Chapter 11

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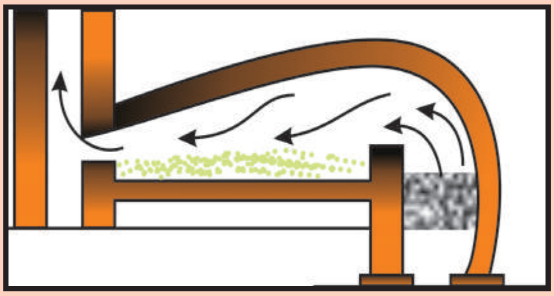


Principles of Metallurgy

In class 8 you have studied about certain properties of metals like, malleability, ductility, sonarity etc. Metals play an important role in our daily life. We use various metals for various purposes like gold and silver as jewellery, copper, iron, aluminium for making conducting wires and for making utensils etc. We use many house hold articles made up of metals and their alloys at our home.

- Can you mention some articles that are made up of metals?
- Do metals exist in nature in the same form as that we use in our daily life?
- Have you ever heard the words like ore, mineral and metallurgy?
- Do you know how these metals are obtained?

To understand these questions you need to know about metallurgy. In this chapter we discuss various concepts related to metallurgy and the process by which we are able to obtain the pure form of metal that we use in our daily life.

"**Metallurgy** is the process of extraction of metals from their ores".

Human history in terms of materials had the Bronze Age and Iron Age pertaining to the metals they started to use the bronze (an alloy of copper and tin) and iron. Now we have more than 75% metals among the elements available.

Occurrence of the metals in nature

- How the metals are present in nature?

The earth's crust is the major source of metals. Sea water also contains some soluble salts such as sodium chloride and magnesium chloride etc.

Some metals like gold (Au), silver (Ag) and copper (Cu) are available in nature in free state (native) as they are least reactive. Other metals mostly are found in nature in the combined form due to their more reactivity. The elements or compounds of the metals which occur in nature in the earth crust are called *minerals*. At some places, minerals contain a very high percentage of a particular metal and the metal can be profitably extracted from it. The minerals from which the metals are extracted without economical loss are called *ores*.

Aluminium, for example, is the most common metal in the Earth's crust, occurring in most of minerals. However, it isn't economically feasible to extract it from most of these minerals. Instead, the usual ore from which it is profitable to extract it is bauxite – which contains from 50 – 70 % of aluminium oxide .

Think and discuss

- Do you agree with the statement "All ores are minerals but all minerals need not be ores?" Why?

Activity 1

Look at the following ores.

Identify the metal present in each ore.

Table - 1

ORE	Formula	metal	ORE	Formula	metal
Bauxite	$Al_2O_3 \cdot 2H_2O$	Al	Zincite	ZnO	Zn
Copper Iron Pyrites	$CuFeS_2$	Cu	Rock salt	$NaCl$	Na
Zinc Blende	ZnS	Zn	Cinnabar	HgS	Hg
Magnesite	$MgCO_3$	Mg	Magnetite	Fe_3O_4	Fe
Epsom salt	$MgSO_4 \cdot 7H_2O$	Mg	Galena	PbS	Pb
Horn Silver	$AgCl$	Ag	Gypsum	$CaSO_4 \cdot 2H_2O$	Ca
Pyrolusite	MnO_2	Mn	Lime stone	$CaCO_3$	Ca
Haematite	Fe_2O_3	Fe	Carnallite	$KCl\,MgCl_2 \cdot 6H_2O$	Mg

Now try to classify them as shown in the table.

Table - 2

Oxides	Sulphides	Chlorides	Carbonates	Sulphates

- What metals can we get from the ores mentioned in the Table – 1?
- Can you arrange these metals in the order of their reactivity?
- What do you notice in Table – 2?

You will notice that the ores of many metals are oxides and sulphides. This is why oxygen - sulphur (16th group) group is called chalcogen family *(chalco = ore; genus = produce)*

The metals like K, Na, Ca, Mg and A*l* are so reactive that they are never found in nature in free state.

The metals like Zn, Fe, Pb etc., are moderately reactive. They are found in the earth crust mainly as oxides, sulphides and carbonates.

Metals like Au, Ag are least reactive and they are found even in free state in nature.

