Practical Workbook

MY-302: Non Ferrous Extractive Metallurgy

Name ________________________

Roll No_______________________

Batch_________________________

Department of Metallurgy Engineering
NED University of Engineering and Technology

Practical Workbook

MY-302: Non Ferrous Extractive Metallurgy

PREPARED BY

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This is to certify that this practical book contains ______________ pages.

Approved by:

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NED University of Engineering and Technology

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Course Teacher

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MY-302: Non Ferrous Extractive Metallurgy

PRACTICAL NO-01

OBJECT: To study extraction of Aluminum

THEORY:

The chemical element aluminum (symbol Al) is a metal, which in its pure, bulk form is relatively soft, light and abundant - 8.07% of the Earth's crust compared, for example, with the familiar metal iron at 5.06% .Only oxygen and silicon (as sand) are more abundant in the Earth's crust, and yet it was only a century ago that aluminium was discovered as the most common of metals. Its Atomic Number is 13, Atomic Mass: 26.97 (approximately), Melting Point: 660^0C, Boiling Point: 2467^0C and Density is 2.7g/cc.

Occurrence

Aluminum is highly reactive and does not occur in the free state. However, it is widely distributed and it is third in abundance on earth after Oxygen and Silicon. Aluminum exists primarily as Alumino-Silicates (i.e., as Felspar, NaAlSi3O8, or KAlSi3O8, or CaAl2Si2O8), in igneous rocks and as Clays, H4Al2Si2O9, in sedimentary rocks.

There are three principal ores of Aluminum. They are:

1. Gibbsite, Al2O3.3H2O,
2. Diaspore, Al2O3.H2O, and
3. Bauxite, Al2O3.3H2O + Al2O3.2H2O,

Extraction Process

Aluminum is extracted by the electrolysis of fused mixture of Bauxite (Al2O3.3H2O + Al2O3.2H2O) and Cryolite, AlF3.3HF.

The process of Primary Al Production can be divided into 3-independent stages, i.e.

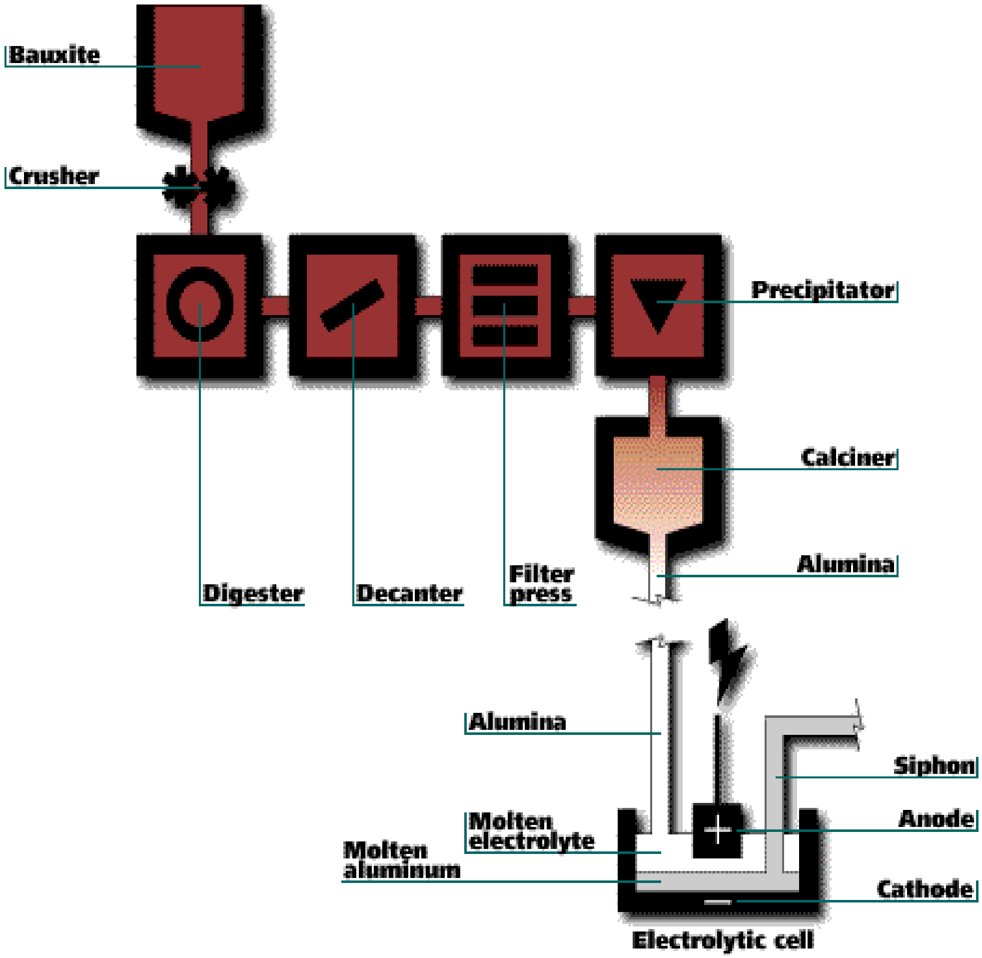
1. Mining of necessary raw materials (Bauxite, etc)
2. Preparation of Aluminum Oxide (Alumina) by Bayer process
3. Production of primary Al from Alumina by Hall Heroult electrolytic process

