PRINCIPLES & PROCESSES OF ISOLATION OF ELEMENTS
[JEE ADVANCED PREVIOUS YEAR SOLVED PAPERS]

JEE ADVANCED

Single Correct Answer Type

1. Copper can be extracted from
   a. kupfernickel   b. dolomite
   c. malachite   d. galena   **(IIT-JEE 1978)**
2. In the metallurgy of iron, when limestone is added to the blast furnace, the calcium ions end up in
   a. slag   b. gangue
   c. metallic calcium   d. calcium carbonate
   (IIT-JEE 1982)
3. Iron is rendered passive by treatment with concentrated
   a. H_2SO_4 b. H_3PO_4
   c. HCl   d. HNO_3 **(IIT-JEE 1982)**
4. In the alumino-thermite process, aluminium acts as
   a. an oxidizing agent   b. a flux
   c. a reducing agent   d. a solder
   (IIT-JEE 1983)
5. The major role of fluorspar (CaF_2), which is added in small quantities in the electrolytic reduction of alumina dissolved in fused cryolite (Na_3AlF_6), is
   a. as a catalyst
   b. to make the used mixture very conducting
   c. to increase the temperature of the melt
   d. to decrease the rate of oxidation of carbon at the anode
   (IIT-JEE 1993)
6. Among the following statements, the incorrect one is
   a. calamine and siderite are carbonates
   b. argentite and cuprite are oxides
   c. zinc blende and pyrites are sulphides
   d. malachite and azurite are ores of copper
   (IIT-JEE 1997)
7. In the commercial electrochemical process for aluminium extraction, the electrolyte used is
   a. $Al(OH)_3$ in NaOH solution
   b. an aqueous solution of $Al_2(SO_4)_3$
   c. a molten mixture of Al_2O_3 and Na_3AlF_6
   d. a molten mixture of AlO(OH) and $Al(OH)_3$
   (IIT-JEE 1999)
8. The chemical process in the production of steel from haematite ore involves
   a. reduction
   b. oxidation
   c. reduction followed by oxidation
   d. oxidation followed by reduction   **(IIT-JEE 2000)**
9. Electrolytic reduction of alumina to aluminium by Hall–Heroult process is carried out
   a. in the presence of NaCl
   b. in the presence of fluorite
   c. in the presence of cryolite, which forms a melt with lower melting temperature
   d. in the presence of cryolite, which forms a melt with higher melting temperature   **(IIT-JEE 2000)**
10. The chemical composition of 'slag' formed during the smelting process in the extraction of copper is
    a. $Cu_2O + FeS$ b. $FeSiO_3$
    c. $CuFeS_2$ d. $Cu_2S + FeO$
    (IIT-JEE 2001)
11. Which of the following process is used in the extractive metallurgy of magnesium?
    a. Fused salt electrolysis
    b. Self-reduction
    c. Aqueous solution electrolysis
    d. Thermite reduction   **(IIT-JEE 2002)**
12. The methods chiefly used for the extraction of lead and tin from their ores, respectively, are
    a. self-reduction and carbon reduction
    b. self-reduction and electrolytic reduction
    c. carbon reduction and self-reduction
    d. cyanide process and carbon reduction
    (IIT-JEE 2004)
13. Which ore contains both iron and copper?
    a. Cuprite   b. Chalcocite
    c. Chalcopyrite   d. Malachite
    (IIT-JEE 2005)
14. Extraction of zinc from zinc blende is achieved by
    a. electrolytic reduction
    b. roasting followed by reduction with carbon
    c. roasting followed by reduction with another metal
    d. roasting followed by self-reduction
    (IIT-JEE 2007)
15. Native silver metal forms a water soluble complex with a dilute aqueous solution of NaCN in the presence of
    a. nitrogen   b. oxygen
    c. carbon dioxide   d. argon   **(IIT-JEE 2008)**
16. Oxidation states of the metal in the minerals haematite and magnetite, respectively, are
    a. II, III in haematite and III in magnetite
    b. II, III in haematite and II in magnetite
    c. II in haematite and II. III in magnetite
    d. III in the haematite and II. III in magnetite
    (IIT-JEE 2011)
17. In the cyanide extraction process of silver from argenitite ore, the oxidising and reducing agent respectively are
    a. O_2 and CO_2 b. O_2 and Zn dust
    c. HNO_3 and CO   d. HNO_3 and Zn dust
    (IIT-JEE 2012)
18. Sulfide ores are common for the metals
    a. Ag. Cu and Pb   b. Ag. Mg and Pb
    c. Ag. Cu and Sn   d. Al. Cu and Pb
    (JEE Advanced 2013)
19. Which series of reactions correctly chemical reactions related to iron and its compound
    a. $Fe \xrightarrow{Cl_2,\ heat} FeCl_2 \xrightarrow{heat,\ air} FeCl_2 \xrightarrow{Zn} Fe$