Based on reactivity we can arrange metal in descending order of their reactivity as shown below:

K, Na, Ca, Mg, Al	**Zn, Fe, Pb, Cu**	**Hg, Ag, Pt, Au**
High reactivity	**Moderate reactivity**	**Low reactivity**

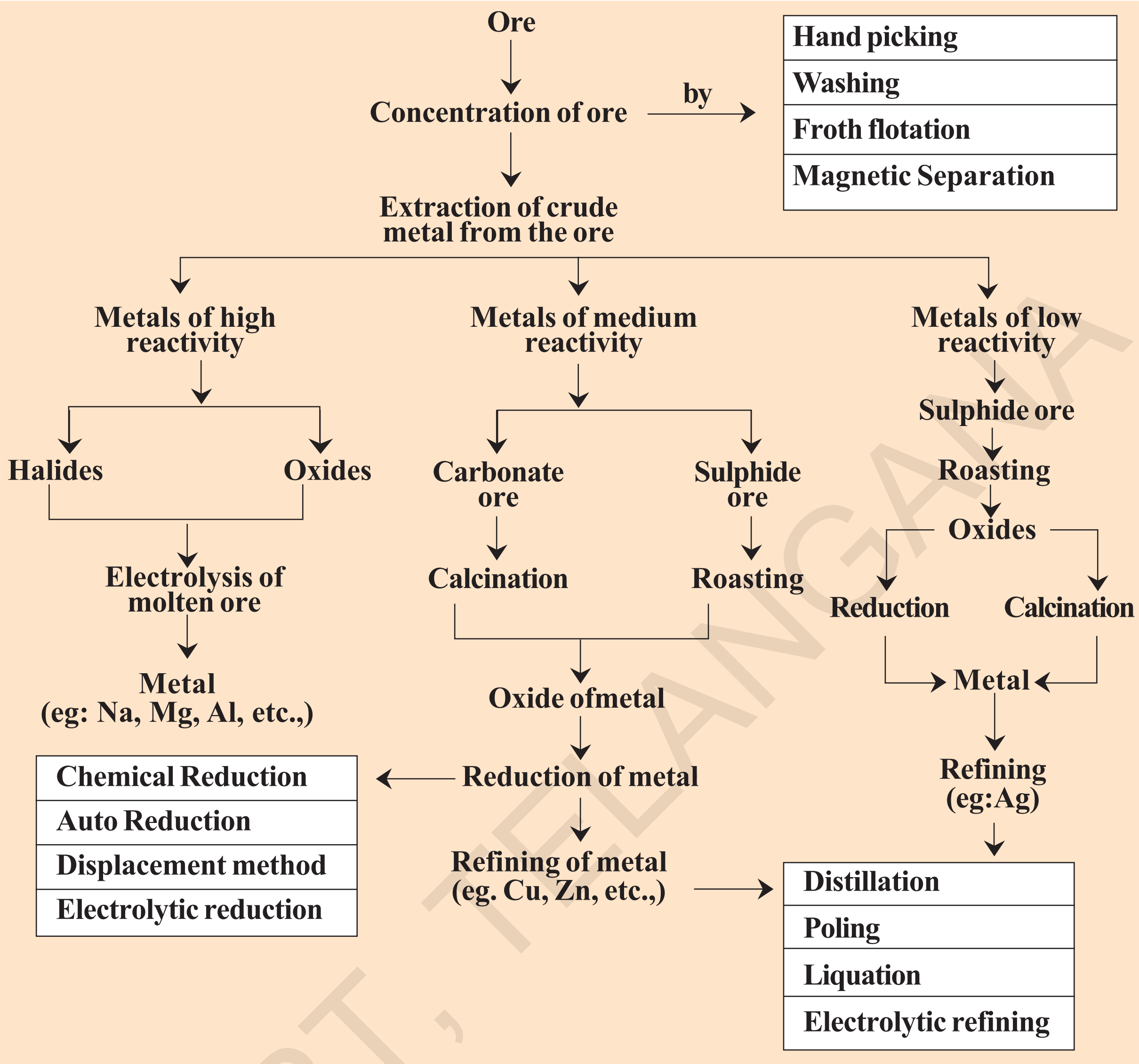
- Can you think how do we get these metals from their ores?
- Does the reactivity of a metal and form of its ore (oxides, sulphides, chlorides, carbonates sulphates) has any relation with process of extraction?
- How are metals extracted from mineral ores?
- What methods are to be used?

Let us find.

Extraction of metals from the ores:

The extraction of a metal from its ore involves mainly three stages. They are:

I) Concentration or Dressing
II) Extraction of crude metal
III)Refining or purification of the metal.



I. Concentration or Dressing of the ore

Ores that are mined from the earth are usually contaminated with large amount of impurities such as soil and sand etc.