Applications

The typical metallic properties of aluminum cause it to be used:

1. in electrical conductors, where its lightness is useful for overhead wires,
2. for cooking utensils,
3. in the form of its salts as mordants in dyeing,
4. in the welding agent, Thermite,
5. is used in alloys, where small quantities of other metals significantly increase its strength and mechanical properties.
6. in the form of its oxide, Alumina, Al2O3, in the synthetic ruby used in laser tubes.

Flow Sheet of Aluminum Production



EXERCISE

Q1. How much quantity (in % approx) of aluminum is present in the earth curst? _

Q2. Which are the three principal ores of aluminum?

Q3.What is the difference between alumina and aluminum?

Q4.What is the name of most common ore of aluminum?

Q5. What is the most common process of primary aluminum production?

PRACTICAL NO: 2

OBJECT: To study the extraction of Copper

THEORY:

Copper is a chemical element with the symbol **Cu** (Latin: *cuprum*) and atomic number 29. It is a ductile metal with very high thermal and electrical conductivity. Pure copper is rather soft and malleable, and a freshly-exposed surface has a pinkish or peachy color. It is used as a thermal conductor, an electrical conductor, a building material, and a constituent of various metal alloys.

Raw Materials

Pure copper is rarely found in nature, but is usually combined with other chemicals in the form of copper ores. There are about 15 copper ores mined commercially in 40 countries around the world. The most common are known as sulfide ores in which the copper is chemically bonded with sulfur. Others are known as oxide ores, carbonate ores, or mixed ores depending on the chemicals present. Many copper ores also contain significant quantities of gold, silver, nickel, and other valuable metals, as well as large quantities of commercially useless material. Most of the copper ores mined in the United States contain only about 1.2-1.6% copper by weight.The most common sulfide ore is chalcopyrite, $CuFeS_2$, also known as copper pyrite or yellow copper ore. Chalcocite, Cu_2S, is another sulfide ore.Cuprite, or red copper ore, Cu_2O, is an oxide ore. Malachite, or green copper ore, $Cu(OH)_2 \bullet CuCO_3$, is an important carbonate ore, as is azurite, or blue copper carbonate, $Cu(OH)_2 \bullet 2CuCO_3$.Other ores include tennantite, boronite, chrysocolla, and atacamite.In addition to the ores themselves, several other chemicals are often used to process and refine copper. These include sulfuric acid, oxygen, iron, silica, and various organic compounds, depending on the process use.Copper can be found as native copper in mineral form (for example, in Michigan's Keweenaw Peninsula). It is a polycrystal, with the largest single crystals measuring 4.4×3.2×3.2 cm. Minerals such as the sulfides: chalcopyrite ($CuFeS_2$), bornite (Cu_5FeS_4), covellite (CuS), chalcocite (Cu_2S) are sources of copper, as are the carbonates: azurite ($Cu_3(CO_3)_2(OH)_2$) and malachite ($Cu_2CO_3(OH)_2$) and the oxide: cuprite (Cu_2O).[2

The Extraction Process

The process of extracting copper from copper ore varies according to the type of ore and the desired purity of the final product. Each process consists of several steps in which unwanted materials are physically or chemically removed, and the concentration of copper is progressively increased. Some of these steps are conducted at the mine site itself, while others may be conducted at separate facilities. Here are the steps used to process the sulfide ores commonly found to refining the copper.

Mining

Most sulfide ores are taken from huge open-pit mines by drilling and blasting with explosives. In this type of mining, the material located above the ore, called the overburden, is first removed to expose the buried ore deposit. This produces an open pit that may grow to be a mile or more across. A road to allow access for equipment spirals down the interior slopes of the pit.The exposed ore is scooped up by large power shovels capable of loading 500-900 cubic feet (15-25 cubic meters) in a single bite. The ore is loaded into giant dump trucks, called haul trucks, and is transported up and out of the pit.

