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**Department of Employment and Training**

Course : TNPSC Group II Exam  
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Topic : **Chemistry of ores and metals**

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# CHEMISTRY OF ORES AND METALS

## Minerals

- ❖ A mineral may be a single compound (or) complex mixture of various compounds of metals which are found in earth.

## Ores

- ❖ The mineral from which a metal can be readily and economically extracted on a large scale is said to be an ore.
- ❖ **All minerals cannot be called as ores, but all ores are minerals.**

## Oxide ores

- Bauxite -  $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$
- Cuprite -  $\text{Cu}_2\text{O}$
- Haematite -  $\text{Fe}_2\text{O}_3$
- Zincite -  $\text{ZnO}$
- Cassiterite  
(or) Tinstone -  $\text{SnO}_2$
- Pyrolusite -  $\text{MnO}_2$
- Pitch Blende -  $\text{U}_3\text{O}_8$

## Halides Ores

- Rock salt -  $\text{NaCl}$
- Carnallite -  $\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$
- Horn silver -  $\text{AgCl}$
- Fluorspar -  $\text{CaF}_2$

## Sulphide ores

- Copper pyrites -  $\text{CuFeS}_2$
- Copper glance -  $\text{Cu}_2\text{S}$
- Zinc blende -  $\text{ZnS}$
- Cinnabar -  $\text{HgS}$
- Galena -  $\text{PbS}$
- Argentite  
(or) Silver glance -  $\text{Ag}_2\text{S}$
- Iron Pyrites -  $\text{FeS}_2$

## Carbonate ores

- Calamine -  $\text{ZnCO}_3$
- Limestone  
(or) Marble -  $\text{CaCO}_3$
- Magnesite -  $\text{MgCO}_3$
- Siderite -  $\text{FeCO}_3$

Sodium peroxide is used in submarine and also to purify closed air in hospital

**Sulphate ores**

- Epsom salt             $-\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
- Gypsum               $-\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
- Barytes                $-\text{BaSO}_4$
- Anglesite             $-\text{PbSO}_4$

**Silicate ores**

- Asbestos             $-\text{CaSiO}_3 \cdot 3\text{MgSiO}_3$
- Felspar               $-\text{KAlSi}_3\text{O}_8$
- Mica                  $-\text{K}_2\text{O} \cdot 3\text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2 \cdot 2\text{H}_2\text{O}$

**Phosphate ores**

- Phosphorite -  $\text{Ca}_3(\text{PO}_4)_2$

**Ores of important Metals**

**1. Iron (Fe)**

- Hamatite             $-\text{Fe}_2\text{O}_3$
- Magnetite            $-\text{Fe}_2\text{O}_4$
- Iron Pyrites         $-\text{FeS}_2$
- Siderite              $-\text{FeCO}_3$

**2. Copper (Cu)**

- Copper pyrites     $-\text{CuFeS}_2$
- Cuprite (or)  
  Ruby Copper                $-\text{Cu}_2\text{O}$
- Copper glance       $-\text{Cu}_2\text{S}$
- Malachite            $-\text{Cu}(\text{OH})_2, \text{CuCO}_3$
- Azurite               $-\text{2CuCO}_3, \text{Cu}(\text{OH})_2$

**3. Aluminium (Al)**

- Bauxite               $-\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$
- Corundum            $-\text{Al}_2\text{O}_3$
- Cryolite              $-\text{Na}_3\text{AlF}_6$
- Mica                  $-\text{KAlSi}_2\text{O}_{10}(\text{OH})_2$
- Felspar               $-\text{KAlSi}_3\text{O}_8$

**4. Mercury (Hg)**

- Chinnabar -  $\text{HgS}$

**5. Lead (Pb)**

- Galena               $-\text{PbS}$
- Cerrusite           $-\text{PbCO}_3$
- Anglesite           $-\text{PbSO}_4$

**6. Tin (Sn)**

- Cassiterite (tinstone -  $\text{SnO}_2$ )

**7. Uranium (Ur)**

- Pitch blende -  $\text{U}_3\text{O}_8$
- Earnotite           $-(\text{K}_2\text{O} \cdot 2\text{UO}_2, \text{U}_2\text{O}_5 \cdot \text{NH}_2\text{O})$

**8. Sodium (Na)**

- Chile saltpetre -  $\text{NaNO}_3$
- Trona -  $\text{Na}_2\text{CO}_3 \cdot 2\text{NaHCO}_3 \cdot 3\text{H}_2\text{O}$
- Borax -  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$
- Common salt -  $\text{NaCl}$

**9. Potassium (K)**

- Nitre (salt peter) -  $\text{KNO}_3$
- Carnalite -  $\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$

**10. Magnesium (Mg)**

- Magnesite           $-\text{MgCO}_3$
- Dolomite           $-\text{MgCO}_3 \cdot \text{CaCO}_3$
- Epsom salt          $-\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
- Kieserite           $-\text{MgSO}_4 \cdot \text{H}_2\text{O}$

