5. Production of metals

Let us Assess

1. Question

Which of the properties of metals is utilized in the following instances?

- Aluminium utensils are used for cooking.

- Copper is used for making vessels.

- Gold wires are used in ornaments.

Answer

i. Aluminium is used for making utensils for cooking because of its high thermal conductivity, corrosion resistance and comparatively cheap rate. Aluminium reacts with oxygen and forms a protective oxide layer which prevents further oxidation. It doesn't corrode like other metals (like iron). It is comparatively cheaper than gold, silver and copper.

ii. Copper is used in making vessels because of its higher thermal conductivity as compared to iron or steel. Moreover, it ensures uniform heat distribution. It is cheaper than silver and gold.

iii. Gold is used in ornaments because it is a noble metal (doesn't corrode or react easily, so lasts long), more lustrous and malleable as compared to other metals like aluminium, copper etc.

2. Question

What are the factors to be considered while selecting minerals for the extraction of metals?

Answer

1. Abundance

2. Easily separable

3. High metal content

Minerals contain both metal and waste called gangue. For the extraction to be economical, the mineral must contain abundant amount of metal. Moreover, the separation of metal from gangue should be easy and mineral should be available in large amounts for economic extraction.

For ex- iron is found in siderate, but in very less quantity. So, its not economical for extraction. Haematite and magnetite are the two principal mineral ores of iron which contain high amounts of iron and can be extracted profitably.

3. Question

Write the different stages involved in metallurgy.

Answer

Metallurgy involves all processes leading to the separation of a pure metal from its ore. The 3 important stages in metallurgy are-

•Concentration of ores – removal of gangue from ore

•Extraction of metal from concentrated ore – conversion of concentrated ore to oxide and reduction of oxide to get metal.

•Refining of metal – removal of impurities from metal to get pure metal.

4. Question

What are the different methods for the refining of metals?

Answer

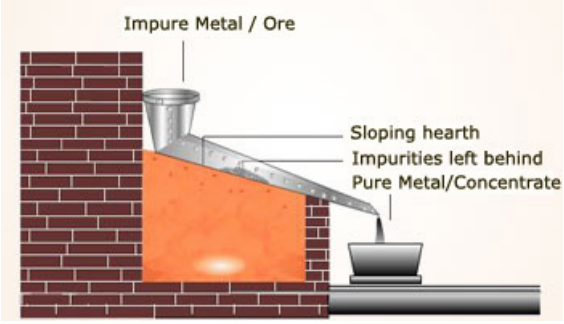
The different methods of refining are -

i. Liquation –

The process of separating low melting metals from high melting impurities by providing temperature required for pure metal to flow down leaving behind impurities.

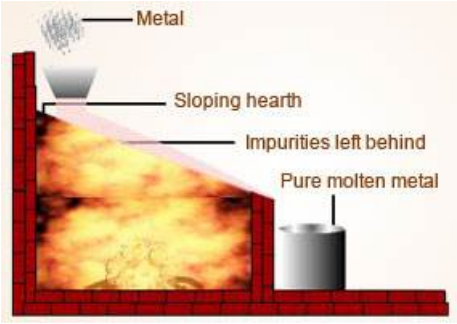
Examples: refining of tin and lead.

The diagram is shown below:



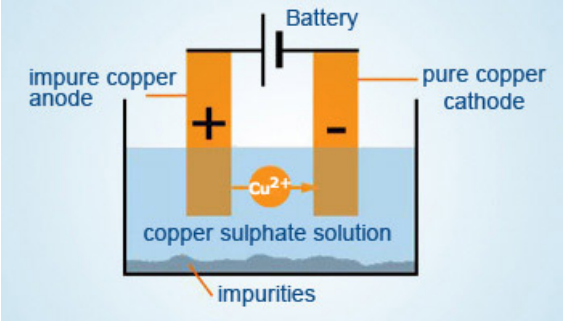
ii. Distillation – process where impure metal is heated to vaporise the low boiling metal leaving behind impurities and condensing the vapour to get pure metal.

Example: refining of zinc , cadmium, mercury



iii. Electrolytic refining – The process of electrolysis of metal-salt solution where pure metal is used as cathode and impure metal is used as anode.

Example – copper and silver are refined using this method.



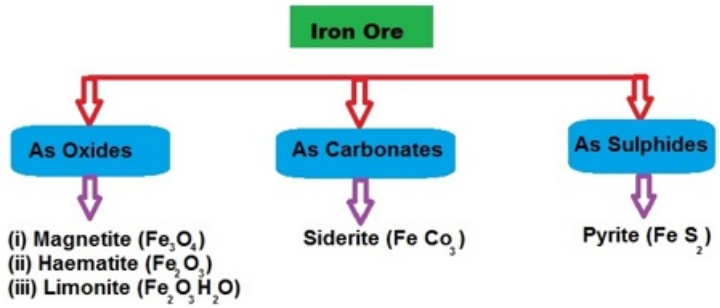
5. Question

How is iron extracted?

