Metallurgy

Introduction

Metallurgy

- The extaction and isolation of an element from its combined from involves various principles of chemistry.
- Some general principles are common to all the extraction processes of metals.

Mineral :

- The naturally occurring chemical substances in form of which the metals occur in the earth crust along with impurities are called minerals.
  Ex. Mineral of Aluminium – Bauxite, Cryolite, Clay, Feldspar, Mica.

Ore :

- The mineral from which metal can be extracted easily & economically

  Ore → Metal

Ex. Fe – Fe_2O_3 (Haematite), Fe_3O_4 (Magnetite), $FeSO_2$ (Iron pyrite), $FeCO_3$ (Siderite)

Definition

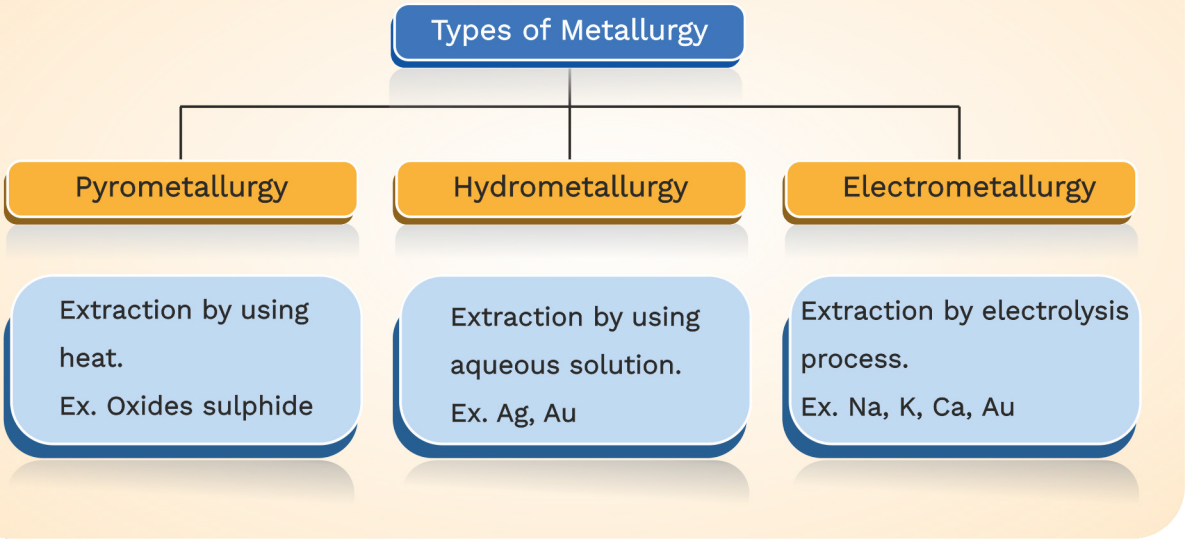
The entire scientific and technological process used for isolation of the metal from its ores is known as metallurgy.

Definition

Those compounds of metals in which metal occurs in nature is called minerals.

Concept Ladder

"All ores are minerals but all minerals cannot be ores."



Metal	Ores	Composition
Aluminium	• Bauxite • Cryolite • Kaolinite (a form of clay)	$AlO_x(OH)_{3-2x}$(where $0 < x < 1$) AlF_6Na_3 $[Al_2(OH)_4Si_2O_5]$
Iron	• Haematite • Magnetite • Siderite • Iron pyrites	Fe_2O_3 Fe_2O_4 $FeCO_3$ FeS_2
Copper	• Copper pyrites • Malachite • Cuprite • Copper glance	$CuFeS_2$ $CuCO_3.Cu(OH)_2$ Cu_2O Cu_2S
Zinc	• Zinc blende or Sphalerite • Calamine • Zincite	ZnS $ZnCO_3$ ZnO
Lead	• Cerussite • Galena • Anglesite	$PbCO_3$ PbS $PbSO_4$
Mercury	• Cinnabar	HgS
Silver	• Silver glance/Argentite • Horn silver	Ag_2S $AgCl$
Potassium	• Carnallite • Indian nitre	$KCl.MgCl_2.6H_2O$ KNO_3
Fluorine	• Cryolite • Fluorspar	Na_3AlF_6 CaF_2

Rack your Brain

Which metal undergoes **Hydrometallurgical Process** and why ?

Q1 Al is absent in
(1) Bauxite
(2) Cryolite
(3) Feldspar
(4) Fluorspar

A1 (4) Fluorspar

Q2 Most abundant metal is
(1) Cu
(2) Al
(3) Fe
(4) Au

A2 (2) Al

Q3 Why Al is costly than Iron ?

A3 In extraction of Al large amount of electrical energy is used as compared to iron.

$\underset{\text{Bauxite}}{Al_2O_3.\ 2H_2O} \longrightarrow Al$ (Difficult process, more electricity required)

$\underset{\text{Haematite ore}}{Fe_2O_3} \longrightarrow Fe$ (Easy process)

Occurrence :

1. Free form (Native form) – Less reactive
   Ex: Noble metal/Inert metal *(Au, Pt, Ag)*
2. Combined form – More reactive metal found in combined form i.e. Oxide, Halide, Sulphide, Sulphate, Carbonate
   Ex:

Previous Year's Questions

Which one is malachite from the following

[NEET-2019]

(1) $CuCO_3$, $Cu(OH)_2$ (2) $CuFeS_2$
(3) $Cu(OH)_2$ (4) Fe_3O_4

- **Oxide –** Bauxite – Al_2O_3 $2H_2O$, Haematite – Fe_2O_3, Magnetite – Fe_3O_4
- **Carbonate :** Limes stone–$CaCO_3$, Dolomite–$CaCO_3.MgCO_3$, Siderite–$FeCO_3$
-
- **Halides :** Common salt–NaCl, Sylvine–KCl, Carnallite–$KCl.MgCl_2.6H_2O$
- **Phosphate** : Phosphorite– $Ca_3(PO_4)_2$, Fluorapatite–$3Ca_3(PO_4)_2.CaF_2$
- **Sulphide :** Cinnabar–HgS, Argentite or Silver glance–Ag_2S
- **Sulphate :** Glauber's salt– $Na_2SO_4.\ 10H_2O$, Angelsite–$PbSO_4$
- Metallurgy of metal involves four main processes.
  1. Concentration or dressing of ore.
  2. Conversion of ore into oxide.
  3. Conversion of oxide into pure metal.
  4. Purification of metal.

Metallurgy is the process in which the entire technological and scientific processes used for isolation of the metal from its ores.
Those principles shall include the thermodynamic and electrochemical aspects involved in the effective reduciton of the concentrated ore to the metal.

Concept Ladder

Oxygen and silicon constitute about 73% by mass of earth's crust.

Rack your Brain

What will happen on equilibrium constant when temperature is increased?

Previous Year's Questions

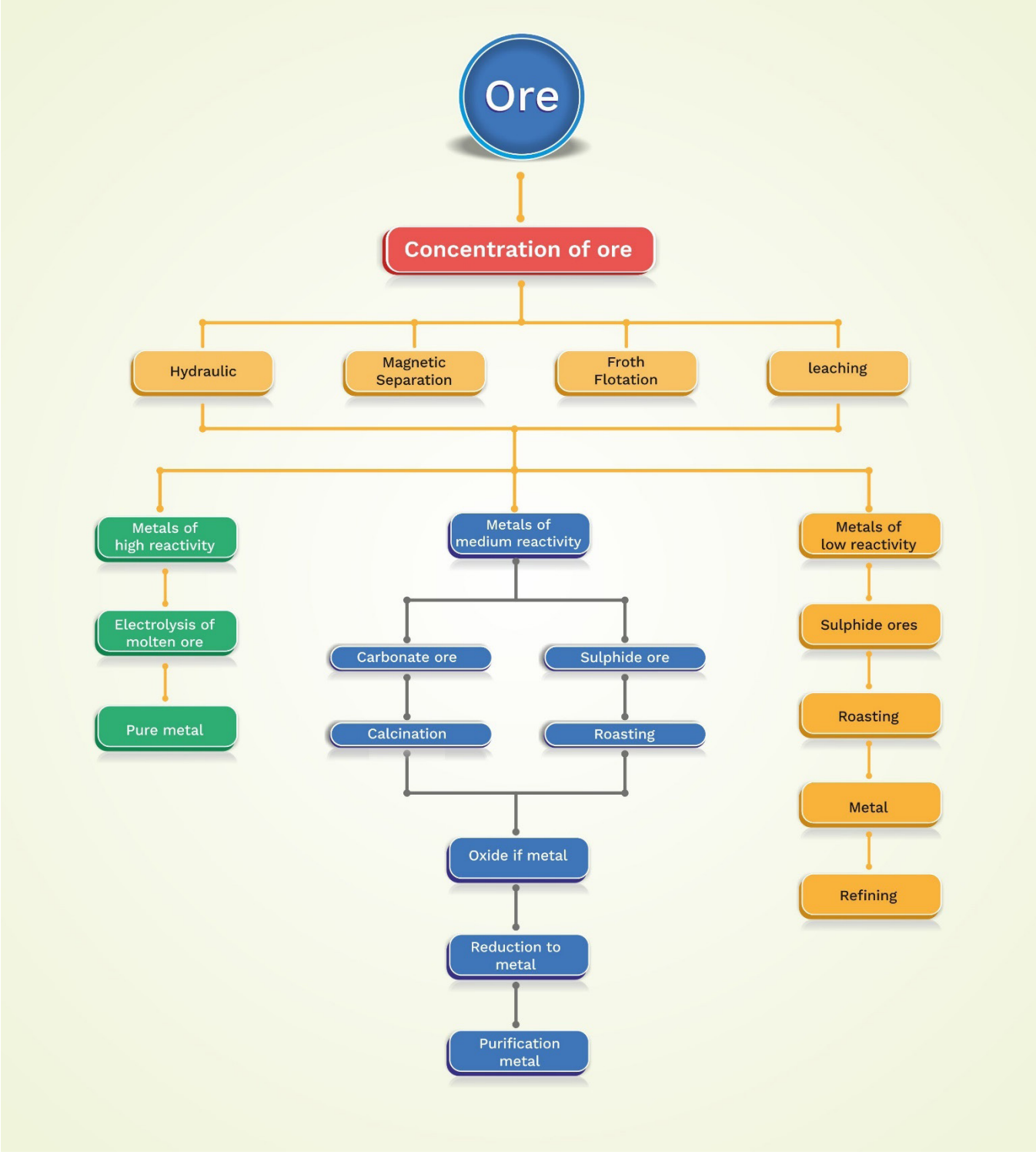
Which one of the following is a mineral of irons

