CHAPTER

7 Metallurgy

IMPORTANT POINTS TO REMEMBER

1. The elements which are having **1, 2** or **3 valence electrons,** can be **drawn** into **wires, beaten** into **sheets,** are **lustrous** and **good conductors** of heat and electricity are called as **metals**. Metals are **electron donors** and can form **positively charged particles** called **cations**. **For example : Metals loose** valence **electrons** to **achieve stable configuration** and thus they **form positively charged particle** known as **cations**.

$Na - e^- \longrightarrow Na^+$ (2, 8, 1 → 2, 8)

$Mg - 2e^- \longrightarrow Mg^{2+}$ (2, 8, 2 → 2, 8)

$Al - 3e^- \longrightarrow Al^{3+}$ (2, 8, 3 → 2, 8)

$K - e^- \longrightarrow K^+$ (2, 8, 8, 1 → 2, 8, 8)

$Ca - 2e^- \longrightarrow Ca^{2+}$ (2, 8, 8, 2 → 2, 8, 8)

2. Metals like **Gold, Copper, Platinum,** etc., occur in **free state** or **native state** as they are **unreactive** in nature.

3. The elements which are having **5, 6** or **7 valence electrons** and **cannot** be **drawn** into **wires** or **beaten** into **sheets,** are **non-lustrous** and **poor conductors** of heat and electricity are called as **non-metals**. Non-metals are **electron acceptors** and can form **negatively charged particles** called **anions**. **For example : Non-metals gain electrons** to **complete their octet** and get **converted** to **negatively charged particle** known as **anions**.

$F + e^- \longrightarrow F^{-1}$ (2, 7 → 2, 8)

$N + 3e^- \longrightarrow N^{-3}$ (2, 5 → 2, 8)

$S + 2e^- \longrightarrow S^{-2}$ (2, 8, 6 → 2, 8, 8)

$O + 2e^- \longrightarrow O^{-2}$ (2, 6 → 2, 8)

$Cl + e^- \longrightarrow Cl^-$ (2, 8, 7 → 2, 8, 8)

4. In the **periodic table** the **metals** are present in **groups 1** and **2** (**highly electropositive elements**). **Transition elements** in the **middle** of the periodic table are **metals**. The **metallic character** (tendency to loose electrons) **increases** as we move **down the group** therefore **metals** are also present at the **bottom** of every **group** in the **periodic table**.

5. Elements of group IA are called as **alkali metal**. The members of this group are Lithium (Li), Sodium (Na), Potassium (K), Rubidium (Rb), Caesium (Cs) and Francium (Fr).

   (*i*) **Reaction of alkali metals with air:** Lithium, sodium and potassium react with oxygen at normal temperature to form their respective oxides.

$4Li + O_2 \longrightarrow 2Li_2O$ $\quad 4Na + O_2 \longrightarrow 2Na_2O$

$4K + O_2 \longrightarrow 2K_2O$

Lithium reacts with nitrogen to form lithium nitride.

$$6Li + N_2 \xrightarrow{\Delta} 2Li_3N$$

   (*ii*) **Reaction of alkali metals with water:** These **metals** on reaction with **cold water** form **soluble** bases called as **alkali**.

$2M + 2H_2O \longrightarrow 2MOH + H_2$ (general equation)
alkali metal — alkali

where M can be Li, Na, K *etc.*

$2Li + 2H_2O \longrightarrow 2LiOH + H_2$ $\quad$ $2Na + 2H_2O \longrightarrow 2NaOH + H_2$

$2K + 2H_2O \longrightarrow 2KOH + H_2$ $\quad$ $2Rb + 2H_2O \longrightarrow 2RbOH + H_2$

(*iii*) **Reaction of alkali metals with acids:** Sodium and potassium reacts with dil. HCl explosively to liberate Hydrogen gas.

$2Na + 2HCl(dil.) \longrightarrow 2NaCl + H_2\uparrow$ $\quad$ $2K + 2HCl(dil.) \longrightarrow 2KCl + H_2\uparrow$

6. All **elements** of this group have **one electron** in their **valence shell** hence, their **valency** is +1.

7. The general characteristics of alkali metals are as follows :

(*i*) They are **highly reactive** elements and does not occur in **free state**.

(*ii*) They have **one electron** in their **valence shell**. Thus, they **loose electrons** and get converted to **unipositive** ions called **cation**. These **elements** have **lowest ionization energy** in their respective **periods** thus, they easily **loose electrons** and get converted to **cation**.

$M - e^- \longrightarrow M^+$ (general equation)
Alkali metal

$Na - e^- \longrightarrow Na^+$
(2, 8, 1)

$Li - e^- \longrightarrow Li^+$
(2, 1)

$K - e^- \longrightarrow K^+$
(2, 8, 8, 1)

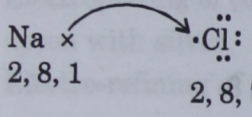
(*iii*) They are stored under **kerosene** because they **easily react** with **oxygen** and **water vapour** to form their **oxides** and **hydroxides**. The **reactivity increases** on moving **down the group**.

(*iv*) **Alkali metals** have **low melting point** and **boiling point**

(*v*) They can be easily cut with the help of knife. Freshly cut **metal imparts** a **silvery appearence**, but after sometime the **metal gets tarnished** due to the formation of **oxide layer.**

(*vi*) **Alkali metals** being **highly electropositive elements** undergo **ionic bond** formation with **non-metals**.

For example : Formation of sodium chloride is by the ionic bond.



$Na - e^- \longrightarrow Na^+$

$Cl + e^- \longrightarrow Cl^{-1}$

(*vii*) **Alkali metals** are strong **reducing agents**.

(*viii*) **Alkali metals** react with **cold water** to form their **respective hydroxides** with the liberation of **hydrogen**. The reaction of **alkali metals** with cold water is **highly vigorous, exothermic** and **proceeds** with **explosion**.

(*ix*) **Alkali metals** displace **hydrogen** on reaction with **dilute acids**. However, this reaction is **highly vigorous** and **exothermic**.

(*x*) **Alkali metals** are obtained by the **electrolysis** of their **fused** or **molten** chlorides.

$NaCl \rightleftharpoons Na^+ + Cl^-$

At Cathode $\Rightarrow Na - e^- \rightarrow Na^+$

At Anode $\Rightarrow Cl + e^- \rightarrow Cl^-$

Alkali metals are obtained at cathode during electrolysis.

8. Elements of group IIA are called as **alkaline earth metals**. The members of this group are Beryllium (Be), Magnesium (Mg), Calcium (Ca), Strantium (Sr), Barium (Ba) and Radium (Ra).

9. The **elements** of these **group** are having **two electrons** in their **valence shell** thus, they get converted to **dipositive ion**.

For example

$M - 2e^- \longrightarrow M^{2+}$
(alkaline earth metal)

$Be - 2e^- \longrightarrow Be^{2+}$
2, 2

$Mg - 2e^- \longrightarrow Mg^{2+}$
2, 8, 2

$Ca - 2e^- \longrightarrow Ca^{2+}$
2, 8, 8, 2

10. The general characteristics of **alkaline earth metals** are.

(*i*) They are **highly reactive** elements and therefore does not occur in **free state**.

(*ii*) They have **two electrons** in their **valence shell** thus in order to **complete** their **octet** the **alkaline earth metals** loose **electrons** and get converted to **dipositive cation**. These elements have low ionization energy (But more than the alkali metals)

General equation

$M - 2e^- \longrightarrow M^{2+}$
(alkaline earth metal)

(*iii*) They are **less reactive** than **alkali metals**. They react with **Oxygen** and **Water vapour** on heating.

(*a*) **Reaction of alkaline earth metals with air:** Magnesium and calcium show no reaction with air at ordinary temperature however on burning they form their respective oxides and nitrides.

$2Mg + O_2 \longrightarrow 2MgO$
$3Mg + N_2 \longrightarrow Mg_3N_2$

$2Ca + O_2 \longrightarrow 2CaO$
$3Ca + N_2 \longrightarrow Ca_3N_2$

(*b*) **Reaction of alkaline earth metals with water:** Magnesium reacts very slowly with water to liberate hydrogen gas.

$$Mg + H_2O \xrightarrow{\Delta} MgO + H_2\uparrow$$

Calcium reacts vigorously with cold water to liberate hydrogen gas.

$$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2\uparrow$$

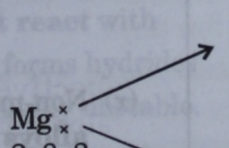
(*c*) **Reaction of alkaline earth metals with acid:** Magnesium and calcium react less vigorously with dil HCl to liberate hydrogen gas.

$Mg + 2HCl(dil.) \longrightarrow MgCl_2 + H_2\uparrow$ $\qquad$ $Ca + 2HCl(dil.) \longrightarrow CaCl_2 + H_2\uparrow$

(*iv*) They have **low melting point** and **boiling point**. The **melting point** and **boiling point** are **more** than the **alkali metals**.

(*v*) They are **harder** than **alkali metals**.

(*vi*) **Alkaline earth metals** being **highly electropositive** (less than alkali metals) undergo **ionic bond formation**.



$Mg - 2e^- \longrightarrow Mg^{2+}$

$2Cl + 2e^- \longrightarrow 2Cl^{-1}$

$Mg^{2+} + 2Cl^{-1} \longrightarrow MgCl_2$

(*vii*) **Alkaline earth metals** are **strong reducing agents**.

(*viii*) **Alkaline earth metals** displace **hydrogen** on reaction with **dilute acids**.

$Mg + 2HCl \longrightarrow MgCl_2 + H_2$

The reactivity increases on moving down the group.

