**Introduction to metals**

* The metals given detailed emphasis here are; **Sodium, Aluminium, Iron, Zinc, Lead** and **Copper.**

The main criteria used in extraction of metals are based on its position in the electrochemical or reactivity series and its occurrence on the earth’s crust.

Position on the earth’s crust

If deep on the earth’s crust deep mining is used

If near the surface, open cast mining / quarrying is used

The ore first roasted if it is a carbonate or sulphide of Zinc, Iron, Tin, Lead, and Copper to form the oxide

The oxide is reduced using carbon/ carbon (II) oxide in a furnace if it is made of Zinc, Tin, Lead ,Copper and Iron

Electrolysis of the ore is used for reactive metals; Potassium, Sodium, Magnesium, Calcium, Aluminium

If the ore is low grade oil, water, and air is blown forming a froth (froth flotation) to concentrate

1. **SODIUM**

* Sodium naturally occurs as:

1. Brine-a concentrated solution of sodium chloride(NaCl(**aq**)) in salty seas and oceans.
2. Rock salt-solid sodium chloride(NaCl(**s**)
3. Trona-sodium sesquicarbonate(NaHCO3.Na2CO3.2H2O) especially in lake Magadi in Kenya.
4. Chile saltpeter-sodium nitrate(NaNO3)

**I.Raw materials**

**(i)** Brine-concentrated solution of sodium chloride (NaCl (**aq**)) from salty seas and oceans.

**(ii)**Mercury

**(iii)**Water from river/lakes

**II. Chemical processes**

Salty lakes, seas and oceans contain large amount of dissolved sodium chloride (NaCl (aq)) solution.

This solution is concentrated to form brine which is fed into an electrolytic chamber made of **suspended** Carbon **graphite**/titanium as the **anode** and a **continuous** flow of Mercury as the **cathode**.Note

**Questions**

I. Write the equation for the decomposition of the electrolyte during the electrolytic process.

**H2O(l) H+(aq) + OH-(aq)**

**NaCl(aq) Na+(aq) + Cl-(aq)**

II. Name the ions present in brine that moves to the:

(i)Mercury cathode; **H+(aq) , Na+(aq)**

(ii)Titanium/graphite; **OH-(aq), Cl-(aq)**

III. Write the equation for the reaction that take place during the electrolytic process at the;

Cathode; **2Na+(aq) + 2e 2Na(s)**

Anode; **2Cl-(aq) Cl2(g)** + **2e**

**Note**

1. Concentration of 2Cl-(aq) ions is higher than OH- ions causing **overvoltage** thus **block**ing OH- ions from being discharged at the anode.
2. Concentration of Na+(aq) ions is higher than H+ ions causing **overvoltage** thus **block**ing H+ ions from being discharged at the cathode.

IV. Name the products of electrolysis in the flowing mercury-cathode cell.

(i)Mercury cathode; **Sodium metal as grey soft metal/solid**

(ii)Titanium/graphite; **Chlorine gas as a pale green**

Sodium produced at the cathode immediately reacts with the mercury at the cathode forming sodium amalgam (NaHg) liquid that flow out of the chamber.

Na(s) + Hg(l) Na Hg (l)

Sodium amalgam is added distilled water and reacts to form sodium hydroxide solution, free mercury and Hydrogen gas.

2Na Hg (l) + 2H2O(l) 2NaOH (aq) + 2Hg(l) + H2(g)

As the electrolysis of brine continues, the concentration of Cl-ions decreases and oxygen gas start being liberated.

Continuous feeding of the electrolyte is therefore very necessary.

**Uses of sodium hydroxide**

The sodium hydroxide produced is very pure and is used mainly in:  
 (i) Making soapy and soapless detergents.

(ii) Making cellulose acetate/rayon

**Environmental effects of Manufacture of Sodium hydroxide from the flowing Mercury-cathode cell.**

1. Most of the Mercury used at the cathode is recycled;

(i) To reduce the cost because mercury is expensive

(ii) To reduce pollution because mercury kills marine life.

(iii) Because it causes chromosomal/genetic mutation to human beings.

2. Chlorine produced at the anode;

(i) Has a pungent irritating smell that causes headache to human beings.

(ii) Bleaches any wet substance.

(iii) Dissolves water to form both hydrochloric acid and chloric(I)acid

Both cause marine pollution and stomach upsets.

**Extraction of sodium from rock salt/The Downs cell/process**

**I. Raw materials**

(i) Rock salt/solid sodium chloride

(ii) calcium(II)chloride

**II. Chemical processes.**

Rock salt/ solid sodium chloride is heated to molten state in a chamber lined with fire bricks on the outside.

Sodium chloride has a melting point of about 800oC. A little calcium (II) chloride is added to lower the melting point of the electrolyte to about 600oC.

