higher melting point than the metal

16. Which one of the following reactions occurs during smelting in the reduction zone at lower temperature (in iron metallurgy) ?
(A) $CaO + SiO_2 \longrightarrow CaSiO_3$ (slag)
(B) $Fe_2O_3 + 3C \longrightarrow 2Fe + CO$
(C) $3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$
(D) $CO_2 + C \longrightarrow 2CO$

Exercise # 3 PART - 1 MATRIX MATCH COLUMN

1.

Column-I (Ore)	Column-II
(A) Iron	(p) Carbon reduction method
(B) Lead	(q) Self reduction
(C) Copper	(r) Thermite process
(D) Chromium	(s) Hydrometallurgical process

2. Match the ores given in column-I with typ(s) of processes given in column-II.

Column – I	Column – II
(A) Haematite	(p) Slag formation during roasting/smelting and bessemerisation.
(B) Copper pyrites	(q) Reduction by carbon monoxide / carbon at different temperatures.
(C) Carnallite	(r) Electrolytic reduction.
(D) Bauxite	(s) Calcination.

3. Match the type of processes involved in the extraction of metal given in column-I with the given ores in column-II.

Column – I	Column – II
(A) Slag formation	(p) Extraction of copper from copper pyrites.
(B) Froth – floatation	(q) Extraction of aluminium form bauxite.
(C) Leaching	(r) Extraction of iron from haematite.
(D) Roasting	(s) Extraction of tin from cassiterite
	(t) Extraction of lead from galena.

4. Match the name of the processes given in column-I with type(s) of metallurgical methods given in column-II.

Column – I	Column – II
(A) Hall – Heroult process	(p) Molten $Al_2O_3 + Na_3AlF_6$ electrolysis.
(B) Dow's sea water process	(q) Molten $MgCl_2 + CaCl_2 + NaCl$ electrolysis.
(C) Hoop's process	(r) Molten impure aluminium + fluorides of Na^+, Ba^{2+} and Al^{3+} electrolysis.
(D) Mac-Arthur Forrest process	(s) Complex formation and displacement method.

Exercise # 4 PART - 1 PREVIOUS YEAR (NEET/AIPMT)

1. The method of zone refining of metals is based on the principle of [CBSE AIPMT 2003]
(A) Greater noble character of the solid metal than that of the impurity
(B) Greater solubility of the impurity in the molten state than in the solid
(C) Greater mobility of the pure metal than that of impurity
(D) Higher melting point of the impurity than that of the pure metal

2. A solid compound X on heating gives CO_2 gas and a residue mixed with water forms Y. On passing an excess of CO_2 through Y inwater, a clear solution Z is obtained. On boiling Z, compound X is reformed. The compound X is [CBSE AIPMT 2004]
(A) $Ca(HCO_3)_2$ (B) $CaCO_3$
(C) Na_2CO_3 (D) K2 CO_3

3. Which of the following statements, about the advantage of roasting of sulphide ore before reduction is not true? [CBSE AIPMT 2007]
(A) Carbon and hydrogen are suitable reducing agents for metal sulphides
(B) The $\Delta_f G^0$ of the sulphide is greater than those for CS_2 and H_2S
(C) The $\Delta_f G^0$ is negative for roasting of sulphide ore to oxide
(D) Roasting of the sulphide to the oxide is thermodynamically feasible

4. Sulphide ores of metals are usually concentrated b y froth floatation process. Which one of the following sulphide ores offers an exception and is concentrated by chemical leaching [CBSE AIPMT 2007]
(A) Argentite (B) Galena
(C) Copper pyrite (D) Sphalerite

5. Which of the following pairs of metals is purified by van Arkel method ? [CBSE AIPMT 2011]
(A) Zr and Ti (B) Ag and Au
(C) Ag and Au (D) Ni and Fe

6. Which of the following elements is present as the impurity to the maximum extent in the pig iron? [CBSE AIPMT 2011]
(A) Carbon (B) Silion
(C) Phosphorus (D) Manganese

7. In the extraction of copper from its sulphide ore, the metal is finally obtained by the reduction of cuprus oxide with [CBSE AIPMT 2012]
(A) copper (I) sulphide (Cu_2S)
(B) Sulphur dioxide
(C) Iron sulphide(FeS)
(D) Carbon Monoxide (CO)

8. Which one of the following is a mineral of iron? [CBSE AIPMT 2012]
(A) Malachite (B) Cassiterite
(C) Pyrolusite (D) Magnetite

9. Aluminium is extracted from alumina (Al_2O_3) by electrolysis of a molten mixture of [CBSE AIPMT 2012]
(A) $Al^2O^3+HF+NaAIF_4$
(B) $Al_2O_3+CaF_2+NaAIF_4$
(C) $Al_2O_3+Na_3AIF_6+CaF_2$ d
(D) $Al_2O_3+KF+Na_3AIF_6$

10. Roasting of sulphides gives the gas X as a by-product. This is a colourless gas with choking smell of burnt sulphur and causes great damage to respiratory organs as a result of acid rain. Its aqueous solution is acideic acts as a reducing agent and its acid has never been insolated. The gas X is [NEET 2013]
(A) H_2S (B) SO_2
(C) CO_2 (D) SO_3

