CHEMISTRY OF METALS

Sodium (Na) and Potassium (K)

Sodium and potassium are very reactive elements and hence do not occur in free state. In combined state they are quite abundant in earth crust.

Ores of sodium : Rock salt (NaCl), salt petre ($NaNO_3$), sodium sulphate ($Na_2SO_4.10H_2O$), borax ($Na_2B_4O_7.10H_2O$), sodium carbonate (Na_2CO_3), albite ($NaAlSi_3O_8$) etc.

Ores of potassium : Carnallite ($KCl.MgCl_2.6H_2O$) sylvinite (KCl.NaCl), felspar ($K_2O.Al_2O_3.6SiO_2$) etc.

Extraction of Sodium

Sodium is prepared by electrolysis of 40% sodium chloride and 60% calcium chloride in Down's cell. On electrolysis, sodium is liberated at anode and collected in an inverted trough. Down's cell is made up of steel, lined with heat resistant bricks. The graphite anode and iron cathode are separated by steel metal gauze to prevent mixing sodium and chlorine.

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

At cathode : $Na^+ + e^- \rightarrow Na$

At anode : $2Cl^- - 2e^- \rightarrow Cl_2$

Calcium chloride is added to lower the melting point of sodium chloride from (803°C to about 600°C). The main reasons for lowering the temperature are :

(i) It is difficult to attain and maintain 803°C temperature.

(ii) Formation of metallic fog is prevented.

(iii) Collection of sodium metal becomes easier as sodium vapours ignite in air at high temperature.

(iv) At low temperature, sodium and chlorine do not corrode the electrolytic cell.

Extraction of potassium : It connot be obtained by electrolysis of potassium chloride because potassium is easily soluble in potassium chloride and does not float on the top of the cell.

$$KOH \rightleftharpoons K^+ + OH^-$$

At cathode : $K^+ + e^- \rightarrow K$

At anode : $4\,OH^- \rightarrow 2H_2O + O_2 + 4e^-$

Potassium metal can be also obtained by reduction of potassium chloride with sodium metal at 900°C.

$$\mathrm{KCl} + \mathrm{Na} \xrightarrow{900^\circ\mathrm{C}} \mathrm{NaCl} + \mathrm{K}$$

Sodium and potassium are soft silvery white metals and can be easily cut with a knife. Their surface gets tarnished if exposed to air due to formation of oxides or carbonates. These metals are stored under kerosene.

Uses of Sodium

I. It is used to manufacture sodium peroxide, sodium cyanide, sodamide etc.
II. As a coolant in nuclear reactors because it has low B.P. and high thermal conductivity.
III. In sodium vapour lamps.
IV. Sodium amalgam is used in synthesis of organic compounds as a reducing agent.
V. Sodium-lead alloy is used in the preparation of lead tetraethyl and antiknock agent.

Uses of Potassium

I. Mixture of potassium and caesium is used in photoelectric cells.

II. Potassium bromide is used in photography.
III. As a reducing and laboratory reagent.
IV. Potassium chloride, potassium sulphate and potassium nitrate are used as fertilizers.
V. Amalgam of potassium is used in preparation of organic compounds.

Magnesium (Mg)

Its minerals are carnellite ($KCl . MgCl_2 . 6H_2O$), magnesite ($MgCO_3$), dolomite ($MgCO_3 . CaCO_3$), asbestos [$CaMg_3(SiO_3)_4$], epsom salt ($MgSO_4 . 7H_2O$) and kieserite ($MgSO_4 . 2H_2O$).

Extraction

It is obtained by Dow's sea water process.

Isolation of $MgCl_2.6H_2O$: Calcium hydroxide when added to sea water precipitates magnesium hydroxide from it. Magnesium hydroxide on treatment with hydrochloric acid gives magnesium chloride.

$$MgCl_2 + Ca(OH)_2 \xrightarrow{-CaCl_2} Mg(OH)_2\downarrow \xrightarrow{\text{Dil. HCl}} MgCl_2.6H_2O$$

Preparation of anhydrous $MgCl_2$: Anhydrous magnesium chloride cannot be prepared by heating as it is hydrolysed by its water of crystallization and forms magnesium oxide.

$$MgCl_2.6H_2O \xrightarrow{\Delta} MgO + 2HCl + 5H_2O$$

Anhydrous magnesium chloride is obtained by passing current of dry hydrochloric acid through it.

$$MgCl_2.6H_2O + HCl \rightarrow MgCl_2 + 6H_2O + HCl$$

Electrolysis of anhydrous magnesium chloride : Electrolysis of fused mixture of magnesium chloride and soidum chloride is carried out in steel tank at 700°C.