The molten electrolyte is the electrolyzed in a carbon graphite anode suspended at the centre and surrounded by steel cathode.

**Questions**

I. Write the equation for the decomposition of the electrolyte during the electrolytic process.

**NaCl(l) Na+(l) + Cl-(l)**

**Note:** In absence of water, the ions are in liquid state.

II. Name the ions present in molten rock salt that move to the;

(i)Steel cathode **-Na+(l)**

**(**ii**)**Carbon graphite anode- **Cl-(l)**

III. Write the equation for the reaction that take place during the electrolytic process at the;

(i)Steel cathode

**2Na+(l) + 2e 2Na(l)**

**(**ii**)**Carbon graphite anode

**2Cl-(l) Cl2(g)+ 2e**

IV. Name the products of electrolysis in the Downs cell at;

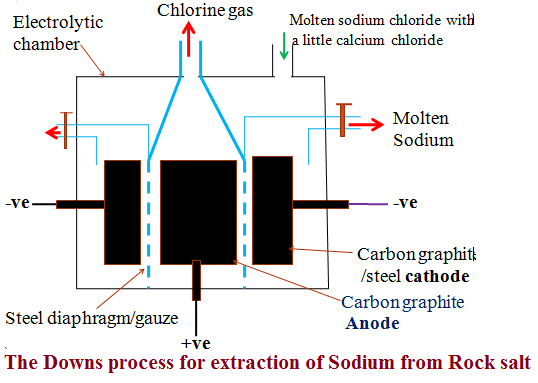
(i)Cathode:

Grey solid Sodium metal is less dense than the molten electrolyte and therefore floats on top of the cathode to be periodically tapped off.

(ii)Anode:

Pale green chlorine gas that turns moist/damp/wet blue/red litmus papers red then bleaches/decolorizes both.

A **steel diaphragm/gauze** is suspended between the electrodes to **prevent** **recombination** of sodium at the cathode and chlorine gas at the anode **back** to sodium chloride.



**IV. Uses of sodium.**

1.Sodium vapour is used as sodium lamps to give a yellow light in street lighting.

2.Sodium is used in making very useful sodium compounds like;

(i)Sodium hydroxide(NaOH)

(ii)Sodium cyanide(NaCN)

(iii)Sodium peroxide(Na2O2)

(iv)Sodamide(NaNH2)

3.An alloy of Potassium and Sodium is used as **coolant** in nuclear reactors.

**V. Environmental effects of Downs cell.**

1.Chlorine produced at the anode;

(i)has a pungent irritating smell that causes headache to human beings.

(ii)bleaches any wet substance.

(iii)dissolves water to form both hydrochloric acid and chloric(I)acid

Both cause marine pollution and stomach upsets.

2.Sodium metal rapidly react with traces of water to form alkaline Sodium hydroxide(NaOH(aq))solution. This raises the pH of rivers/lakes killing aquatic lifein case of leakages.

**VI. Test for presence of Na.**

If a compound has **Na+** ions in solid/molten/aqueous state then it changes a non-luminous clear/colourless flame to a **yellow coloration** but does not burn

**Practice**

**(i)Calculate the time taken in hours for 230kg of sodium to be produced in the Downs cell when a current of 120kA is used.**

**(ii)Determine the volume of chlorine released to the atmosphere. (Na=23.0), Faraday constant=96500C.I mole of a gas =24dm3 at r.t.p)**

Working:

Equation at the cathode:

2Na+ (**l**) + **2e** 2Na(**l**)

2 mole of electrons = 2 Faradays = 2 x 96500 C deposits a mass = molar mass of Na = 23.0g thus;

23.0 g -> 2 x 96500 C

(230 **x 1000**)g -> 230 x 1000 x 2 x 96500

23

= **1,930,000,000 / 1.93 x 10** 9**C**

Time(**t**) in seconds = **Q**uantity of electricity Current(**I**) in amperes

Substituting = 1,930,000,000 / 1.93 x 10 9C

120 x 1000A

**= 4.4676hours**

Volume of Chlorine

Method 1

Equation at the anode:

2 Cl- (**l**) Cl2(g) + **2e**

From the equation:

2 moles of electrons = 2 Faradays =2 x 96500C

2 x 96500C -> 24dm3

1,930,000,000

1,930,000,000 / 1.93x10 9C x 24

2 x 96500C

Volume of Chlorine = **240,000dm3 /2.4 x 105dm3**

2. **ALUMINIUM**

Aluminium is the most common naturally occurring metal. It makes 7% of the earth’s crust as:

(i)Bauxite ore- Hydrated aluminium oxide (Al2O3.2H2O)

