14

General Principles and Processes of Isolation of Metals

TOPIC 1

Occurrence, Thermodynamic and Electrochemical Principles of Metallurgy

01 Identify the incorrect statement. **[NEET (Odisha) 2019]**

(a) The scientific and technological process used for isolation of the metal from its ore is known as metallurgy
(b) Minerals are naturally occurring chemical substances in the earth's crust
(c) Ores are minerals that may contain a metal
(d) Gangue is an ore contaminated with undesired materials

Ans. *(d)*

The earthly impurities like sand, clay, mica, etc., associated with ores are called gangue or matrix. In other words, contaminated undesired materials present in an ore is called gangue. Thus, statement (d) is incorrect while other options contain correct statements.

02 Which one is malachite from the following? **[NEET (National) 2019]**

(a) $Cu(OH)_2$
(b) Fe_3O_4
(c) $CuCO_3 \cdot Cu(OH)_2$
(d) $CuFeS_2$

Ans. *(c)*

Malachite is an ore of copper and its composition is $CuCO_3 \cdot Cu(OH)_2$.

Azurite ($Cu(OH)_2$) and copper pyrites ($CuFeS_2$) are also the ores of copper (Cu).

Mgnetite (Fe_3O_4) is an ore of iron (Fe).

Hence, option (c) is correct.

03 Considering Ellingham diagram, which of the following metals can be used to reduce alumina? **[NEET 2018]**

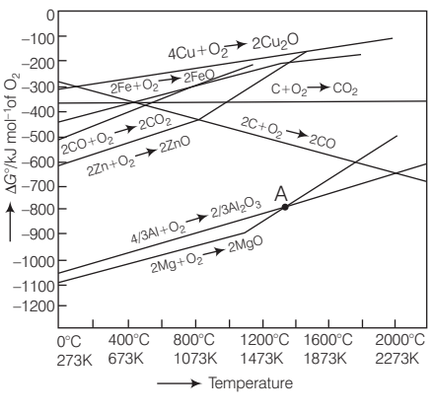
(a) Mg (b) Zn
(c) Fe (d) Cu

Ans. *(a)*

Key concept *Ellingham diagrams help us in predicting the feasibility of thermal reduction of an ore. The criterion of feasibility is that at a given temperature, Gibbs energy of the reaction must be negative.*

Gibbs energy ΔG° *vs* T plots (schematic) for formation of some oxides (Ellingham diagram).

According to Ellingham diagram, the temperature at which two lines intersect shows that the metal will reduce the oxide of other metals which lie above it in Ellingham diagram.



In other words, the metal oxide having more negative value of ΔG_f° can reduce the oxide having less negative ΔG_f°. As, Mg has more $-\Delta G^\circ$ value than alumina, so it will be in lower part of Ellingham diagram. Hence, Mg will be used to reduce alumina.

04 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 acidic 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

Ans. *(b)*

SO_2 gas is obtained when any sulphide ore is roasted.

$$2\,M_2S + 3\,O_2 \xrightarrow{\Delta} 2\,M_2O + 2\,SO_2$$

This gas exhibits all the characteristics that are given in the question.

05 Which one of the following is a mineral of iron? **[CBSE AIPMT 2012]**

(a) Malachite (b) Cassiterite
(c) Pyrolusite (d) Magnetite

Ans. *(d)*

Mineral	Chemical composition
Malachite	$CuCO_3 \cdot Cu(OH)_2$
Cassiterite	SnO_2
Pyrolusite	MnO_2
Magnetite	FeO_4

Thus, magnetite is a mineral of iron.

06 Sulphide ores of metals are usually concentrated by 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

Ans. *(d)*

Galena (PbS), copper pyrites ($CuFeS_2$) and argentite (Ag_2S) are concentrated by froth floatation process but sphalerite (ZnS) is concentrated by chemical leaching.

07 Cassiterite is an ore of **[CBSE AIPMT 1999]**

(a) Mn (b) Ni
(c) Sb (d) Sn

Ans. *(d)*

Cassiterite is an ore of Sn, its chemical composition is SnO_2. It is also known as tin stone.

08 Calcium is obtained by the **[CBSE AIPMT 1997]**

(a) roasting of limestone
(b) electrolysis of solution of calcium chloride in H_2O
(c) electrolysis of molten anhydrous calcium chloride
(d) reduction of calcium chloride with carbon

Ans. *(c)*

Calcium is obtained by electrolysis of molten anhydrous calcium chloride.

09 Cinnabar is an ore of **[CBSE AIPMT 1991]**

(a) Hg (b) Cu
(c) Pb (d) Zn

Ans. *(a)*

Cinnabar is an ore of mercury which have formula HgS.