[AIPMT-2012]

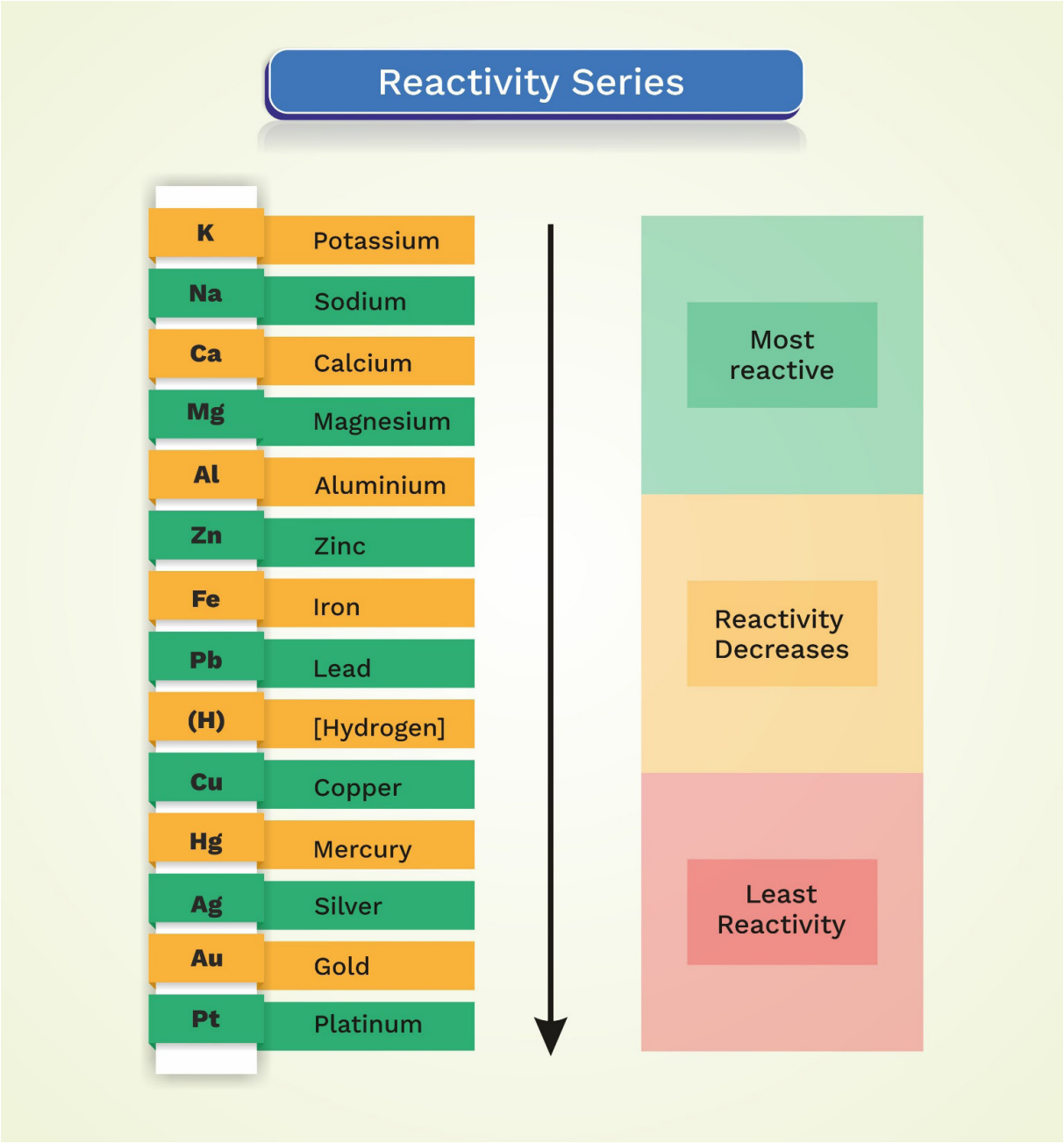
(1) Malachite (2) Cassiterite
(3) Pyrolusite (4) Magnetite

Q4 Which of the following ores does not represent the ore of iron
(1) Haematite
(2) Magneite
(3) Cassiterite
(4) Limonite

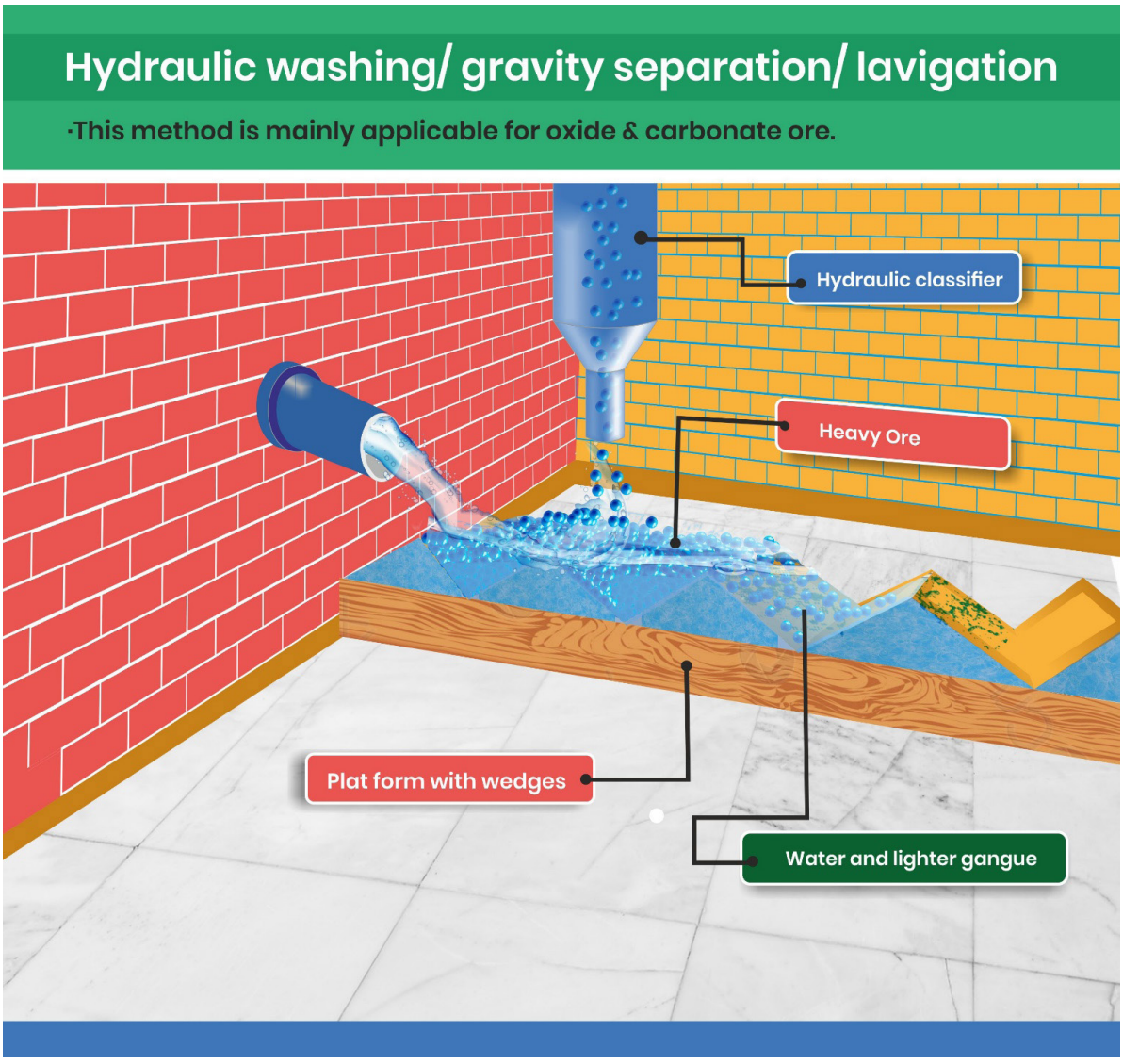
A4 (3) Cassiterite


Ore
Concentration of ore
Hydraulic
Magnetic Separation
Froth Flotation
leaching
Metals of high reactivity
Electrolysis of molten ore
Pure metal
Metals of medium reactivity
Carbonate ore
Sulphide ore
Calcination
Roasting
Oxide if metal
Reduction to metal
Purification metal
Metals of low reactivity
Sulphide ores
Roasting
Metal
Refining