(ii)Mica ore-Potassium aluminium silicate (K2Al2Si6O16)

(iii)China clay ore- aluminium silicate (Al2Si6O16)

(iv)Corrundum-Anhydrous aluminium oxide (Al2O3)

**Extraction of aluminium from Bauxite/Halls cell/process)**

* The main ore from which aluminium is extracted is **Bauxite** ore- hydrated aluminium oxide (Al2O3.2H2O).
* The ore is mined by open-caste mining method/quarrying where it is scooped together with silica/sand/silicon (IV) oxide (SiO2) and soil/ iron (III) oxide (**Fe2O3**) as **impurities**.
* The mixture is first dissolved in hot concentrated sodium/potassium hydroxide solution.
* The alkalis dissolve both bauxite and silicon (IV) oxide.
* This is because bauxite is **amphotellic** while silicon (IV) oxide is **acidic**.
* Iron(III)oxide (**Fe2O3**) is filtered of /removed as a residue.
* Carbon (IV) oxide is bubbled into the filtrate to precipitate aluminium (III) hydroxide (Al(OH)**3**) as residue.
* The aluminium (III) hydroxide **(Al(OH)3)** residue is filtered off. Silicon (IV) oxide remain in the solution as filtrate. Aluminium (III) hydroxide (Al(OH)**3**) residue is then heated to form pure aluminium (III)oxide(**Al2O3**)

2Al(OH)**3** (s)Al2O3 (s) + 3H2O(l)

* Pure aluminium (III) oxide (**Al2O3**) has a very high melting point of **2015oC**.
* A lot of energy is required to melt the oxide.
* It is therefore dissolved first in molten **cryolite**/Na3AlF6 to lower the melting point to about **800oC**.
* The molten electrolyte is put in the Hall cell made up of a steel tank lined with carbon graphite and an anode suspended into the electrolyte.

During the electrolysis:

(**i**)At the cathode;

4Al3+(**l**) + 12e 4Al(**l**)

(**ii**) At the anode;

6O2-(l) 3O2(g) + 12e

* Aluminium is denser than the electrolyte therefore sink to the bottom of the Hall cell.
* At this temperature, the Oxygen evolved/produced at the anode **reacts** with carbon anode to form carbon (IV) oxide gas that **escape** to the atmosphere.

C(s) + O2(g) CO2(g)

* The anode thus should be continuously **replaced** from time to time.

Hot concentrated sodium hydroxide

Powdered mixture

Crush (increase surface area)

Bauxite (Al2O3.2H2O) ore with impurities Fe2O3 and SiO2

Iron (III) oxide- Fe2O3 as residue

Sodium aluminate (NaAl(OH)4)

and sodium silicate (Na2SiO3) as filtrate

Carbon (IV)oxide

Cryolite

Aluminium hydroxide (Al(OH)3) as residue

Sodium silicate (Na2SiO3)

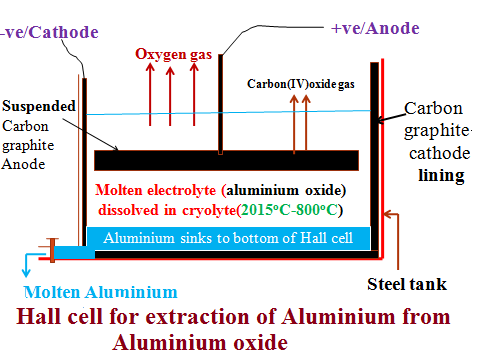
Aluminium (III) Oxide

Roast at 1000oC

Electrolysis

Oxygen gas at anode

Pure aluminium

Diagram showing the **Hall cell / process for extraction of Bauxite** 

**Uses of aluminium**

(i) In making aero plane parts, buses, tankers, furniture because aluminium is very light.

(ii) Making duralumin-an alloy which is harder and has a higher tensile strength

(iii) Making utensils, sauce pans, spoons because it is light and good conductor of electricity.

(iv) Making overhead electric cables because it is light, ductile and good conductor of electricity.

(iv) Used in the thermite process for production of Manganese, Chromium and Titanium.

**Environmental effects of extracting aluminium from Bauxite.**

* Carbon (IV) oxide gas that **escapes** to the atmosphere is a green house gas that causes global warming.
* Bauxite is extracted by open caste mining that causes soil/environmental degradation.