b. $Fe \xrightarrow{O_2, heat} Fe_2O_4 \xrightarrow{CO, 600^\circ C} FeCl_3 \xrightarrow{CO, 700^\circ C} Fe$

c. $Fe \xrightarrow{dil. H_2SO_4} FeSO_4 \xrightarrow{H_2SO_4, O_2} Fe(SO_4)_3 \xrightarrow{heat} Fe$

d. $Fe \xrightarrow{O_2, heat} FeO \xrightarrow{dil. H_2SO_4} FeSO_4 \xrightarrow{heat} Fe$

(JEE Advanced 2014)

Multiple Correct Answers Type

1. In the electrolysis of alumina, cryolite is added to
   a. lower the melting point of a alumina
   b. increase the electrical conductivity
   c. minimise the anode effect
   d. remove the impurities from alumina
   (IIT-JEE 1988)
2. Of the following, the metals that cannot be obtained by electrolysis of the aqueous solution of their salts are
   a. Ag **b.** Mg c. Cu **d.** Al
   (IIT-JEE 1990)
3. Extraction of metal from the ore *cassiterite* involves
   a. carbon reduction of an oxide ore
   b. self-reduction of a sulphide ore
   c. removal of copper impurity
   d. removal of iron impurity **(IIT-JEE 2011)**
4. The equilibrium
   $$2Cu^I \rightleftharpoons Cu^0 + Cu^{II}$$
   In aqueous medium at 25°C shift towards the left in the presence of
   a. NO_3^- **b.** Cl^-
   c. SCN^- **d.** CN^- **(IIT-JEE 2011)**
5. The carbon-based reduction method is *NOT* used for the extraction of
   a. tin from SnO_2
   b. iron from Fe_2O_3
   c. aluminium from Al_2O_3
   d. magnesium from $MgCO_3 \cdot CaCO_3$
   (JEE Advanced 2013)
6. Upon heating with Cu_2S, the reagent(s) that give copper metal is/are
   a. $CuFeS_2$ **b.** CuO
   c. Cu_2O **d.** $CuSO_4$
   (JEE Advanced 2014)

Note: These all reactions are a part of steps involved in Cu from copper pyrites.
Copper is purified by electrolytic refining of blister copper. The correct statement(s) about this process is(are)
   a. impure Cu strip is used as cathode
   b. acidified aqueous $CuSO_4$ is used as electrolyte
   c. pure Cu deposits at cathode
   d. impurities settle as anode-mud
   (JEE Advanced 2015)

Linked Comprehension Type

Passage: Copper is the most noble of the first row transition elements. It occurs in small deposits in several countries. Ores of copper include chalcanthite ($CuSO_4.5H_2O$), atacamite [$Cu_2Cl(OH)_3$], cuprite (Cu_2O), copper glance (Cu_2S), and malachite [$Cu_2(OH)_2CO_3$]. However, 80% of the world copper production comes from the ore chalcopyrite ($CuFeS_2$). Extraction of copper from chalcopyrite includes roasting, iron removal; and self-reduction.

1. Partial roasting of chalcopyrite produces
   a. Cu_2S and FeO **b.** Cu_2O and FeO
   c. CuS and Fe_2O_3 **d.** Cu_2O and Fe_2O_3
   (IIT-JEE 2010)
2. Iron is removed from chalcopyrite as
   a. FeO **b.** FeS
   c. Fe_2O_3 **d.** $FeSiO_3$ **(IIT-JEE 2010)**
3. In self-reduction, the reducing species is
   a. S **b.** O^{2-}
   c. S^{2-} **d.** SO_2 **(IIT-JEE 2010)**

Matching Column Type

1. Match the extraction processes listed in **Column I** with metals listed in **Column II**: **(IIT-JEE 2006)**

Column I	Column II
a. Self-reduction	**p.** Lead
b. Carbon reduction	**q.** Silver
c. Complex formation and displacement by metal	**r.** Copper
d. Decomposition of iodide	**s.** Boron

2. Match the conversions in **Column I** with the type(s) of reaction(s) given in **Column II**. **(IIT-JEE 2008)**

Column I	Column II
a. $PbS \rightarrow PbO$	**p.** Roasting
b. $CaCo_3 \rightarrow CaO$	**q.** Calcination
c. $ZnS \rightarrow Zn$	**r.** Carbon reduction
d. $Cu_2S \rightarrow Cu$	**s.** Self-reduction