11. In the extraction of copper from its sulphide ore, the metal finally obtained by the reduction of cuprous oxide with [CBSE AIPMT 2015]
(A) iron (II) sulphide (B) carbon monoxide
(C) copper (I) sulphide (D) sulphur dioxide

12. Match items of Column I with the items of Column II and assign the correct code. [NEET 2016, Phase I]

Column I	Column II
(A) Cyanide process	(1) Ultrapure Ge
(B) Froth floatation process	(2) Dressing of ZnS
(C) Electrolytic reduction	(3) Extraction of Al
(D) Zone refining	(4) Extraction of Au
	(5) Purification of Ni

Codes

	a	b	c	d
(A)	2	3	1	5
(B)	1	2	3	4
(C)	3	4	5	1
(D)	4	2	3	1

13. Extraction of gold and silver involves leaching with CN^- ion. Silver is later recovered by [NEET 2017]
(A) liquation (B) distillation
(C) zone refining (D) displacement with Zn

MOCK TEST

STRAIGHT OBJECTIVE TYPE

1. Match the column (I) and (II) and select the correct answer using the codes given below.

Column - I	Column - II
(A) Argentite	(1) Halide ore
(B) Cuprite	(2) Carbonate one
(C) Siderite	(3) Oxide ore
(D) Carnallite	(4) Sulphide ore

Codes :–

	a	b	c	d
(A)	4	3	2	1
(B)	1	2	3	4
(C)	2	3	4	1
(D)	3	4	1	2

2. NaCN is sometimes added in the froth floatation process as a depressant when mineral contains ZnS and PbS because,
(A) $Pb(CN)_2$ is precipitated while there is no effect on ZnS.
(B) ZnS forms soluble complex $Na_2[Sn(CN)_4]$ while PbS forms froth
(C) PbS forms soluble complex $Na_2[Pb(CN)_4]$ while ZnS forms froth.
(D) silicious impurities settle down on the bottom.

3. Main source of lead is galena (PbS). It is converted to Pb by :

(A) : $PbS \xrightarrow[\Delta]{air} PbO + SO_2$, $PbO \xrightarrow{C} Pb + CO_2$

(B) : $PbS \xrightarrow[\Delta]{air} PbO + PbS \longrightarrow Pb + SO_2$

Self-reduction process is :
(A) A (B) B (C) both (D) none

4. The chemical composition of "slag" formed during the smelting process in the extraction of copper is :
(A) $Cu_2O + FeS$ (B) $FeSiO_3$ (C) $CuFS_2$ (D) $Cu_2S + FeO$

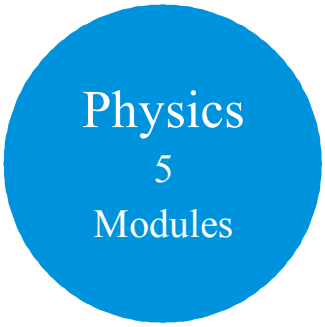
5. Which of the following statement is incorrect about the extractive metallurgy of copper?
(A) Matte chiefly consists of cuprous sulphide and some ferrous sulphide
(B) Most of the impurity of iron sulphide is removed as fusible slag during roasting.
(C) The copper pyrites is concentrated by froth floatation process.
(D) The copper obtained from Bessemer converter is called as blister copper

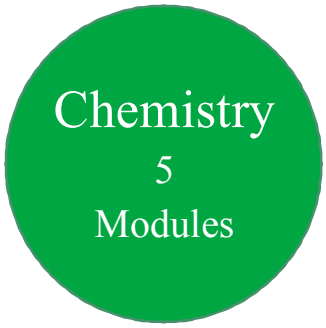
6. Roasted silver ore + $CN^-_{(aq)} + O_2 \rightarrow [X]_{(aq)} + OH^-_{(aq)}$; $[X]_{(aq)} + Zn \rightarrow [Y]_{(aq)} + Ag \downarrow$
The [X] and [Y] are respectively :
(A) $[Ag(CN)_2]^-$, $[Zn(CN)_6]^{-4}$ (B) AgCN, $[Zn(CN)_4]^{-2}$
(C) $[Ag(CN)_4]^{-3}$, $[Zn(CN)_4]^{-2}$ (D) $[Ag(CN)_2]^-$, $[Zn(CN)_4]^{-2}$

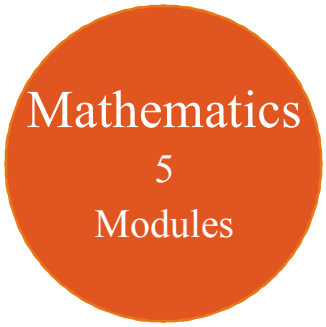
7. Match column (I) with column (II) and select the correct answer using codes given below in the lists.