Concentration or Dressing means, simply getting rid of as much of the unwanted rocky material as possible from the ore. The impurities like sand and clay are called *gangue.* Here, we should get as for as possible pure or more concentrated ore.

Enrichment (concentration) of the ore: Various physical methods are used to enrich the ore. In many cases, it is possible to separate the metal compound from unwanted rocky material by physical means. An example for this is ***froth flotation.***

The physical methods adopted in dressing of the ore (or) enriching of the ore depends upon difference between physical properties of ore and gangue.

Table-3

Name of the method	Process
Hand picking	If the ore particles and the impurities are different in one of the properties like colour, size etc., Using that property the ore particles are handpicked separating them from other impurities.
Washing	Ore particles are crushed and kept on a slopy surface. They are washed with controlled flow of water. Less densive impurities are carried away by water flow, leaving the more densive ore particles behind.
Froth flotation	This method is mainly useful for sulphide ores which have no wetting property whereas the impurities get wetted. The ore with impurities is finely powdered and kept in water taken in a flotation cell. Air under pressure is blown to produce froth in water. Froth so produced, takes the ore particles to the surface whereas impurities settle at the bottom. Froth is separated and washed to get ore particles.(see fig.1)
Magnetic separation	If the ore or impurity, one of them is magnetic substance and the other non-magnetic substance they are separated using electromagnets. (see Fig.2)

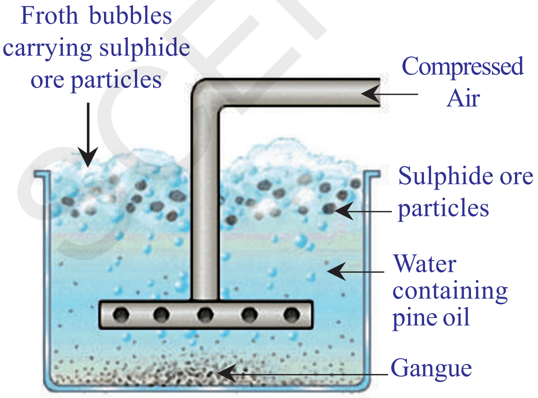


fig-1: Froth flotation process for the concentration of sulphide ores

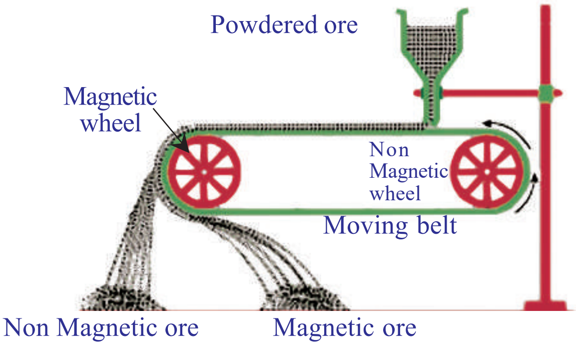


fig-2: Magnetic separation

There are some other methods also for dressing which you will learn at higher classes

Reactivity of Metals

Table-4

Metals	Action of Oxygen	Reaction with cold water	Reaction with steam	Reaction with dilute strong Acids	Reaction with chlorine on heating
K	Form Na_2O, K_2O in limited supply of O_2 but form peroxides in excess of O_2	K to Mg displace H_2 from cold water with decreasing reactivity {K violently but Mg very slowly}	K to Fe displace H_2 with steam without decreasing reactivity. {K very violently but Fe very slowly}	K to Pb displace H_2 from dilute strong acids with decreasing reactivity. {K-explosively, Mg-very vigorously, Fe-steadily, Pb-very slowly}	All metals react with Chlorine on heating toform their respective Chlorides but with decreasing reactivity from top to bottom. This is understood from the heat evolved when the metal reacts with one mole of Chlorine gas to form Chloride. KCl, $NaCl$, $CaCl_2$, $MgCl_2$, $AlCl_3$, $ZnCl_2$, $FeCl_3$, $PbCl_2$, $CuCl_2$, $HgCl_2$, $AgCl$, $PtCl_3$ and $AuCl_3$ are formed
Na					
Ca	Burn with decreasing vigour to form oxides CaO, MgO, Al_2O_3, ZnO, Fe_2O_3				
Mg					
Al		From Al to Au do not displace H_2 from cold water			
Zn					
Fe					
Pb	Don't burn, but only form a surface layer of oxide PbO, CuO, HgO		From Pb to Au donot displace H_2 from steam		
Cu				Cu to Au do not displace H_2 from dilute strong acids	
Hg					
Ag	Don't burn or oxidise even on the surface				
Pt					
Au					

II Extraction of crude metal from the ore

Extraction of the metal from its ores depends on the reactivity of the metal. To understand the order of reactivity of metals that are very familiar, we study their chemical reactions with cold water, steam, dilute, strong acids and Cl_2 and based on their vigorous activity order in these reactions we frame out activity series. Arrangement of the metals in decreasing order of their reactivity is known as *activity series*. (See table - 4)

Reduction of purified ore to the metal

The method used for a particular metal for the reduction of its ore to the metal depends mainly on the position of the metal in the activity series.