- Carnalite -  $\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$

### 11. Calcium (Ca)

- Dolomite -  $\text{CaCO}_3 \cdot \text{MgCO}_3$
- Calcite -  $\text{CaCO}_3$
- Gypsum -  $\text{CaF}_2$
- Fluorspar -  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
- Asbestos -  $\text{CaSiO}_3 \cdot \text{MgSiO}_3$

### 12. Strontium (Sr)

- Strontianite -  $\text{SrCO}_3$
- Silestine -  $\text{SrSO}_4$

### 13. Silver (Ag)

- Ruby Silver-  $3 \text{Ag}_2 \text{S} \cdot \text{Sb}_2\text{S}_3$
- Horn Silver-  $\text{AgCl}$

### 14. Gold (Au)

- Calaverite -  $\text{AuTe}_2$
- Silvenites -  $[(\text{Ag}, \text{Au}) \text{Te}_2]$

### 15. Barium (Ba)

- Barytes -  $\text{BaSO}_4$

### 16. Zinc (Zn)

- Zinc blende -  $\text{ZnS}$
- Zincite -  $\text{ZnO}$
- Calamine -  $\text{ZnCO}_3$

### 17. Tin (Sn)

- Cassiterite -  $\text{SnO}_2$

### 18. Antimony (Sb)

- Stibnite -  $\text{Sb}_2\text{S}_3$

### 19. Cadmium (Cd)

- Greenocite -  $\text{CdS}$

### 20. Bismuthinite ( $\text{Bi}_2\text{S}_3$ )

- Bismuthite -  $\text{Bi}_2\text{S}_3$

### 21. Cobalt (Co)

- Smelite -  $\text{CoAsS}_2$

### 22. Nickel (Ni)

- Milarite -  $\text{NiS}$

### 23. Magnese (Mn)

- Pyrolusite -  $\text{MnO}_2$
- Magnite -  $\text{Mn}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$

### 24. Uranium (U)

- Carnetite -  $\text{K}(\text{UO})_2 \cdot \text{VO}_4 \cdot 3\text{H}_2\text{O}$
- Pitch blende -  $\text{U}_3\text{O}_8$

Lead pipe is not used for drinking water because it forms poisonous lead hydroxide  $\text{Pb}(\text{OH})_2$

The difficulty in the Mendeleev's periodic table is overcome by introduction of Modern periodic table. It is also known as Long form of periodic table. In this table, properties of elements are dependent on their electronic configurations-distributions. Hence, modern periodic law is defined as the properties of elements and the periodic function of their atomic numbers.

- ❖ Among metals, silver is the best conductor of electricity.
- ❖ Among nonmetals, graphite is the only conductor of electricity.
- ❖ Mercury is a metal with a very low melting point and it becomes liquid at room temperature.

### **Metals and Non Metals**

- ❖ Tungsten has the highest melting point of any metal-over  $3410^{\circ}\text{C}$ .
- ❖ The lightest metal is Lithium.
- ❖ It weighs about half as much as water.

- ❖ Osmium is the heaviest metal. It is about 22 times heavier than water and nearly 3 times heavier than iron.

### **Alloys:**

- ❖ Alnicos are alloys of Iron, Aluminium and Nickel, Cobalt.
- ❖ Alnicos are used to make magnets, up to 25 times as strong as ordinary magnets.

### **Methods of making Alloys**

- 1) By fusing the metals together.
- 2) By compressing finely divided metals one over the other.

**Amalgam:** An amalgam is an alloy of mercury with metals such as sodium, gold, silver, etc.

Zinc Oxide is known as flower of Zinc. Also known as Chinese white is used as paints.

### Copper Alloys

Name of the alloy	Reason for alloying	Uses
i.Brass(Cu,Zn)	Lustrous,easily cast,malleable, ductile,harder than Cu.	Electrical fittings, medals, hardware, decorative items.
ii.Bronze(Cu,Sn)	Hard, brittle and polishable.	Statues, coins, bells, gongs.

### Aluminum Alloys

Name of the alloy	Reason for alloying	Uses
i.Duralumin (Al,Mg,Mn,Cu)	Light,strong,resistant to corrosion, stronger than aluminium.	Aircraft,tools, pressure cookers
ii.Magnalium(Al,Mg)	Light, hard, tough, corrosion resistant.	Aircraft, scientific instruments

### Iron Alloys

Name of the alloy	Reason for alloying	Uses
i.Stainless steel (Fe,C,Ni,Cr)	Lustrous,corrosion resistant,high tensile strength.	Utensils,cutlery,automobile parts.
ii.Nickel steel (Fe,C,Ni)	Hard, corrosion resistant,elastic.	Cables,aircraft parts,propeller.

### Metallurgy

- ◆ Metallurgy is as old as our civilization. Copper was the first metal to be used in making utensils and weapons. Metals play a significant role in our life.
- ◆ They constitute the mineral wealth of a country which is the measure of its prosperity. Metals like Titanium, Chromium, Manganese, Zirconium etc. find their applications in the

manufacture of defence equipments. These are called strategic metals. The metal Uranium plays a vital role in nuclear reactions releasing enormous energy called nuclear energy. Copper, Silver and Gold are called coinage metals as they are used in making coins, jewelry etc.