**Sample questions**

1. Aluminium is obtained from the ore with the formula Al2O3. 2H2O. the ore is first heated and refined to obtain pure aluminium oxide (Al2O3). The oxide is then electrolysed to get Aluminium and oxygen gas using carbon anodes and carbon as cathode.
2. **Give the common name of the ore from where aluminium is extracted from ½ mark**

* Bauxite

1. **What would be the importance of heating the ore first before refining it?1 mark**

* To remove the water of crystallization

1. **The refined ore has to be dissolved in cryolite first before electrolysis. Why is this** **necessary? 1½ mark**

* To lower the melting point of aluminium oxide from about 2015oC to 900oC so as to lower/reduce cost of production

1. Why are the carbon anodes replaced every now and then in the cell for electrolysing aluminium oxide? 1 mark

* **Oxygen produced at anode react with carbon to form carbon(IV)oxide gas that escape**

1. State two uses of aluminium

* **In making aeroplane parts, buses, tankers, utensils, sauce pans,spoons** 
  + **Making overhead electric cables**
  + **Making duralumin**

**3. IRON**

* Iron is the second most common naturally occurring metal. It makes 4% of the earths crust as:

1. Haematite (Fe2O3)
2. Magnetite (Fe3O4)

(iii) Siderite (FeCO3)

**The blast furnace for extraction of iron from Haematite and Magnetite**

**a) Raw materials:**

(i) Haematite (Fe2O3)

(ii) Magnetite (Fe3O4)

(iii) Siderite (FeCO3)

(iv) Coke/ carbon

(v) Limestone

**b) Chemical processes:**

* Iron is usually extracted from Haematite (Fe2O3), Magnetite (Fe3O4) Siderite (FeCO3).
* These ores contain silicon(IV)oxide(SiO2) and aluminium(III)oxide (Al2O3) as impurities.
* When extracted from siderite, the ore must first be roasted in air to decompose the iron(II)Carbonate to Iron(II)oxide with production of carbon(IV)oxide gas:

FeCO3(s) FeO(s) + CO2(g)

* Iron (II) oxide is then rapidly oxidized by air to iron (III) oxide (Haematite).

4FeO(s) + O2(g) 2Fe2O3(s)

* Haematite (Fe2O3), Magnetite (Fe3O4), coke and limestone are all then fed from top into a tapered steel chamber lined with refractory bricks called a blast furnace.
* The furnace is covered with **inverted** double cap to prevent/reduce amount of any gases escaping .

As the air enters ,it reacts with coke/charcoal/carbon to form carbon(IV)oxide gas. This reaction is highly exothermic.

C(s)+ O2(g)CO2 (g) ∆H = -394kJ

As Carbon (IV) oxide gas rises up the furnace it reacts with more coke to form carbon (II) oxide gas. This reaction is endothermic.

CO2 (g) + C(s)2CO (g) ∆H = +173kJ

Carbon (II) oxide gas is a strong reducing agent that reduces the ores at the upper parts of the furnace where temperatures are about 750K(500oC) i.e.

For Haematite;

Fe2O3 (s) + 3CO(g) 2Fe(s) + CO2(g)

For Magnetite;

Fe3O4 (s) + 4CO(g) 3Fe(s) + 4CO2(g)

Iron is denser than iron ore. As it falls to the hotter base of the furnace it melts and can easily be tapped off.

Limestone fed into the furnace decomposes to quicklime/calcium oxide and produce more carbon (IV) oxide gas.

CaCO3(s) CaO(s) + CO2(g)

Quicklime/calcium oxide reacts with the impurities silicon (IV)oxide(SiO2) and aluminium(III)oxide(Al2O3)in the ore to form calcium silicate and calcium aluminate.

CaO(s) + SiO2(s) CaSiO3 (l)

CaO(s) + Al2O3(s) Ca Al2O4 (l)

* Calcium silicate and calcium aluminate mixture is called **slag**.
* Slag is denser than iron ore but less dense than iron therefore float on the pure iron. It is tapped at different levels to be tapped off for use in:

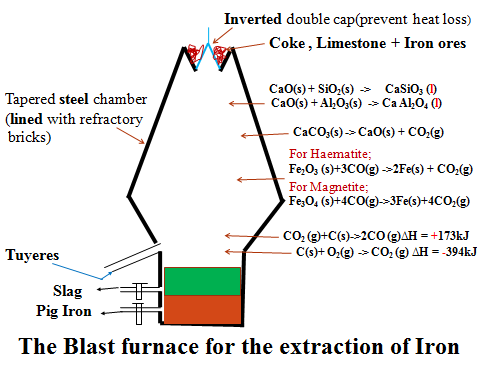
1. tarmacing roads
2. cement manufacture
3. as building construction material

**(c)Uses of Iron**

Iron obtained from the blast furnace is hard and brittle. It is called **Pig iron.** It is re-melted, added scrap steel then cooled. This iron is called cast iron.