A) Extraction of Metals at the top of the activity series

(K, Na, Ca, Mg and Al). Simple chemical reduction methods like heating with C, CO etc to reduce the ores of these metals are not feasible. The temperature required for the reduction is too high and more expensive. To make the process economical, electrolysis methods are to be adopted. Again the electrolysis of their aqueous solutions also is not feasible because water in the solution would be discharged at the cathode in preference to the metal ions.

The only method available is to extract these metals by electrolysis of their fused compounds. For example to extract Na from NaCl, fused NaCl is electrolysed with steel cathode (-) and graphite anode (+). The metal (Na) will be deposited at cathode and chloride liberated at the anode.

At Cathode $2Na^+ + 2e^- \rightarrow 2Na$

At Anode $2Cl^- \rightarrow Cl_2 + 2e^-$

For the above electrolysis, a large quantity of electricity is required to keep the ore in molten state. Suitable impurities are added to the ore to decrease its melting point.

B) Extraction of metals in the middle of the activity series

(Zinc, iron, tin, lead and copper): The ores of these metals are generally present as sulphides or carbonates in nature. Therefore prior to reduction of ores of these metals, they must be converted into metal oxides.

Sulphide ores are converted into oxides by heating them strongly in excess of air. This process is known as *roasting*. Generally the sulphide ores are roasted to convert them into oxides before reducing them to metal.

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

The metal oxides are then reduced to the corresponding metal by using suitable reducing agent such as carbon

i) Reduction of metal oxides with carbon: The oxides are reduced by coke in a closed furnace which gives the metal and carbon monoxide (CO).

Eg: $PbO + C \xrightarrow{\text{at } 1400\ ^{\circ}C} Pb + CO$

ii) Reduction of oxide ores with CO.

Eg: $Fe_2O_3 + 3CO \xrightarrow{\text{in blast furnace}} 2Fe + 3CO_2$

iii) Auto (self) reduction of sulphide ores: In the extraction of Cu from its sulphide ore, the ore is subjected partial roasting in air to give its oxide.

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

When the supply of air is stopped and the temperature is raised. The rest of the sulphide reacts with oxide and forms the metal and SO_2.

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

iv) Reduction of ores (compounds) by more reactive metals.

Thermite process involves the reaction of metal oxides with aluminium. When highly reactive metals such as sodium, calcium, aluminium etc., are used as reducing agents, they displace metals of lower reactivity from the compound. These displacement reactions are highly exothermic. The amount of heat evolved is so large that the metals produced are in molten state.

Eg: $TiCl_4 + 2Mg \xrightarrow{850\ ^{\circ}C} Ti + 2MgCl_2$

$TiCl_4 + 4Na \xrightarrow{850\ ^{\circ}C} Ti + 4NaCl$

The reaction of Iron (III) oxide (Fe_2O_3), with aluminium produces molten iron which is used to join railings of railway tracks or cracked machine parts. This reaction is known as the **thermite reaction**.

$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe + Heat$

$Cr_2O_3 + 2Al \rightarrow Al_2O_3 + 2Cr + Heat$

fig-3(a)

fig-3(b)

fig-3(c)

C) Extraction of metals at the bottom of the activity series (Ag, Hg etc)

Metals at the bottom of the activity series are often found in free state. Their reactivity with other atoms is very low. The oxides of these metals can be reduced to metals by heat alone and sometimes by displacement from their aqueous solutions.

i) When cinnabar (HgS) which is an ore of mercury, heated in air, it is first converted into (HgO) then reduced to mercury on further heating.