Reactivity Series



(1) Concentraion/Benefaction/Enrichment/Dressing of Ore
(A) Physical Method
(i) Hydraulic washing/ gravity separation/ lavigation :

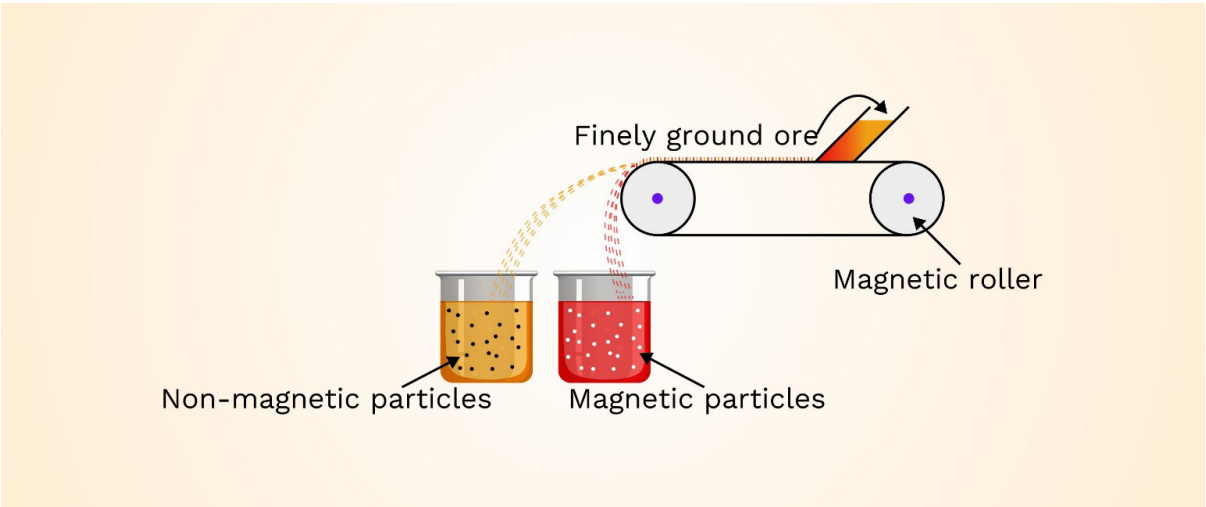


- Basic principle of this method is the difference in specific gravity (density) of ore and gangue particle.
- Gangue particle being lighter are washed away by jet of water & ore particle being heavier remains.
- This method is mainly applicable for oxide & **(ii)**

Concept Ladder

Unwanted earthy impurities are called **gangue/matrix.**

(ii) Magnetic separation :



Ex. SnO_2 (Cassiterite (Tin stone)) + $FeWO_4+MnWO_4$ (Gangue)

↓

Ore

Ex. $FeO.Cr_2O_3$ (Chromite) + $(SiO_2)n$ (Gangue)

↓

Ore

- Basic principle of electromagnetic separation is the difference in magnetic property of either ore or gangue.
- If the metal bearing particles have magnetic nature then they can be separated from non-magnetic impurities by the help of this method.
- On a conveyer belt (passess over a magnetic roller) the ground ore is carried.

Previous Year's Questions

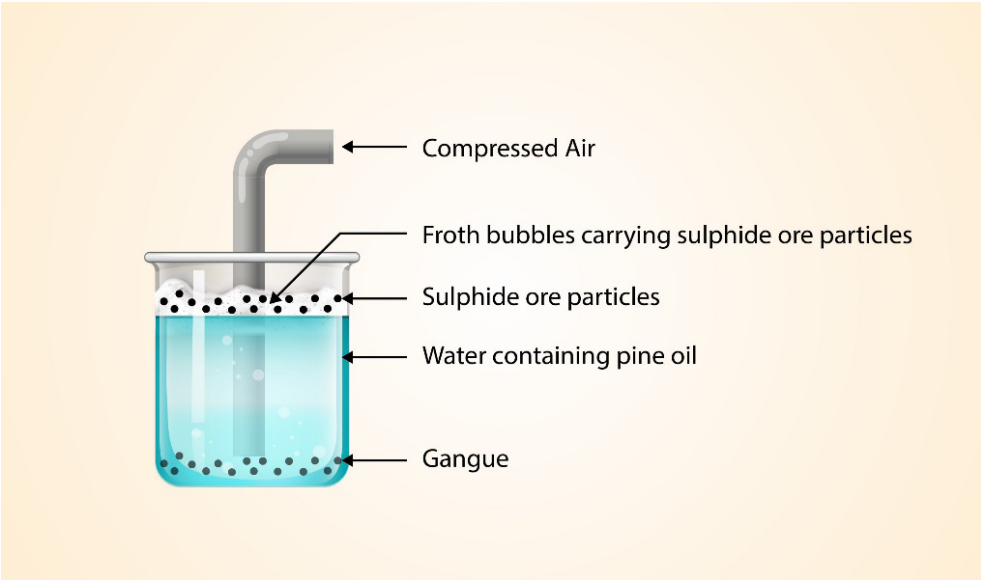
An ore of tin containing $FeCrO_4$ is concentrated by **[AIPMT]**

(1) Magnetic separation
(2) Froth floatation
(3) Electrostatic method
(4) Gravity separation

Concept Ladder

Michael Faraday discovered that when a substance is put in a magnetic environment, the intensity of the environment is modified by it. With this information, he discovered that different material can be separated with their magnetic properties.

(iii) Froth Floatation Method : It is used for the concentration of sulphide ores. It is a physical method.



- In this method mainly sulphide ores are used.
- The basic principle of Froth floatation method is the difference in wetting properties of ore & gauge particles.
  Ore particles are wetted by oil & gangue particles are wetted by water.
- Frother/frothing agent – pine oil/ turpentine/ mustard oil etc
- Collector/ floating agent – Na-alkyl xanthate
- Froth stabiliser – Cresol/ aniline
- Depressant – NaCN (Concentration of galena ore)
- Activator – Na_2S activators increase the effect of collectors. Ex. Na_2S

Previous Year's Questions

Froth floatation process is used for the concentration of

[AIPMT]

(1) Oxide ores
(2) Sulphide ores
(3) Chloride ores
(4) Amalgams

Chemical Reaction :

$$ZnS + PbS + NaCN \longrightarrow \underset{\text{(Soluble)}}{Na_2[Zn(CN)_4]} + \underset{\substack{\text{Galena} \\ \text{(Goes away with froth)}}}{PbS}$$

(B) Chemical Method

(i) Leaching :

- In case of leaching, suitable reagent is used which combines with ore to make it soluble while impurities like gangue remain insoluble.
  Ex- Ag, Au, Al
- **Al**
  Chief ore – Bauxite ($Al_2O_3.2H_2O$)
  (i) Red (impurities of Fe_2O_3)
  (ii) White (impurities of SiO_2)

Mac-Arthur forest cyanide process (Cyanide process) :

(for Ag and Au)

$$\underset{\text{(Ag–glance)}}{Ag_2S} + NaCN \xrightarrow{O_2} Na[Ag(CN)_2] + Na_2SO_4$$

In the absence of O_2, reaction becomes reversible.

$$Na[Ag(CN)_2] \xrightarrow{Zn} Na_2[Zn(CN)_4] + Ag$$

Similarly, Au can be extracted by using KCN.