3. Match the following choosing one item from Column I and the appropriate item from Column II.
   (IIT-JEE 1983)

Column I	Column II
a. Al	**p.** Calamine
b. Cu	**q.** Cryolite
c. Mg	**r.** Malachite
d. Zn	**s.** Carnallite

4. Match the anionic species given in Column I that are present in the ore(s) given in Column II.
   (JEE Advanced 2015)

Column I	Column II
a. Carbon	**p.** Siderite
b. Sulphide	**q.** Malachite
c. Hydroxide	**r.** Bauxite
d. Oxide	**s.** Calamine
	t. argentic

Fill in the Blanks Type

1. Casseterite is ore of ______. **(IIT-JEE 1998)**
2. In the thermite process ______ is used as reducing agent. **(IIT-JEE 1980)**
3. In the basic Bessemer process for the manufacture of steel the lining of the converter is made of ______. The slag formed consists of ______. **(IIT-JEE 1980)**
4. In extractive metallurgy of zinc partial fusion of ZnO with coke is called ______ and reduction of the ore the molten metal is called ______. **(IIT-JEE 1988)**
(Smelting, Calcining, Roasting, Sintering)

Subjective Type

1. **a.** Write the chemical equation involved in the extraction of lead from galena by self-reduction process.
   b. Match the following extraction processes with the appropriate metals listed below:

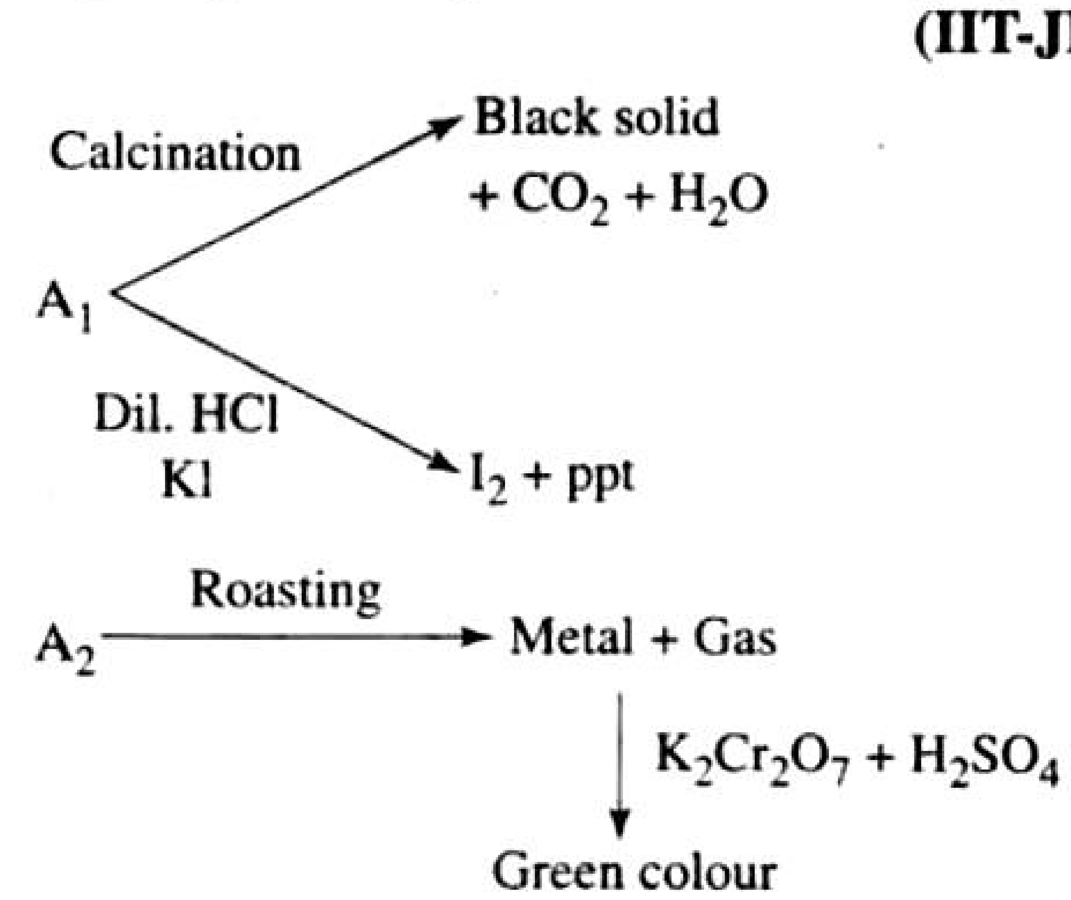
i.	Silver	(A)	Fused salt electrolysis
ii.	Calcium	(B)	Carbon reduction
iii.	Zinc	(C)	Carbon monoxide reduction
iv.	Iron	(D)	Amalgamation
v.	Copper	(E)	Self-reduction