Eg: $2HgS_{(s)} + 3O_{2(g)} \xrightarrow{Heat} 2HgO_{(s)} + 2SO_{2(g)} \xrightarrow{Heat} 2HgO_{(s)} \xrightarrow{Heat} 2Hg_{(s)} + O_{2(g)}$

ii) Displacement from aqueous solutions:

Eg: $Ag_2S_{(s)} + 4CN^-_{(aq)} \rightarrow 2[Ag(CN)_2]^-_{(aq)} + S^{2-}_{(aq)}$

$2[Ag(CN)_2]^-_{(aq)} + Zn_{(s)} \rightarrow [Zn(CN)_4]^{2-}_{(aq)} + 2Ag_{(s)}$

Here Ag_2S is dissolved in say KCN solution to get dicyanoargentate (I) ions. From these ions Ag is precipitated by treating with Zn dust powder.

III. Purification of the crude metal

The metal obtained by the reduction of the ore is usually contaminated with impurities like unchanged ore, other metals present in the ore and non metals from the anions in the ore.

For example, the (blister) copper obtained from its sulphide ore, a compound of copper iron pyrites ($CuFeS_2$), contains some copper sulphide, iron and sulphur. It is purified by suitable methods including electrolysis. The process of obtaining the pure metal from the impure metal is called *refining* of the metal. Refining of the metal involves several types of processes. Some refining methods are given below:

a) Distillation (b) Poling (c) Liquation (d) Electrolysis etc.

The process that has to be adopted for purification of a given metal depends on the nature of the metal and its impurities.

a) Distillation: This method is very useful for purification of low boiling metals like zinc and mercury containing high boiling metals as impurities. The extracted metal in the molten state is distilled to obtain the pure metal as distillate.

b) Poling: The molten metal is stirred with logs (poles) of green wood. The impurities are removed either as gases or they get oxidized and form scum (slag) over the surface of the molten metal. Blister copper is purified by this method. The reducing gases, evolved from the wood, prevent the oxidation of copper.

c) Liquation: In this method a low melting metal like tin can be made to flow on a slopy surface to separate it from high melting impurities.

d) Electrolytic refining: In this method, the impure metal is made to act as anode. A strip of the same metal in pure form is used as cathode. They are put in a suitable electrolytic bath containing soluble salt of the same metal. The required metal gets deposited on the cathode in the pure form. The metal, constituting the impurity, goes as the anode mud. The reactions are:

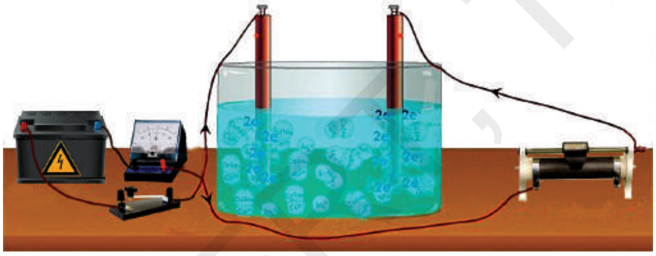


fig-4: Experimental setup for the electrolytic refining of copper

Anode: $M \rightarrow M^{n+} + ne^-$

Cathode: $M^{n+} + ne^- \rightarrow M$

(M = pure metal)

Where n = 1,2,3, ...

We use this electrolytic method to refine copper.

For this an impure copper is taken as anode and pure copper strips are taken as cathode. The electrolyte is an acidified solution of copper sulphate. As a result of electrolysis copper in pure form is transferred from the anode to the cathode.

Anode: $Cu \rightarrow Cu^{2+} + 2e^-$

Cathode: $Cu^{2+} + 2e^- \rightarrow Cu$

The soluble impurities go into the solution, where as insoluble impurities from the blister copper get deposited at the bottom of anode as anode mud which contains metals like antimony selenium, tellurium, silver, gold and platinum; recovery of these metals may meet the cost of refining.

Zinc may also be refined this way.

Corrosion

The rusting of iron (iron oxide), tarnishing of silver (silver sulphide), development of green coating on copper (copper carbonate) and bronze are some of the examples of corrosion.

- Do you know why corrosion occurs?

  Let us find

Activity 2

- Take three test tubes and place clean iron nails in each of them.
- Label these test tubes A,B and C. pour some water in test tube A and cork it.
- Pour boiled distilled water in test tube B, add about 1 ml of oil and cork it. The oil will float on water and prevent the air from dissolving in the water.
- Put some anhydrous calcium chloride in test tube C and cork it. Anhydrous calcium chloride will absorb the moisture, if any, from the air. Leave these test tubes for a few days and then observe (see figure).

You will observe that iron nails rust in test tube A, but they do not rust in test tubes B and C. In the test tube A, the nails are exposed to both air and water. In the test tube B, the nails are exposed to only water, and the nails in test tube C are exposed to dry air.