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

At cathode : $Mg^{2+} + 2e^- \rightarrow Mg$

At anode : $2Cl^- - 2e^- \rightarrow Cl_2$

Sodium chloride is added to magnesium chloride to reduce its melting point and to increase its electrical conductivity.

Physical Properties

(*i*) It is a silvery white hard metal (M.P. 650°C)

(*ii*) It is one of the lightest metal.

(*iii*) It is good conductor of heat and electricity.

(*iv*) It is sold in the form of ribbons or wires as it is maleable and ductile.

Uses

(*i*) It is used in flashlight photography.

(*ii*) It is used as a reducing agent in preparation of boron and silicon from their oxides.

(*iii*) It is used as a de-oxidizer in making brass.

(*iv*) It is used in manufacture of alloys like magnelium (95% Al and 5% Mg) used for making blances and duralium (95% Al, 4% Cu, 0.5% Mg, 0.5% Mn) used in construction of aircrafts etc.

(*v*) It is used for preparing Grignard reagent which is widely used in organic chemistry.

Calcium (Ca)

Occurrence : *Minerals of calcium :* Limestone ($CaCO_3$), fluorspar (CaF_2), gypsum ($CaSO_4.2H_2O$), fluorapatite [$3Ca_3.(PO_4)_2.CaF_2$] and phosphorite [$Ca_3(PO_4)_2$].

Extraction of calcium : It is extracted by the electrolysis of a fused mixture of calcium chloride with 16% calcium fluoride.

$$CaCl_2 \rightarrow Ca^{2+} + 2Cl^-$$

At cathode : $Ca^{2+} + 2e^- \rightarrow Ca$

At anode : $2Cl^- - 2e^- \rightarrow Cl_2$

Physical Properties

(*i*) It is a silvery white, lusturous metal. If exposed to air, its surface gets tarnished due to oxidation.

(*ii*) It is good conductor of heat and electricity.

(*iii*) It is malleable and hard like tin.

Uses

I. In iron and steel industry as a deoxidizer for cast iron.

II. As a reducing agent.

III. As a dehydrating agent for the preparation of absolute alcohol.

IV. As a scavenger for phosphorus, oxygen and sulphur.

V. For making alloys with Al for bearings.

VI. For removing last traces of nitrogen from inert gases and vacuum tubes.

Aluminium (Al)

Occurrence : Its important ores are as follows :

Oxides : Corrundum (Al_2O_3), diaspore ($Al_2O_3 . H_2O$), bauxite ($Al_2O_3 . 2H_2O$) and gibbsite ($Al_2O_3 . 3H_2O$).

Fluoride : Cryolite (Na_3AlF_6)

Sulphate : Alunite or alumstone [$K_2SO_4 . Al_2(SO_4)_3 . 4Al(OH)_3$].

Silicates : Feldspar ($KAlSi_3O_8$), mica [$KAISi_3O_{10}(OH)_2$].

Extraction : Aluminium is extracted from bauxite ore by following method :

(a) *Baeyer's process for removal of ferric oxide* : Sodium hydroxide is added to the ore, ferric oxide remains undissolved but Al dissolves and forms sodium aluminate. Aluminium hydroxide is precipitated from sodium aluminate by treating the solution with alumina. At last the precipitate of aluninium hydroxide is filtered, washed, dried and heated.

(b) *Serpeck's process for removal of silica* : It involves heating of powdered ore with coke at 1800°C when silica is reduced to silicon and vapories off.

Electrolytic Reduction of Pure Alumina

Alumina is a bad conductor of electricity and it has high melting point, is electrolysed by dissolving in cryolite (Na_3AlF_6) and adding fluorospar (CaF_2) to it. The electrolysis is carried out in iron tank lined inside with gas carbon that serves as cathode and carbon rods dipped in fused electrolyte serve as anode. On passing current through it, Al is obtained at cathode.