(ii) Oxide formation :

(a) Calcination : Strong heating in the absence of air

(1) $\underset{\text{Cerrusite}}{PbCO_3} \xrightarrow{\Delta} \underset{\text{litharge}}{PbO} + CO_2$

(2) $\underset{\text{Calamine}}{ZnCO_3} \xrightarrow{\Delta} ZnO + CO_2$

(3) $\underset{\text{limestone}}{CaCO_3} \xrightarrow{\Delta} CaO + CO_2$

(4) $\underset{\text{Siderite}}{FeCO_3} \xrightarrow{\Delta} FeO + CO_2$

(5) $CuCO_3.Cu(OH)_2 \xrightarrow{\Delta} CuO + CO_2 + H_2O$

(6) $Al_2O_3.2H_2O \xrightarrow{\Delta} \underset{\text{(alumina)}}{Al_2O_3} + 2H_2O$

(7) $\underset{\text{Hametite}}{Fe_2O_3.3H_2O} \xrightarrow{\Delta} Fe_2O_3 + 3H_2O$

(8) $Al(OH)_3 \xrightarrow{\Delta} \underset{\text{alumina}}{Al_2O_3} + H_2O$

Rack your Brain

What is the significance of Leaching?

Concept Ladder

Leaching is widely used in the biological and food processing industries for the separation of sugar from sugar beets with hot water.

Definition

The process of removal of volatile impurities (CO_2, H_2O etc.) from an ore in the absence of air is known as Calcination.

Previous Year's Questions

The following reactions take place in the blast furnace int he preparation of impure iron. Identify the reaction pertaining to the formation of the slag **[AIPMT-2011]**

(1) $CaO(s) + SiO_2 \rightarrow CaSiO_3(s)$
(2) $2C(s) + O_2(g) \rightarrow 2CO(g)$
(3) $Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$
(4) $CaCO_3(s) \rightarrow CaO(s) + CO_2$

Note : Calcination is carried out in case of carbonate, hydroxide, hydrated oxide

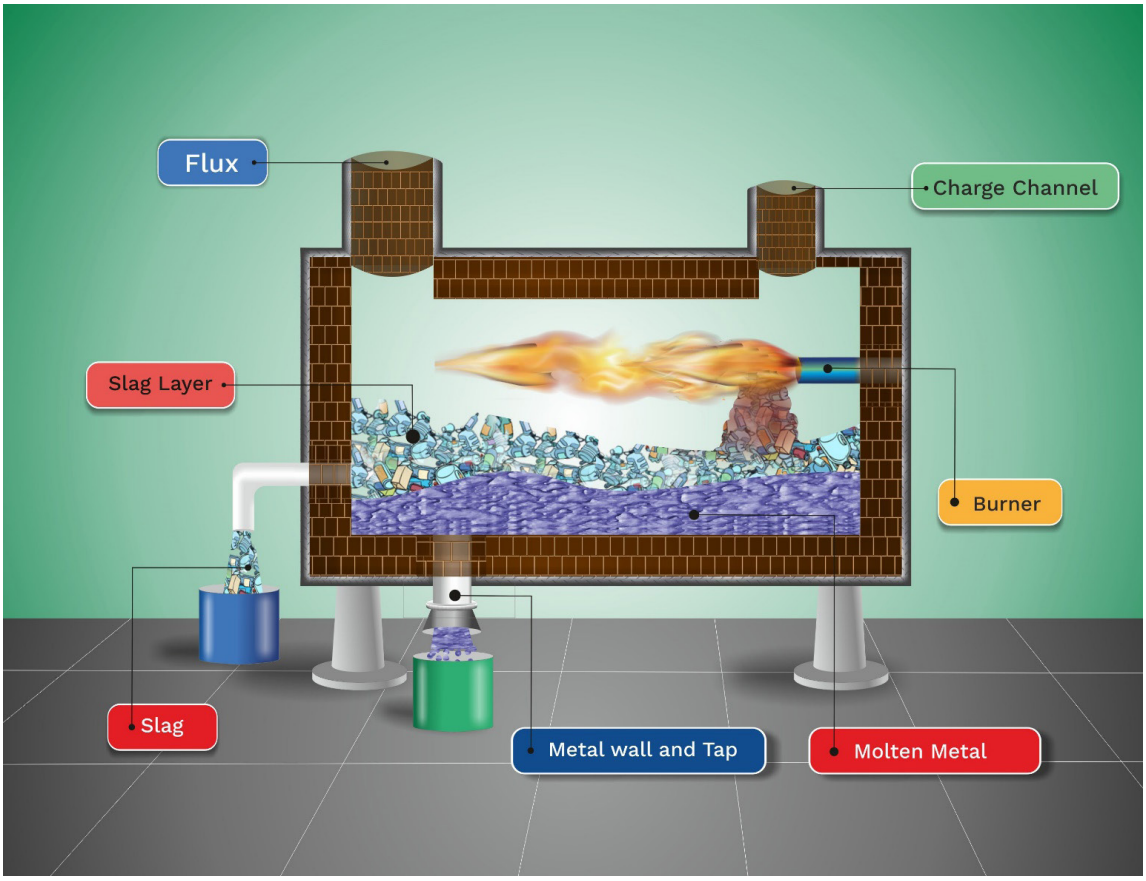
Advantage of calcination

- Organic matter is destroyed
- Ore becomes porous & easily workable (rate of reaction increase)
- Moisture is removed.
- Oxide is formed.

Concept Ladder

Calcination and roasting may be carried out in the same reverberatory furnace.

(b) Roasting :



Definition

The removal of excess sulphur contained in the form of SO_2 from sulphide ore by the heating and presence of air called as Roasting.

- Strong heating in the presence of air

$$\underset{\text{galena}}{PbS} + O_2 \longrightarrow PbO + SO_2 \qquad \underset{\text{zinc blend}}{ZnS} + O_2 \longrightarrow ZnS + SO_2$$

Advantage of Roasting :

- Impurities of Arsinic, Sb, P are removed in the form of their volatile oxides.
- In the form of SO_2 excess sulphur can be removed.
- Metal oxide is formed.

Roasting in the Fe-metallurgy :

$FeO + O_2 \rightarrow Fe_2O_2 + SiO_2 \rightarrow$ No reaction

$FeO + SiO_2 \rightarrow \underset{\text{(slag)}}{FeSiO_3}$

$\because$ Wastage of iron is prevented by roasting of $FeO \rightarrow Fe_2O_3$

Roasting in Cu-metallurgy :

Chief Ore – Copper pyrites ($CuFeS_2$)

$$CuFeS_2 \xrightarrow[\text{partial roasting}]{+O_2} \underset{\text{(major)}}{Cu_2S.FeS} + SO_2 + \underset{\text{(minor)}}{CU_2O.FeO}$$

Principles of metallurgy :

Gibbs free energy (ΔG) = $\Delta H - T\Delta S$

where ΔH = change in enthalpy, ΔS = change in entropy, T = absolute temperature

ΔG is also related to equilibrium constant (K).

$\Delta G° = -RT \ln K$

If $\Delta G°$ is –ve, then K will be positive, reaction will proceed towards forward direction.

Note :

- The feasibility of reaction at any temperature is when ΔG of the reaction is negative. Thus, on increasing the temperature, ΔS becomes positive, the value $T\Delta S$ will increase and ΔG will be negative. ($T\Delta S > \Delta H$). This will proceed the reaction in forward direction.

Previous Year's Questions

In the extraction of copper from its sulphide ore, the metal is finally obtained by the reduciton of cuprous oxide with

[AIPMT-2012]

(1) Copper (I) sulphide (Cu_2S)
(2) Sulphur dioxide (SO_2)
(3) Iron sulphide (FeS)
(4) Carbon monoxide (CO)

Rack your Brain

Why all ores are rosted and not reduced directly?

Concept Ladder

If ΔG is positive, the reaction can still be made to occur by coupling it with another reaction having large negative ΔG, as a result of the two reactions is negative.

Ellingham Diagram :

It helps use in predicting the feasibility of the thermal reduction of an ore.