(*ix*) **Alkaline earth metals** are obtained by the **electrolysis** of their **fused** or **molten chloride**. During **the electrolysis, metals** are obtained at **cathode**.

$$MgCl_2 \rightleftharpoons Mg^{+2} + 2Cl^-$$

Cathode : $Mg^{2+} + 2e^- \longrightarrow Mg$

Anode : $2Cl^- - 2e^- \longrightarrow 2[Cl]$

$2[Cl] \longrightarrow Cl_2$

11. Differences between metals and non-metals :

(*a*) Physical differences :

Metals	*Non-Metals*
(*i*) Metals are generally **solids** except **Mercury** which exists in **liquid** state at **room temperature**. **Gallium** and **Caesium** exist in **liquid** state at **30°C**.	(*i*) Non-metals are generally **gases**, sometimes **solids** like **Carbon**, **Sulphur** and **Phosphorus**. **Bromine** is a **liquid non-metal**.
(*ii*) Metals have **high density** except Sodium and Potassium.	(*ii*) Non-metals have **low density** except **diamond**.
(*iii*) Metals are **hard** except **Sodium** and **Potassium** which are very soft and can be easily cut with the help of knife.	(*iii*) Non-metals are generally **soft** except **diamond** an allotropic modification of carbon which is the **hardest** naturally occurring known substance.
(*iv*) Metals have **high melting point** and **boiling point** except **Sodium**, **Potassium**, **Gallium** etc.	(*iv*) Non-metals have **low melting point** and **boiling point** except **Boron**, **Silicon** and **Carbon**.
(*v*) Metals are **lustrous**, *i.e.*, they have shining surface.	(*v*) Non-metals are **non-lustrous** except **Iodine** and **Graphite**-allotropic modification of carbon.
(*vi*) Metals are **malleable**, *i.e.*, can be beaten into sheets except **Mercury, Zinc.**	(*vi*) Non-metals are **non-malleable**, *i.e.*, when beaten they do not form sheets.
(*vii*) Metals are **ductile**, *i.e.*, can be drawn into wires except **Mercury, Zinc.**	(*vii*) Non-metals are **non-ductile**.
(*viii*) Metals are **good conductors** of heat and electricity.	(*viii*) Non-metals are **poor conductors** of heat and electricity except two allotropic modifications of carbon – **graphite** and **gas carbon**.
(*ix*) Metals are usually **insoluble** in **liquid solvents**. If any metal dissolves in liquid solvent then always a **chemical change** takes place, *i.e.*, like **dissolution** of **Gold** and **Platinum** in **Aqua regia**.	(*ix*) Non-metals readily **dissolve** in **liquid solvents** like **Sulphur** is **soluble** in **Carbon disulphide** or **Ethyl alcohol**.
(*x*) Metals **easily** form **amalgams** and **alloys**.	(*x*) Non-metals **do not** form **amalgams** or **alloys** (Except **carbon** which is a constituent of steel)
(*xi*) Metals are **monoatomic.**, *i.e.*, each molecule has only one atom.	(*xi*) The molecules of non-metals are mainly **diatomic** or **polyatomic**. *i.e.*, having two or more than two atoms in each molecule *e.g.*, **Oxygen**, **Nitrogen** are **diatomic**. **Phosphorus** is **tetratomic**. **Sulphur** is **octatomic**.
(*xii*) Metals are **hard** but **not brittle**	(*xii*) Non-metals are generally **brittle**
(*xiii*) Metals are **sonorous**.	(*xiii*) Non-metals are **non-sonorous**.

(b) Chemical differences :

Metals	*Non-Metals*
(*i*) Metals have **1, 2** or **3** electrons in their **valence shell**.	(*i*) Non-metals have **5, 6** or **7** electrons in their **valence shell**.
(*ii*) Metals readily form **cation**. Thus these are **electropositive** in nature. **Metals** $Na - e^- \longrightarrow Na^+$ $K - e^- \longrightarrow K^+$ $Mg - 2e^- \longrightarrow Mg^{2+}$ $Ca - 2e^- \longrightarrow Ca^{2+}$ $Al - 3e^- \longrightarrow Al^{+3}$	(*ii*) Non-metals readily form **anion**. Thus these are **electronegative** in nature. **Non-metals** $F + e^- \longrightarrow F^{-1}$ $O + 2e^- \longrightarrow O^{-2}$ $N + 3e^- \longrightarrow N^{-3}$ $Cl + e^- \longrightarrow Cl^{-1}$ $S + 2e^- \longrightarrow S^{-2}$ $P + 3e^- \longrightarrow P^{-3}$
(*iii*) During electrolysis metals are obtained at **cathode**. $NaCl \rightleftharpoons Na^+ + Cl^-$ **Cathode :** $Na^+ + e^- \longrightarrow Na$ Sodium ions migrate towards cathode and undergo the process of reduction to form sodium metal.	(*iii*) During electrolysis non-metals are obtained at **anode**. **Anode :** $Cl^- - e^- \longrightarrow Cl$ $2[Cl] \longrightarrow Cl_2$ Chloride ions migrate towards anode and undergo the process of oxidation to form chlorine.
(*iv*) Metals usually form **basic oxides** except **Zinc oxide, Aluminium oxide, Beryllium oxide, Stanous oxide, Lead oxide** are **amphoteric oxides**.	(*iv*) Non-metals usually form **acidic oxides** except **Water, Carbon monoxide, Nitrous oxide** and **Nitric oxide** are **neutral oxides**.
(*v*) Metals form **ionic chlorides** and they act as strong electrolytes.	(*v*) Non-metals form **covalent chlorides**. They are non-electrolytes.
(*vi*) Metals are **reducing agents**, *i.e.*, **electron donors.**	(*vi*) Non-metals are **oxidizing agents**, *i.e.*, **electron acceptors**.
(*vii*) Metals generally **do not react** with **Hydrogen**. In case if it forms hydrides like NaH, KH they are highly unstable.	(*vii*) Non-metals form **stable hydrides** like **Water, Ammonia, Methane**, etc.
(*viii*) Active metals react with dilute acids to liberate **Hydrogen** (Except dilute nitric acid) $Mg + 2HCl \longrightarrow MgCl_2 + H_2$ $Fe + H_2SO_4 \longrightarrow FeSO_4 + H_2$	(*viii*) Non-metals do not react with either dilute Hydrochloric acid or dilute Sulphuric acid.

12. The series in which the metals are arranged in the decreasing order of their reactivity is called as **activity series**.

Activity Series: Relative Reactivities of Metals

K	Na	Ca	Mg	Al	Zn	Fe	Pb	H	Cu	Hg	Ag	Au	Pt
Potassium	Sodium	Calcium	Magnesium	Aluminium	Zinc	Iron	Lead	Hydrogen	Copper	Mercury	Silver	Gold	Platium
Most reactive				Reactivity increases								Least reactive	

Therefore, **Potassium** is placed at the top as it is **most reactive element** and **Gold** is placed at the bottom as it is the **least reactive element**.

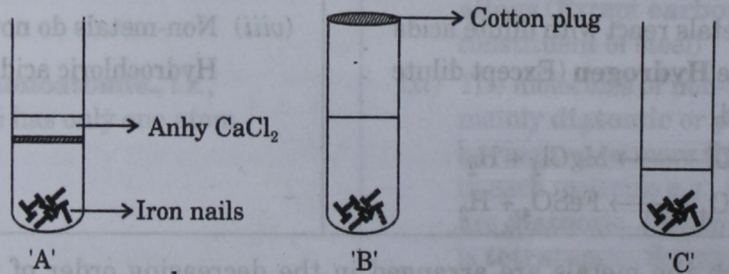
13. **The main features of activity series are :**
    (*i*) Metals lying **above** in activity series **can displace** the metals lying **below** from their salt solutions.
    (*ii*) Metals lying **above** hydrogen are **more electropositive** than the metals lying **below** hydrogen.
    (*iii*) Metals lying **below** hydrogen **do not displace** hydrogen from **water** and **dilute acids**.
14. **Sodium, Potassium, Calcium, Beryllium, Magnesium, Lithium** are **extracted** by the **electrolysis** of their **fused chlorides**. Their oxides are **not reduced** by **Carbon, Hydrogen** or **Carbon monoxide**.
15. **Oxides** of **Zinc, Copper, Lead** and **Iron** are reduced by **Carbon** or **Carbon monoxide** or **Hydrogen**.

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2 \qquad PbO + C \longrightarrow Pb + CO$$
$$PbO + CO \longrightarrow Pb + CO_2 \qquad PbO + H_2 \longrightarrow Pb + H_2O$$
$$ZnO + C \longrightarrow Zn + CO \qquad FeO + C \longrightarrow Fe + CO$$

16. **Loss** of **metal** layer by layer by the **action of impurities** (may be atmospheric gases) is referred to as **corrosion**.
17. **Corrosion** in the case of **iron** is referred as **Rusting of iron**.
18. The process in which **iron gets coated** with **reddish brown** layer is called as **Rusting**.
19. The **reddish brown layer** is commonly called as **Rust**. Which is chemically hydrated ferric oxide ($Fe_2O_3.xH_2O$).

$$4Fe + 3O_2 \longrightarrow 2Fe_2O_3 \qquad Fe_2O_3 + xH_2O \longrightarrow Fe_2O_3.xH_2O \quad (x, \text{ is any whole number})$$

20. The **essential condition** for the **process of rusting** is the **presence** of
    (*i*) **Oxygen**
    (*ii*) **Moisture**
21. In the absence of anyone of the above the process of rusting will not take place. This can be demonstrated with the help of the following experiments.
    Take three test-tubes A, B and C.
    In test-tube 'A; put some iron nails and then put a wire guage and on the wire gauge place some **anhydrous $CaCl_2$** and keep it for few days.
    In test-tube 'B' put some iron nails and to it add boiled water and plug the end of test-tube with the help of cotton. Keep the arrangement undisturbed for few days.
    In test-tube 'C' put some iron nails and to it add water and leave it open. Keep the arrangement undisturbed for few days.