Concentrating

The copper ore usually contains a large amount of dirt, clay, and a variety of non-copper bearing minerals. The first step is to remove some of this waste material. This process is called concentrating and is usually done by the flotation method.

Smelting

Once the waste materials have been physically removed from the ore, the remaining copper concentrate must undergo several chemical reactions to remove the iron and sulfur. This process is called smelting and traditionally involves two furnaces as described below. Some modern plants utilize a single furnace, which combines both operations.

The copper concentrate is fed into a furnace along with a silica material, called a flux. Most copper smelters utilize oxygen-enriched flash furnaces in which preheated, oxygen-enriched air is forced into the furnace to combust with fuel oil. The copper concentrate and flux melt, and collect in the bottom of the furnace. Much of the iron in the concentrate chemically combines with the flux to form a slag, which is skimmed off the surface of the molten material. Much of the sulfur in the concentrate combines with the oxygen to form sulfur dioxide, which is exhausted from the furnace as a gas and is further treated in an acid plant to produce sulfuric acid. The remaining molten material in the bottom of the furnace is called the matte. It is a mixture of copper sulfides and iron sulfides and contains about 60% copper by weight.

The molten matte is drawn from the furnace and poured into a second furnace called a converter. Additional silica flux is added and oxygen is blown through the molten material. The chemical reactions in the converter are similar to those in the flash furnace. The silica flux reacts with the remaining iron to form a slag, and the oxygen reacts with the remaining sulfur to form sulfur dioxide. The slag may be fed back into the flash furnace to act as a flux, and the sulfur dioxide is processed through the acid plant. After the slag is removed, a final injection of oxygen removes all but a trace of sulfur. The resulting molten material is called the blister and contains about 99% copper by weight.