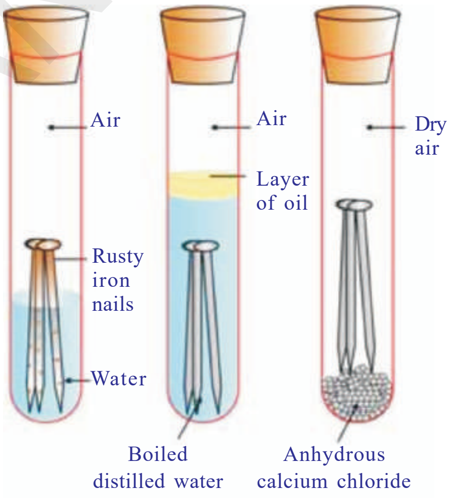


fig-5: Investigating the conditions under which iron rusts

- What does this tell us about the conditions under which iron articles rust?

In metallic corrosion, a metal is oxidised by loss of electrons generally to oxygen and results in the formation of oxides. Corrosion of iron (commonly known as rusting) occurs in presence of water and air.

The chemistry of corrosion is quite complex but it may be considered essentially as an electrochemical phenomenon. During corrosion at a particular spot on the surface of an object made of iron, oxidation takes place and that spot behaves as anode. We can write the reaction as.

Anode: $2Fe_{(s)} \rightarrow 2Fe^{2+} + 4e^{-}$

Electrons released at this anodic spot move through the metal and go to another spot on the metal and reduce oxygen at that spot in presence of H^+ (which is believed to be available from H_2CO_3 formed due to dissolution of carbon dioxide from air into water in moist air condition of atmosphere. Hydrogen ion in water may also be available due to dissolution of other acidic oxides from the atmosphere). This spot behaves as cathode with the reaction is.

Cathode: $O_{2(g)} + 4H^+_{(aq)} + 4e^- \rightarrow 2H_2O_{(l)}$

The overall reaction is: $2Fe_{(s)} + O_{2(g)} + 4H^+_{(aq)} \rightarrow 2Fe^{2+}_{(aq)} + 2H_2O_{(l)}$

The Ferrous ions (Fe^{2+}) are further oxidised by atmospheric oxygen to Ferric ions (Fe^{3+}) which come out as rust in the form of hydrated ferric oxide ($Fe_2O_3.XH_2O$) and with further production of hydrogen ions.

Prevention of corrosion

Prevention of corrosion is of prime importance. It not only saves money but also helps in preventing accidents such as a bridge collapse or failure of a key component due to corrosion.

One of the simplest methods of preventing corrosion is to prevent the surface of the metallic object to come in contact with atmosphere. This can be done by covering the surface with paint or by some chemicals (eg: bisphenol).

Another simple method is to cover the surface by other metals (Sn, Zn etc) that are inert or react themselves with atmosphere to save the object. This is generally done by electroplating.

An electrochemical method is to provide a sacrificial electrode of another metal (like Mg, Zn etc) which corrodes itself but saves the object.

Do you know?

Alloying is a method of improving the properties of a metal. We can get desired properties by this method. For example, iron is the most widely used metal. But it is never used in its pure state. This is because pure iron is very soft and stretches easily when hot. But, if it is mixed with a small amount of carbon, it becomes hard and strong. When iron is mixed with nickel and chromium we get stainless steel which will not rust. Pure gold, known as 24 carat gold, is very soft. It is, therefore, not suitable for making jewellery. It is alloyed with either silver or copper to make it hard. Generally in India 22carat gold is used for making ornaments. It means that 22 parts of pure gold is alloyed with 2 parts of either silver or copper.

A few important processes used in metallurgy

Smelting: Smelting is a pyrochemical (*pyre = heat*) process, in which the ore is mixed with flux and fuel and strongly heated. The heat is so strong that the ore is reduced to even metal as in the case of iron (Fe), and the metal is obtained in molten state. During smelting the impurities (gangue) in the ore react with flux to form slag which is removed. For haematite (Fe_2O_3)ore, coke is used as fuel and lime stone ($CaCO_3$) is used as flux. The smelting is carried out in a specially built furnace known as blast furnace.