(IIT-JEE 1979)

2. Write the matching pairs:

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

3. State the conditions under which the preparation of alumina from aluminium is carried out. Give the necessary equations which need not be balanced. **(IIT-JEE 1983)**
4. Give reasons for the following: **(IIT-JEE 1984)**
   i. Metals can be recovered from their ores by chemical methods.
   ii. High purity metals can be obtained by zone refining method.
5. Why is chalcocite roasted and not calcinated during recovery of copper? **(IIT-JEE 1987)**
6. Give the equation for the recovery of lead from galena by air reduction. **(IIT-JEE 1987)**
7. Answer the following questions briefly: **(IIT-JEE 1987)**
   i. What is the actual reducing agent of haematite in blast furnace?
   ii. Zinc, not copper, is used for the recovery of metallic silver from the complex $[Ag(CN)_2]^{\ominus}$, explain.
8. Write the balanced equations for extraction of silver from glance by cyanide process. **(IIT-JEE 1988)**
9. Write the balanced chemical equations for the following: **(IIT-JEE 1989)**
   i. Silver chloride is treated with aqueous sodium cyanide and the product thus formed is allowed to react with zinc in an alkaline medium.
   ii. Cobalt(II) solution reacts with KNO_2 in acetic acid medium.
10. Write the balanced equation for 'the extraction of copper from pyrites by self-reduction'. **(IIT-JEE 1990)**
11. Give reasons for the following. "Although aluminium is above hydrogen in the electrochemical series, it is stable in air and water". **(IIT-JEE 1994)**
12. Write a balanced equation for the reaction of argentite with KCN and name the products in solution. **(IIT-JEE 1996)**
13. When the ore haematite is burnt in air with coke around 2000° C along with lime, the process not only produces steel but also produces a silicate slag that is useful in making building materials such as cement. Discuss the same and show through balanced chemical equations. **(IIT-JEE 1998)**
14. Write the chemical reactions involved in the extraction of metallic silver from argentite. **(IIT-JEE 2000)**
15. Write down the reactions involved in the extraction of Pb. What is the oxidation number of lead in litharge? **(IIT-JEE 2003)**
16. A_1 and A_2 are two ores of metal M. A_1 on calcinations gives black precipitate, CO_2 and water. Identify A_1 and A_2. **(IIT-JEE 2004)**



Answer Key

JEE Advanced

Single Correct Answer Type

1. c.	**2.** a.	**3.** d.	**4.** c.	**5.** b.
6. b.	**7.** c.	**8.** d.	**9.** c.	**10.** b.
11. a.	**12.** a.	**13.** c.	**14.** b.	**15.** b.
16. d.	**17.** b.	**18.** a.	**19.** b.	

Multiple Correct Answers Type

1. a., b.	**2.** b., d.	**3.** a., d.
4. b., c., d.	**5.** c., d.	**6.** b., c., d.

Linked Comprehension Type

1. a. **2.** d. **3.** c.

Matching Column Type

1. (a) $\rightarrow$ (p), (r); (b) $\rightarrow$ (p), (r); (c) $\rightarrow$ (q); (d) $\rightarrow$ (s)
2. (a) $\rightarrow$ (p); (b) $\rightarrow$ (q); (c) $\rightarrow$ (p), (r); (d) $\rightarrow$ (p), (s)
3. (a) $\rightarrow$ (p), (r); (b) $\rightarrow$ (p); (c) $\rightarrow$ (q); (d) $\rightarrow$ (s)
4. (a) $\rightarrow$ (p), (q), (s); (b) $\rightarrow$ (t); (c) $\rightarrow$ (q), (r); (d) $\rightarrow$ (r)

Fill in the Blanks Type

1. Tin **2.** Aluminium
3. Magnesia and lime; calcium silicate
4. Sintering, smelting

Hints and Solutions

JEE ADVANCED

Single Correct Answer Type

1. c. Malachite is $CuCO_3 \cdot Cu(OH)_2$; it is ore of copper.

2. a. In the metallurgy of iron, when limestone is added to the blast furnace, the calcium ions end up in slag.

$$CaCO_3 \rightarrow CaO + CO_2$$
$$CaO + SiO_2 \rightarrow CaSiO_3 \text{ (slag)}$$

3. d. The inertness exhibited by metals under conditions in which chemical activity is expected is known as passivity. The phenomenon of passivity is explained by assuming the formation of a thin film of oxide on the surface of the metal which prevents the action of the reagent. The concentrated nitric acid makes metals such as Fe, Co, Ni, Cr, Al, etc., passive.