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

$$\textit{At cathode}: \quad Al^{3+} + 3e^- \rightarrow Al$$

$$\textit{At anode}: \quad 4AlO_3^{3-} \rightarrow 2Al_2O_3 + 3O_2 + 12e^-$$

Physical Properties

(*a*) Pure aluminium is silvery white lusturous metal (M.P. 932 K and B.P. 2743K).

(*b*) It is mealleable, ductile and is a good conductor of heat and electricity.

Uses

I. Aluminium is malleable and can be beaten into thin foils, so it is used for packing medicines, food articles, cigarettes etc.

II. Being a good conductor of electricity, it is used in making transmission wires.

III. Used for making silvery paints.

IV. Used in thermite welding.

V. Because of good thermal conductivity, it is used for making cooking utensils.

VI. For making various alloys.

VII. Used in making aircrafts and body parts of automobiles.

VIII. Aluminium amalgum is used as reducing agent.

Iron (Fe)

It is the second most abundant metal in the earth crust after aluminium. Ores of iron are : Haematite (Fe_2O_3), Limonite ($Fe_2O_3.2H_2O$), Magnetite (Fe_3O_4), Siderite ($FeCO_3$), Iron pyrities (FeS_2) and chalcopyrites ($CuFeS_2$).

Extraction of iron : It is extracted from haematite by following process :

Concentration of ore : The crushed ore is washed with water to remove sand, clay etc.

Calcination and roasting : The concentrated ore is roasted in excess of air.

(*i*) To remove moisture, phosphorus, carbon dioxide and arsenic as their volatile oxides.

(*ii*) To oxidize ferrous oxide to ferric oxide.

$$\underset{\text{Ferrous oxide}}{4FeO} + \underset{\text{Oxygen}}{O_2} \rightarrow \underset{\text{Ferric oxide}}{2Fe_2O_3}$$

(*iii*) To make ore porous then making it suitable for easy reduction to iron.

Smelting : Blast furnace is charged with lime stone, $CaCO_3$ (flux), coke (a reductant) and haematite. Then hot air blast is forced from the bottom of the furnace. Reactions taking place in its different zones are :

I. Combustion zone (1500°C – 2000°C).

$$\underset{\text{Coke}}{C} + O_2 \rightarrow CO_2 \qquad \Delta H = -400kJ$$

II. Absorption zone (800°C – 1000°C) : Carbon dioxide rising up form combustion zone is reduced to carbon monoxide.

$$CO_2 + C \rightarrow 2CO \qquad \Delta H = +160\ kJ$$

III. Reduction zone (400°C – 700°C) : In this zone charge moving down meets carbon monoxide.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

$$Fe_3O_4 + CO \rightarrow 3FeO + CO_2$$

$$FeO + CO \rightarrow Fe + CO_2$$

IV. Slag formation zone : In this zone limestone decomposes to give calcium oxide then with silica (impurity) forms fusible slage.

$$CaCO_3 \rightarrow CaO + CO_2$$

$$CaO + \underset{\text{Silica}}{SiO_2} \rightarrow \underset{\text{Calcium silicate (slag)}}{CaSiO_3}$$

V. **Fusion zone (1500°C) :** It is the lowest part of the furnace form where molten iron is tapped off.

Forms of Iron

(*a*) **Cast iron or pig iron :** It is most impure form of iron. It contains about 3–5% of carbon and other impurities like Si, P, Mn and S due to which it is very hard and brittle.The two types of cast iron are white cast iron and grey cast iron. Cast iron is used for casting articles as it expands on solidification. It cannot be welded and magnetized permanetly.

(*b*) **Wrought iron :** It is the most pure form of iron. It is extermely though, malleable, ductile and resistant towards rusting and corrosion. It contains least amount of carbon (about) (0.2–0.5%).

Preparation of wrought iron : It is prepared by heating cast iron with haematite in reverberatory furnace. Oxides of carbon and sulphur escape out as gases but oxides of manganese, phosphorus and silicon form slag.

$$\underset{\text{Haematite}}{Fe_2O_3} + 3C \rightarrow 2Fe + 3CO\uparrow$$

$$MnO + SiO_2 \rightarrow MnSiO_3$$

$$\underset{\text{Haematite}}{2Fe_2O_3} + P_4O_{10} \rightarrow \underset{\text{(slag)}}{4FePO_4}$$

Uses of Wrought Iron : It is used to make hourse shoes, iron nails, magnets, chains, fire-bars and anchors etc. as it can withstand sudden stress because presence of slag between its different layers.