## **Terminology**

- ❖ **Minerals:** A mineral may be a single compound or a complex mixture of various compounds of metals found in the earth.

Purity of gold is expressed in carats. 24 carat gold = pure gold. For making ornaments 22 carat gold is used which contains 22 parts of gold by weight and 2 parts of copper by weight. The percentage of purity is  $\left(\frac{22}{24}\right) \times 100 = 91.6\%$  (916 Make gold) From one gram of gold, nearly 2km of filament can be drawn. It is an amazing fact indeed!

### ❖ **Ores:**

The mineral from which a metal can be readily and economically extracted on a large scale is said to be an ore.

For example, clay ( $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$ ) and bauxite ( $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ ) are the two minerals of Aluminium, but Aluminium can be profitably extracted only from bauxite.

Hence bauxite is an ore of aluminium and clay is its mineral.

### **Mining:**

- ❖ The process of extracting the ores from the earth's crust is called mining.
- ❖ **Metallurgy:** The various steps involved in the extraction of metals from their

ores as well as refining of crude metals are collectively known as metallurgy.

- ❖ **Gangue of Matrix:** The rocky impurity, associated with the ore is called gangue of matrix
- ❖ **Flux:** It is the substance added to the ore to reduce the fusion temperature and to remove impurities. e.g. Calcium oxide, Silica.
- ❖ **Slag:** It is the fusible product formed when flux reacts with gangue during the extraction of metals.
- ❖ **Flux + Gangue** → Slag
- ❖ **Smelting:** Smelting is the process of reducing the roasted metallic oxide to metal in molten condition. In this process, impurities are removed by the addition of flux as slag.

## **METALLURGY OF ALUMINIUM, COPPER AND IRON**

### **Metallurgy of Aluminium**

Al	13
ALUMINUM	
26.98	2.70
660	2467



**Symbol : Al**

**Colour : Silvery white**

**Atomic number : 13**

**Electronic configuration: 2, 8, 3**

**Valency : 3**

**Atomic mass : 27**

Silver Spoon is not used in egg food because it forms black silver sulphide.



```

graph TD
    ORE[ORE] -- "Gravity separation, Froth floatation, Magnetic separation, Leaching" --> CO[Concentrated ore]
    CO --> H[Metals of high reactivity  
Electrolytic reduction, Refining]
    CO --> M[Metals of moderate reactivity  
Calcination, Roasting, Reduction, Refining]
    CO --> L[Metals of low reactivity  
Roasting, Reduction, Refining]
    H --> PM1[Pure Metal]
    M --> PM2[Pure Metal]
    L --> PM3[Pure Metal]
  
```

Aluminium is the metal found most abundantly in the earth's crust. Since it is a reactive metal, it occurs in the combined state. The important ores of aluminium are as follows:

Name of the ore	Formula
Bauxite	$\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$
Cryolite	$\text{Na}_3\text{AlF}_6$
Corundum	$\text{Al}_2\text{O}_3$

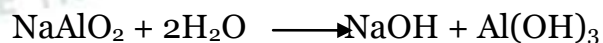
Extraction of aluminium from bauxite involves two stages:

The conversion of Bauxite into Alumina involves the following steps:

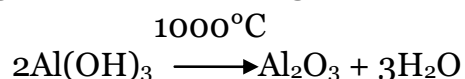
$$\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O} + 2\text{NaOH} \xrightarrow{150^\circ\text{C}} 2\text{NaAlO}_2 + 3\text{H}_2\text{O}$$

Bauxite                      Sodium meta  
Aluminate

ii. On diluting sodium meta aluminate with water, aluminium hydroxide precipitate is obtained.