4. c. Al reduces Fe_2O_3 or Cr_2O_3 to respective metals and acts as a reducting agent.

$$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe$$

5. b. The electrolysis of pure alumina faces some difficulties. Pure alumina is a bad conductor of electricity. The fusion temperature of pure alumina is about 2000°C. At this temperature when electrolysis is carried out on the fused mass, the metal formed vaporizes, as the boiling point of aluminium is 1800°C. These difficulties are overcome by using a mixture, containing alumina, cryolite (Na_3AlF_6), and fluorspar (CaF_2).

6. b. Argentite (Ag_2S) is a sulphide ore. It is not an oxide ore.

7. c. The electrolysis of pure alumina faces some difficulties. Pure alumina is a bad conductor of electricity. The fusion temperature of pure alumina is about 2000°C, and at this temperature, when the electrolysis is carried out on the fused mass, the metal formed vaporizes as the boiling point of aluminium is 1800°C. These difficulties are overcome by using a mixture containing alumina, cryolite (Na_3AlF_6), and fluorspar (CaF_2).

8. d. First, by calcinations and roasting, the ferrous oxide is oxidized to ferric oxide. Then, in balst furnace smelting is done, where it is reduced to get iron.

$$4FeO + O_2 \rightarrow 2Fe_2O_3$$
$$Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$$
$$Fe_2O_3 + CO \rightarrow FeO + CO_2$$
$$FeO + CO \rightarrow Fe + CO_2$$

9. c. The electrolysis of pure alumina faces some difficulties. Pure alumina is a bad conductor of electricity. The fusion temperature of pure alumina is about 2000°C, and at this temperature, when the electrolysis is carried out on the fused mass, the metal formed vaporizes as the boiling point of aluminium is 1800°C. These difficulties are overcome by using a mixture containing alumina, cryolite (Na_3AlF_6), and fluorspar (CaF_2).

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

$$2FeS + 3O_2 \rightarrow 2FeO + 2SO_2\uparrow;$$
$$FeO + SiO_2 \rightarrow \underset{\text{Slag}}{FeSiO_3}$$

11. a. $\underset{\text{(fused anhydrous)}}{MgCl_2} \rightarrow Mg^{+2} + 2Cl^-$

At Cathode : $Mg^{+2} + 2e^- \rightarrow Mg$;
At anode : $2Cl^- - 2e^- \rightarrow Cl_2\uparrow$

12. a. The methods chiefly used for the extraction of lead and tin from their ores are self-reduction and carbon reduction, respectively.
Tin is extracted from oxide ore cassiterite by reduction with carbon in a reverberatory furnace.

$$SnO_2 + 2C \rightarrow Sn + 2CO$$

Lead is mainly extracted from sulphide ore called galena. Self-reducing finally takes place.

$$2PbO + PbS \rightarrow 3Pb + SO_2$$
$$PbSO_4 + PbS \rightarrow 2Pb + 2SO_2$$

13. c. Cuprite: Cu_2O; Chalcocite: Cu_2S; Chalcopyrite: $CuFeS_2$; Malachite : $Cu(OH)_2$. $CuCo_3$. We see that $CuFeS_2$ contais both Cu and Fe.

14. b. Extraction of Zn from ZnS (zinc blende) is achieved by roasting followed by reduction with carbon.

$$2ZnS \rightarrow + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2\uparrow$$
$$ZnO + C \xrightarrow{\Delta} Zn + CO\uparrow$$

15. b. Native silver metal forms a water soluble complex with a dilute aqueous solution of NaCN in the presence of oxygen as follows.

$$4Ag + 8NaCN + 2H_2O + O_2 \rightarrow 4Na[Ag(CN)_2] + 4NaOH$$

16. d. i. Haematite is Fe_2O_3 in which Fe is present in III oxidation state.

ii. Magnetite (Fe_3O_4) is an equimolar mixture of FeO and Fe_2O_3.
Oxidation state of Fe in FeO is II.
Oxidation state of Fe in Fe_2O_3 is III.

17. b. In the extraction of silver, Ag_2S is reached with KCN in the presence of air.

$$2\overset{+1}{Ag_2} S + 8CN^{\ominus} + \overset{0}{O_2} + 2H_2O \rightarrow 4[Ag(CN)_2]^{\ominus} + 2S + 2\overset{-2}{O}H$$

(Thus O_2 is oxidant)

$$2[Ag(CN)_2]^{\ominus} + Zn \rightarrow [Zn(CN)_4]^{2-} + 2\overset{0}{Ag}\downarrow$$

(Thus Zn is reductant)

18. a. Silver, copper and lead are commonly found in earth's crust as Ag_2S (silver glance), $CuFeS_2$ (copper pyrites) and PbS (galena).