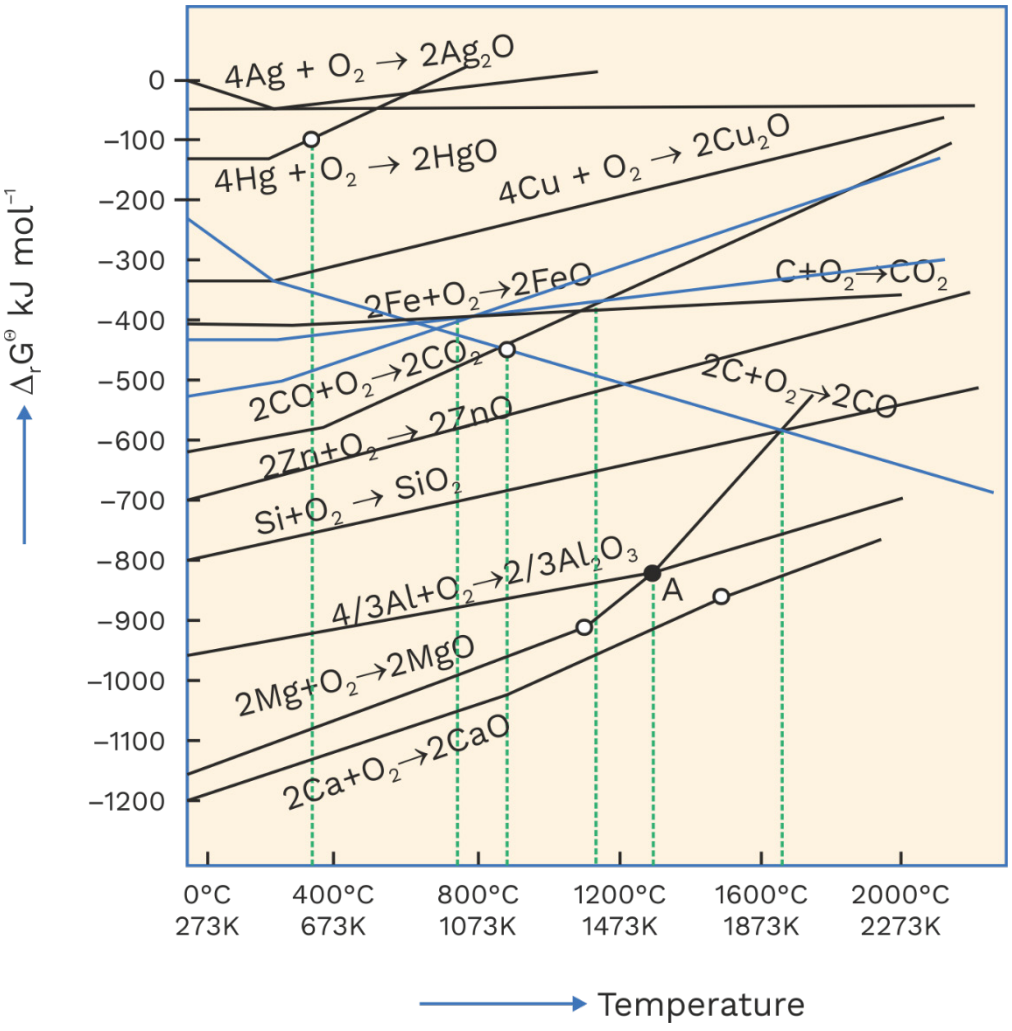
$$2x\ M(s) + O_2(g) \longrightarrow 2M_xO(s)$$

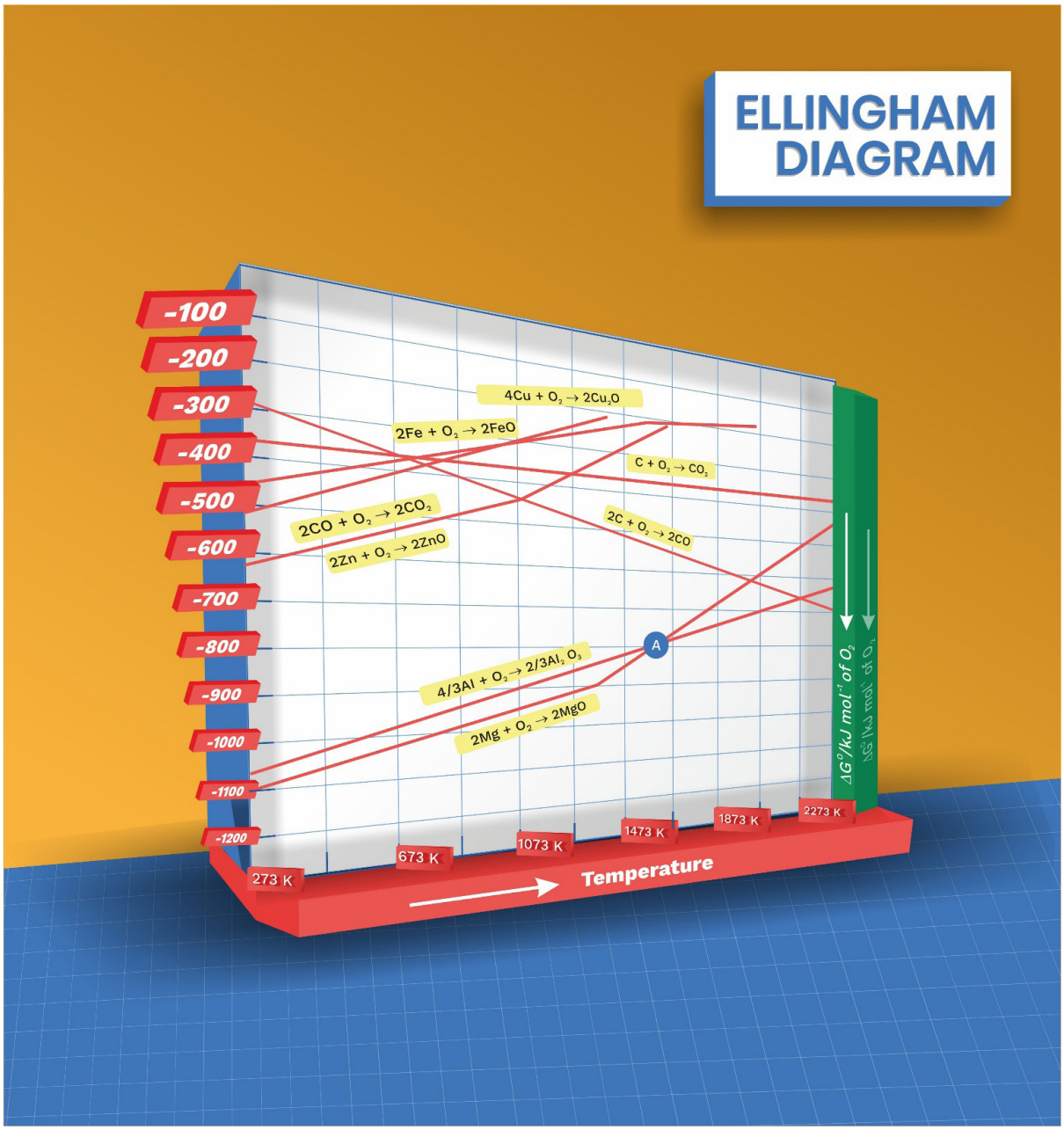
Gases have higher entropy than liquids and solids. Therefore, during this reaction, ΔS becomes negative. Thus, if temperature is increased, $T\Delta S$ becomes more and more negative. ΔG increases with increase in temperature (normally, ΔG decreases with increase in temperature). In other words, $\Delta_f G^\circ$ vs T lines have +ve slopes for most of the reactions involving the formation of metal oxides, M_xO (s) as shown in figure.

Previous Year's Questions

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

(1) Fe (2) Zn
(3) Mg (4) Cu





Rack your Brain

Metal sulphides occur mainly in rocks and metal halides in lakes and seas. Why?

(2) Conversion of ore into oxide

(i) Red (impurities of Fe_2O_3) :

(a) Bayer's process

Fe_2O_3 + $NaOH \rightarrow$ no reaction
(impurity) (Base)

$$Al_2O_3 + NaOH \longrightarrow \underset{\text{(Soluble complex)}}{NaAlO_2} \xrightarrow[\text{excess}]{H_2O} \underset{\text{gelateneous white ppt}}{Al(OH)_3}$$

(b) Hall's process

$$\underset{\text{(impurity)}}{Fe_2O_3} + \underset{\text{(base)}}{Na_2CO_3} \longrightarrow \text{no reaction}$$

$$Al_2O_3 + Na_2CO_3 \longrightarrow \underset{\text{(Soluble complex)}}{NaAlO_2} \xrightarrow[\text{excess}]{H_2O} \underset{\text{gelateneous white ppt}}{Al(OH)_3}$$

(ii) White (impurities of SiO_2) :

(a) Serpeck's process

$$Al_2O_3 + C + N_2 \xrightarrow[\approx 1800°C]{\Delta} AlN + CO/CO_2$$

$$\downarrow H_2O$$

$$Al(OH)_3 + NH_3$$

$$2Al(OH)_3 \xrightarrow{1500°C} Al_2O_3 + 3H_2O$$

$$\underset{\text{(impurity)}}{SiO_2} + 2C \xrightarrow{\Delta} Si + CO\uparrow$$

Rack your Brain

What is the purpose of using cryolite and CaF_2 in electrolytic reduction of Al_2O_3.

Concept Ladder

Beach sands of Kerala and Tamilnadu contain a useful mineral monazite used for the extraction of thorium and rare earths.