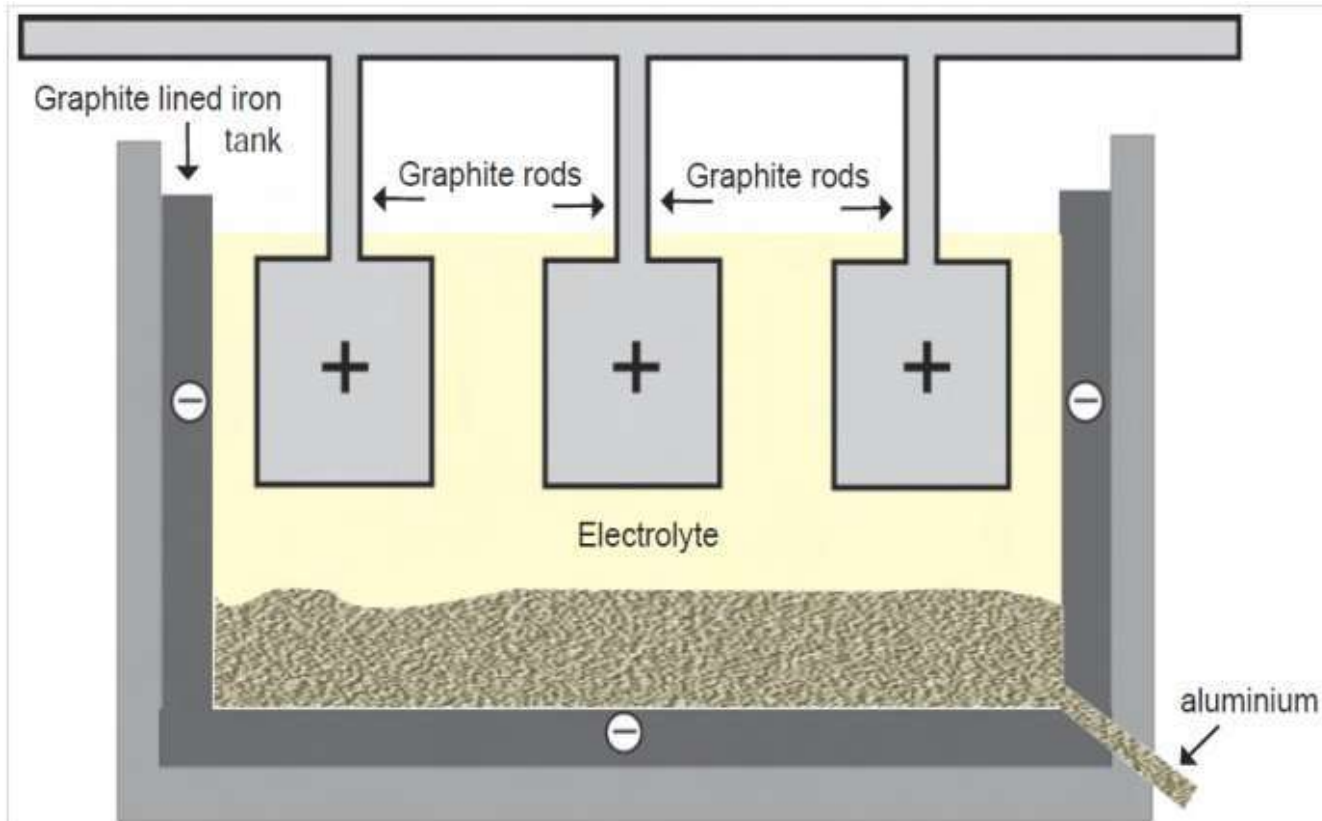


iii. The precipitate is filtered, washed, dried and ignited at  $1000^{\circ}\text{C}$  to get alumina.



Aluminium is produced by the electrolytic reduction of fused alumina ( $\text{Al}_2\text{O}_3$ ) in the electrolytic cell.

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*Electrolytic reduction of alumina*

**Cathode:** Iron tank lined with graphite.

**Anode:** A bunch of graphite rods suspended in molten electrolyte.

**Electrolyte:** Pure alumina + molten cryolite + fluorspar (fluorspar lowers the fusion temperature of electrolyte)

**Temperature :** 900-950°C

**Voltage used :** 5-6V

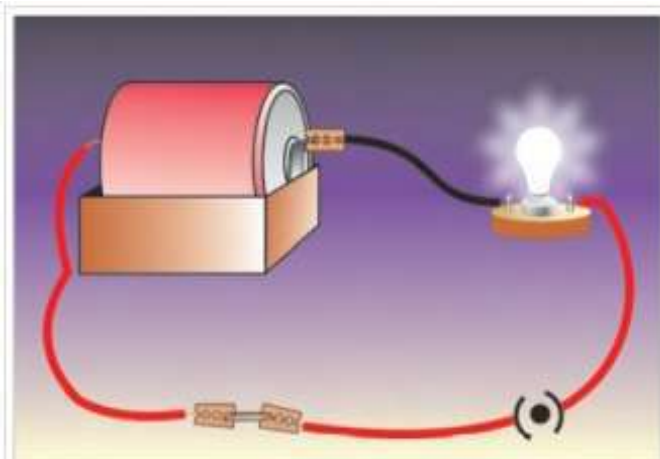
The overall equation for aluminium extraction is  $2\text{Al}_2\text{O}_3 \rightarrow 4\text{Al} + 3\text{O}_2\uparrow$

Aluminium is deposited at the cathode and oxygen gas is liberated at the anode. Oxygen combines with graphite to form  $\text{CO}_2$ .

### Properties of Aluminium

#### Physical properties:

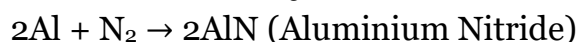
- It is a silvery white metal.
- It has low density and it is light.
- It is malleable and ductile.
- It is a good conductor of heat and electricity.



*Electric conductivity of metal*

- vi. It can be polished to produce a shiny attractive appearance.