(*c*) Steel : Steel is the most useful iron which contains 0.2–2% of carbon. Various types of steel are :

(*i*) Mild steel : it contains about 0.1–0.4% carbon.

(*ii*) Hard steel : It contains carbon upto 1.5%.

(*iii*) Alloy steel : It has small amounts of nickel, cobalt, chromium, tungsten, molybdenum, manganese etc. are added to obtain desired properties are known as alloy steel. e.g. stainless steel (Cr 18%, Ni 8%) does not rust or corrode and is used for making utensils, shaving blades etc. Alnico (Al 12%, Ni 20%) that is higlly magnetic and is used for making permanent magnets.

Copper (Cu) : It exists in earth crust in free state (due to low reactivity) as well as in combined state. Its main ores are cuprite (Cu_2O), copper pyrites ($CuFeS_2$), copper glance (Cu_2S), indigo copper (CuS) malachite [$Cu(OH)_2 . CuCO_3$] and azurite [$Cu(OH)_2 . 2CuCO_3$].

Extraction : It is extracted form its sulphide ore copper pyrites ($CuFeS_2$).

Concentration of ore : Copper pyrites ore is concentrated by froth floatation process.

Roasting : Roasting is carried out by heating concentrated ore in presence of air to remove volatile impurties in the form of their oxides.

$$\underset{\text{Copper pyrites}}{2CuFeS_2} + O_2 \rightarrow Cu_2S + 2FeS + SO_2$$

$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$$

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

$$S + O_2 \rightarrow SO_2 \uparrow$$

$$4As + 5O_2 \rightarrow 2As_2O_5 \uparrow$$

$$4P + 5O_2 \rightarrow 2P_2O_5 \uparrow$$

Smelting : The roasted ore is heated with coke (to produce heat) and sand (to form fusible slag) in the presence of air in blast furnace.

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

$FeO + SiO_2 \rightarrow FeSiO_3$

$Cu_2O + FeS \rightarrow Cu_2S + FeO$

Copper sulphide still contains some ferrous sulphide. It is known as matte.

Bessemerization : A blast of hot air and sand is blown through a Bessemer converter charged with molten matte. Ferrous sulphide present in matte is oxidized to ferrous oxide and forms fusible slag with silica that is drained off. Cuprous sulphide is partially oxidized to cuprous oxide and reacts with cuprous sulphide to form copper.

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

Volatile impurities come out during cooling of copper and large blisters are formed on the surface. Copper then obtained is known as blister copper.

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

Volatile impurities come out during cooling of copper and large blisters are formed on the surface. Copper then obtained is known as blister copper.

Refining of copper : Refining of copper is done either by poling or by electrolytic refining. In electrolytic refining of copper, acidified copper sulphate is used as electrolyte, impure copper metal serves as anode and a plate of pure copper is made cathode.

$$\text{At cathode : } Cu^{2+} + 2e^{-} \rightarrow \underset{\text{Pure copper}}{Cu}$$

$$\text{At anode : } \underset{\text{Impure cupper}}{Cu} \rightarrow Cu^{2+} + 2e^{-}$$

Uses

I. Being a good conductor of electricity, it is used in the manufacture of electrical wires, cable etc.

II. As it is good conductor of heat and resistant towards steam, it is used for making household untensils, boilers etc.

III. Wide range of alloys of copper are used for various purposes.

IV. For electroplating and electrotyping.

V. Used in making ornaments and coins.

Silver (Ag) : It exists in native state as well as in combined state as horn silver (AgCl), silver glance or argentite (Ag_2S), ruby silver or pyrargyrite ($Ag_2S . SbS_3$).

Extraction : It is extracted from silver glance by cyanide process.

Concentration : Crushed ore is concentrated by froth floatation process.

Treatment with sodium cyanide : Silver sulphide present in concentrated ore forms soluble complex with sodium cyanide in presence of air, but impurities are filtered off.

$$\underset{\text{Silver sulphide}}{Ag_2S} + 4NaCN \rightarrow \underset{\text{Sodium argento cyanide}}{2Na[Ag(CN)_2]} + Na_2S$$

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

$$AgCl + 2NaCN \rightarrow Na[Ag(CN)_2] + NaCl$$

$$4Na_2S + 5O_2 + 2H_2O \rightarrow 2Na_2SO_4 + 4NaOH + 2S$$

Recovery of silver : It is recovered by adding scrap zinc to the cyanide complex soluton.