Column - I	Column - II
(i) Cyanide process	(A) Extraction of Al
(ii) Self reduction	(B) Extraction of Ag
(iii) Electrolytic reduction	(C) Extraction of Cu
(iv) Carbon reduction	(D) Extraction of Sn
(A) (i) - (b), (ii) - (c), (iii) - (a), (iv) - (d)	(B) (i) - (b), (ii) - (d), (iii) - (a), (iv) - (c)
(C) (i) - (d), (ii) - (a), (iii) - (c), (iv) - (b)	(D) (i) - (c), (b) - (ii) - (d), (iv) - (a)

11th Class Modules Chapter Details

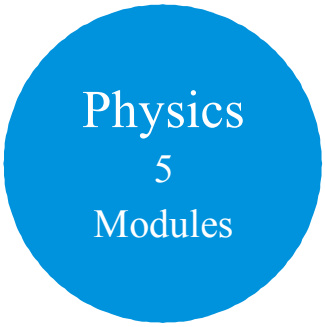


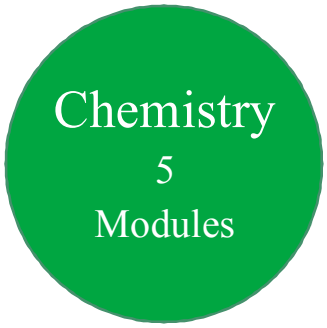


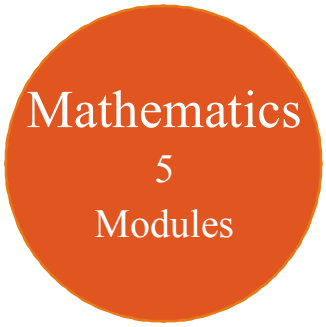


PHYSICS	CHEMISTRY	BIOLOGY
Module-1 1. Physical World & Measurements 2. Basic Maths & Vector 3. Kinematics **Module-2** 1. Law of Motion & Friction 2. Work, Energy & Power **Module-3** 1. Motion of system of particles & Rigid Body 2. Gravitation **Module-4** 1. Mechanical Properties of Matter 2. Thermal Properties of Matter **Module-5** 1. Oscillations 2. Waves	**Module-1(PC)** 1. Some Basic Conceps of Chemistry 2. Atomic Structure 3. Chemical Equilibrium 4. Ionic Equilibrium **Module-2(PC)** 1. Thermodynamics & Thermochemistry 2. Redox Reaction 3. States Of Matter (Gaseous & Liquid) **Module-3(IC)** 1. Periodic Table 2. Chemical Bonding 3. Hydrogen & Its Compounds 4. S-Block **Module-4(OC)** 1. Nomenclature of Organic Compounds 2. Isomerism 3. General Organic Chemistry **Module-5(OC)** 1. Reaction Mechanism 2. Hydrocarbon 3. Aromatic Hydrocarbon 4. Environmental Chemistry & Analysis Of Organic Compounds	**Module-1** 1. Diversity in the Living World 2. Plant Kingdom 3. Animal Kingdom **Module-2** 1. Morphology in Flowering Plants 2. Anatomy of Flowering Plants 3. Structural Organization in Animals **Module-3** 1. Cell: The Unit of Life 2. Biomolecules 3. Cell Cycle & Cell Division 4. Transport in Plants 5. Mineral Nutrition **Module-4** 1. Photosynthesis in Higher Plants 2. Respiration in Plants 3. Plant Growth and Development 4. Digestion & Absorption 5. Breathing & Exchange of Gases **Module-5** 1. Body Fluids & Its Circulation 2. Excretory Products & Their Elimination 3. Locomotion & Its Movement 4. Neural Control & Coordination 5. Chemical Coordination and Integration

12th Class Modules Chapter Details







PHYSICS

Module-1

1. Electrostatics
2. Capacitance

Module-2

1. Current Electricity
2. Magnetic Effect of Current and Magnetism

Module-3

1. Electromagnetic Induction
2. Alternating Current

Module-4

1. Geometrical Optics
2. Wave Optics

Module-5

1. Modern Physics
2. Nuclear Physics
3. Solids & Semiconductor Devices
4. Electromagnetic Waves

CHEMISTRY

Module-1(PC)

1. Solid State
2. Chemical Kinetics
3. Solutions and Colligative Properties

Module-2(PC)

1. Electrochemistry
2. Surface Chemistry

Module-3(IC)

1. P-Block Elements
2. Transition Elements (d & f block)
3. Co-ordination Compound
4. Metallurgy

Module-4(OC)

1. HaloAlkanes & HaloArenes
2. Alcohol, Phenol & Ether
3. Aldehyde, Ketone & Carboxylic Acid

Module-5(OC)

1. Nitrogen & Its Derivatives
2. Biomolecules & Polymers
3. Chemistry in Everyday Life

BIOLOGY

Module-1

1. Reproduction in Organisms
2. Sexual Reproduction in Flowering Plants
3. Human Reproduction
4. Reproductive Health

Module-2

1. Principles of Inheritance and Variation
2. Molecular Basis of Inheritance
3. Evolution

Module-3

1. Human Health and Disease
2. Strategies for Enhancement in Food Production
3. Microbes in Human Welfare

Module-4

1. Biotechnology: Principles and Processes
2. Biotechnology and Its Applications
3. Organisms and Populations

Module-5

1. Ecosystem
2. Biodiversity and Conservation
3. Environmental Issues