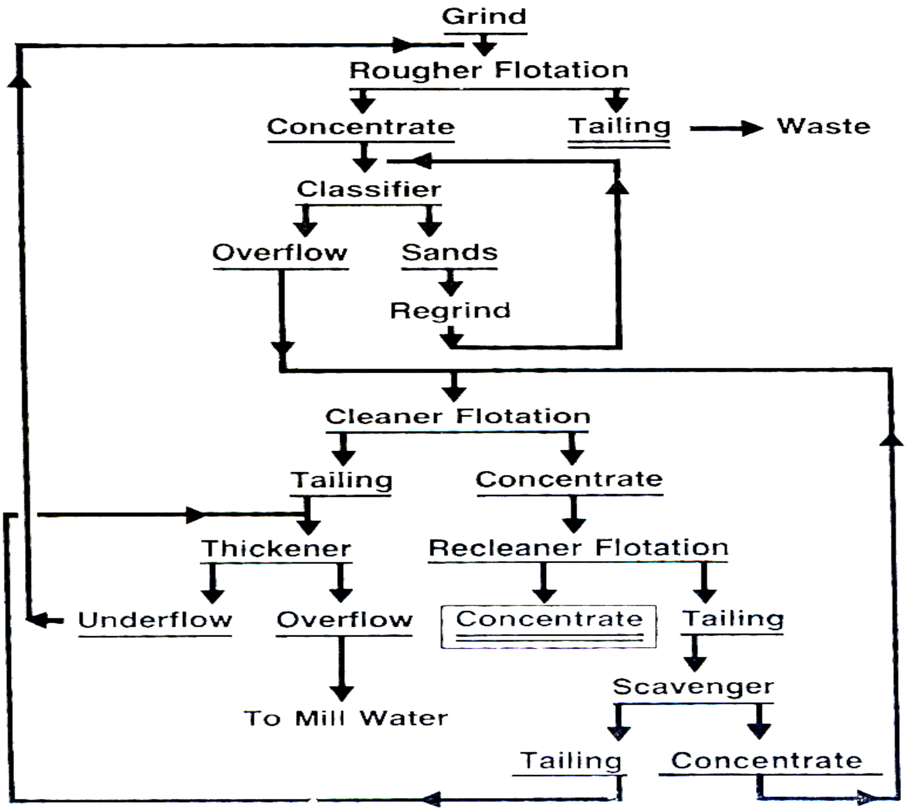
Refining

Even though copper blister is 99% pure copper, it still contains high enough levels of sulfur, oxygen, and other impurities to hamper further refining. To remove or adjust the levels of these materials, the blister copper is first fire refined before it is sent to the final electro-refining process. The blister copper is heated in a refining furnace, which is similar to a converter described above. Air is blown into the molten blister to oxidize some impurities. A sodium carbonate flux may be added to remove traces of arsenic and antimony. A sample of the molten material is drawn and an experienced operator determines when the impurities have reached an acceptable level. The molten copper, which is about 99.5% pure, is then poured into molds to form large electrical anodes, which act as the positive terminals for the electrorefining process. Each copper anode is placed in an individual tank, or cell, made of polymer-concrete. There may be as many as 1,250 tanks in operation at one time. A sheet of copper is placed on the opposite end of the tank to act as the cathode, or negative terminal. The tanks are filled with an acidic copper sulfate solution, which acts as an electrical conductor between the anode and cathode. When an electrical current is passed through each tank, the copper is stripped off the anode and is deposited on the cathode. Most of the remaining impurities fall out of the copper sulfate solution and form a slime at the bottom of the tank. After about 9-15 days, the current is turned off and the cathodes are removed. The cathodes now weigh about 300 lb (136 kg) and are 99.95-99.99% pure copper.The slime that collects at the bottom of the tank contains gold, silver, selenium, and tellurium. It is collected and processed to recover these precious metals.

Casting

After refining, the copper cathodes are melted and cast into ingots, cakes, billets, or rods depending on the final application. Ingots are rectangular or trapezoidal bricks, which are remelted along with other metals to make brass and bronze products. Cakes are rectangular slabs about 8 in (20 cm) thick and up to 28 ft (8.5 m) long. They are rolled to make copper plate, strip, sheet, and foil products. Billets are cylindrical logs about 8 in (20 cm) in diameter and several feet (meters) long. They are extruded or drawn to make copper tubing and pipe. Rods have a round cross-section about 0.5 in (1.3 cm) in diameter. They are usually cast into very long lengths, which are coiled. This coiled material is then drawn down further to make copper wire.

Flow Sheet of Copper Extraction Process



Applications

Copper is malleable and ductile and is a good conductor of both heat and electricity.

The purity of copper is expressed as 4N for 99.99% pure or 7N for 99.99999% pure. The numeral gives the number of nines after the decimal point when expressed as a decimal (e.g. 4N means 0.9999, or 99.99%). Copper is often too soft for its applications, so it is incorporated in numerous alloys. For example, brass is a copper-zinc alloy, and bronze is a copper-tin alloy.

It is used extensively, in products such as:

Piping

Assorted copper fittings

including water supply.used extensively in refrigeration and air conditioning equipment because of its ease of fabrication and soldering, as well as high conductivity to heat.

Electrical applications

- Copper wire
- Oxygen-free copper
- Electromagnets
- Printed circuit boards
- Lead free solder, alloyed with tin
- Electrical machines, especially electromagnetic motors, generators and transformers
- Electrical relays, electrical busbars and electrical switches
- Vacuum tubes, cathode ray tubes, and the magnetrons in microwave ovens
- Wave guides for microwave radiation
- Integrated circuits, increasingly replacing aluminium because of its superior electrical conductivity
- As a material in the manufacture of computer heat sinks, as a result of its superior heat dissipation capacity to aluminium

EXERCISE

Q1.What is the Latin word of copper?

Q2.What is the sulfide ores and its color?

Q3.Through which ores copper is extracted?

Q4.What is the function of concentration and at which method is carried out?

Q5.What is the main function of smelting and what is the product of smelting?

Q6.What is matte and through which process it is obtained?

PRACTICAL NO: 3

OBJECT: To Study the Extraction of Zinc

THEORY:

Zinc (from German: *Zink*), also known as spelter, is a metallic chemical element; it has the symbol **Zn** and atomic number 30. It is the first element in group 12 of the periodic table. Zinc is, in some respects, chemically similar to magnesium, because its ion is of similar size and its only common oxidation state is +2. Zinc is the 24th most abundant element in the Earth's crust and has five stable isotopes. The most exploited zinc ore is sphalerite, a zinc sulfide. The largest exploitable deposits are found in Australia, Canada, and the United States. Zinc production includes froth flotation of the ore, roasting, and final extraction using electricity (electrowinning).Brass, which is an alloy of copper and zinc, has been used since at least the 10th century BC. Impure zinc metal was not produced in large scale until the 13th century in India, while the metal was unknown to Europe until the end of the 16th century. Alchemists burned zinc in air to form what they called "philosopher's wool" or "white snow".