10 Calgon used as a water softner, is **[CBSE AIPMT1989]**

(a) $Na_2[Na_4(PO_3)_6]$
(b) $Na_4[Na_2(PO_3)_6]$
(c) $Na_4[Na_4(PO_4)_5]$
(d) $Na_4[Na_2(PO_4)_6]$

Ans. *(a)*

Sodium polymetaphosphate is used to remove the permanent hardness of water. The commercial name of sodium polymetaphosphate is calgon meaning calcium gone.

The molecular formula of calgon is $Na_2[Na_4(PO_3)_6]$.

TOPIC 2
Extraction and Isolation of Metals

11 The maximum temperature that can be achieved in blast furnace is **[NEET 2021]**

(a) upto 1200 K
(b) upto 2200 K
(c) upto 1900 K
(d) upto 5000 K

Ans. *(b)*

A blast furnace is generally used for reduction of iron oxides but it can be used for extraction of other metals like Pb from PbO, etc.

In a blast furnace, hot air is blown from the bottom of furnace. This bottom surface has the maximum temperature of upto 2200 K.

12 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

Ans. *(d)*

Extraction of gold and silver involves leaching with CN^- ion. Silver is later recovered by distillation of Zn.

In the metallurgy of silver or gold, the respective metal is leached with a dilute solution of NaCN or KCN in the presence of air to obtain the metal in solution as complex. From the complex, metal is obtained later by replacement.

In general,

$$4M(s) + 8CN^-(aq) + 2H_2O(aq) + O_2(g) \longrightarrow 4[M(CN)_2]^-(aq) + 4OH^-(aq)$$

$$2[M(CN)_2]^-(aq) + Zn(s) \longrightarrow [Zn(CN)_4]^{2-}(aq) + 2M(s)$$

M = Ag or Au

This method is known as **Mac-Arthur** Forest cyanide process.

13 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

Ans. *(c)*

$$Cu_2S + 2Cu_2O \longrightarrow 6Cu + SO_2 \uparrow$$

14 Aluminium is extracted from alumina (Al_2O_3) by electrolysis of a molten mixture of **[CBSE AIPMT 2012]**

(a) $Al_2O_3 + HF + NaAlF_4$
(b) $Al_2O_3 + CaF_2 + NaAlF_4$
(c) $Al_2O_3 + Na_3AlF_6 + CaF_2$
(d) $Al_2O_3 + KF + Na_3AlF_6$

Ans. *(c)*

Alumina, Al_2O_3 is a bad conductor of electricity and has very high melting point, so before subjecting to electrolysis, it is mixed with fluorspar (CaF_2) and cryolite (Na_3AlF_6), which lower its melting point and make it more conducting. Mainly CaF_2 and Na_3AlF_6 are mixed with Al_2O_3 for converting Al_2O_3 in molten state.

15 In the extraction of copper from its sulphide ore, the metal is finally obtained by the reduction of cuprous oxide with **[CBSE AIPMT 2012]**

(a) copper (I) sulphide (Cu_2S)
(b) sulphur dioxide (SO_2)
(c) iron sulphide (FeS)
(d) carbon monoxide (CO)

Ans. *(a)*

In the extraction of copper from its sulphide ore, when ore is subjected to roasting, some of it is oxidised to Cu_2O which reacts with the remaining Cu_2S (sulphide ore) to give copper metal.

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

$$2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2 \uparrow$$

In this process Cu_2S behaves as reducing agent.

16 Which of the following elements is present as the impurity to the maximum extent in the pig iron? **[CBSE AIPMT 2011]**

(a) Carbon (b) Silicon
(c) Phosphorus (d) Manganese

Ans. *(a)*

Pig iron contains about 4% carbon (major impurity) and other impurities (S, P, Si, Mn) in trace amounts.

17 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 $\Delta_f G°$ of the sulphide is greater than those for CS_2 and H_2S

(c) The $\Delta_f G°$ is negative for roasting of sulphide ore to oxide

(d) Roasting of the sulphide to the oxide is thermodynamically feasible

Ans. *(a)*

Carbon and hydrogen are not suitable reducing agents for metal sulphides.

18 Which one of the following elements constitutes a major impurity in pig iron? **[CBSE AIPMT 1998]**

(a) Silicon (b) Oxygen

(c) Sulphur (d) Graphite

Ans. *(d)*

Graphite produces impurity in pig iron. Pig iron contains 2.5 to 5.0% of carbon.