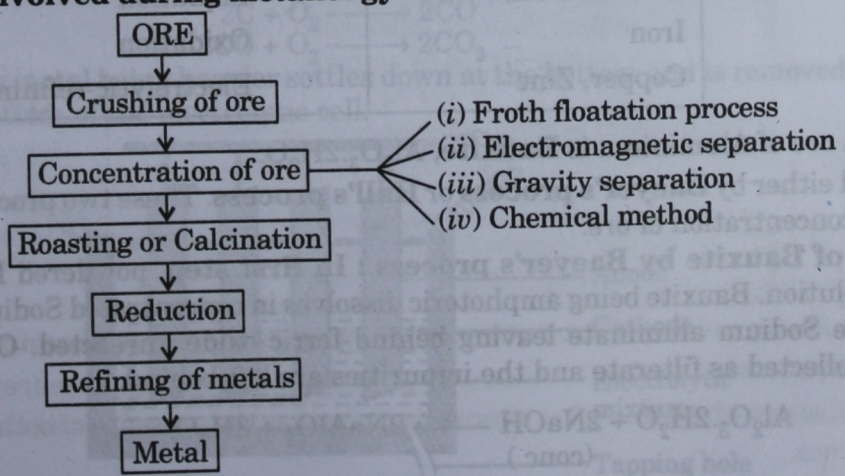


22. The following observations were made
    (*i*) In test-tube 'A' the **iron nails** do not undergo **rusting** as there was **absence of moisture**.
    (*ii*) In test-tube 'B', the **iron nails** do not undergo rusting as there was absence of oxygen.
    (*iii*) In test-tube 'C', the iron nails undergo rusting as there was the presence of both oxygen and moisture.

23. Thus, from the above experiments it can be concluded that for the process of rusting both oxygen and moisture are required. In the absence of any component the rusting will not take place.
24. Rusting of iron can be prevented by
    (*i*) Greasing (*ii*) Oiling (*iii*) Painting
    (*iv*) Galvanization : The **coating** of **thin** uniform layer of zinc over the surface of iron is called as **galvanization**.
    (*v*) Electroplating
25. Most of the **metals** are found in the **combined state** in the form of **compounds**. The compounds are in the form of **sulphates, sulphides, oxides, halides, carbonates**, etc.
26. Most of the **metals** occur in the **combined state** in the form of **ores**.

Compounds	*Ores*	*Formulae*
Sulphides	Zinc blende	ZnS.
	Galena	PbS
	Iron pyrites	FeS_2
	Copper pyrites	$CuFeS_2$
	Cinnabar	HgS
Carbonates	Calamine	$ZnCO_3$
	Siderite	$FeCO_3$
	Limestone	$CaCO_3$
	Magnesite	$MgCO_3$
	Dolomite	$CaCO_3.MgCO_3$
Oxides	Haematite	Fe_2O_3
	Bauxite	$Al_2O_3.2H_2O$
Halides	Rock salt	NaCl
	Fluorspar	CaF_2
	Cryolite	Na_3AlF_6

27. **Minerals** are the naturally occurring compounds of a metal.
28. **Ores** are the naturally occurring compounds of a metal from which metals are extracted **cheaply, profitably** and **conveniently**.
29. The **unwanted earthy impurities** associated with the ore is called as **Gangue** or **Matrix**.
30. **Flux** is a chemical substance which is added with the charge to remove the gangue or matrix in the form of **fusible slag**.
31. The **fusible product** formed when flux reacts with gangue during the extraction of metals is called as **Slag**.
32. **Metallurgy** is the process of extracting pure metal from its ore by physical or chemical means.
33. **The processes involved during metallurgy are :**



34. During **crushing** or **grinding**, huge lumps of ore are crushed to a **fine powder**.
35. The process of removal of gangue impurities from the ore is called as **Concentration**. The ore can be concentrated by the following named processes :
    (*a*) **Froth floatation process** is used to concentrate **sulphide ores**.
    (*b*) **Electromagnetic separation** is used to concentrate **Iron ores**.
    (*c*) **Gravity separation** is used to concentrate **oxide** and **hydroxide ores**.
    (*d*) **Chemical method** by using **NaOH** for purifying **Bauxite.**
36. The concentrated ore is subjected to either **Roasting** or **Calcination**.
37. The purpose of both **Roasting** and **Calcination** is
    (*a*) to convert ore into oxide. (*b*) the ore becomes light and porous.
    (*c*) the volatile impurities are driven off.
38. **Roasting** is done for **Sulphide ores**. Roasting is the process of heating of concentrated ore in the **sufficient supply** of **air** or **Oxygen**.

$$\underset{\text{Zinc blende}}{2ZnS} + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2$$

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

$$\underset{\text{Iron pyrite}}{4FeS_2} + 11O_2 \xrightarrow{\Delta} 2Fe_2O_3 + 8SO_2$$

39. **Calcination** is done for **Hydroxide** and **Carbonate** ores. Calcination is the process of concentrated heating of ore in the **absence** of **air** or **oxygen**.

$$\underset{\text{Calamine}}{ZnCO_3} \xrightarrow{\Delta} ZnO + CO_2 \qquad \underset{\text{Siderite}}{FeCO_3} \xrightarrow{\Delta} FeO + CO_2$$

40. Metallic oxide is reduced either by **electrolysis** or by using reducing agents like **Carbon monoxide, Carbon, Hydrogen**, etc.

$$ZnO + C \longrightarrow Zn + CO,$$
$$PbO + C \longrightarrow Pb + CO,$$
$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$

The differences between **Roasting** and **Calcination** can be summarized as

Roasting	*Calcination*
(*i*) It is the process of heating of concentrated ore in the presence of air or oxygen.	(*i*) It is the process of heating the concentrated ore in the absence of air or oxygen.
(*ii*) It is usually done for sulphide ore.	(*ii*) It is usually done for carbonate ores.
(*iii*) Volatile impurities of sulphur dioxide are removed.	(*iii*) Impurities of moisture and carbon dioxide are removed.

41. The metals which are obtained after reduction are **not absolutely pure**, they contain certain impurities. The impurities are removed by **electrolytic refining, liquation, distillation** and **oxidation**.

Metals	*Method of Refining*
Zinc	Distillation
Lead and Tin	Liquation
Iron	Oxidation
Copper, Zinc	Electrolytic-refining

42. The most common ore of Aluminium is **Bauxite**, $Al_2O_3.2H_2O$.
43. Bauxite is purified either by **Baeyer's process** or **Hall's process**. These two processes are the chemical processes for the concentration of ore.
    (*a*) **Purification of Bauxite by Baeyer's process : In first step**, powdered Bauxite is mixed with caustic soda solution. Bauxite being amphoteric dissolves in concentrated Sodium hydroxide solution to form soluble Sodium aluminate leaving behind ferric oxide unreacted. On filteration, Sodium aluminate is collected as filterate and the impurities are left behind.

$$Al_2O_3.2H_2O + \underset{\text{(conc.)}}{2NaOH} \xrightarrow{\Delta} 2NaAlO_2 + 3H_2O.$$

In second step, Sodium aluminate solution is diluted with water, it gets hydrolysed to give white precipitate of Aluminium hydroxide, which is filtered, washed and dried.

$$NaAlO_2 + 2H_2O \longrightarrow NaOH + Al(OH)_3\downarrow$$
(White ppt.)

In **third step**, the dried Aluminium hydroxide is heated to high temperature, so as to obtain pure Alumina.

$$2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$$

(*b*) Purification of Bauxite by Hall's process.

In first step, Bauxite is **fused** with Sodium carbonate on heating, then it forms Sodium aluminate which is cooled and then ground to a fine powder.

$$Al_2O_3.2H_2O + Na_2CO_3 \xrightarrow{\Delta} 2NaAlO_2 + 2H_2O + CO_2$$

In second step, the fine powder is dissolved in water and filtered. The filterate contains Sodium aluminate (water soluble) and the insoluble impurities are filtered out. Then carbon dioxide is passed through the filterate, when Aluminium hydroxide gets precipitated out. It is filtered, washed and dried.

$$2NaAlO_2 + 3H_2O + CO_2 \longrightarrow Na_2CO_3 + 2Al(OH)_3$$

In third step, Aluminium hydroxide is heated to high temperature to get pure Alumina.

$$2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$$

44. Aluminium oxide obtained as a result of concentration of ore, which is a very stable compound and thus, it cannot be reduced by common reducing agents like coke, hydrogen, carbonmonoxide, ammonia etc. It can only be reduced electrolytically. The electrolytic process for the extraction of pure aluminium from aluminium oxide is called **Hall's Heroult's process**.

45. In this, the **inner carbon lining** of the cell serves as **cathode** and the **block of carbon** dipped in electrolyte serves as **anode**.

46. The electrolyte used is a mixture of pure **molten alumina**, **cryolite** and **fluorspar**.

47. **Cryolite and fluorspar are added to pure alumina :**

(*a*) to reduce the melting point or fusion temperature of pure alumina.

(*b*) to increase the electrical conductivity of the electrolyte.

(*c*) cryolite acts as a solvent.