Iron is mainly used to make:

1. Gates, pipes, engine blocks, rails, charcoal iron boxes, lamp posts because it is cheap.
2. Nails, cutlery, scissors, sinks, vats, spanners, steel rods, and railway points from steel.
3. Steel is an alloy of iron with carbon, and/or Vanadium, Manganese, Tungsten, Nickel ,Chromium. It does **not rust**/corrode like iron.



**Environmental effects of extracting Iron from Blast furnace**

1. Carbon (IV)oxide(CO2) gas is a green house gas that causes/increases global warming if allowed to escape/leak from the furnace.
2. Carbon (II)oxide(CO)gas is a highly poisonous/toxic odourless gas that can kill on leakage.
3. Haematite (Fe2O3), Magnetite (Fe3O4) and Siderite (FeCO3) are extracted through quarrying /open cast mining that cause soil / environmental degradation .

4. **COPPER**

* Copper is found as uncombined element/metal on the earths crust in Zambia, Tanzania, USA and Canada .The chief ores of copper are:

1. Copper pyrites(CuFeS2)
2. Malachite(CuCO3.Cu(OH)2)

(iii) Cuprite(Cu2O)

**Extraction of copper from copper pyrites.**

* Copper pyrites are first crushed into fine powder.
* The powdered ore is the added water and oil.
* The purpose of water is to dissolve hydrophilic substances.
* The purpose of oil is to make cover copper ore particle so as to make it hydrophobic
* Air is blown through the mixture.
* Air creates bubbles that stick around hydrophobic copper ore.
* A concentrated ore floats at the top as froth
* The ore is then roasted in air to form copper (I) sulphide, sulphur (IV) oxide and iron (II) oxide.

2CuFeS2(s) + 4O2(g) Cu2S(s) + 3SO2(g) + 2FeO(s)

* Limestone (CaCO3) and silicon (IV) oxide (SiO2) are added and the mixture heated in absence of air. Silicon (IV) oxide (SiO2) reacts with iron (II) oxide to form Iron silicate which constitutes the slag and is removed.

FeO(s) + SiO2(s)  FeSiO3(s)

The slag separates off from the copper (I) sulphide.

* Copper (I) sulphide is then heated in a regulated supply of air where some of it is converted to copper (I) oxide.

2Cu2S (s) + 3O2(g) 2Cu2O(s) + 2SO2(g)

The mixture then undergo self reduction in which copper(I)oxide is reduced by copper(I)sulphide to copper metal.

Cu2S (s) + 2Cu2O (s) 6Cu (s) + SO2(g)

* The copper obtained has Iron, sulphur and traces of silver and gold as impurities. It is therefore about 97.5% pure. It is refined by electrolysis/electrolytic method.

At the anode;

Cu(s) Cu2+ (aq) + 2e

Note: Impure copper anode dissolves/erodes into solution and decreases in size.

At the Cathode;

Cu2+ (aq) + 2e Cu(s)

**(c)Flow chart summary of extraction of copper from Copper pyrites**

Oil

Water

Froth flotation

Crush (increase surface area)

Copper pyrites(CuFeS2) ore with impurities Fe2O3 and SiO2

Rocky impurities

Excess air

Concentration chamber

Silicon(IV)

oxide

Limestone

1st roasting chamber

Cu2S

Sulphur(IV)Oxide

Smelting furnace

Limited air

2nd roasting furnace

Calcium aluminate (CaAl2O4)slag

Iron Silicate (FeSiO3)Slag

Cu2S, Cu2O

Impure copper

Self reduction

Sulphur(IV)Oxide

Electrolysis using Copper electrodes

Anode; Impure Copper eroded.

Cathode; Pure Copper deposited.

**Uses of copper**

Copper is mainly used in:

1. Making low voltage electric cables, contact switches, cockers and plugs because it is a good conductor of electricity.
2. Making solder because it is a good thermal conductor.

(iii) Making useful alloys e.g.

-Brass is an alloy of copper and Zinc (Cu/Zn)

-Bronze is an alloy of copper and Tin (Cu/Sn)

-German silver is an alloy of copper, Zinc and Nickel (Cu/Zn/Ni)

(iv) Making coins and ornaments.

**Environmental effects of extracting copper from Copper pyrites**

1. Sulphur (IV)oxide is a gas that has a pungent poisonous smell that causes head ache to human in high concentration.
2. Sulphur(IV)oxide gas if allowed to escape dissolves in water /rivers/rain to form weak sulphuric (IV)acid lowering the pH of the water leading to marine pollution, accelerated corrosion/rusting of metals/roofs and breathing problems to human beings.
3. Copper is extracted by open caste mining leading to land /environmental /soil degradation.