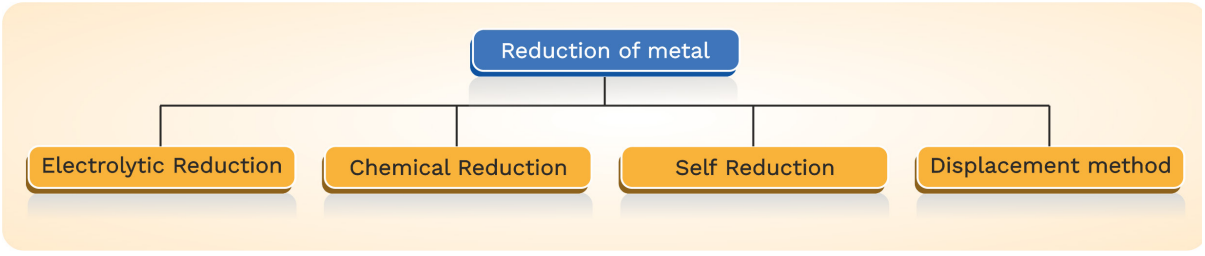
Previous Year's Questions

Alumino-thermic process is used for metallurgy of

[AIPMT]

(1) Pb (2) Ag
(3) Al (4) None

(3) Reduction to obtain Crude Metal (impure) :



Smelting (C-reduction) :

$$\text{Metal Oxide} + \text{impurities} + \text{flux} \xrightarrow[\text{(coke) furrance}]{\text{C blast}} \text{metal (molten)} + \text{slag} + \text{C O / CO}_2$$

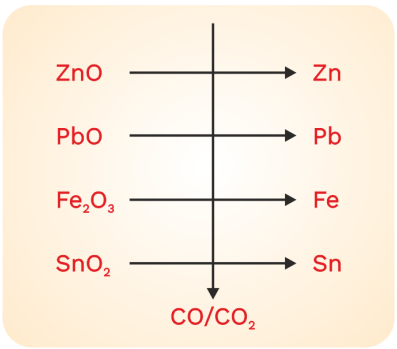
- Slag is lighter than metal, forms a protective layer on molten. Metal which decreases the negativity of molten metal. Slag also decreases the melting point (fusion temperature) of impurity.
- In the metallurgy of iron impurity is acidic. So, flux used is basic.
- In the metallurgy of Copper impurity is basic. So, flux used is acidic.

Concept Ladder

The reduction of metal oxide easier if the metal formed is in liquid state at the temperature of reduction.

$$\underset{\text{(Basic flux)}}{CaO} + \underset{\text{(imp)}}{SiO_2} \longrightarrow \underset{\text{(metallurgy of iron)}}{CaSiO_3} \qquad \text{Copper} \quad \underset{\text{(acidic flux)}}{SiO_2} + \underset{\text{(imp)}}{FeO} \longrightarrow \underset{\text{(metallurgy of copper)}}{FeSiO_3}$$

- Neutral flux is used in metallurgy of Al $(\underset{\text{cryolite}}{Na_3AlF_6} + \underset{\text{flourouspar}}{CaF_2})$



- Neutral flux decreases the melting point of Al_2O_3 & increases conductivity of salt.

Previous Year's Questions

Purification of aluminum, by electrolytic refining, is known as. **[1999]**

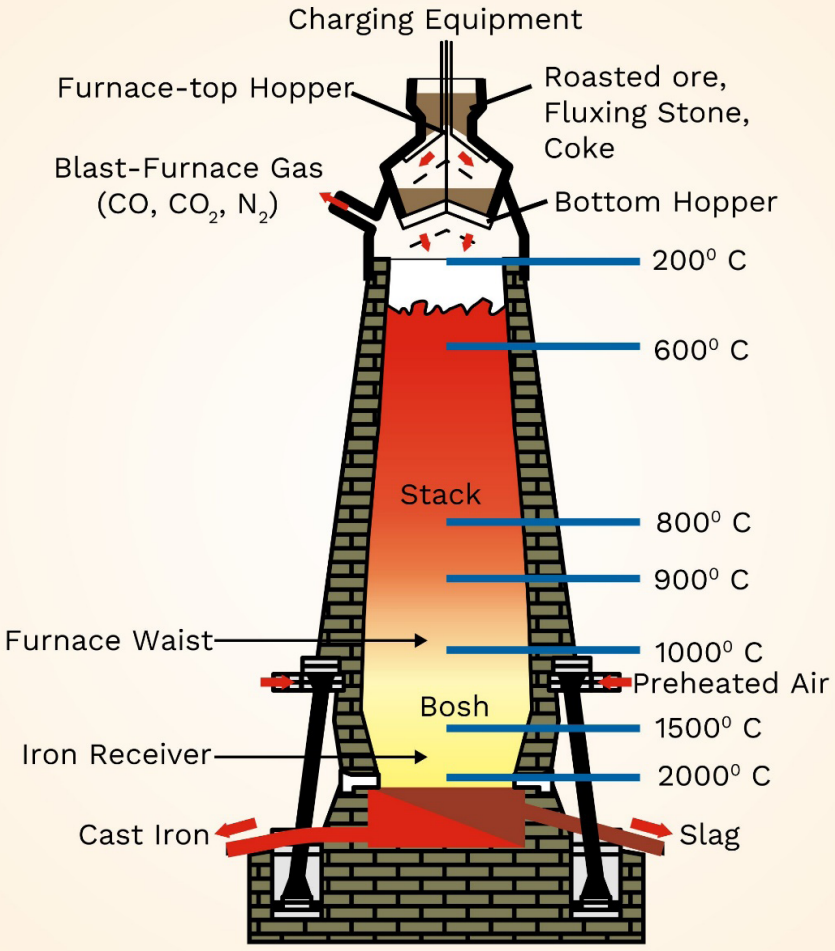
(1) Hoope's pocess
(2) Baeyer's process
(3) Hall's process
(4) Serpeck's process

$$ZnO \xrightarrow{C} Zn + CO / CO_2 \qquad PbO \xrightarrow{C} Pb + CO / CO_2$$
$$Fe_2O_3 \xrightarrow{C} Fe + CO / CO_2 \qquad SnO_2 \xrightarrow{C} Sn + CO / CO_2$$

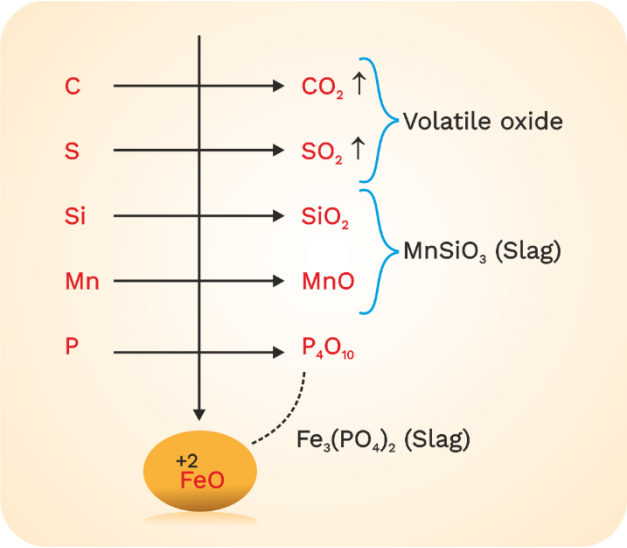
Rack your Brain

Why carbon and hydrogne are suitable reducing agents for metal sulphides?

Smelting of iron metallurgy :



Pudding process :



$$\text{Cast iron } (\simeq 3\%\,C) + \xrightarrow[\text{fernace lined with } Fe_2O_3 \text{ (hametite)}]{\text{Reverbattery}} \underset{(\simeq 0.25-0.5\%\,C)}{\text{Wrought iron}}$$

Smelting of copper metallurgy :

$$Cu_2O + FeS \longrightarrow Cu_2S + FeO \qquad FeO + SiO_2 \longrightarrow \downarrow FeSiO_3 \text{ (slag)}$$

Self-reduction :

(Pb, Hg, Cu)

$$PbS + O_2 \longrightarrow PbO + SO_2 \qquad PbS + PbO \longrightarrow Pb + SO_2$$

Self-reduction in Cu-metallurgy (Bessemerisation) :

$$\underset{\text{(copper matte)}}{Cu_2S} + FeS + \underset{\text{(basic impurities)}}{FeO} + \underset{\text{(acidic flux)}}{SiO_2} + O_2(air) \longrightarrow \underset{\text{(Blister Copper)}}{Cu} + SO_2 + \underset{\text{(slag)}}{FeSiO_3}$$

Mechanism :

$$Fe + SO_2 \longrightarrow FeO + SWO_2 \qquad FeO + SiO_2 \longrightarrow \underset{\text{(slag)}}{FeSiO_3} \downarrow$$

$$Cu_2S + \underset{\text{(limited)}}{O_2} \longrightarrow Cu_2O + SO_2 \qquad Cu_2S + Cu_2O \longrightarrow \underset{\text{Blister}}{Cu} + SO_2$$

Thermal Reduction :

(i) (a) $Ag_2S + O_2 \longrightarrow Ag_2O$ (b) $Ag_2O \xrightarrow{\Delta} 2Ag + \frac{1}{2}O_2$

(ii) (a) $HgS + o_2 \longrightarrow HgO + SO_2$ (b) $HgO \xrightarrow{\Delta} Hg + \frac{1}{2}O_2$

Previous Year's Questions

The following reactions take place in the blast furnace in the preparation of impure iron. Identify the reaction pertaining to the formation of the slag. *[2011]*