**1. Reaction with air:** It is not affected by dry air. On heating at  $800^{\circ}\text{C}$ , aluminium burns very brightly forming its oxide and nitride.


$$\underset{\text{Steam}}{2\text{Al}} + \underset{\text{Aluminium}}{3\text{H}_2\text{O}} \longrightarrow \underset{\text{Aluminium}}{\text{Al}_2\text{O}_3} + \underset{\text{Oxide}}{3\text{H}_2\uparrow}$$
$$2\text{Al} + 2\text{NaOH} + 2\text{H}_2\text{O} \longrightarrow 2\text{NaAlO}_2 + 3\text{H}_2 \uparrow$$

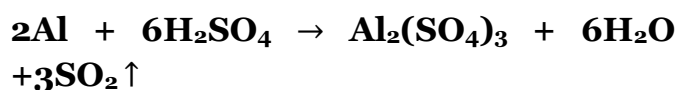
Sodium meta  
aluminate

$$2\text{Al} + 6\text{HCl} \longrightarrow 2\text{AlCl}_3 + 3\text{H}_2 \uparrow$$

Aluminium  
Chloride

$$\text{2Al} + \text{3H}_2\text{SO}_4 \rightarrow \text{Al}_2(\text{SO}_4)_3 + \text{3H}_2 \uparrow$$

Dilute



hot & conc. Aluminium  
Sulphuric acid Sulphate

*Dilute or concentrated nitric acid does not attack aluminium, but it renders aluminium passive due to the formation of an oxide film on its surface.*

$$\text{Fe}_2\text{O}_3 + 2\text{Al} \rightarrow 2\text{Fe} + \text{Al}_2\text{O}_3 + \text{Heat}$$

<b>USES</b>	<b>FORM</b>	<b>REASON</b>
Household utensils	Aluminium metal	It is light, cheap, corrosion resistant, and a good conductor of heat.
Electrical cable industry	Aluminium wires	Aluminium wires
Aeroplanes and other Industrial parts	Duralumin Al,Cu,Mg,Mn Magnalium Al,Mg	Its alloys are light, have high tensile strength and corrosion resistant.
Thermite welding	Al powder and $\text{Fe}_2\text{O}_3$	Its powder is a strong reducing agent and reduces $\text{Fe}_2\text{O}_3$ to iron.



Aircraft - An alloy of aluminium

## Metallurgy of Copper



**Symbol :** Cu

**Atomic mass :** 63.55

**Atomic number :** 29

**Electronic configuration :** 2, 8, 18, 1

**Valency :** 1 and 2

**Occurrence:** It was named as cuprum by the Romans because they got it from the Island of Cyprus. Copper is found in the **native state** as well as in the combined state.

Ores of copper	Formula
Copper pyrites	$\text{CuFeS}_2$
Cuprite or ruby copper	$\text{Cu}_2\text{O}$
Copper glance	$\text{Cu}_2\text{S}$

The chief ore of copper is copper pyrite. It yields nearly 76% of the world production of copper.

### Extraction from Copper Pyrites:

Extraction of copper from copper pyrites involves the following steps:

**1. Crushing and concentration:** The ore is crushed and then concentrated by froth-floatation process.

**2. Roasting:** The concentrated ore is roasted in excess of air. During the process of roasting,

i. moisture and volatile impurities are removed.

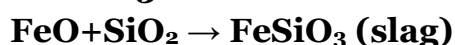
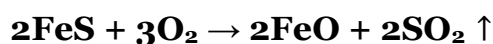
ii. **sulphur**, phosphorus, arsenic and antimony are removed as oxides. Copper pyrite is partly converted into sulphides of copper and iron.



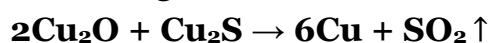
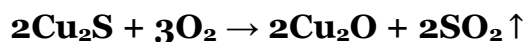
**3. Smelting:** The roasted ore is mixed with powdered coke and sand and is heated in a blast furnace to obtain matte and slag.

(**Matte** =  $\text{Cu}_2\text{S} + \text{FeS}$ ) The slag is removed as waste.

**4. Bessemerisation:** The molten matte is transferred to Bessemer converter in order to obtain **blister copper**. Ferrous sulphide from matte is oxidised to ferrous oxide, which is removed as slag using silica.



**Iron silicate**



**Blister copper**



**5. Refining:** Blister copper contains 98% of pure copper and 2% of impurities and is purified by electrolytic refining.

### Electrolytic Refining

This method is used to get metal of a high degree of purity. For electrolytic refining of copper, we use:

**Cathode:** A thin plate of pure copper metal.

**Anode:** A block of impure copper metal.

**Electrolyte:** Copper sulphate solution acidified with sulphuric acid.

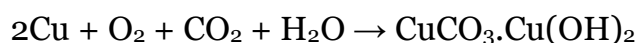
When electric current is passed through the electrolytic solution, pure copper gets deposited at the cathode and the impurities settle at the bottom of the anode in the form of sludge called **anode mud**.

### Properties

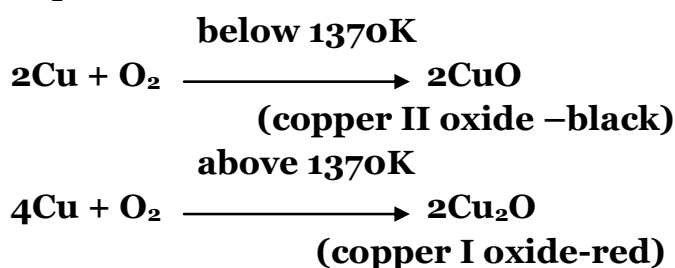
**Physical properties:** Copper is a reddish brown metal, with high lustre, high density and high melting point (1356°C).