5. **ZINC and LEAD**

Zinc occurs mainly as:

(i)Calamine-Zinc carbonate (ZnCO3)

(ii)Zinc blende-Zinc sulphide (ZnS)

Lead occurs mainly as Galena-Lead (II) Sulphide mixed with Zinc blende:

**Extraction of Zinc/Lead from Calamine, Zinc blende and Galena.**

During extraction of Zinc, the ore is first roasted in air:

For Calamine Zinc carbonate decompose to Zinc oxide and carbon (IV) oxide gas.

ZnCO3(s) ZnO(s) + CO2(g)

Zinc blende does not decompose but reacts with air to form Zinc oxide and sulphur (IV) oxide gas.

Galena as a useful impurity also reacts with air to form Lead(II) oxide and sulphur(IV) oxide gas.

2ZnS(s) + 3O2(g) 2ZnO(s) + 2SO2(g)

(Zinc blende)

2PbS(s) + 3O2(g) 2PbO(s) + 2SO2(g)

(Galena)

The oxides are mixed with coke and limestone/Iron(II)oxide/ Aluminium (III) oxide and heated in a blast furnace.

At the furnace temperatures limestone decomposes to quicklime/CaO and produce Carbon(IV)oxide gas.

CaCO3(s) CaO(s) + CO2 (g)

Carbon(IV)oxide gas reacts with more coke to form the Carbon(II)oxide gas.

C(s) + CO2 (g) 2CO (g)

Both Carbon (II)oxide and carbon/coke/carbon are reducing agents.

The oxides are reduced to the metals by either coke or carbon (II)oxide.

ZnO(s) + C(s) Zn(**g**) + CO (g)

PbO(s) + C(s) Pb(**l**) + CO (g)

PbO(s) + CO(s) Pb(**l**) + CO2 (g)

PbO(s) + CO(s) Pb(**g**) + CO2 (g)

At the furnace temperature:

1. Zinc is a gas/vapour and is collected at the **top** of the furnace. It is condensed in a spray of molten lead to prevent reoxidation to Zinc oxide. On further cooling , Zinc collects on the surface from where it can be tapped off
2. Lead is a liquid and is ale to trickle to the bottom of the furnace from where it is tapped off.

Quicklime/CaO, Iron(II)Oxide, Aluminium (III)oxide are used to remove silica/silicon(IV)oxide as silicates which float above Lead preventing its reoxidation back to Lead(II)Oxide.

CaO(s) + SiO2(s) CaSiO3(s/l)

(Slag-Calcium silicate)

FeO(s) + SiO2(s) FeSiO3(s/l)

(Slag-Iron silicate)

Al2O3(s) + SiO2(s) Al2SiO4(s/l)

(Slag-Aluminium silicate)

**Flow chart on extraction of Zinc from Calamine ,Zinc blende.**

Water

Oil

SO2

CO2 from calamine

Zinc ore (calamine /Zinc blende

Froth flotation

Condenser

Coke

Iron/aluminium/ Limestone

Powdered ore

Roasting chamber

Reduction chamber

Slag (Iron silicate/ aluminium silicate/calcium silicate)

Granulated Zinc

Granulating tank

Water

Lead liquid

Filtration

**Flow chart on extraction of Lead from Galena**

Froth flotation

Water

oil

LEAD VAPOUR

Zinc residue

Filtration

Condenser

Slag(Iron silicate)

SO2(g)

coke

Iron/Limestone

Reduction chamber

Roasting chamber

Powdered ore

Lead ore/Galena

**Uses of Lead**

Lead is used in:

1. Making gun-burettes.
2. Making protective clothes against nuclear (alpha rays/particle) radiation in a nuclear reactor.
3. Mixed with tin(Sn) to make **solder** alloy

**Uses of Zinc**

Zinc is used in:

1. Galvanization-when iron sheet is dipped in molten Zinc ,a thin layer of Zinc is formed on the surface.Since Zinc is more reactive than iron ,it reacts with elements of air(CO2/ O2 / H2O) to form basic Zinc carbonate(ZnCO3.Zn(OH)2).This **sacrificial** method protects iron from corrosion/rusting.
2. As negative terminal and casing in dry/Laclanche cells.
3. Making brass alloy with copper(Cu/Zn)