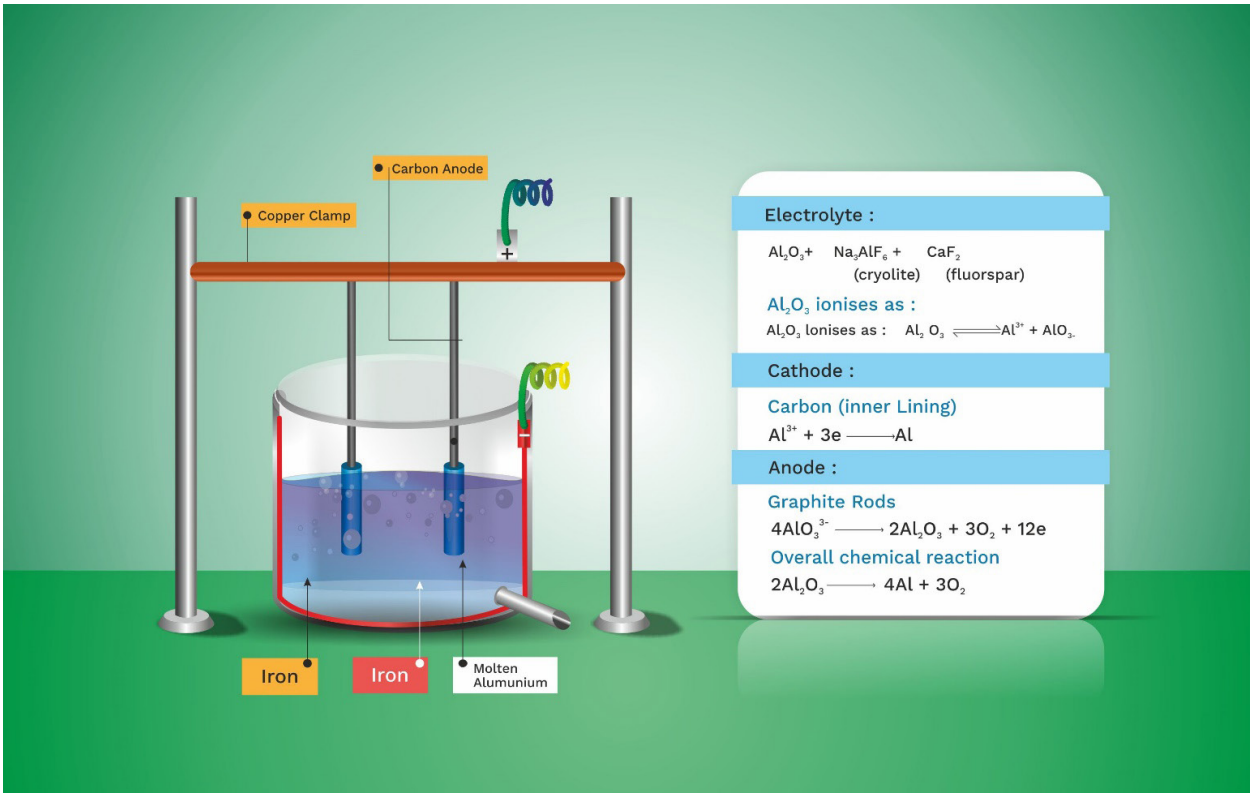
(1) $Fe_2O_{3(s)} + 3CO_g \rightarrow 2Fe_{(\ell)} + 3CO_{2(g)}$

(2) $CaCO_{3(s)} \rightarrow CaO_s + CO_{2(g)}$

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

(4) $2C_{(s)} + O_{2(s)} \rightarrow 2CO_{(g)}$

Hall-Heroult Process (electrolytic reduction of Al_2O_3) :



Electrolyte :

$Al_2O_3 + Na_3AlF_6 + CaF_2$
(cryolite) (fluorspar)

Al_2O_3 ionises as :

$$Al_2O_3 \rightleftharpoons Al^{3+} + AlO_3^{3-}$$

Cathode :

Carbon (inner lining)

$$Al^{3+} + 3e \longrightarrow Al$$

Anode :

Graphite rods

$$4AlO_3^{3-} \longrightarrow 2Al_2O_3 + 3O_2 + 12e$$

Overall chemical reaction

$$2Al_2O_3 \longrightarrow 4Al + 3O_2$$

Note: 99.8% pure aluminium is obtained from this process.

Note: $O_2 \xrightarrow{C} CO / CO_2$

- Due to the formation of CO corrosion of anode starts so the main drawback of this process is anode must be replaced time to time.

Rack your Brain

Can the value of equilibirum constant be affected by change in concentration of reactant ?

Concept Ladder

Na, K, Mg, Ca, Al etc. (Highly electropositive metals) are extracted from their molten salts by using electricity is known as electrometallurgy.

Previous Year's Questions

minium is rumina (Al_2O_3) by electrolysis of a molten mixture of **[AIPMT-2012]**

(1) $Al_2O_3 + HF + NaAlF_4$
(2) $Al_2O_3 + CaF_2 + NaAlF_4$
(3) $Al_2O_3 + Na_3AlF_6 + CaF_2$
(4) $Al_2O_3 + KF + Na_3AlF_6$

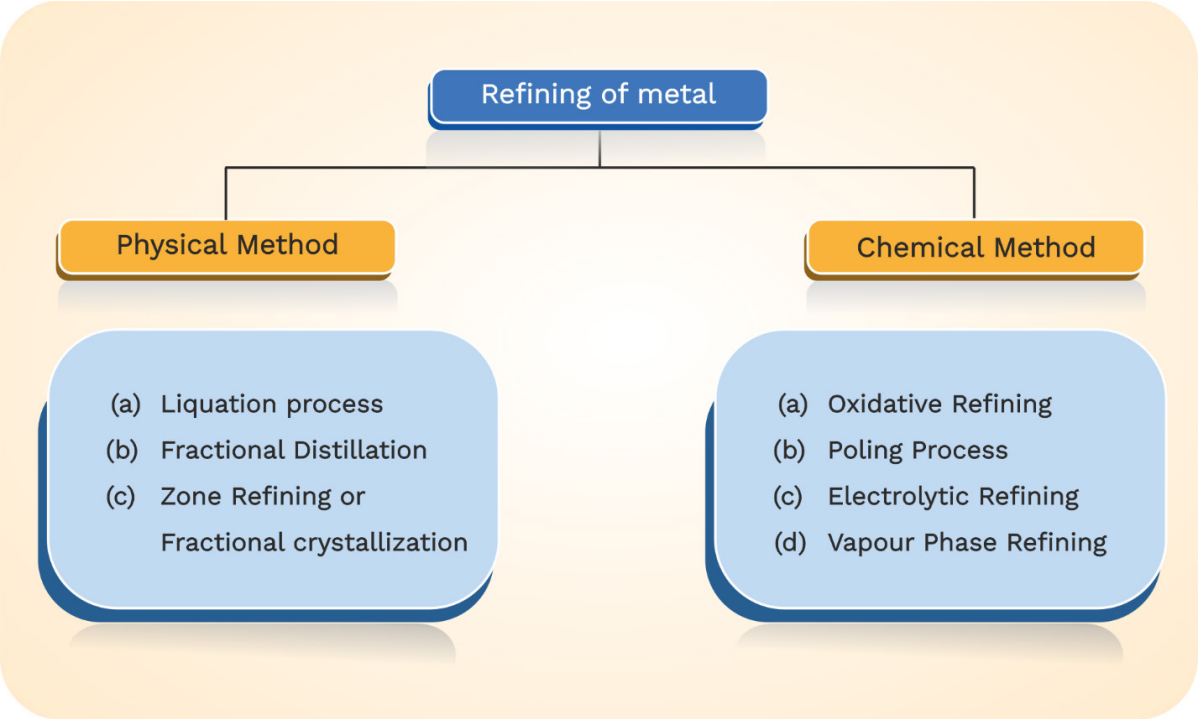
Aluminothermic Process (gold Schmidt's process) :

Ex- Cr_2O_3, Mn_3O_4, B_2O_3, TiO_2 etc.

$$Al + Cr_2O_3 \longrightarrow \underset{\text{alumina}}{Al_2O_3} + Cr$$

$Al + Fe_2O_3 \longrightarrow Al_2O_3 + Fe$ (Thermite wielding used for joining railway track)

4. Refining to obtain ultra-pure Metal



(a) Liquation :

- Liquation process based on the difference in fusibility of the metal & impurities.
- This method used to purify the metals like Pb, Sn, Sb, Bi.

(b) Distillation :

- In this case metals having lower values of BP are purifies easily.
- This method used to purify the metals like Zn, Cd, Hg.