48. The **Carbon anodes** are **periodically** replaced because they get **oxidized** to **Carbon dioxide**.

49. The **electrolytic mixture** is covered with **coke** or **sawdust** so as to prevent the loss of heat by radiation.

50. The following reactions take place :

$$\underset{\text{Alumina}}{Al_2O_3} \rightleftharpoons 2Al^{3+} + 3O^{2-}$$

$$\underset{\text{Cryolite}}{Na_3AlF_6} \rightleftharpoons 3Na^+ + Al^{3+} + 6F^-$$

$$\underset{\text{Fluorspar}}{CaF_2} \rightleftharpoons Ca^{2+} + 2F^-$$

At Cathode : $Al^{3+} + 3e^- \longrightarrow Al$

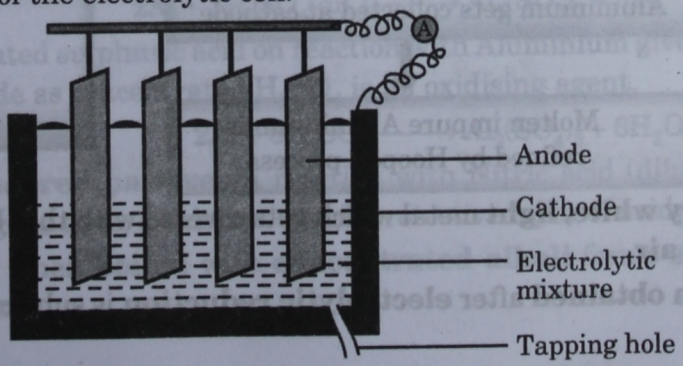
At Anode : $O^{2-} - 2e^- \longrightarrow [O]$

$[O] + [O] \longrightarrow O_2$

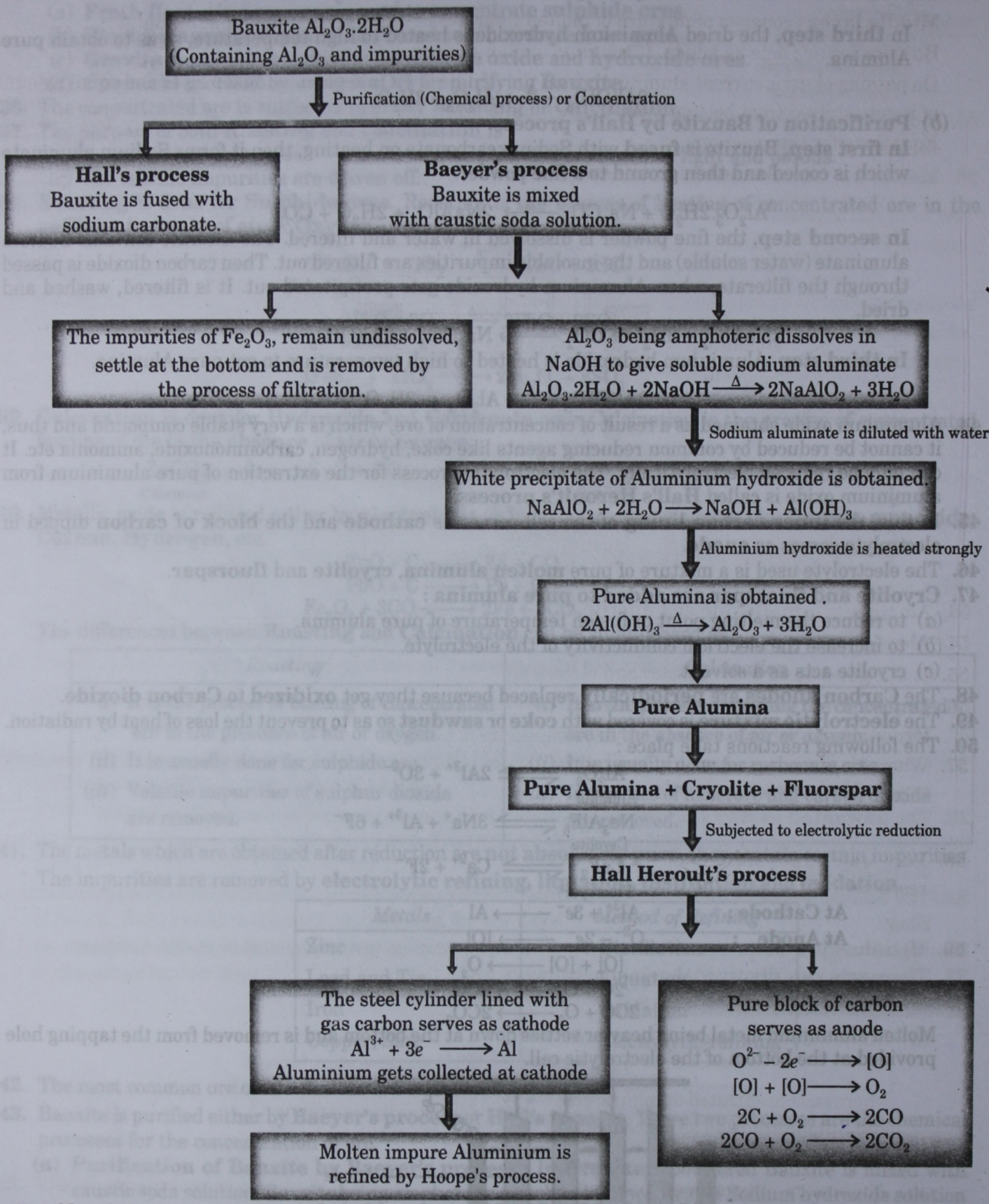
$2C + O_2 \longrightarrow 2CO$

$2CO + O_2 \longrightarrow 2CO_2$

Molten aluminium metal being heavier settles down at the bottom and is removed from the tapping hole provided at the bottom of the electrolytic cell.



Flow Chart for the Metallurgy of Aluminium



51. **Aluminium** is a **silvery white, light** metal which gets covered with thin but tough protective **layer of oxide on exposure to air**.

The molten **aluminium obtained** after **electrolytic reduction** is subjected to **electrolytic refining** by **Hoope's process**.

52. **Hoope's process** uses an **electrolytic cell** which contains **three layer** of **molten substances** of **different specific gravity**. These three layers are

Top layer : acts as cathode. It contains molten pure aluminium

Middle layer : consists of mixture of molten flourides of sodium, barium and aluminium.

Bottom layer : acts as anode. It contains molten impure aluminium.

On passing electric current aluminium from the middle layer passes on to the top layer and equal amount of it gets shifted from bottom layer to the middle layer.

Equations for the reactions

At Cathode : $Al^{3+} + 3e^- \longrightarrow Al$

At Anode : $Al - 3e^- \longrightarrow Al^+$

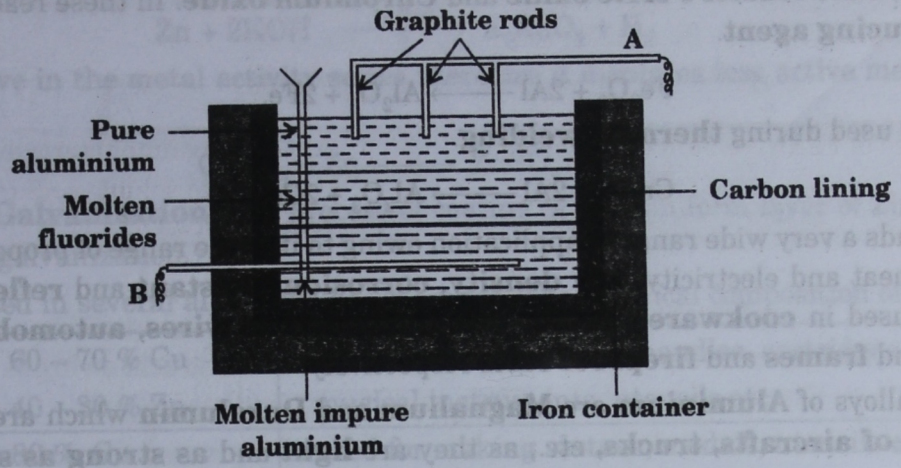


Fig. 1 Refining of Aluminium by Hoope's process

53. Aluminium is **malleable** and **ductile**.

54. Aluminium is a **light** but yet very **strong** having **high tensile strength**.

55. It is a **good conductor** of heat and electricity.

56. **Dry air** has **no effect** on **Aluminium**. However in **moist air** aluminium readily **tarnishes** due to the formation of thin but tough layer of oxide.

57. When Aluminium is **strongly heated in air**, it burns without flame producing a dazzling white light.

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

$$2Al + N_2 \longrightarrow 2AlN$$

58. Pure water **does not react** with Aluminium. However **steam reacts** with **Aluminium** to form its respective **oxide** with the **liberation of Hydrogen**. However, the reaction is **very slow**.

$$2Al + 3H_2O \longrightarrow Al_2O_3 + 3H_2$$

59. (*i*) Dilute hydrochloric acid **reacts slowly** with Aluminium whereas concentrated hydrochloric acid **reacts rapidly** with Aluminium, both forming Aluminium chloride and Hydrogen.

$$2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$$

(*ii*) Dilute sulphuric acid reacts with Aluminium to give Aluminium sulphate and Hydrogen gas.

$$2Al + 3H_2SO_4(dil.) \longrightarrow Al_2(SO_4)_3 + 3H_2$$

whereas, concentrated sulphuric acid on reaction with Aluminium gives Aluminium sulphate, Water and Sulphur dioxide as concentrated H_2SO_4 is an oxidising agent.

$$2Al + 6H_2SO_4 \longrightarrow Al_2(SO_4)_3 + 6H_2O + 3SO_2$$

(*iii*) Aluminium is **rendered passive** on reaction with Nitric acid (dilute or concentrated) as it is a strong oxidising agent thus, a thin but tough protective layer of oxide is formed.

60. **Aluminium powder** when **boiled** with **concentrated alkali** forms soluble complex salts with the liberation of **Hydrogen**.

$$2Al + 2NaOH + 2H_2O \xrightarrow{\text{boiled}} \underset{\text{Sodium aluminate}}{2NaAlO_2} + 3H_2$$

$$2Al + 2KOH + 2H_2O \xrightarrow{\text{boiled}} \underset{\text{Potassium aluminate}}{2KAlO_2} + 3H_2$$

61. Aluminium reacts with the following **non-metals**

(*i*) with **Chlorine :** $2Al + 3Cl_2 \longrightarrow 2AlCl_3$

(*ii*) with **Sulphur :** $2Al + 3S \longrightarrow Al_2S_3$

(*iii*) with **Carbon :** $4Al + 3C \longrightarrow Al_4C_3$

62. **Aluminium powder** reduces **Ferric oxide** and **Chromium oxide**. In these reactions **Aluminium** is acting as a **reducing agent**.

$$Fe_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Fe.$$

This reaction is used during **thermite welding**.

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

63. **Aluminium** finds a very wide range of application owing to its wide range of properties. As it is a **good conductor** of heat and electricity, **low density**, **corrosion resistant** and **reflects heat** and **light**, therefore it is used in **cookwares, cables** and **transmission wires, automobile parts, outdoor equipments** and **frames** and **fireproof suits** respectively.