19 The reaction of H_2O_2 with hydrogen sulphide is an example of ..... reaction. **[CBSE AIPMT 1988]**

(a) addition (b) oxidation

(c) reduction (d) acidic

Ans. *(b)*

When H_2O_2 is reacted with hydrogen sulphide (H_2S), it form S and water. In this reaction H_2S is oxidised to sulphur. H_2O_2 act as oxidising agent.

$$H_2O_2 + H_2S \longrightarrow S + 2H_2O$$

TOPIC 3
Refining of Metals

20 Which one of the following methods can be used to obtain highly pure metal which is liquid at room temperature? **[NEET 2021]**

(a) Electrolysis

(b) Chromatography

(c) Distillation

(d) Zone refining

Ans. *(c)*

Mercury is the only metal which is liquid at room temperature. Impure mercury metal is evaporated to obtain highly pure mercury metal as distillate. This method is known as distillation.

21 Match the elements in Column I with methods of purification in Column II. **[NEET (Oct.) 2020]**

	Column I		Column II
A.	Boron	I.	van-Arkel method
B.	Tin	II.	Mond's process
C.	Zirconium	III.	Liquation
D.	Nickel	IV.	Zone refining

	A	B	C	D		A	B	C	D
(a)	IV	III	I	II	(b)	IV	III	II	I
(c)	II	I	IV	III	(d)	III	IV	I	II

Ans. *(a)*

(A) Boron (and Ge, Si, Ga, In) get purified by zone refining (IV).

(B) Tin (and Bi, Pb) get purified by Liquation (III).

(C) Zirconium (and Ti, Hf) get purified by van Arkel method (I).

(D) Nickel is purified by Mond's process (II).

Hence, option (a) is correctly match.

22 Identify the correct statement from the following: **[NEET (Sep.) 2020]**

(a) Blister copper has blistered appearance due to evolution of CO_2.

(b) Vapour phase refining is carried out for nickel by van Arkel method.

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

(d) Wrought iron is impure iron with 4% carbon.

Ans. *(c)*

(a) Matte on auto-reduction produces blister copper, which has blistered appearance due to evolution of SO_2 (not CO_2).

$$\underset{\text{Matte}}{Cu_2S} + 2Cu_2O \longrightarrow \underset{\text{Blister copper}}{6\,Cu} + SO_2\uparrow$$

(b) Vapour phase refining is carried out for Ni by Mond's process (not by van Arkel method).

$$\underset{\text{Impure}}{Ni} \xrightarrow[80°C]{4CO} Ni(CO)_4 \xrightarrow[-4CO]{200°C} \underset{\text{Pure}}{Ni}$$

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

(d) Wrought iron the purest form of iron which contains 0.2-0.5% carbon (not 4%).

So, option (c) is correct.

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

Ans. *(d)*

A – 4, B – 2, C – 3, D – 1

- **Cyanide process** It is a metallurgical technique for extracting Au (gold) from low grade ore by converting the Au to a water-soluble coordination complex.
- **Froth floatation process** This process is used for dressing of sulphide ore, i.e. ZnS.
- **Electrolytic reduction** This process is used for extraction of Al which is carried out in a steel tank lined inside with graphite. Here, graphite serves as cathode. The electrolyte consists of alumina dissolved in fused cryolite (Na_3AlF_6) and fluorspar (CaF_2).
- **Zone refining** This process is used for ultra pure Ge element. An ingot of Ge is first purified by zone refining. Then a small amount of antimony is placed in the molten zone which is passed through the pure Ge with the proper choice of rate of heating and other variables.

24 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) Ni and Fe

(d) Ga and In

Ans. *(a)*

Zr and Ti are purified by van-Arkel method.

$$\underset{\text{Impure}}{Zr} + 2I_2 \xrightarrow{600\,^\circ C} ZrI_4 \xrightarrow{1800\,^\circ C} \underset{\text{Pure}}{Zr} + 2I_2$$

This method is useful for removing all the oxygen and nitrogen present in the form of impurity in certain metals like Zr and Ti.

25 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

Ans. *(b)*

The method of zone refining of metals is based on the principle of greater solubility of the impurity in the molten state than in the solid.

Elements which are used as semiconductors like Si, Ge, Ga etc, are refined by this method. Gallium arsenide and indium antimonide (also used as semiconductor) are also refined by this method.

26 Purification of aluminium by electrolytic refining is known as

[CBSE AIPMT 1999]

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

Ans. *(c)*

Purification of aluminium by electrolytic refining is known as Hoope's process. By this process 99.9% pure aluminium metal is obtained.

The cell used for this process consist of three layers. In this cell pure Al acts as cathode and anode is made up of impure Al.

27 Elemental silicon to be used as a semiconductor is purified by

[CBSE AIPMT 1996]

(a) heating under vacuum
(b) floatation
(c) zone refining
(d) electrolysis

Ans. *(c)*

Zone refining is used for metals which are required in very high purity. Semiconductor grade silicon is purified by this method (Si, Ge).