**b) Summary of extraction of common metal.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Metal** | **Chief ore/s** | **Chemical formula of ore** | **Method of extraction** | **Main equation during extraction** | |
| Sodium | Rock salt | NaCl(s) | **Downs process**  Through electrolysis of molten NaCl (CaCl2 lower m.pt from 800oC- 600oC) | | **Cathode:**  2Na+(l) + 2e 2Na(l)  **Anode:**  2Cl-(l) Cl2(g) + 2e |
| Sodium/  sodium hydroxide | Brine | NaCl(aq) | **Flowing mercury cathode cell**  Through electrolysis of concentrated NaCl(aq) | **Cathode:**  2Na+(aq)+2e 2Na(aq)  **Anode:**  2Cl-(aq) Cl2(g) + 2e | |
| Aluminium | Bauxite | Al2O3.2H2O | **Halls process**  **Through electrolysis of molten** Al2O3. (Cryolite lower m.pt from 2015oC -> 800oC) | **Cathode:**  4Al3+(l) + 12e 4Al(l)  **Anode:**  6O2-(l) 3O2(g) + 12e | |
| Iron | Haematite  Magnetite | Fe2O3  Fe3O4 | **Blast furnace**  Reduction of the ore by carbon(II)oxide | Fe2O3(s)+ 3CO(g)  2Fe(l) +3CO2(g)    Fe3O4(s)+ 4CO(g)  3Fe(l) +4CO2(g) | |
| Copper | Copper pyrites | CuFeS2 | **Roasting** the ore in air to get Cu2S.  **Heating** Cu2S ore in regulated supply of air.  **Reduction** of Cu2O by Cu2S | 2CuFeS2 (s)+ 4O2(g)  Cu2S(s)+3SO2(g) +2FeO(s)  2Cu2S (s)+ 3O2(g)  2Cu2O(s)+2SO2(g)  Cu2S (s)+ 2Cu2O(s) 6Cu(s)+ SO2(g) | |
| Zinc | Calamine | ZnCO3 | **Roasting** the ore in air to get ZnO  **Blast furnace /reduction** of the oxide by Carbon(II)Oxide/Carbon | ZnCO3(s) ZnO(s) + CO2(g)  2ZnS(s) +3O2(g) 2ZnO(s) + 2SO2(g)  ZnO(s) + CO(g  Zn(s) + CO2(g) | |
| Lead | Galena | PbS | **Blast furnace-Reduction of the oxide by carbon(II)oxide /Carbon** | PbO(s) + CO(g)  Pb(s) + CO2(g) | |

**Common alloys of metal.**

|  |  |  |
| --- | --- | --- |
| **Alloy name** | **Constituents of the alloy** | **Uses of the alloy** |
| Brass | Copper and Zinc | Making scews and bulb caps |
| Bronze | Copper and Tin | Making clock springs,electrical contacts and copper coins |
| Soldier | Lead and Tin | Soldering, joining electrical contacts because of its low melting points and high thermal conductivity |
| Duralumin | Aluminium, Copper and Magnesium | Making aircraft , utensils ,windows frames because of its light weight and corrosion resistant. |
| Steel | Iron, Carbon ,Manganese and other metals | Railway lines , car bodies girders and utensils. |
| Nichrome | Nichrome and Chromium | Provide resistance in electric heaters and ovens |
| German silver | Copper,Zinc and Nickel | Making coins |

**Physical properties of metal.**

Metals form giant metallic structure joined by metallic bond from electrostatic attraction between the metallic cation and free delocalized electrons.

This makes metals to have the following physical properties:

**(i)High melting and boiling points**

The giant metallic structure has a very close packed metallic lattice joined by strong electrostatic attraction between the metallic cation and free delocalized electrons. The more delocalized electrons the higher the melting/boiling points

**(ii)High thermal and electrical conductivity**

All metals are good thermal and electrical conductors as liquid or solids. The more delocalized electrons the higher the thermal and electrical conductivity.

**(iii)Shiny/Lustrous**

The free delocalized electrons on the surface of the metal absorb, vibrate and then scatter/re-emit/lose light energy. All metals are therefore usually shades of grey in colour except copper which is shiny brown.

**(iv)High tensile strength**

The free delocalized electrons on the surface of the metalatoms binds the surface immediately when the metal is coiled/folded preventing it from breaking /being brittle.

**(v)Malleable.**

Metals can be made into thin sheet.

**(vi)Ductile.**

Metals can be made into thin wires.

**Revision questions**

**1. In the extraction of aluminium,the oxide is dissolved in cryolite.**

**(i) What is the chemical name of cryolite?**

Sodium hexafloroaluminate/Na3AlF6

**(ii) What is the purpose of cryolite?**

To lower the melting point of the electrolyte/Aluminium oxide from about 2015oC to 900oC

**(iii) Name the substance used for similar purpose in the Down cell**

Calcium chloride/CaCl2

**(iv) An alloy of sodium and potassium is used as coolant in nuclear reactors. Explain.**

Nuclear reactors generate a lot of heat energy. Sodium and potassium alloy reduce/lower the high temperature in the reactors.