64. The two main alloys of **Aluminium** are **Magnalium** and **Duralumin** which are exclusively used in making **bodies of aircrafts, trucks,** etc., as they are **light** and **as strong as steel** and **corrosion resistant**.

The composition of the two alloys are :

(*i*) **Duralumin** 95 % Al, 4 % Cu, 0.5 % Mg, 0.5 % Mn

(*ii*) **Magnalium** 90–95 % Al, 10–5 % Mg

65. Most common ore of **Zinc** is **Zinc blende-ZnS**. The others are

Calamine	–	$ZnCO_3$
Zincite	–	**ZnO**

66. Zinc is a **bluish white metal** and is a **good conductor** of heat and electricity.

67. **Dry air** has **no effect** on **Zinc**. However in the presence of **moisture** Zinc **tarnishes** due to the formation of oxide layer.

68. **Zinc** reacts with **steam** to form **Zinc oxide** with the liberation of **Hydrogen**

$$Zn + H_2O \longrightarrow ZnO + H_2$$

69. **Sulphur** and **Chlorine** directly react with **Zinc**

$$Zn + S \xrightarrow{\Delta} ZnS$$

$$Zn + Cl_2 \longrightarrow ZnCl_2$$

70. (*i*) Dilute Hydrochloric acid reacts with **Zinc** to form **Zinc chloride** and **Hydrogen gas.**

$$Zn + 2HCl(dil.) \longrightarrow ZnCl_2 + H_2$$

(*ii*) Zinc displaces Hydrogen from dilute Sulphuric acid.

$$Zn + H_2SO_4(dil.) \longrightarrow ZnSO_4 + H_2$$

(*iii*) Zinc reacts with concentrated Sulphuric acid to form Zinc sulphate, Water and Sulphur dioxide as concentrated H_2SO_4 is an oxidising agent.

$$Zn + 2H_2SO_4(conc.) \longrightarrow ZnSO_4 + 2H_2O + SO_2$$

(*iv*) Zinc reacts with dilute Nitric acid to form Zinc nitrate, Water and Nitric oxide.

$$3Zn + 8HNO_3(dil.) \longrightarrow 3Zn(NO_3)_2 + 4H_2O + 2NO$$

(*v*) Zinc reacts with concentrated Nitric acid to form Zinc nitrate, Water and Nitrogen dioxide.

$$Zn + 4HNO_3(conc.) \longrightarrow Zn(NO_3)_2 + 2H_2O + 2NO_2$$

71. **Zinc** powder when boiled with **concentrated alkali** it forms its respective **soluble complex salt** and **Hydrogen gas**

$$Zn + 2NaOH \xrightarrow{\text{boiled}} Na_2ZnO_2 + H_2$$
$$Zn + 2KOH \xrightarrow{\text{boiled}} K_2ZnO_2 + H_2$$

72. Zinc is lying above in the metal activity series therefore it displaces less active metals from their salt solutions.

$$CuSO_4 + Zn \longrightarrow ZnSO_4 + Cu$$

73. Zinc is used for **Galvanization**. The process of coating of thin uniform layer of Zinc on the surface of Iron is called as galvanization.

74. Zinc is widely used in several alloys like brass bronze. The chemical composition of the two alloys are

(*i*) Brass	60 – 70 % Cu 40 – 30 % Zn	used for making screw, handles, cartridges, electrical goods musical instruments, utensils etc
(*ii*) Bronze	80 % Cu 2 % Zn 18 % Sn	used for making statues, medals, utensils coins etc.

75. The most common ore of iron is **Haematite - Fe_2O_3**

The other ores are

Magnetite	–	Fe_3O_4
Siderite	–	$FeCO_3$
Iron pyrites	–	FeS_2
Limonite	–	$Fe_2O_3.3H_2O$

76. The ore is **crushed** and concentrated by **magnetic separation** followed by **gravity separation**.

77. **Cast Iron** obtained from blast furnace is the **impure** form of Iron. **Carbon** is the major impurity present in cast Iron.

78. The **residual gases** leaving the furnace are **Carbon monoxide**, **Carbon dioxide** and **Nitrogen**.

79. The **major impurity** present in cast Iron is removed by the process of **oxidation** during steel making.

80. **Steel** is an alloy of **pure Iron** and **Carbon** and contains only 0.2 - 0.3% of Carbon.

81. **Steel** is converted into **stainless steel** by adding **Chromium** and **Nickle**.

82. Iron is a **greyish black** metal. It is **good conductor** of heat and electricity. It is **tough, malleable** and **ductile**.

83. **Dry air** has **no effect** on Iron. However in the **presence of moisture** and **air** iron gets coated with **reddish brown layer** commonly called as **rust** which is chemically **hydrated Ferric oxide**.

$$4Fe + 3O_2 \longrightarrow 2Fe_2O_3$$
$$Fe_2O_3 + xH_2O \longrightarrow Fe_2O_3.xH_2O$$

Rust (Hydrated Ferric oxide)

84. When **steam** is passed over **heated Iron** it forms Magnetic oxide of Iron – **Triferric tetraoxide** and **Hydrogen**.

$$\underset{\text{heated}}{3Fe} + \underset{\text{steam}}{4H_2O} \rightleftharpoons \underset{\substack{\text{Triferric}\\ \text{tetraoxide}}}{Fe_3O_4} + 4H_2$$

85. **Iron** directly reacts with **Chlorine** and **Sulphur** on heating.

$$\underset{\text{heated}}{2Fe} + \underset{\text{dry}}{3Cl_2} \longrightarrow \underset{\substack{\text{Anhydrous}\\ \text{Iron(III) chloride}}}{2FeCl_3}$$

$$Fe + S \xrightarrow{\Delta} FeS$$

86. (*i*) Iron displaces Hydrogen from dilute Hydrochloric acid and dilute Sulphuric acid.

$$Fe + 2HCl\ (dil.) \longrightarrow FeCl_2 + H_2$$

$$Fe + H_2SO_4\ (dil.) \longrightarrow FeSO_4 + H_2$$

(*ii*) Iron reacts with concentrated Sulphuric acid to give Sulphur dioxide.

$$Fe + 2H_2SO_4(conc.) \longrightarrow FeSO_4 + 2H_2O + SO_2$$

$$2FeSO_4 + 2H_2SO_4\ (conc.) \longrightarrow Fe_2(SO_4)_3 + SO_2 + 2H_2O$$

Or

$$2Fe + 6H_2SO_4(conc.) \longrightarrow Fe_2(SO_4)_3 + 6H_2O + 3SO_2$$

(*iii*) Iron is **rendered passive** on reaction with concentrated Nitric acid owing to the formation of oxide layer on the surface as concentrated HNO_3 is a strong oxidising agent.

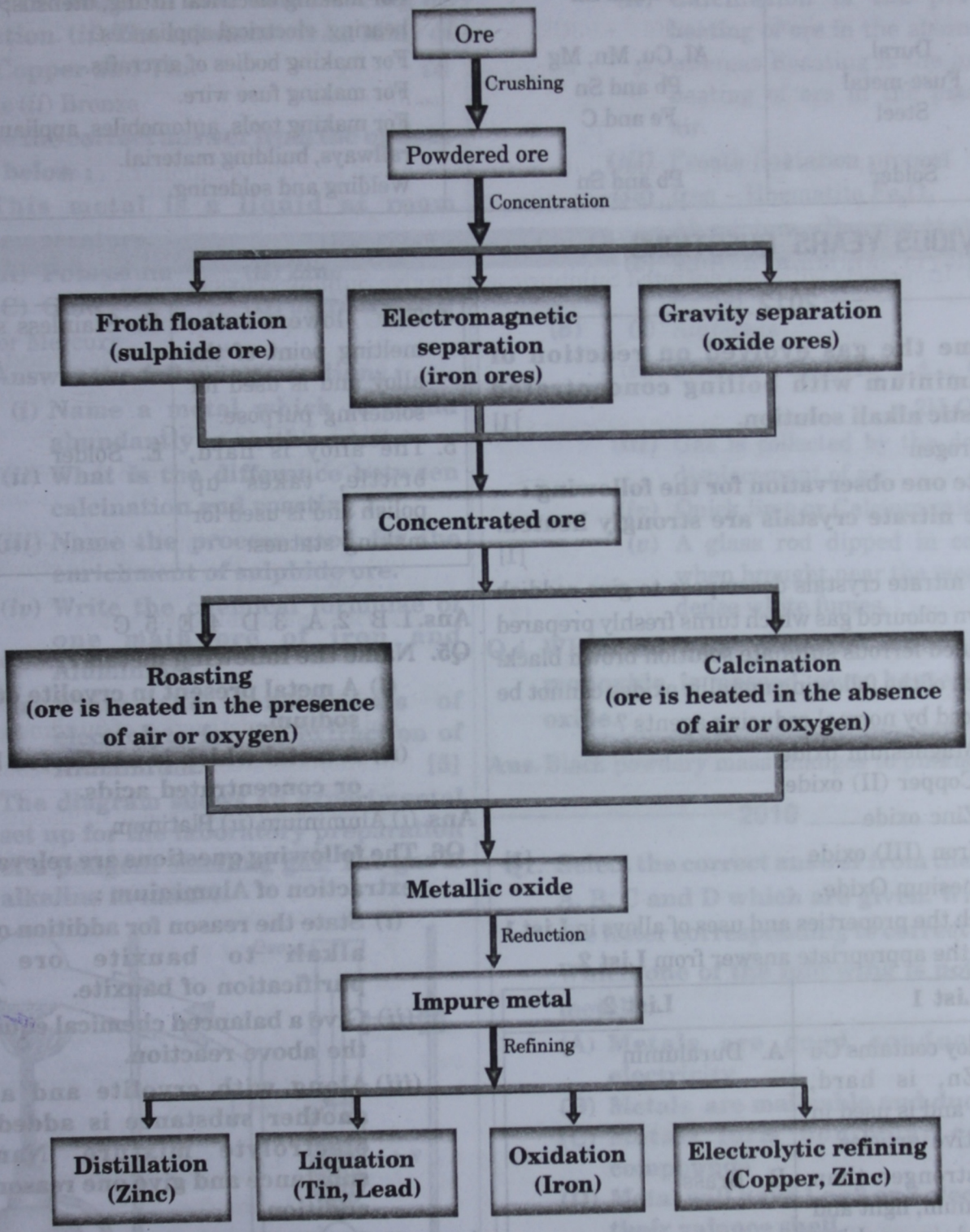
87. Iron displaces the metals which lie below it in the metal activity series from their salt solutions.

$$CuSO_4 + Fe \longrightarrow FeSO_4 + Cu$$

- Iron is used in the manufacture of shutters, raining grills, main hole covers etc.
- The most common alloy of iron are steel and stainless steel. The composition and uses of the alloys are

1. Steel	98.5 – 99.9% Iron 0.1 – 1.5% Carbon	used for the construction of buildings, machines, and stainless steel as it has high tensil strength.
2. Stainless steel	73% Fe, 18% Cr 8% Ni, 1% Carbon	used for making surgical instruments, utensiles cutlery etc. as it is resistant to corrosion

The metallurgical processes can be briefly summarized in the form of a flow chart as follows



88. Alloys are the **homogeneous mixture** of **two metals** or **metal with non-metal** mixed together in fused state.
89. Alloys are made to **modify appearance, increase strength, colour, reactivity,** etc.
90. An alloy of metal with mercury is called as an **amalgam**.