### Chemical properties:

i. **Action of Air and Moisture:** Copper gets covered with a green layer of basic copper carbonate in the presence of CO<sub>2</sub> and moisture.



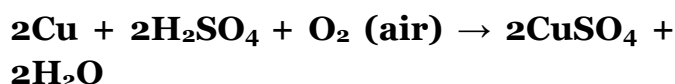
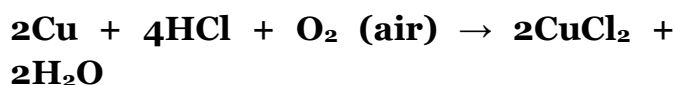
ii. **Action of Heat:** On heating at different temperatures in the presence of oxygen, copper forms two types of oxides CuO, Cu<sub>2</sub>O.



### iii. Action of Acids:

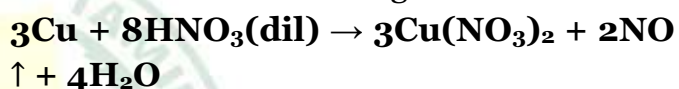
#### a) With dil.HCl and dil.H<sub>2</sub>SO<sub>4</sub>:

Dilute acids such as HCl and H<sub>2</sub>SO<sub>4</sub> have no action on these metals in the absence of air. Copper dissolves in these acids in the presence of air.



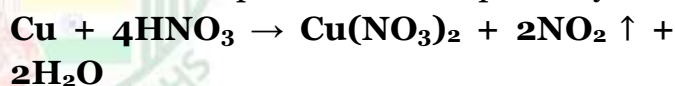
#### b) With dil.HNO<sub>3</sub>:

Copper reacts with dil.HNO<sub>3</sub> with the liberation of Nitric Oxide gas.



#### c) With con.HNO<sub>3</sub> and con.H<sub>2</sub>SO<sub>4</sub>:

Copper reacts with con. HNO<sub>3</sub> and con. H<sub>2</sub>SO<sub>4</sub> with the liberation of nitrogen dioxide and sulphur dioxide respectively.

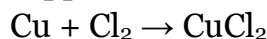


(conc.)



(conc.)

iv. **Action of Chlorine:** Chlorine reacts with copper, resulting in the formation of copper (II) chloride.



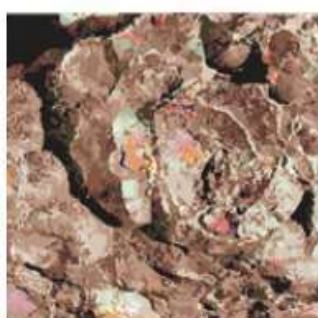
v. **Action of Alkalis:** Copper is not attacked by alkalis.

### Uses of Copper:

- It is extensively used in manufacturing electric cables and other electric appliances.

- It is used for making utensils, containers, calorimeters and coins.
- It is used in electroplating.
- It is alloyed with gold and silver for making coins and jewels.

## Metallurgy of Iron



**Symbol:** Fe

**Colour:** Greyish white

**Atomic mass:** 55.9

**Atomic number:** 26

**Electronic configuration :** 2, 8, 14, 2

**Valency:** 2 & 3

### Occurrence:

Iron is the second most abundant metal available next to aluminium. It occurs in nature as oxides, sulphides and carbonates.

The ores of iron are given in the following table:

Ores of iron	Formula
Haematite	Fe <sub>2</sub> O <sub>3</sub>
Magnetite	Fe <sub>3</sub> O <sub>4</sub>
Iron pyrite	FeS <sub>2</sub>

## Extraction of Iron from Haematite Ore (Fe<sub>2</sub>O<sub>3</sub>)

### 1. Concentration by Gravity Separation

The powdered ore is washed with a stream of water. As a result, the lighter sand particles and other impurities are washed

away and the heavier ore particles settle down.

### 2. Roasting and Calcination

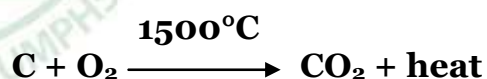
The concentrated ore is strongly heated in a limited supply of air in a reverberatory furnace. As a result, moisture is driven out and sulphur, arsenic and phosphorus impurities are oxidised off.

### 3. Smelting (in a Blast Furnace)

The **charge** consisting of roasted ore, coke and limestone in the ratio **8 : 4 : 1** is smelted in a blast furnace by introducing it through the **cup and cone** arrangement at the top. There are three important regions in the furnace.

#### i. The Lower Region (Combustion Zone)-the temperature is at 1500°C.

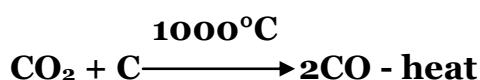
In this region, coke burns with oxygen to form CO<sub>2</sub> when the charge comes in contact with a hot blast of air.



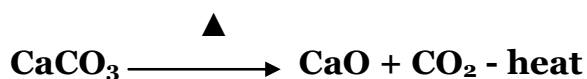
It is an exothermic reaction since heat is liberated.

#### ii. The Middle Region (Fusion Zone)-

The temperature prevails at 1000°C. In this region, CO<sub>2</sub> is reduced to CO.