19. b. In (a), $FeCl_3$ cannot be reduced when heated in air.
In (c), $Fe_2(SO_4)_3$ cannot be converted to Fe on heating; instead oxide(s) will be formed.
In (d), Fe_2SO_4 cannot be converted to Fe on heating; instead oxide(s) will be formed.
Hence (b) is correct.

Multiple Correct Answers Type

1. a., b.
The electrolysis of pure alumina faces some difficulties. Pure alumina is a bad conductor of electricity. The fusion temperature of pure alumina is about 2000°C, and at this temperature, when the electrolysis is carried out on the fused mass, the metal formed vaporizes as the boiling point of aluminium is 1800°C. These difficulties are overcome by using a mixture containing alumina, cryolite (Na_3AlF_6), and fluorspar (CaF_2).

2. b., d.
Both Mg and Al have their reduction potentials less than that of water [$E^\circ = -0.83$ V]. Hence, their ions in the aqueous solution cannot reduce. Instead water will be reduced: $2H_2o + 2e^- \rightarrow H_2 + 2OH^-$

3. a., d.
Cassiterite ore (SnO_2):

$$\left.\begin{aligned} SnO_2 + C &\rightarrow SnO + CO \\ SnO_2 + C &\rightarrow Sn + CO_2 \end{aligned}\right\} \text{carbon reduction}$$

Also iron is present as impurity in the ore.

4. b., c., d.
Cu^{2+} ions will react with CN^- and SCN^- forming $[Cu(CN)4]^{3-}$ and $[Cu(SCN)_4]^{3-}$ leading the reaction in the backward direction.

$$Cu^{2+} + 2CN^- \rightarrow Cu(CN)_2$$
$$2Cu(CN)_2 \rightarrow 2CUCN + (CN)_2$$
$$CuCN + 3CN^- \rightarrow [Cu(CN)_4]^{3-}$$
$$Cu^{2+} + 4SCN^- \rightarrow [Cu(SCN)_4]^{3-}$$

Cu^{2+} also combines with $CuCl_2$ which reacts with Cu to produce CuCl pushing the reaction in the backward direction.

$$CuCl_2 + Cu \rightarrow 2CuCl\downarrow$$

5. c., d.
Al from Al_2O_3 and Mg from $MgCO_3 \cdot CaCO_3$ are separately extracted by electrolytic reduction.

6. **b., c., d.**

a. $2CuFeS_2 + O_2 \xrightarrow{\Delta} Cu_2S + 2FeS + SO_2$

b. $4CuO \xrightarrow{1100°C} 2Cu_2O + O_2$

$2Cu_2O + Cu_2S \xrightarrow{\Delta} 6Cu + SO_2$

c. $Cu_2S + 2Cu_2O \xrightarrow{\Delta} 6Cu + SO_2$

d. $CuSO_4 + 2Cu_2O \xrightarrow{720°C} CuO + SO_2 + \frac{1}{2}O_2$

$4CuO \xrightarrow{1100°C} 2Cu_2O + O_2$

$2Cu_2O + Cu_2S \xrightarrow{\Delta} 6Cu + SO_2$

In electrolytic refining of blister Cu, acidified $CuSO_4$ is used as electrolyte, pure Cu deposits at cathode and impurities settle as anode mud.

Linked Comprehension Type

1. a. Partial roasting:

$2CuFeS_2 + O_2 \xrightarrow{\Delta} Cu_2S + 2FeS + SO_2$

$2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$

2. d. Removal of iron by adding SiO_2 as flux.

$FeO + SiO_2 \rightarrow FeSiO_3$ (Slag)

3. c. Self-reducing

$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$

The oxidation number of sulphur increases from −1 to +4. Therefore, S^{2-} is the reducing species.

Matching Column Type

1. (a) → (p), (r); (b) → (p), (r); (c) → (q); (d) → (s)

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

$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$;
$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$] self reduction

$2PbS + 3O_2 \rightarrow 2PbO + 2SO_2$;
$PbS + 2PbO \rightarrow 3Pb + SO_2$] self reduction

Hence (a) → (p), (r)

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

$PbO + C \rightarrow Pb + CO_2$;

$2Cu_2O + C \rightarrow 4Cu + CO_2$

Hence (b) → (p), (r)

c. Extraction from argentite (Ag_2S)

$Ag_2S + 2NaCN \rightleftharpoons Na_2S + 2AgCN$;

$AgCN + NaCN \rightarrow \underset{\text{Sod. argentocyanide soluble}}{Na[Ag(CN)_2]}$

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

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

Hence (c) → (q)

d. Among the halides of boron, BI_3 is unstable because of the large size of Iodine and small size of boron atom. Hence it decomposes to given boron. Thus, (d) → (s).