91. Alloys are made to **change the property of their constituents** to achieve specific objective *e.g.*, Steel, Bronze, Brass, Duralumin, Fuse metal, solder.

Name of Alloy	*Constituents*	*Uses*
Bronze	Cu and Sn	For making statues, coins, utensils, medals.
Brass	Cu and Zn	For making electrical fitting, utensils, statues, bearing, electrical appliances.
Dural	Al, Cu, Mn, Mg	For making bodies of aircrafts.
Fuse-metal	Pb and Sn	For making fuse wire.
Steel	Fe and C	For making tools, automobiles, appliances, railways, building material.
Solder	Pb and Sn	Welding and soldering.

PREVIOUS YEARS' QUESTIONS

2012

Q1. Name the gas evolved on reaction of Aluminium with boiling concentrated caustic alkali solution. [1]

Ans. Hydrogen

Q2. State one observation for the following : Zinc nitrate crystals are strongly heated. [1]

Ans. Zinc nitrate crystals decompose to give reddish brown coloured gas which turns freshly prepared acidified ferrous sulphate solution brown black.

Q3. Which of the following metallic oxides cannot be reduced by normal reducing agents ?

(A) Magnesium oxide
(B) Copper (II) oxide
(C) Zinc oxide
(D) Iron (III) oxide [1]

Ans. Magnesium Oxide.

Q4. Match the properties and uses of alloys in **List 1** with the appropriate answer from **List 2.**

List 1	List 2
1. The alloy contains Cu and Zn, is hard, silvery and is used in decorative articles.	A. Duralumin
2. It is stronger than Aluminium, light and is used in making light tools.	B. Brass
3. It is lustrous, hard, corrosion resistant and used in surgical instruments.	C. Bronze
4. Tin lowers the melting point of the alloy and is used for soldering purpose.	D. Stainless steel
5. The alloy is hard, brittle, takes up polish and is used for making statues.	E. Solder

[5]

Ans. 1. B 2. A 3. D 4. E 5. C

Q5. Name the following metals :

(*i*) A metal present in cryolite other than sodium.

(*ii*) A metal which is unaffected by dilute or concentrated acids. [2]

Ans. (*i*) Aluminium (*ii*) Platinum

Q6. The following questions are relevant to the extraction of Aluminium :

(*i*) State the reason for addition of caustic alkali to bauxite ore during purification of bauxite.

(*ii*) Give a balanced chemical equation for the above reaction.

(*iii*) Along with cryolite and alumina, another substance is added to the electrolyte mixture. Name the substance and give one reason for the addition. [3]

Ans. (*i*) Bauxite dissolves in caustic alkali to form soluble sodium aluminate and the impurities remain unreacted.

(*ii*) $Al_2O_3.2H_2O + 2\ NaOH \longrightarrow 2NaAlO_2 + 3H_2O$.

(iii) Calcium fluoride. It increases the electrical conductivity of the electrolyte.

2011

Q1. Name (i) The black powdery substance used for the reduction of Zinc oxide during its extraction. (ii) The substance is an alloy of Zinc, Copper and Tin. [2]

Ans. (i) Coke (ii) Bronze

Q2. Choose the correct answer from the options given below :

(i) This metal is a liquid at room temperature.

(A) Potassium (B) Zinc
(C) Gold (D) Mercury [1]

Ans. (i) D or Mercury

Q3. (a) Answer the following questions :

(i) Name a metal which is found abundantly in earth's crust.

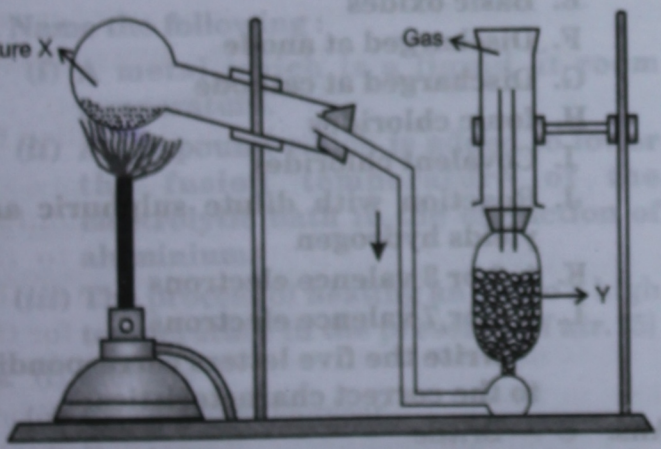
(ii) What is the difference between calcination and roasting ?

(iii) Name the process used for the enrichment of sulphide ore.

(iv) Write the chemical formulae of one main ore of iron and Aluminium.

(v) Write the constituents of electrolyte for the extraction of Aluminium. [5]

(b) The diagram shows an experimental set up for the laboratory preparation of a pungent smelling gas. The gas is alkaline in nature.



(i) Name the gas collected in the jar.

(ii) Write the balanced equation for the above preparation.

(iii) How is the gas being collected?

(iv) Name the drying agent used.

(v) How will you find that the jar is full of gas ? [5]

Ans. (a) (i) Aluminium or Iron

(ii) Calcination is the process of heating of ore in the absence of air whereas Roasting is the process of heating of ore in the presence of air.

(iii) Froath floatation process.

(iv) Iron – Haematite Fe_2O_3
Aluminium – Bauxite $Al_2O_3.2H_2O$

(v) Molten alumina, cryolite and fluorspar.

(b) (i) Ammonia

(ii) $2NH_4Cl + Ca(OH)_2 \xrightarrow{\Delta} CaCl_2 + 2H_2O + 2NH_3$

(iii) Gas is collected by the downward displacement of air.

(iv) Quick lime or Calcium oxide.

(v) A glass rod dipped in conc. HCl when brought near the mouth gives dense white fumes.

Q.4 What do you observe when carbon monoxide is passed over heated copper oxide. [1]

Ans. Black powdery mass changes to pinkish metal.

2010

Q1. Select the correct answer from the choices A, B, C and D which are given. Write only the letter corresponding to correct answer.

Which one of the following is not true of metals :

(A) Metals are good conductors of electricity
(B) Metals are malleable and ductile
(C) Metals form non-polar covalent compounds
(D) Metal will have 1 or 2 or 3 electrons in their valence shell. [1]

Ans. C.

Q2. Name the main constituent metal in the following alloys :

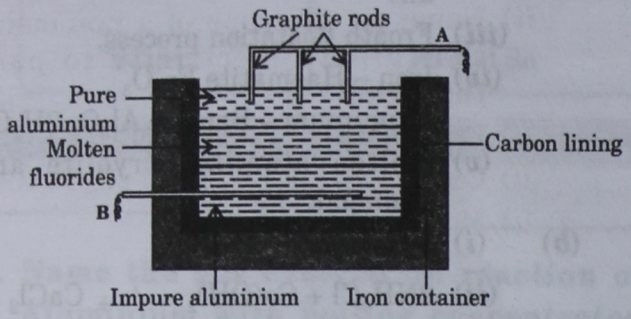
(i) Duralumin

(ii) Brass
(iii) Stainless steel. [3]

Ans. (i) Al
(ii) Zn
(iii) Fe, Cr, Ni

2009

Q1. (a) The sketch below illustrates the refining of aluminium by Hoope's process.



(i) Which of A and B is the cathode and which one is the anode?
(ii) What is the electrolyte in the tank?
(iii) What material is used for the cathode? [3]

(b) State the property of the metal being utilized in the following: [2]

Use of metal	Property
Zinc in Galvanization	
Aluminium in Thermite welding	

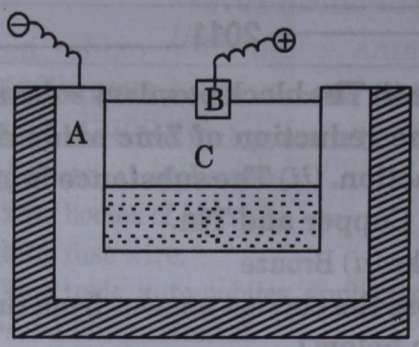
Ans. (a) (i) A is cathode and B is anode.
(ii) Molten fluorides
(iii) Graphite
(b) Zinc in Galvanization – Resistant to corrosion.
Aluminium in Thermite welding – Reducing agent.

2008

Q1. Select the correct answer from the choices A, B, C, D which are given : [1]
Brass is an alloy of
A. Copper and tin
B. Copper and zinc
C. Zinc and lead
D. Lead and tin

Ans. B. Copper and Zinc

Q2. The following is a sketch of an electrolytic cell used in the extraction of aluminium.