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

Refining : It is refined by electrolysis of a solution of silver nitrate and 10% nitric acid having impure silver as anode and pure silver as cathode.

Uses

I. In making coins, oranaments, silver wares etc.
II. In high capactiy Ag-Zn and Ag-Cd batteries.
III. In silvering of mirrors and in photography.
IV. In medicines and silver amalgam in filling teeth.

Gold (Au) : It occurs native in alluvial deposits, in quartz veins and in lead or copper sulphide ores. In combined state it occurs as tellurides, calaverite ($AuTe_2$) and sylvanite ($AuAgTe_2$).

Extraction

I. **Amalgamation process :** Gold rock are crushed and its amalgam is prepared with mercury. On distillation of amalgam, gold is obtained.

II. **MacArthur-Forrest cyanide process :**
Concentration of ore : The crushed ore is concentrated by froth-floatation process.
Treatment with potassium cyanide : Here, the concentrated ore is leached with potassium cyanide in presence of air.

$$4Au + 8KCN + 2H_2O + O_2 \rightarrow \underset{\text{Potassium dicyanoaurate (I)}}{4K[Au(CN)_2]} + 4KOH$$

Recovery : Gold precipitates down if the solution is treated with more electropositive metal than gold like zinc.

$$2K[Au(CN)_2] + Zn \rightarrow \underset{\text{Potassium tetra cyanozincate (II)}}{K_2[Zn(CN)_4]} + 2Au$$

Refining : Impure gold thus obtained is refinet by one of the following methods :

(*a*) **Parting :** Impure gold is boiled with concentrated sulphuric acid or concentrated nitric acid. Silver and copper are soluble in acid thus they go into the solution, while gold is left behind.

$$2Ag + 2H_2SO_4 \rightarrow Ag_2SO_4 + SO_2 + 2H_2O$$
$$Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$$

(b) Electrolytic refining : Electrolytic refining of gold is carried out by using gold (III) chloride acidified with 10-12% hydrochloric acid as electrolyte, impure gold as anode and pure gold as cathode. Thus highly pure gold is obtained by this method.

Properties

I. It is yellow lusturous, malleable, ductile and noble metal.

II. It is resistant towards attack of air, water, acids or alkalies.

III. Reaction with aqua regia (3 parts HCl + 1 part HNO_3). It dissolves in aqua regia.

$$\underbrace{3HCl + HNO_3}_{\text{Aqua regia}} \rightarrow \underset{\text{Nitrosyl chloride}}{NOCl} + 2H_2O + Cl_2$$

$$2Au + 3Cl_2 \rightarrow \underset{\text{Gold (III) Chloride}}{2AuCl_3}$$

I. It is used in the manufacture of jewellery and coins.

II. For gold plating.

Zinc (Zn) : It occurs in combined state and its important ores are zincite (ZnO), zinc ferrite ($ZnO.Fe_2O_3$), zinc spinel ($ZnO_2 . AlO_3$), zinc blende (ZnS), calamine ($ZnCO_3$) and willemite (Zn_2SiO_4).

Extraction : It is extracted form zinc blende.

Concentration of ore : Finely powdered ore is concentrated by froth floatation process.

Roasting : The concentrated ore is heated in excess of air at 1200 K to convert zinc sulphide and zinc sulphate to zinc oxide.

$$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2$$

$$ZnS + 2O_2 \xrightarrow{\Delta} ZnSO_4$$

$$2ZnSO_4 \xrightarrow{\Delta} 2ZnO + 2SO_2 + O_2$$

When calamine is used, it decomposes to zinc oxide and carbon dioxide.

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

Reduction : Zinc oxide is reduced by coke in a blast furnace.

$$ZnO + C \rightarrow Zn + CO$$

Electrolytic refining : Zinc is refined by electrolytic method by using zinc sulphate with dilute sulphuric acid as electrolyte, impure zinc as anode and pure zinc as cathode.