2. (a) → (p); (b) → (q); (c) → (p), (r); (d) → (p), (s)

(a) Conversion of sulphide ore to oxide is called roasting.

(b) Conversion of carbonate ore to oxide is called calcinations.

(c) $ZnS \xrightarrow{\text{Roasting}} ZnO \xrightarrow{\text{Reduction with C}} Zn$

(d) $2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$ (Roasting)

$Cu_2S + Cu_2O \rightarrow 6Cu + SO_2$ (Self- or auto-reduction)

3. (a) → (p), (r); (b) → (p); (c) → (q); (d) → (s)

Cryolite : Na_3AlF_6

Malachite : $CuCO_3 \cdot Cu(OH)_2$

Carnallite : $KClMgCl_2 \cdot 6H_2O$

Calamine : $ZnCO_3$

4. (a) → (p), (q), (s); (b) → (t); (c) → (q), (r); (d) → (r)

Siderite → $FeCO_3$
Malachite → $CuCO_3 \cdot Cu(OH)_2$
Bauxite → $Al_2O_3 \cdot Cu(OH)_2$
Calamine → $ZnCO_3$
Argentite → $Ag2S$

Fill in the Blanks Type

1. Tin: It is SnO_2. [The formulae of Casseterite ore in SnO_2]
2. Aluminium

$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe + \text{Heat}$ [Thermite reaction]

3. Magnesia and lime; calcium silicate

The lining of converter is made of magnesia and lime slag formed consists of $CaSiO_3$.

4. Sintering, smelting.

Subjective Type

1. a. Galena is roasted in excess of air in ore reverberatory furnace

$2PbS + \underset{\text{(air)}}{3O_2} \rightarrow 2PbO + 2SO_2$

$PbS + 2O_2 \rightarrow PbSO_4$

It is followed by self-reduction

$PbS + PbSO_4 \rightarrow 2Pb + 2SO_2$

$PbS + 2PbO \rightarrow 2Pb + SO_2$

b.

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

2.

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

3. $Al + NaOH \xrightarrow{\text{Aqueous}} NaAlO_2 + H_2O$

$NaAlO_2 \xrightarrow{CO_2} Al(OH)_3 + Na_2CO_3$

$Al(OH)_3 \xrightarrow{\Delta} \underset{\text{Alumina}}{AlO_3} + H_2O$

4. i. Because they occur as oxides, carbonats sulphides which can be calcined or roasted and then further by chemical methods they can be converted to metals.

ii. Zone refining is based on the difference in solubility of impurities in molten and solid state of the metal. This method is used for obtaining metals of very high purity.
Ge, Si and Ga used in semi-conductors are refined in this manner. These metals can be easily melted and can easily crystallize out from the melt form.

5. Excess of air (used during roasting) is necessary for converting chalcocite (a sulphide ore) to oxide. Calcination does not convent it to oxide.

6. Recovery of Pb from galena:
$2PbS + 3O_2 \rightarrow 2PbO + 2SO_2\uparrow$
$PbS + 2PbO \rightarrow 3Pb + SPO_2\uparrow$

7. i. For iron, first by calcinations and roasting, the ferrous oxide is oxidized to ferric oxide. Then in blast furnace, smelting is done, where it is reduced to iron.

$$4FeO + O_2 \rightarrow 2Fe_2O_3$$
$$Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$$
$$Fe_2O_3 + CO \rightarrow 2FeO + CO_2$$
$$FeO + CO \rightarrow Fe + CO_2$$

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

ii. Zinc is more reducing and cheaper than copper.

8. In case of silver metal, sulphide ore is treated with sodium cyanide. Sodium argentocyanide complex is formed which on treating with zinc metal gives silver.

$$Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2] + Na_2S$$
$$2Na[Ag(CN)_2] + Zn \rightarrow \underset{\text{Soluble}}{Na_2[Zn(CN)_4]} + \underset{\text{ppt}}{2Ag\downarrow}$$

9. i. $AgCl + 2NaCN \rightleftharpoons NaCl + Na[Ag(CN)_2]$

$$2Na[Ag(CN)_2] + Zn \rightarrow \underset{\text{soluble}}{Na_2[Zn(CN)_4]} + 2Ag\downarrow$$

ii. $CoCl_2 + 2KNO_2 \rightarrow Co(NO_2)_2 + 2KCl$

$$KNO_2 + CH_3COOH \rightarrow CH_3COOK + HNO_2$$
$$Co(NO_2)_2 + 3KNO_2 + 2HNO_2 \rightarrow \underset{\text{Potassium hexanitrocobaltate (III)}}{K_3[Co(NO_2)_6]\downarrow} + NO + H_2O$$