(i) What is the substance of which the electrodes A and B are made ?
(ii) At which electrode (A or B) is the aluminium formed ?
(iii) What are the two aluminium compounds in the electrolyte C ?
(iv) Why is it necessary for electrode 'B' to be continuously replaced ? [5]

Ans. (i) Carbon *or* Graphite
(ii) A *or* Cathode
(iii) Pure alumina (Al_2O_3) and Cryolite (Na_3AlF_6)
(iv) Electrode 'B' is periodically replaced because it gets oxidized to carbon dioxide.

2007

Q1. From the list of characteristics given below, select the five which are relevant to non-metals and their compounds :
A. Ductile
B. Conduct electricity
C. Brittle
D. Acidic oxides
E. Basic oxides
F. Discharged at anode
G. Discharged at cathode
H. Ionic chlorides
I. Covalent chlorides
J. Reaction with dilute sulphuric acid yields hydrogen
K. 1, 2 or 3 valence electrons
L. 5, 6 or 7 valence electrons
(Write the five letters corresponding to the correct characteristics) [5]

Ans. C — Brittle
D — Acidic oxides
F — Discharged at anode
I — Covalent chlorides
L — 5, 6 or 7 valence electrons.

Q2. The following is an extract from 'Metals in the Service of Man, Alexander and Street/Pelican 1976':

'Alumina (aluminium oxide) has a very high melting point of over 2000°C so that it cannot readily be liquified. However, conversion of alumina to aluminium and oxygen, by electrolysis, can occur when it is dissolved in some other substance.'

(i) Which solution is used to react with bauxite as a first step in obtaining pure aluminium oxide ?

(ii) The aluminium oxide for the electrolytic extraction of aluminium is obtained by heating aluminium hydroxide. Write the equation for this reaction.

(iii) Name the element which serves both as the anode and the cathode in the extraction of aluminium.

(iv) Write the equation for the reaction that occurs at the cathode during the extraction of aluminium by electrolysis.

(v) Give the equation for the reaction which occurs at the anode when aluminium is purified by electrolysis. [5]

Ans. (i) Sodium hydroxide (NaOH)

(ii) $2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$

(iii) Carbon

(iv) $Al^{3+} + 3e^- \longrightarrow Al$

(v) $Al - 3e^- \longrightarrow Al^{3+}$

2006

Q1. Name the following :

(i) A metal which is a liquid at room temperature.

(ii) A compound which is added to lower the fusion temperature of the electrolytic bath in the extraction of aluminium.

(iii) The process of heating an ore to a high temperature in the presence of air. [5]

Ans. (i) Mercury

(ii) Cryolite and fluorspar

(iii) Roasting

Q2. Write balanced chemical equation for the reaction of aluminium oxide with sodium hydroxide solution. [1]

Ans. $Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$

Q3. (a) Write balanced chemical equations for the following reactions :

(i) Iron(III) oxide and carbon monoxide.

(ii) Calcium bicarbonate and dilute hydrochloric acid. [2]

(b) (i) Is the amount of carbon in pig iron/ cast iron more than, less than or the same as the amount of carbon in steel ?

(ii) Name an allotrope of a non-metal that allows electricity to pass through it. [2]

Ans. (a) (i) $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

(ii) $Ca(HCO_3)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O + 2CO_2$

(b) (i) More

(ii) Graphite, Gas carbon

2005

Q1. A to F below related to the source and extraction of either Zinc or Aluminium.

A. Bauxite

B. Coke

C. Cryolite

D. Froth floatation

E. Sodium hydroxide solution

F. Zinc blende.

(i) Write down the three letters each from the above list which are relevant to

1. Zinc

2. Aluminium

(ii) Fill in the blanks using the most appropriate words form A to F.

1. The ore from which aluminium is extracted must first be treated with _____ so that pure aluminium oxide can be obtained.

2. Pure aluminium oxide is dissolved in _____ to make a conducting solution.

(iii) Write the formula of cryolite. [5]

Ans. (i) 1. B, D, F

2. A, C, E

(ii) 1. Sodium hydroxide

2. Cryolite

(iii) Na_3AlF_6

Q2. In the manufacture of iron, a mixture of limestone, coke and iron ore is added to

the blast furnace. In this context, Give the equation for the reduction of iron ore. [1]

Ans. $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

Q3. Calcium, Copper, Lead, Aluminium, Zinc, Chromium, Magnesium, Iron.

Choose the major metals from the list given above to make the following alloys.

1. Stainless steel

2. Brass. [2]

Ans. 1. Iron, Chromium 2. Copper, Zinc

IMPORTANT QUESTIONS

Q1. What is added to steel to make it stainless steel ?

Ans. Chromium and Nickel

Q2. (a) For each substance listed below, explain its significance in the extraction of Aluminium :

(i) Bauxite

(ii) Sodium hydroxide

(iii) Cryolite

(iv) Graphite

(b) The following questions related to the extraction of Aluminium by electrolysis :

(i) Give the equation for the reaction that takes place at the cathode.

(ii) Explain why it is necessary to renew anode from time to time.

(c) (i) What is an alloy ?

(ii) An alloy usually has some property which makes it particularly useful. What is the special property of

(1) Duralumin (2) Type metal

Ans. (a) (i) Bauxite is the most common ore of Aluminium.

(ii) Sodium hydroxide is used for the purification of Bauxite by Baeyer's process.

(iii) Cryolite is added to pure alumina to decrease the melting point or fusion temperature of pure Alumina.

(iv) Graphite acts as anode.

(b) (i) $Al^{3+} + 3e^- \longrightarrow Al$

(ii) Anode is renewed from time to time because they get oxidized.

(c) (i) An alloy is a homogeneous mixture of two or more metals or non-metals mixed in a molten state.

(ii) (1) Light and strong or high tensile strength.

(2) Expands on cooling.

Q3. The following questions refer to the extraction of Aluminium and Iron from their ores :

(a) Name the principal ore from which (i) Iron and (ii) Aluminium are extracted.

(b) What is the most important chemical process in the extraction of any metal ? State how the essential step is carried out in the extraction of

(c) Aluminium ores both contain impurities. Explain briefly how these impurities are removed in each case.

Ans. (a) (i) Iron - Haematite

(ii) Aluminium - Bauxite

(b) In case of Al it is reduced electrolytically.

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

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

Impurities in Aluminium ore are removed by Baeyer's process. In this process, Bauxite is heated with Sodium hydroxide to get soluble Sodium aluminate which on hydrolysis gives Aluminium hydroxide, which on igniting, gives pure Alumina.

Q4. (a) Give the name and formula of the ore of Zinc.

(b) Write equations for the following steps in the extraction of Zinc :

(i) Roasting of ore

(ii) Reduction of Zinc compound which is the product of the above reaction.

(c) What, in addition to a Zinc compound, is put into the blast furnace ?

(d) State one large scale use of Zinc.

Ans. (a) Zinc blende - ZnS

(b) (i) $2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$

(ii) $ZnO + C \longrightarrow Zn + CO$

(c) Carbon

(d) Galvanization

Q5. Name the following :

(a) A metal which exists in liquid state at room temperature.

(b) A liquid non-metal.

(c) Allotropic modification of Carbon and good conductor of electricity.

(d) Sulphide ore of Mercury.

(e) Bonding present in metallic chlorides.

(f) The process of removal of Gangue from ore.

(g) A naturally occurring compound of metal from which metal is extracted cheaply, profitably and conveniently.

(h) The process by which Sulphide ores are concentrated.

(i) The process of heating of ore in the presence of air.

(j) The process by which impurities are removed from Iron obtained from blast furnace.

(k) The most common ore of Aluminium.

(l) The electrode at which Aluminium is obtained during electrolysis.

(m) Metallic oxides which are reduced by Aluminium.

(n) Alloy of Copper and Zinc.

(o) The most common ore of Zinc.

(p) The formula of slag.

(q) The chemical name of slag.

(r) The metals added to steel to make it stainless steel.

(s) The major impurity associated with Iron obtained from blast furnace.

(t) Metal which is rendered passive on reaction with concentrated Nitric acid.

(u) A metal which reacts reversibly with steam.

(v) Gas obtained when Zinc blende is roasted.

(w) Two metals which are amphoteric in nature.

(x) The process of coating thin layer of Zinc over the surface of Iron.

(y) The process by which Zinc is purified.

Ans. (a) Mercury (b) Bromine
(c) Graphite (d) Cinnabar
(e) Ionic bonding (f) Concentration
(g) Ore
(h) Froath floatation process
(i) Roasting (j) Oxidation
(k) Bauxite (l) Cathode
(m) Ferric oxide, Chromium oxide
(n) Brass (o) Zinc blende
(p) $CaSiO_3$ (q) Calcium silicate
(r) Chromium and Nickel
(s) Carbon (t) Iron
(u) Iron (v) Sulphur dioxide
(w) Aluminium, Zinc
(x) Galvanization (y) Distillation

Q6. Write balanced chemical equations :

(a) The reduction of Ferric oxide.

(b) Formation of slag inside the blast furnace.

(c) Heating of Aluminium hydroxide.

(d) Heating of Iron with Sulphur.

(e) Reaction of Zinc with hot concentrated Sodium hydroxide.

(f) Reduction of Zinc oxide.

(g) Reduction of Ferric oxide by Aluminium powder.

(h) Burning of Aluminium in air.

(i) Calamine is heated.

(j) Zinc is placed in a Ferrous sulphate solution.

Ans. (a) $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$

(b) $CaO + SiO_2 \longrightarrow CaSiO_3$

(c) $2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$

(d) $Fe + S \xrightarrow{\Delta} FeS$

(e) $Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2$

(f) $ZnO + C \longrightarrow Zn + CO$

(g) $Fe_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Fe$

(h) $4Al + 3O_2 \xrightarrow{\Delta} 2Al_2O_3$

$2Al + N_2 \xrightarrow{\Delta} 2AlN$

(i) $ZnCO_3 \xrightarrow{\Delta} ZnO + CO_2$

(j) $Zn + FeSO_4 \longrightarrow ZnSO_4 + Fe$

Q7. The following questions are related to Iron :

(a) Name the acid with which iron is rendered passive.