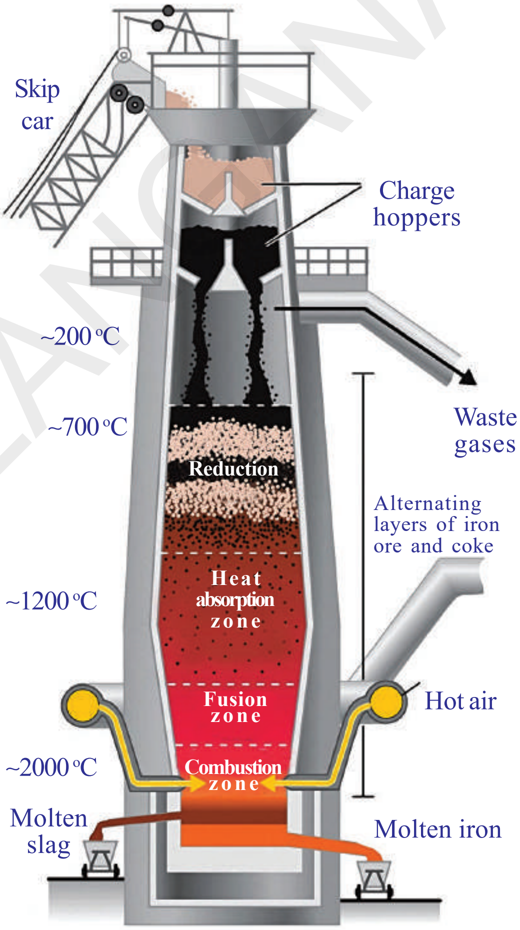


fig-6: Blast furance

The reactions inside the furnace are:

$$\underset{\text{Fuel}}{2C_{(s)}} + O_{2\,(g)} \longrightarrow 2CO_{(g)}$$

$$\underset{\text{haematite}}{Fe_2O_{3(s)}} + 3CO_{(g)} \longrightarrow 2Fe_{(l)} + 3CO_{2(g)}$$

$$\underset{\text{Limestone(flux)}}{CaCO_{3(s)}} \longrightarrow \underset{\text{lime}}{CaO_{(s)}} + CO_{2\,(g)}$$

$$\underset{\text{Lime}}{CaO_{(s)}} + \underset{\text{silica(gangue)}}{SiO_{2(s)}} \longrightarrow \underset{\text{calcium silicate(slag)}}{CaSiO_{3(l)}}$$

Roasting: Roasting is a pyrochemical process in which the ore is heated in the presence of oxygen or air below its melting point. The products (like metal oxide from sulphide ore) obtained in the process also are in solid state. Generally reverberatory furnace is used for roasting.

$$\underset{\text{zinc blende}}{2ZnS_{(s)}} + 3O_{2(g)} \longrightarrow 2ZnO_{(s)} + 2SO_{2(g)}$$

Calcination: Calcination is a pyrochemical process in which the ore is heated in the absence of air. The ore gets generally decomposed in the process.

Eg: $MgCO_{3(s)} \rightarrow MgO_{(s)} + CO_{2(g)}$

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

Flux: Flux is a substance added to the ore to remove the gangue from it by reacting with the gangue. If the impurity (gangue) is acidic substance like SiO_2, basic substance like CaO is used as flux and if the impurity is of basic nature like FeO acidic flux like SiO_2 is added to the gangue.

$$\underset{\text{flux}}{CaO_{(s)}} + \underset{\text{silica(gangue)}}{SiO_{2(s)}} \longrightarrow \underset{\text{calcium silicate(slag)}}{CaSiO_{3(l)}}$$

$$\underset{\text{gangue}}{FeO_{(s)}} + \underset{\text{flux}}{SiO_{2(s)}} \longrightarrow \underset{\text{Ferrous silicate(slag)}}{FeSiO_{3(l)}}$$

- What is the role of furnace in metallurgy?
- How they bear large amounts of heat?
- Do all furnaces have same structure?

Let us see:

Furnace: Furnace is the one which is used to carry out pyrochemical processes in metallurgy. We have mainly three parts in a furnace known as Hearth, Chimney and fire box.

Hearth is the place inside the furnace where the ore is kept for heating purpose.

Chimney is the outlet through which flue (waste) gases go out of the furnace.

Fire box is the part of the furnace where the fuel is kept for burning.

In Blast furnace both fire box and hearth are combined in big chamber which accommodates both ore and fuel. Reverberatory furnace has both fire box and hearth separated, but the vapours (flame) obtained due to the burning of the fuel touch the ore in the hearth and heat it.