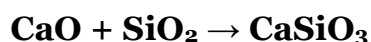


Limestone decomposes to calcium oxide and CO<sub>2</sub>.

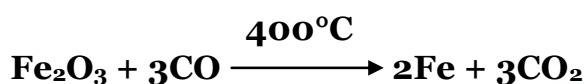




These two reactions are endothermic due to the absorption of heat. Calcium oxide combines with silica to form calcium silicate slag.



**iii. The Upper Region (Reduction Zone)**-The temperature prevails at 4000C. In this region carbon monoxide reduces ferric oxide to form a fairly pure spongy iron.



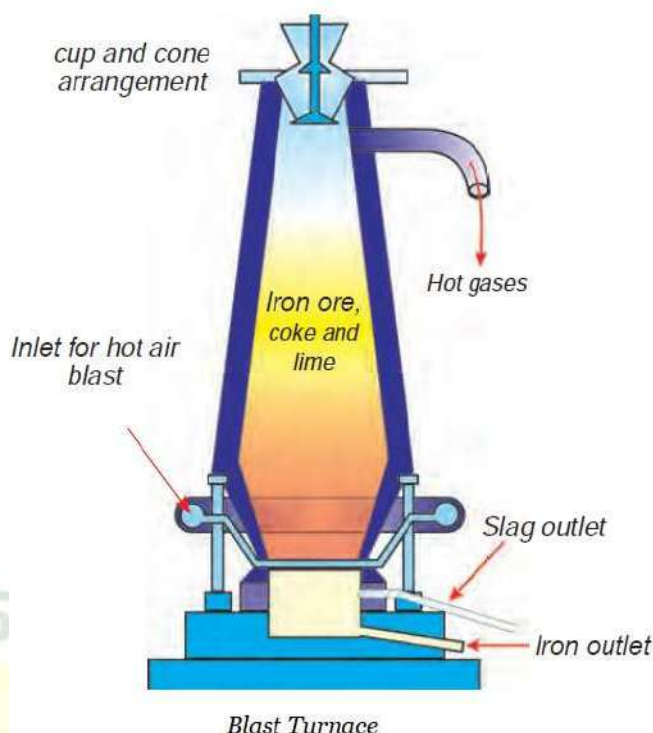
The molten iron is collected at the bottom of the furnace after removing the slag.

The iron thus formed is called pig iron. It is remelted and cast into different moulds. This iron is called cast iron.

#### MORE TO KNOW

**CALCINATION:** It is a process in which ore is heated in the absence of air. As a result of calcination, the carbonate ore is converted into its oxide.

**ROASTING:** It is a process in which ore is heated in the presence of excess of air. As a result of roasting, the sulphide ore is converted into its oxide.



#### MORE TO KNOW

Depending on the carbon content, iron is classified into 3 types:

Pig iron with carbon content of 2- 4.5%

Wrought iron with carbon content of <0.25%

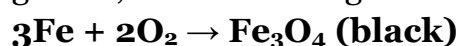
Steel with carbon content of 0.25-2%.

#### Physical Properties

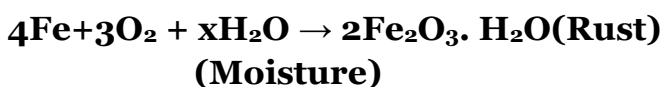
- It is a heavy metal of density 7.9 g/cc.
- It is a lustrous metal, greyish white in colour.
- It has high tensility, malleability and ductility.
- It is a good conductor of heat and electricity.
- It can be magnetised.

#### Chemical properties

**1. Reaction with air or oxygen:** Only on heating in air, iron forms magnetic oxide.



**2. Reaction with moist air:** When iron is exposed to moist air, it forms a layer of brown hydrated ferric oxide on its surface. This compound is known as rust and the phenomenon of formation of rust is known as rusting.



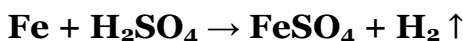
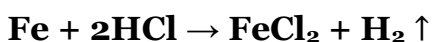
**3. Reaction with steam:** When steam is passed over red hot iron, magnetic oxide is formed.



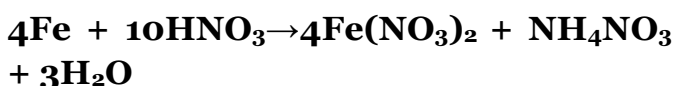
**4. Reaction with chlorine:** Iron combines with chlorine to form ferric chloride.



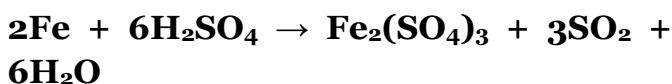
**5. Reaction with acids:** With dilute HCl and dilute H<sub>2</sub>SO<sub>4</sub> it liberates H<sub>2</sub> gas.



With dilute HNO<sub>3</sub> in cold condition it gives ferrous nitrate.



With conc. H<sub>2</sub>SO<sub>4</sub> it forms ferric sulphate.



**When iron is dipped in conc. HNO<sub>3</sub>** it becomes chemically **inert or passive** due to the formation of a layer of iron oxide (Fe<sub>3</sub>O<sub>4</sub>) on its surface.