Answer

Haematite

magnetite



Iron Ore	Colour	Iron Content (%)
Magnetite	Black	72
Haematite	Red	70
Limonite	Brown	60-65
Siderite	Brown	48

Haematite and magnetite are the ores of iron.

i. Haematite is the principal ore of iron. The earthy impurities are removed and haematite is finely powdered. Methods like gravity separation, levigation are often used for concentration.

ii. If its magnetite ore, then magnetic separation is employed because magnetite has iron which is magnetic. The ore so obtained is subjected to roasting. Roasting is the process of heating the concentrated ore at a temperature below the melting point in a current of air.

iii. Impurities like sulphur, arsenic, phosphorous are removed as their gaseous oxides along with water. But silicon oxide will be present in large amounts.

A mixture of roasted haematite, coke and lime stone is fed into a blast furnace. Limestone (flux) acts as flux and helps in removal of silicon oxide(gangue) and forms slag. The reactions are given-

$CaCO_3 \rightarrow CaO + CO_2$

$CaO + SiO_2 \rightarrow CaSiO_3$

At the bottom of blast furnace coke combines with oxygen in hot current of air to form carbon dioxide and large amount of heat.

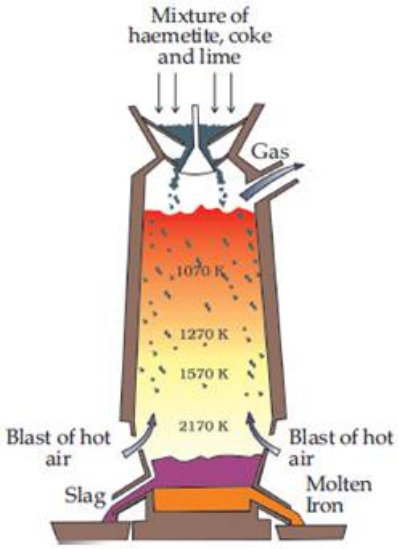
$C + O_2 \rightarrow CO_2 + heat$

This carbon dioxide rises up and is reduced by coke to produce carbon monoxide. This carbon monoxide reacts with iron oxide to produce iron.

$CO_2 + C + heat \rightarrow 2CO$

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

Molten iron is denser than slag. Slag floats on molten iron and these are separated. This iron which is obtained from blast furnace is called pig iron.



This is further processed to get cast iron, steel etc.

6. Question

Write the uses of the following:

• Pig iron

• Cast iron

• Alnico

Answer

•Pig iron – this is the iron obtained from blast furnace. This is

further processed to obtain different types of steel, cast iron etc.

•cast iron – this is used in making objects of different shapes in automobiles, pipes etc. These objects are hard and brittle.

•Alnico – for the manufacture of permanent magnets.

The product of iron as a result of processing is:

Process		**Product**
traditional	modern	
Smelting in the blast furnace		pig iron
with charcoal	with coke	
Refining		wrought iron
in a hearth with charcoal	in a puddling furnace with coal	
Shaping		bar iron (rails)
by the hammer	by a rolling mill	

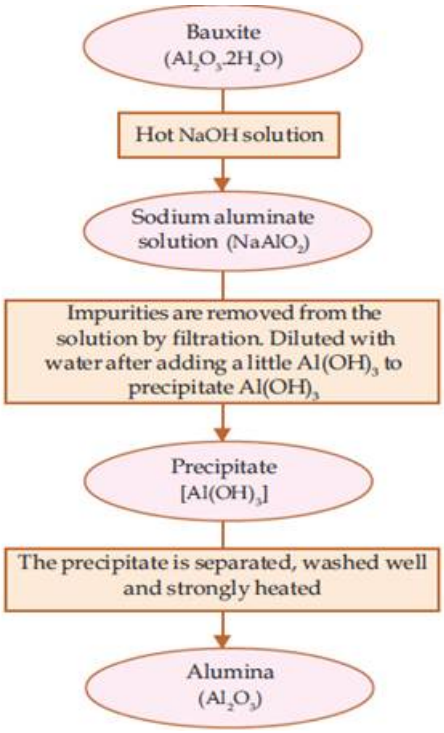
7. Question

Explain the process of producing alumina from bauxite.

Answer

Bauxite is mixed with hot concentrated NaOH solution to dissolve aluminium oxide in it to produce sodium aluminate solution. This is filtered to remove impurities. This is diluted with water after adding a little $Al(OH)_3$ to precipitate $Al(OH)_3$. This precipitate is separated, washed well and strongly heated to remove water and obtain alumina.