At cathode : $Zn^{2+} + 2e^- \rightarrow Zn$

At anode : $2H_2O \rightarrow 4H^+ + O_2 + 4e^-$

Uses

I. It is used in galvanising iron and making alloys like brass and german silver.

II. In extraction of silver and gold by cyanide process.

III. As a reducing agent.

IV. In making electric batteries.

Mercury (Hg) : The only important ore of mercury is cinnabar (HgS).

Extraction

Concentration : The ore is concentrated by froth floatation process.

Simultaneous roasting and distillation : The concentrated ore is roasted in excess of air to oxidise mercury (II), sulphide (cinnabar) to mercury (II) oxide.

$$2HgS + 3O_2 \rightarrow 2HgO + 2SO_2$$

Further, mercury (II) oxide decomposes to produce mercury vapours that are condensed.

$$2HgO \rightarrow 2Hg + O_2$$

Refining : Impure mercury thus obtained contains copper, zinc, lead and bismuth. These are removed by following methods.

I. Filteration

II. Treatment with dilute nitric acid. It involves dissolution of all metals while mercury remains unaffected.

III. Distillation under reduced pressure.

Uses

I. It has high boiling point and low freezing point, therefore used in making barometers and thermometers.

II. In the manufacture of caustic soda and as a catalyst in many chemical reactions.

III. Silver and gold amalgam are used for dental filling.

IV. In the preparation of calomel which is used to prepare standard electrode.

V. In silvering of mirrors, mercury vapour lamps and in the extraction of silver and gold.

Tin (Sn) : The important ore of tin is cassiterite (SnO_2).

Extraction

Concentration : The finely powdered ore is concentrated by gravity process.

Roasting : The ore is roasted in a current of air if impurities like sulphur and arsenic escape as volatile oxides. Iron and copper pyrites are converted into their oxides and sulphates.

$$4As + 3O_2 \rightarrow 2As_2O_3 \uparrow$$

$$S + O_2 \rightarrow SO_2 \uparrow$$

Electromagnetic separation : Wolframite (ore of tungsten) and iron oxide are separated from cassiterite by magnetic separation.

Washing : The concentrated ore is treated with water to dissolve out ferrous sulphate and copper sulphate, but lighter impurities are washed off. Thus heavier tin sinks to the bottom and it is referred as **black tin**.

Smelting : Black tin is heated with coke to reduce tin oxide to tin metal and with limestone that acts as flux to remove impurities.

$$\underset{\text{Cassiterite}}{SnO_2} + \underset{\text{Coke}}{2C} \rightarrow Sn + 2CO$$

$$\underset{\text{(flux)}}{CaCO_3} \rightarrow CaO + CO_2$$

$$CaO + \underset{\text{(impurity)}}{SiO_2} \rightarrow \underset{\text{(fusible slag)}}{CaSiO_3}$$

Refining : Impure tin metal is refined by following methods :

I. Liquation.
II. Electrolytic refining containing tin sulphate with fluorosilicic acid (H_2SiF_6) and sulphuric acid as the electrolyte, impure tin as anode and pure tin sheet as cathode.

$$PbS + PbSO_4 \xrightarrow{\Delta} 2Pb + 2SO_2$$

Uses

I. For tin plating iron, for wrapping foils.
II. Tin amalgam is used for making mirrors.
III. It is used for making alloys.

Lead (Pb) : Its important ores are galena (Pbs), anglesite ($PbSO_4$), cerussite ($PbCO_3$) and lanarkite ($PbO.PbSO_4$).

Extraction : It is extracted from galena by following ways :

Concentration : The powdered ore is concentrated by froth-floatation process.

Reduction : The concentrated ore is reduced to the metal by following process :

I. Air reduction process : The concentrated ore is roasted in the reverberatory furnace in a limited supply of air.

$$2PbS + 3O_2 \rightarrow 2PbO + 2SO_2$$

$$PbS + 2O_2 \rightarrow PbSO_4$$

Smelting : Then the temperature is raised and air supply is cut off.

$$PbS + 2PbO \xrightarrow{\Delta} 3Pb + SO_2$$

$$PbS + PbSO_4 \xrightarrow{\Delta} 2Pb + 2SO_2$$

II. Carbon reduction process : The concentrated ore is mixed with lime (flux) and roasted in excess of air.

$$2PbS + 3O_2 \rightarrow 2PbO + 2SO_2$$

$$S + O_2 \rightarrow SO_2 \uparrow$$

$$4As + 3O_2 \rightarrow 2As_2O_3 \uparrow$$

Smelting : Coke is added to roasted ore and smelted.

$$\underset{\text{Coke}}{PbO + C} \rightarrow Pb + CO$$

$$PbO + CO \rightarrow Pb + CO_2$$

Electrolytic refining : Impure Pb is refined by taking a solution of lead fluoro-silicate ($PbSiF_6$) with 8-12% of hydrofluoro silicic acid (H_2SiF_6) as electrolyte, impure lead as anode and pure lead as cathode.