### Uses of Iron

**i. Pig iron** is used in making pipes, stoves, radiators, railings, manhole covers and drain pipes.

**ii. Steel** is used in the construction of buildings, machinery, transmission cables and T.V. towers and in making alloys.

**iii. Wrought iron** is used in making springs, anchors and electromagnets.

### ALLOYS

An alloy is a homogeneous mixture of a metal with other metals or with non-metals that are fused together.

**Alloys are solid solutions.** Alloys can be considered as solid solutions in which the metal with high concentration is the **solvent** and the metal with low concentration is the **solute**. For example, brass is an alloy of zinc(solute) in copper(solvent).

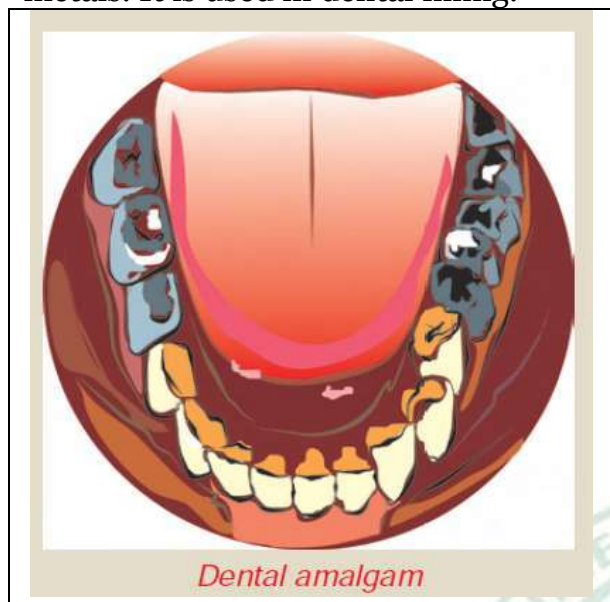
### Methods of making Alloys

1. By fusing the metals together.
2. By compressing finely divided metals one over the other.

**Amalgam:** An amalgam is an alloy of mercury with metals such as sodium, gold, silver, etc.

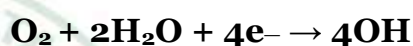
### DENTAL AMALGAMS

It is an alloy of mercury with silver and tin metals. It is used in dental filling.



**Corrosion** is defined as the slow and steady destruction of a metal by the environment. It results in the deterioration of the metal to form metal compounds by means of chemical reactions with the environment.

When the surface of iron is exposed to moisture and other gases present in the atmosphere, chemical reaction takes place.



### Copper Alloys

Name of the alloy	Reason for alloying	Uses
i. Brass (Cu, Zn)	Lustrous, easily cast, malleable, ductile, harder than Cu.	Electrical fittings, medals, hardware, decorative items.
ii. Bronze (Cu, Sn)	Hard, brittle and polishable.	Statues, coins, bells, gongs.

### Aluminium Alloys

Name of the alloy	Reason for alloying	Uses
i. Duralumin (Al, Mg, Mn, Cu)	Light, strong, resistant to corrosion, stronger than aluminium.	Aircraft, tools, pressure cookers
ii. Magnalium (Al, Mg)	Light, hard, tough, corrosion resistant.	Aircraft, scientific instruments

### Iron Alloys

Name of the alloy	Reason for alloying	Uses
i. Stainless steel (Fe, C, Ni, Cr)	Lustrous, corrosion resistant, high tensile strength.	Utensils, cutlery, automobile parts.
ii. Nickel steel (Fe, C, Ni)	Hard, corrosion resistant, elastic.	Cables, aircraft parts, propeller.

- ◆.....◆
- The  $\text{Fe}^{2+}$  ions are oxidised to  $\text{Fe}^{3+}$  ions. The  $\text{Fe}^{3+}$  ions combine with  $\text{OH}^-$  ions to form  $\text{Fe}(\text{OH})_3$ . This becomes rust ( $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ) which is hydrated ferric oxide.

**Methods of preventing corrosion:**

- ❖ Corrosion of metals is prevented by not allowing them to come in contact with moisture  $\text{CO}_2$  and  $\text{O}_2$ . This is achieved by the following methods:
- ❖ By coating with paints: Paint coated metal surfaces keep out air and moisture.
- ❖ By coating with oil and grease: Application of oil and grease on the surface of iron tools prevent them from being acted upon by moisture and air.
- ❖ By alloying with other metals: Alloyed metals are more resistant to corrosion. Example: stainless steel.
- ❖ By the process of galvanization: This is a process of coating zinc on iron sheets by using electric current. In this, zinc forms a protective layer of zinc carbonate on the surface of iron. This prevents corrosion.

- ❖ Electroplating: It is a method of coating one metal with another by passing electric current. Example: silver plating, nickel plating. This method not only protects but also enhances the metallic appearance.
- ❖ Sacrificial protection: Magnesium is more reactive than iron. When it is coated on the articles made of steel it sacrifices itself to protect steel.

Silver is the best conductor while lead is the poorest conductor, While lead is the poorest condition of electricity.