10. **Roasting:**

$$2CuFeS_2 + O_2 \xrightarrow{\Delta} Cu_2S + 2FeS + SO_2$$
$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 3SO_2$$
$$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$$
$$2FeS + 3O_2 \rightarrow 2FeO + 2SO_2$$

11. When Al is exposed to air, it forms a thin invisible continuous resistant protective film of Al_2O_3.

12. Potassium dicyanoargentate (I).

$$Ag_2S + 4KCN \rightarrow 2K[Ag(CN)_2] + K_2S$$

13. First, by calcinations and roasting, the ferrous oxide is oxidized to ferric oxide. Then, in balst furnace, smelting is done, where it is reduced to get iron.

Calcination:

$$2Fe_2O_3 \cdot 3H_2O \rightarrow 2Fe_2O_3 + 3H_2O$$
$$FeCO_3 \rightarrow FeO + CO_2$$
$$2FeO + \frac{1}{2}O_2 \rightarrow Fe_2O_3$$

Reduction:

$$3Fe_2O_3 + CO \xrightarrow{573\text{–}673\text{ K}} 2Fe_3O_4 + CO_2$$
$$Fe_3O_4 + CO \xrightarrow{773\text{–}873\text{ K}} 3FeO + CO_2$$
$$FeO + CO \xrightarrow{773\text{–}873\text{ K}} Fe + CO_2$$

In the basic Bessemer process for the manufacture of steel, the lining of the converter is made up of lime. The slag formed consists of $Ca_3(PO_4)_2$.
Phosphorous is oxidized to P_4O_{10}, which reacts with lime to form slag.

$$P_4 + 5O_2 \rightarrow P_4O_{10}$$
$$6CaO + P_4O_{10} \rightarrow \underset{\text{(Thomas slag)}}{2Ca_3(PO_4)_2}$$
$$SiO_2 + \underset{\text{(Lime)}}{CaO} \rightarrow \underset{\text{(Slag)}}{CaSiO_3}$$ (Slag $CaSiO_3$ is used as building material)

14. Silver is extracted from argentite ore by MacArthur Forrest cyanide process. In case of silver metal, the sulphide ore is treated with sodium cyanide and a current of air is continuously circulated. Sodium argentocyanide complex is formed, which on treating with zinc metal gives silver.

$$Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2] + Na_2S$$ (oxidation of Ag)

$$2Na[Ag(CN)_2] + Zn \rightarrow \underset{\text{Soluble}}{Na_2[Zn(CN)_4]} + \underset{\text{ppt.}}{2Ag\downarrow}$$ (Reduction of Ag)

15. Lead is mainly extracted from sulphide ore called galena. Roasting is done followed by reduction with carbon. Self-reducing finally takes place.

$$\left.\begin{array}{l}2PbS + 3O_2 \rightarrow 2PbO + SO_2\uparrow \\ PbS + 2O_2 \rightarrow PbSO_4\end{array}\right\} \text{Roasting}$$

The roasted mineral is smelted into lead

$$\left.\begin{array}{l}PbSO_4 + PbS \rightarrow 2Pb + 2SO_2\uparrow \\ PbS + 2PbO \rightarrow 3Pb + SO_2\end{array}\right\} \text{Smelting}$$

Litharge is chemically PbO and the oxidation state of lead is +2.

16. **Concept:** Calcination is used for carbonate ores.
Roasting is done for sulphide ore.
SO_2 gas gives green coloured solution with $K_2Cr_2O_7$.
A_1 is malachite $CuCO_3 \cdot Cu(OH)_2$.

$$CuCO_3 \cdot Cu(OH)_2 \xrightarrow{\Delta} 2CuO + CO_2\uparrow + H_2O$$

CuO is the black solid.

$$CuCO_3 . Cu(OH)_2 \xrightarrow{\text{dil.HCl}} CuCl_2 + CO_2\uparrow + H_2O$$
$$CuCl_2 \xrightarrow{KI} Cu_2I_2 + KCl + I_2$$

A_2 is copper glance Cu_2S, a sulphide ore.

$$Cu_2S \xrightarrow[\Delta]{O_2} Cu_2O + SO_2\uparrow$$
$$Cu_2S + Cu_2O \rightarrow Cu + SO_2\uparrow$$

The gas SO_2 gives green colour with acidified $K_2Cr_2O_7$.

$$K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \rightarrow K_2SO_4 + \underset{\text{Green}}{Cr(SO_4)_3} + 4H_2O$$