Uses

I. To prepare lead tetraethyl, $(C_2H_5)_4Pb$ which is used as an antiknocking agent in petrol.
II. In making useful alloys such as solder, type metal, pewter etc.
III. In the manufacture of sulphuric acid for making chambers in lead chamber process.
IV. For making telegraph and telephone wires buried under earth.
V. For making lead pigments, lead pipes, lead accumulators and bullets etc.

IMPORTANT ORES

	Ore	Formulae	Ore of metal
1.	Alumina	Al_2O_3	Aluminium
2.	Alunite	$K_2SO_4.Al_2(SO_4)_3.4Al(OH)_3$	Aluminium
3.	Anhydrite	$CaSO_4$	Calcium
4.	Argentite	Ag_2S	Silver
5.	Azurite	$2CuCO_3.Cu(OH)_2$	Copper
6.	Brine	NaCl (Solution)	Sodium
7.	Borax	$Na_2B_4O_7.10H_2O$	Boron
8.	Bauxite	$Al_2O_3.2H_2O$	Aluminium
9.	Calaverite	$AuTe_2$	Gold
10.	Chile Saltpeter	$NaNO_3$	Sodium
11.	Cinnabar	HgS	Mercury
12.	Chlorapatite	$Ca_5(PO_4)_3Cl$	Calcium
13.	Calcia	CaO	Calcium
14.	Chalk, Marble, Aragonite, Calcite, Iceland spar, Limestone	$CaCO_3$	Calcium
15.	Carnallite	$KCl.MgCl_2.6H_2O$	Magnesium
16.	Calamine	$ZnCO_3$	Zinc
17.	Cassiterite	SnO_2	Tin
18.	Copper Pyrites, Chalcopyrite	$CuFeS_2$	Copper
19.	Copper glance, Chalcocite	Cu_2S	Copper

20.	Cuprite	Cu_2O	Copper
21.	Clay, Kaolin, Chinaclay,Mica, Feldspar	Aluminosilicates	Aluminium
22.	Corundum emery	Al_2O_3	Aluminium
23.	Cryollite	Na_3AlF_6	Aluminium
24.	Diaspore	$Al_2O_3.H_2O$	Aluminium
25.	Dolomite	$MgCO_3.CaCO_3$	Magnesium
26.	Epsom salt	$MgSO_4.7H_2O$	Magnesium
27.	Fluorapatite	$3Ca_3(PO_4)_2.CaF_2$	Calcium
28.	Fluorspar	CaF_2	Calcium
29.	Greenockite	CdS	Cadmium
30.	Gypsum	$CaSO_4.2H_2O$	Calcium
31.	Galena	PbS	Lead
32.	Heavy spar	$BaSO_4$	Barium
33.	Horn silver, chloragyrite	AgCl	Silver
34.	Haematite (red)	Fe_2O_3	Iron
35.	Nitre	KNO_3	Potassium
36.	Magnesite	$MgCO_3$	Magnesium
37.	Malachite	$CuCO_3.Cu(OH)_2$	Copper
38.	Magnetite	Fe_3O_4	Iron
39.	Pyragyrite	Ag_3SbS_3	Silver
40.	Pyrolusite	MnO_2	Manganese
41.	Rock salt	NaCl	Sodium
42.	Schonite	$K_2SO_4.MgSO_4.6H_2O$	Potassium
43.	Sylvanite	(Ag, Au) Te	Gold

44.	Sylvine	KCl	Potassium
45.	Trona, Natrona	Na_2CO_3	Sodium
46.	Whitherite	$BaCO_3$	Barium
47.	Washing soda	$Na_2CO_3.10H_2O$	Sodium
48.	Zincite	ZnO	Zinc
49.	Zinc blends	ZnS	Zinc