(b) Name an alloy of Iron and Carbon.

(c) Name the process by which Iron ore is concentrated.

Ans. (a) Concentrated nitric acid

(b) Steel

(c) Electromagnetic separation

Q8. Write balanced chemical equations for the following :

(a) Iron is exposed to moist air

(b) Iron is added to copper sulphate solution

(c) Zinc is boiled with caustic potash solution

(d) Dry chlorine is passed over heated iron

(e) Zinc pieces are added to dilute hydrochloric acid.

Ans. (a) $4Fe + 3O_2 \longrightarrow 2Fe_2O_3$

$Fe_2O_3 + xH_2O \longrightarrow Fe_2O_3 . xH_2O$

(b) $Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$

(c) $Zn + 2KOH \longrightarrow K_2ZnO_2 + H_2\uparrow$

(d) $2Fe + 3Cl_2 \xrightarrow[\text{Dry}]{\text{heated}} 2FeCl_3$

(e) $Zn + 2HCl(dil.) \longrightarrow ZnCl_2 + H_2\uparrow$

Q9. State two necessary conditions for rusting.

Ans. The presence of oxygen and moisture are two necessary conditions for rusting.

Q10. State two ways by which rusting can be prevented ?

Ans. By painting and galvanisation rusting can be prevented.

Let's Recall

Fill Your Answer in the Space Given for Each Question.

Q1. Match the following :

A.

Column-I	Column-II
(*i*) Mercury	(*a*) Non-metal, good conductor of electricity.
(*ii*) Bromine	(*b*) Liquid metal
(*iii*) Graphite	(*c*) Tetra-atomic
(*iv*) Sulphur	(*d*) Liquid non-metal
(*v*) Phosphorus	(*e*) Octa-atomic

Ans. (*i*) ☐ (*ii*) ☐ (*iii*) ☐ (*iv*) ☐ (*v*) ☐

B.

Column-I	Column-II
(*i*) Malleable	(*a*) Wires
(*ii*) Ductile	(*b*) Metals
(*iii*) Lustrous	(*c*) Mercury
(*iv*) Monoatomic	(*d*) Shining surface
(*v*) Amalgam	(*e*) Sheets

Ans. (*i*) ☐ (*ii*) ☐ (*iii*) ☐ (*iv*) ☐ (*v*) ☐

C.

Column-I	Column-II
(*i*) Metals	(*a*) 5, 6 or 7 valence electrons
(*ii*) Non-metals	(*b*) Carbon dioxide
(*iii*) Acidic oxide	(*c*) Carbon monoxide
(*iv*) Basic oxide	(*d*) 1, 2 or 3 valence electrons
(*v*) Neutral oxide	(*e*) Zinc oxide
(*vi*) Amphoteric oxide	(*f*) Sodium oxide

Ans. (*i*) ☐ (*ii*) ☐ (*iii*) ☐ (*iv*) ☐ (*v*) ☐ (*vi*) ☐

D.

Column-I	Column-II
(*i*) Baeyer's process	(*a*) Gangue
(*ii*) Hall's process	(*b*) Sodium hydroxide
(*iii*) Cryolite	(*c*) Carbon dioxide
(*iv*) Roasting	(*d*) Sodium carbonate
(*v*) Calcination	(*e*) Sulphur dioxide
(*vi*) Concentration	(*f*) Solvent for Alumina

Ans. (*i*) ☐ (*ii*) ☐ (*iii*) ☐ (*iv*) ☐ (*v*) ☐ (*vi*) ☐

E.

Column-I	Column-II
(*i*) Galvanization	(*a*) Duralumin
(*ii*) Bodies of aircrafts	(*b*) Stainless steel
(*iii*) Surgical instruments	(*c*) Type metal
(*iv*) Expands on cooling	(*d*) Brass
(*v*) Statues	(*e*) Zinc

Ans. (*i*) ☐ (*ii*) ☐ (*iii*) ☐ (*iv*) ☐ (*v*) ☐

Q2. Fill in the blanks.

(*i*) Steel is an alloy of _____ and Carbon.

(*ii*) Brass is an alloy of _____ and Zinc.

(*iii*) Bronze is an alloy of _____ and Copper.

(*iv*) Steel is converted to stainless steel by adding _____ and _____.

(*v*) The chemical compound present in Zinc blende is _____.

(*vi*) Sulphide ores are concentrated by _____.

(*vii*) During thermite welding _____ acts as a reducing agent.

(*viii*) The most common ore of Aluminium is _____.

(*ix*) Iron ores are concentrated by _____.

(*x*) _____ is a non-metal which sublimes on heating.

Q3. State whether the following statements are True or False.

(*i*) Metals gain electrons and get converted to cations. ☐

(*ii*) Non-metals loose electrons and get converted to anions. ☐

(*iii*) Metals collect at cathode. ☐

(*iv*) Aluminium reacts both with acids and alkalies. ☐

(*v*) Solder is a metal. ☐

Q4. Each question has four options out of which only one option is correct. Dark the bubble for correct answer.

(*i*) Impure iron is purified by the process of

(*a*) reduction (*b*) oxidation

(*c*) redox (*d*) None of these

Ans. (*a*) (*b*) (*c*) (*d*)

(*ii*) The major impurity present in iron is

(*a*) carbon (*b*) sodium

(*c*) calcium (*d*) phosphorus.

Ans. (*a*) (*b*) (*c*) (*d*)

(*iii*) Which of the following pair of metals is rendered passive on reaction with concentrated nitric acid ?

(*a*) Fe, Al (*b*) Zn, Al

(*c*) Mg, Fe (*d*) Cu, Zn

Ans. (*a*) (*b*) (*c*) (*d*)

(*iv*) Chemically rust is

(*a*) Fe_3O_4 (*b*) Fe_2O_3

(*c*) $Fe_3O_4.xH_2O$ (*d*) $Fe_2O_3.xH_2O$

Ans. (*a*) (*b*) (*c*) (*d*)

(*v*) The main purpose of Roasting and Calcination is to convert

(*a*) ore into metal (*b*) ore into metallic carbonate

(*c*) ore into oxide (*d*) None of these.

Ans. (*a*) (*b*) (*c*) (*d*)

(*vi*) Which of the following pair of metals are extracted electrolytically ?

(*a*) Copper and Sodium (*b*) Zinc and Potassium

(*c*) Copper and Zinc (*d*) Sodium and Potassium.

Ans. (*a*) (*b*) (*c*) (*d*)

(*vii*) Metal which reacts reversibly with steam is

(*a*) sodium (*b*) potassium

(*c*) iron (*d*) calcium.

Ans. (*a*) (*b*) (*c*) (*d*)

(*viii*) The chemical compound present in zinc blende is

(*a*) zinc carbonate (*b*) zinc sulphite

(*c*) zinc sulphate (*d*) zinc sulphide

Ans. (*a*) (*b*) (*c*) (*d*)

(*ix*) The solvent used during electrolytic reduction of pure alumina is

(*a*) molten cryolite (*b*) solid cryolite

(*c*) molten fluorspar (*d*) solid fluorspar

Ans. (*a*) (*b*) (*c*) (*d*)

(*x*) Two metals which react both with acids and alkalies to liberate hydrogen are

(*a*) lead and copper (*b*) sodium and copper

(*c*) lead and silver (*d*) aluminium and zinc

Ans. (*a*) (*b*) (*c*) (*d*)

ANSWERS

1. **A** (*i*) *b* (*ii*) *d* (*iii*) *a* (*iv*) *e* (*v*) *c*

B (*i*) *e* (*ii*) *a* (*iii*) *d* (*iv*) *b* (*v*) *c*

C (*i*) *d* (*ii*) *a* (*iii*) *b* (*iv*) *f* (*v*) *c* (*vi*) *e*

D (*i*) *b* (*ii*) *d* (*iii*) *f* (*iv*) *e* (*v*) *c* (*vi*) *a*

E (*i*) *e* (*ii*) *a* (*iii*) *b* (*iv*) *c* (*v*) *d*

2. (*i*) pure iron (*ii*) copper (*iii*) tin (*iv*) chromium, nickel

(*v*) zinc sulphide (*vi*) froth floatation process (*vii*) aluminium (*viii*) bauxite

(*ix*) electromagnetic separation (*x*) iodine

3. (*i*) False (*ii*) False (*iii*) True (*iv*) True (*v*) False

4. (*i*) *b* (*ii*) *a* (*iii*) *a* (*iv*) *d* (*v*) *c*

(*vi*) *d* (*vii*) *c* (*viii*) *d* (*ix*) *a* (*x*) *d*

Self Evaluation Test

Time : 30 minutes **Marks : 25**

Q1. Compare the properties of metals and non-metals on the basis of
(*i*) Type of oxides **1**

Q2. Name the process by which impure Aluminium is purified. Name the electrolyte used also. Give equations for the reactions taking place at Cathode and at Anode. **4**

Q3. Copy, complete and balance the following equations :

(*i*) $Fe + O_2 \xrightarrow{\text{moisture}}$
(*ii*) $ZnS + O_2 \longrightarrow$
(*iii*) $Zn + NaOH \longrightarrow$
(*iv*) $Fe + Cl_2 \longrightarrow$
(*v*) $Fe + H_2O \longrightarrow$ **5**

Q4. Name the following :
(*i*) Metal which exists in liquid state at room temperature.
(*ii*) Two metals which exist in liquid state at or above 28 °C.
(*iii*) Two non-metals which exist as crystalline solids.
(*iv*) Two metals extracted only by electrolysis.
(*v*) Two metals which can be easily cut with the help of knife. **5**

Q5. The following questions are related to the extraction of Aluminium from its most common ore.
(*i*) Name the most common ore of Aluminium.
(*ii*) Name two processes by which Aluminium ore is purified.
(*iii*) What is the basic difference between the above named processes ?
(*iv*) Give equation for the action of heat on Aluminium hydroxide.
(*v*) Name two substances which are added to pure alumina before electrolytic reduction and why ?
(*vi*) At which electrode, aluminium is obtained during electrolytic reduction ? **10**