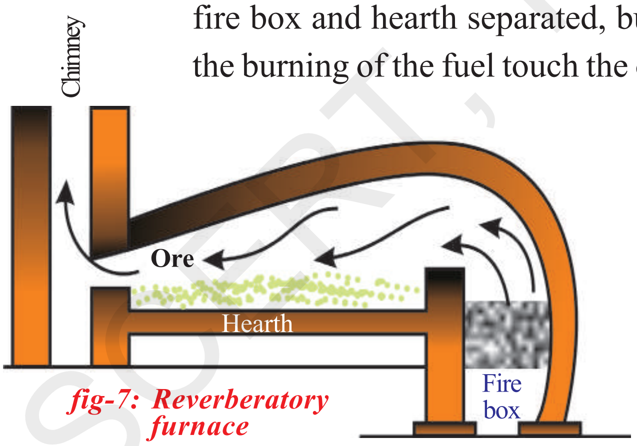


fig-7: Reverberatory furnace

In furnaces like retort furnaces there is no direct contact between the hearth or fire box and even the flames do not touch the ore.

Key words

Minerals, ores, froth flotation, Thermite process, distillation, poling, liquation, electrolytic refining, smelting, roasting, calcinations, blast furnace, reverberatory furnace.

What we have learnt

- A metallic compound occurring in the earth crust along with impurities is called mineral.
- A mineral from which a metal can be extracted economically and conveniently is called ore.
- The impurity present in the ore is called gangue..
- The substance added to the ore to remove gangue from it is called flux.
- The extraction of metal from its ore involves mainly three stages: Concentration, Extraction of crude metal, Refining of the metal.
- Physical methods adopted in dressing the ore are : hand picking, washing, froth flotation, Magnetic separation etc.
- The methods used for Extracting of Crude metal are Calcination, Roasting, Chemical reduction, Auto reduction, Displacement method, Electrolytic reduction .
- Calcination is a process of heating the ore strongly in the absence of air or oxygen.
- During calcinations, carbonate is converted to its oxide.
- Roasting is a process of heating the ore strongly in a free supply of air or oxygen.
- Calcination and Roasting are carried out in a reverberatory furnace

Improve your learning

I9C1D8

Reflections on concepts

1. List three metals that are found in nature as Oxide ores.(AS_1)
2. List three metals that are found in nature in un combined form. (AS_1)
3. Write a note on dressing of ore in metallurgy? (AS_1)
4. How do metals occur in nature? Give examples to any two types of minerals. (AS_1)
5. When do we use magnetic seperation method for concentration of an ore? Explain with an example. (AS_1)
6. What is the difference between roasting and calcination? Give one example for each. (AS_1)
7. Draw the diagram showing i) Froth floatation ii) Magnetic separation. (AS_5)
8. Draw a neat diagram of riverboratory furnace and label it. (AS_5)

Application of concepts

1. Magnesium is an active metal, if it occurs as a chloride in nature, which method of reduction is suitable for its extraction? (AS_2)
2. Mention two methods which produce very pure metals from impure metals. (AS_1)
3. Which method do you suggest for extracting of high reactivity metals? (AS_2)
4. Explain Thermite process and mention its applications in our daily life. (AS_7)

5. Where do we use handpicking and washing methods in our daily life? Give examples. How do you correlate these examples with enrichment of ore? (AS_7)

Multiple choice questions

1. The impurity present in the ore is called as [ ]

a) Gangue b) flux c) Slag d) Mineral

2. Which of the following is a carbonate ore? [ ]

a) Magnesite b) Bauxite c) Gypsum d) Galena

3. Which of the following is the correct formula of Gypsum [ ]

a) $CuSO_4 . 2H_2O$ b) $CaSO_4 . ½ H_2O$ c) $CuSO_4 . 5H_2O$ d) $CaSO_4 . 2H_2O$

4. The oil used in the froth floatation process is [ ]

a) kerosene oil b) pine oil c) coconut oil d) olive oil.

5. Froth floatation is method used for the purification of ______ ore. [ ]

a) sulphide b) oxide c) carbonate d) nitrate

6. Galena is an ore of [ ]

a) Zn b) Pb c) Hg d) Al

7. The metal that occurs in the native form is [ ]

a) Pb b) Au c) Fe d) Hg

8. The most abundant metal in the earth's crust is [ ]

a) Silver b) Aluminium c) zinc d) iron

9. The reducing agent in thermite process is [ ]

a) Al b) Mg c) Fe d) Si

10. The purpose of smelting an ore is [ ]

a) Oxidise b) Reduce c) Neutralise d) None of these

Suggested Experiments

1. Suggest an experiment to prove that the presence of air and water are essential for corrosion. Explain the procedure. (AS_3)

Suggested Projects

1. Collect information about extraction of metals of low reactivity silver, platinum and gold and prepare a report. (AS_4)