(c) Zone Refining :

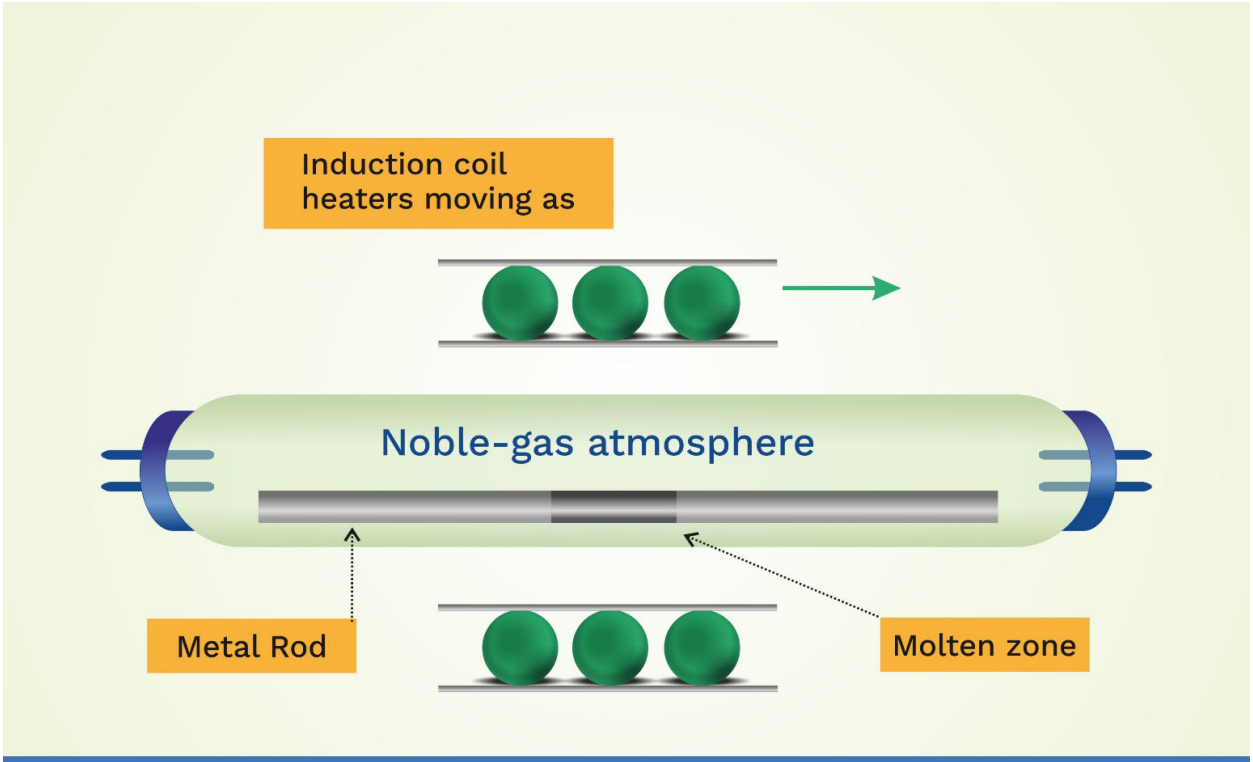
- The basic concept of zone refining is "Impurities are more soluble in molten state of metal than in solid state of metal."
- This method used to purify the metals like Silicone, germanium, gallium.

Rack your Brain

Why distillation process is use for low boiling metals.

Concept Ladder

In Zone refining, very high purity semi-conductors are obtained.



Zone Refining Used For Ge, Si, B, Ga, In, etc

Chemical process :

(a) Cupellation – It is used to refine silver containing impurity of lead.

(b) Polling – Wooden pole (green wood) % hydrocarbon more.
It is used to refine metal which has impurity of its own oxide.

(c) Electrolytic Refining
(Cu, Zn, Pb, Al, Ag, Au, etc)

Anode : impure metal
Cathode : Thin strip of pure metal
Electrolyte : aqua solution of metallic salt.
Refining of iron : Fe_3C – cementite

$$\text{Pig iron } (\approx 4\%C) \xrightarrow[\Delta]{\text{strips of Fe}} \text{Cast iron } (\approx 3\%C)$$

Concept Ladder

Goldmine in Kolar (Karnataka) is the deepest mines of the world.

Rack your Brain

Does German Silver consists of silver ?

(d) Vapour phase refining :

(i) Mond's process :

$$\underset{\text{(impure)}}{Ni} + 4CO \xrightarrow[\Delta]{350K} \underset{\text{volatile}}{[Ni(CO)_4]} \xrightarrow{450\ K} \underset{\text{(pure)}}{Ni} + 4CO$$

(ii) Van Arkle's Method :

Small amount of Ti, Zr or Bi can be produced by this method.

$$\underset{\text{(impure)}}{Ti} + 2I_2 \longrightarrow \underset{\text{(volatile)}}{TiI_4} \xrightarrow{1400°C} \underset{\text{(pure)}}{Ti} + 2I_2$$

This method is very expansive.

Previous Year's Questions

Which of the following pairs of metals is purified by van Arkel method? **[2011]**

(1) Ga and In (2) Zr and Ti

(3) Ag and Au (4) Ni and Fe

Q5 Name the form of copper which is termed as blister copper?

A5 The solidified copper obtained has blistered appearance due to the evolution of SO_2 , so it is called blistered copper.

Q6 Electrode potentials of both zinc and copper are less than that of Ag, then also zinc is used but not copper for the recovery for metallic silver from the complex $[Ag(CN)_2]^-$, Explain why ?

A6 Zinc reacts at faster rate as compared with copper, further zinc is cheaper than copper

Q7 Write the name with percentage of constituents of German silver?

A7 Cu = 25-30%, Zn = 25-30%, Ni = 40-50%

Q8 What is hydrometallurgy ? Give one example where it is used for metal extraction.

A8 Leaching followed by reduction is called hydrometallurgy. It is used in extraction of copper.

Q9 Name the elements present in anode mud during refining of copper. Why does it contain such elements ?

A9 Au and Ag. They are not oxidized at anode. They are less electropositive than copper.

Q10 Write names of any three ores concentrated by froth floatation process?

A10 Galena (PbS), Zinc blende (ZnS), Cinnabar (HgS).

Q11 What is the difference between the oxidation state of sulphur in product and reactant?

$$\text{Galena} \xrightarrow{\text{Roasting}} \text{Metal oxide} + \text{Gas}$$

A11 $\underset{s=-2}{PbS} + \frac{3}{2}O_2 \longrightarrow PbO + \underset{s=+4}{SO_2}$

Q12 What is the oxidation state of Fe in fools gold?

A12 $FeS_2 = Fe^{2+}\,\overset{-}{S}\!-\overset{-}{S}$

Q13 Find the number of native ores out of given ores
Pyrolusite, Chromite, Siderite, Cassiterite, Calamine, Argentite, Lime stone, Chalcopyrite.

A13 All the ores given in question are combining ore.

Q14 Total no. of metals given below which can replace Mg^{2+} ion from aq. solution of $MgCl_2$
Sodium, Gold, Copper, Lithium, Aluminium, Silver, Zinc

A14 It is not possible to displace Mg2+ ion from aqueous solution due to high reactivity of Mg

Q15 Predict conditions under which Al might be expected to reduce MgO.

A15 Above 1350°C, the standard Gibbs free energy of formation of Al_2O_3 from Al is less than that of MgO from Mg. Therefore, above 1350°C, Al can reduce MgO.

Q16 Why can't aluminium be reduced by carbon ?

A16 Al is stronger reducing agent than carbon.

Q17 Name the most important form of iron. Mention its one use.

A17 Cast iron is one of the most important form of iron. It is used for making railway sleepers, gutter pipes, castings, toys etc.

Chapter Summary

1. (i) Abudance of elements in earth crust (by weight)
O > Si > Al > Fe > Ca > K
(ii) Abudance of elements in earth (by no. of atoms/100 g)
O > Si > Al > H > Na > Ca > Fe

2. Noble metals (Au, Ag) are obtained by cyanide or amalgamation process.

3. Iron is never manufactured by thermite process because Al is much more expensive than Fe. Thermite process produces lot of heat so it is used for welding of iron.

4. Carbon reduction is not possible with alkaline erath metals as they form carbide on reaction with carbon.

5. Sea weeds are source of iodine.

6. **Types of metallurgy**
Pyrometallurgy : Heat ios used. Ex.- oxides sulphides
Hydrometallurgy : Aqueous solution is used. Ex.- Ag, Au
Electro metallurgy : Electrolysis is done. Ex.- Na, K, Ca.

7. Pulverisation is process of grinding crushed ore into fine powder.

8. Pickling - Process of removing layers of basic oxides from electrode.

9. Amalgamation - Process of combining metal with Hg to form alloy.

10. Bassemerisation is process of passing hot blast of air through impure molten metal in a bessmer convertor to oxidise impurities. e.g.- Pig iron and copper are purified by this method.

11. Most electropositive metals are isolated from their ores by electrolysis of fused ionic salts.

12. Molten zinc is converted into granulated zinc by adding water to it.

- **Refining:** The metals obtained by the application of above reduction methods from the concentration ores are usually impure. The impure metal is thus subjected to some purifying process known as refining in order to remove undesired impurities. Various process for this are :
  (a) Liquation process (b) Distillation process
  (c) Cupellation (d) Poling
  (e) Electrolytic refining (f) Bessemerisation
- **Hydrometallurgy (solvent extraction):** Solvent extraction is the latest separation technique and has become popular because of its elegance, simplicity and speed. The method is based on preferential solubility principles.