The process is represented with the help of flowchart –



8. Question

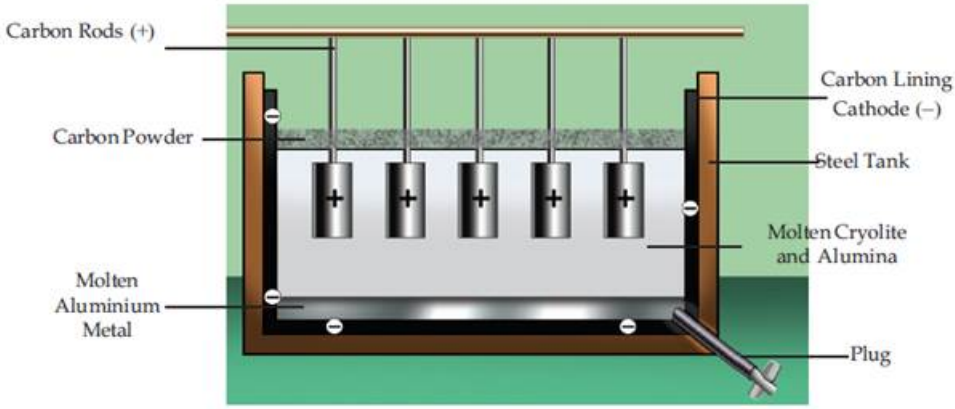
Explain the method of obtaining pure aluminium from alumina by electrolysis. In this process the carbon rods are replaced from time to time. Why?

Answer

Alumina produced by concentration of bauxite is mixed with cryolite and subjected to electrolysis. Electricity is passed through this mixture, it gets heated, cryolite melts and alumina dissolves in it. Electricity acts as reducing agent here. The alumina gets dissociated into aluminium cations and oxygen anions. The following reactions occur at cathode and anode. Aluminium is produced at cathode.

$Al^{3+} + 3e^- \rightarrow Al$ at cathode

$2O^{2-} \rightarrow O_2 + 4e^-$ at anode



The carbon rods which are used as anodes are periodically

replaced because oxygen liberated at anodes as a result of electrolysis reacts with carbon to produce carbon dioxide. So anodes are consumed slowly. Hence, they are replaced.

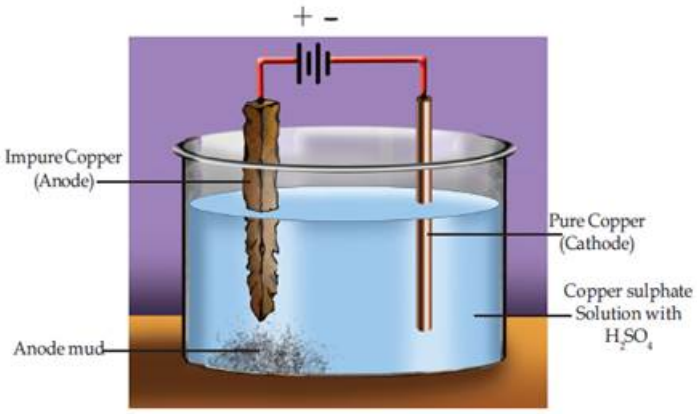
9. Question

Explain what is anode mud.

Answer

The impurities which settle at the bottom of anode as a result of electrolysis, which contain costly metals are called as anode mud.

This can be considered as a deposit of insoluble residue formed from the dissolution of anode in commercial electrolysis. For ex – in copper refining we get anode mud which contains little gold.



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Extended Activities

1. Question

You know that metals can be separated from molten compounds of metals by electrolysis.

Find out how metals like Na, Ca and Mg are extracted

Answer

Metals of high reactivity such as sodium, calcium, magnesium, aluminium, etc. are extracted from their ores by electrolytic reduction. Electrolytic Reduction is the process where electric current is passed through the molten state of metal ores. Metal being positively charged is deposited over the cathode.

i. Sodium

Sodium is usually mined from the ore called rock salt, which is made up of sodium chloride (NaCl). This ore is dissolved and filtrated to remove impurities. Solution of sodium chloride will be left behind from which sodium chloride is crystallized out. This is melted and then mixed with calcium chloride which reduces the melting point of NaCl. Electrolysis of molten NaCl is carried out in Down's cell. sodium chloride dissociates into sodium cations and chloride anions. Sodium is obtained at cathode and chlorine at anode.

ii. Calcium

Calcium occurs in combined form like slaked lime, calcium chloride, calcium carbonate etc. on industrial scale calcium can be obtained by the electrolysis of molten calcium chloride. A mixture of molten calcium chloride with 16% calcium fluoride is melted in an iron tank lined from inside with graphite which acts as anode. The cathode is a water-cooled iron tube which just touches the electrolyte. When the current is passed through the electrolyte, calcium is deposited at the cathode.

iii. Magnesium

Electrochemical processes are used to extract the metal from dolomite and magnesite ore. Then dolomite is crushed, roasted and mixed with seawater in large tanks, magnesium hydroxide settles to the bottom. Heating, mixing in coke, and reacting with chlorine, produces molten magnesium chloride. This can be electrolyzed, releasing magnesium, which floats to the surface.

Pidgeon process is a popular commercial technique to produce magnesium. In this process, closed-end, nickel-chromium-steel alloy retorts are filled with a mixture of calcined dolomite ore and ferrosilicon, which are heated until magnesium crowns form.