**(v)Aluminium metal is used to make cooking utensils in preference to other metals. Explain.**

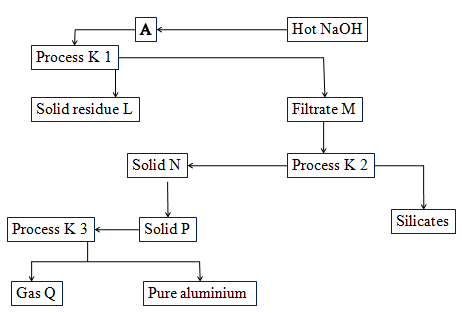
Aluminium

(i) Is a very good conductor of electricity because it has three delocalized electrons in its metallic structure

(ii) is cheap, malleable, ductile and has high tensile strength

(iii) On exposure to fire/heat form an impervious layer that prevent it from rapid corrosion.

**2.Study the scheme below and use it to answer the questions that follow.**



**(a)Identify:**

**(i) solid residue L**

Iron(III)Oxide/Fe2O3

**(ii)Solid N**

Aluminium hydroxide /Al(OH)3

**(iii)Filtrate M**

Sodium tetrahydroxoaluminate/ NaAl(OH)4 and sodium silicate/ NaSiO3

**(iv)Solid P**

Aluminium oxide/ Al2O3

**(v)Gas Q**

Oxygen/O2

**(vi) Process K1**

Filtration

**(vii)Process K2**

Electrolysis

**(b)Write the equation for the reaction taking place in the formation of solid P from solid N**

2Al(OH)3 Al2O3 (s) + 3H2O(l)

**(c)Name a substance added to solid N before process Process K2 take place.**

Cryolite/Sodium tetrahydroxoaluminate/ NaAl(OH)4

**(d)State the effect of evolution of gas Q on**

**(i) process K2**

Oxygen produced at the anode reacts with the carbon anode to form carbon(IV) oxide which escape. The electrolytic process needs continuous replacement of the carbon anode.

**(ii) the environment**

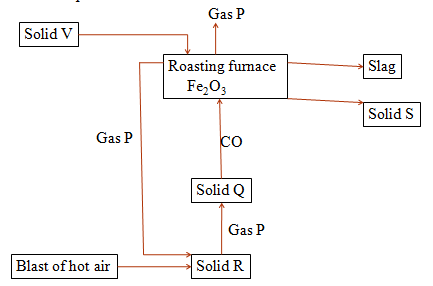
Oxygen produced at the anode reacts with the carbon anode to form carbon (IV) oxide which escape to the atmosphere.CO2 is a green house gas that cause global warming**.**

(e)An aluminium manufacturing factory runs for 24 hours. If the total mass of aluminium produced is 27000kg,

(i)Calculate the current used. (Faraday constant=96500Coulombs, Al=27.0).

(ii) Assuming all the gas produced react with 200kg of anode, calculate the loss in mass of the electrode.(Molar gas volume at room temperature = 24dm3,C=12.0)

1. The flow chart below shows the extraction of iron metal.Use it to answer the questions that follow.



**(a)Identify:**

**(i)gas P**

Carbon(IV)oxide/CO2

**(ii)Solid Q**

Carbon/coke/charcoal

**(iii)Solid R**

Carbon/coke/charcoal

**(iv)Solid V**

Limestone/calcium carbonate/CaCO3

**(v)Solid S**

Iron/Fe

**(b)Write the chemical equation for the reaction for the formation of:**

**(i) Solid S**

Fe2O3(s) + 3CO(g) 2Fe(s) + 3CO2(g)

**(ii) Carbon(II)oxide**

C(s) + CO2 (g) - 2CO (g)

**(iii)Slag**

SiO2(s) + CaO(s) - CaSiO3(s)

Al2O3 (s) + CaO(s) Ca Al2O4(s)

**(iv)Gas P**

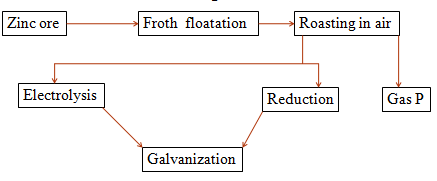
C(s) + O2 (g) CO2 (g)

**(c)State two uses of:**

**(i)Solid S**

**(ii)Slag**

**4. Use the flow chart below showing the extraction of Zinc metal to answer the questions that follow**

****

**(a)Name:**

**(i)two ores from which Zinc can be extracted**

Calamine(ZnCO3)

Zinc blende(ZnS)

**(ii)two possible identity of gas P**

Sulphur(IV)oxide(SO2) from roasting Zinc blende

Carbon(IV)oxide(CO2) from decomposition of Calamine.

**(b)Write a possible chemical equation taking place in the roasting chamber.**

2ZnS(s) + 3O2 (g) 2ZnO(s) + 2SO2(g)

ZnCO3(s) ZnO(s) + CO2(g)

**5.The flow chart below illustrate the industrial extraction of Lead metal**