The element was probably named by the alchemist Paracelsus after the German word *Zinke*. German chemist Andreas Sigismund Marggraf is normally given credit for discovering pure metallic zinc in 1746. Work by Luigi Galvani and Alessandro Volta uncovered the electrochemical properties of zinc by 1800. Corrosion-resistant zinc plating of steel (hot-dip galvanizing) is the major application for zinc. Other applications are in batteries and alloys, such as brass. A variety of zinc compounds are commonly used, such as zinc carbonate and zinc gluconate (as dietary supplements), zinc chloride (in deodorants), zinc pyrithione (anti-dandruff shampoos), zinc sulfide (in luminescent paints), and zinc methyl or zinc diethyl in the organic laboratory.

Zinc is an essential mineral of "exceptional biologic and public health importance" Zinc deficiency affects about two billion people in the developing world and is associated with many diseases. In children it causes growth retardation, delayed sexual maturation, infection susceptibility, and diarrhea, contributing to the death of about 800,000 children worldwide per year. Enzymes with a zinc atom in the reactive center are widespread in biochemistry, such as alcohol dehydrogenase in humans. Consumption of excess zinc can cause ataxia, lethargy and copper deficiency.

Occurrence

Zinc makes up about 75 ppm (0.0075%) of the Earth's crust, making it the 24th most abundant element there. Soil contains 5–770 ppm of zinc with an average of 64 ppm. Seawater has only 30 ppb zinc and the atmosphere contains 0.1–4 µg/m^3.

Sphalerite (ZnS).The element is normally found in association with other base metals such as copper and lead in ores. Zinc is a chalcophile , meaning the element has a low affinity for oxides and prefers to bond with sulfides. Chalcophiles formed as the crust solidified under the reducing conditions of the early Earth's atmosphere. Sphalerite, which is a form of zinc sulfide, is the most heavily mined zinc-containing ore because its concentrate contains 60–62% zinc.

Other minerals, from which zinc is extracted, include smithsonite (zinc carbonate), hemimorphite (zinc silicate), wurtzite (another zinc sulfide), and sometimes hydrozincite

(basic zinc carbonate). With the exception of wurtzite, all these other minerals were formed as a result of weathering processes on the primordial zinc sulfides.
World zinc resources total about 1.8 gigatonnes. Nearly 200 megatonnes were economically viable in 2008; adding marginally economic and subeconomic reserves to that number, a total reserve base of 500 megatonnes has been identified. Large deposits are in Australia, Canada and the United States with the largest reserves in Iran. At the current rate of consumption, these reserves are estimated to be depleted sometime between 2027 and 2055. About 346 megatonnes have been extracted throughout history to 2002, and one estimate found that about 109 megatonnes of that remains in use.

Top 5 zinc producing countries in 2009		
Rank	**Country**	**tonnes**
1	China	2,875,000
2	Peru	1,439,000
3	Australia	1,279,000
4	United States	735,000
5	Canada	695,000

Extraction Process of Zinc

A method of extracting zinc from calcined zinc ore comprising the following steps:

1. The step of removing acid from the anode compartment for use in the leaching step.

2. The step of purifying the zinc sulfate solution to remove other metals from the calcined zinc ore so that the zinc sulfate solution introduced into the container is free of other metals.

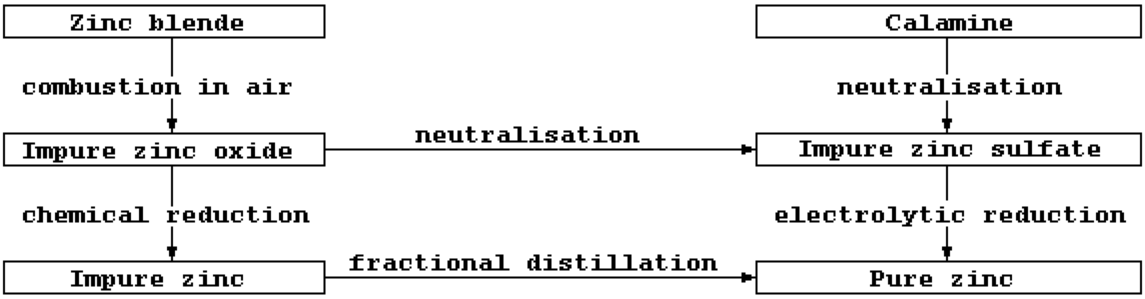
3. The step wherein said permeable diaphragm extends above the surface of the solution in the container, and including the step of removing the cathode periodically to remove elemental zinc plated thereon.

4. The step wherein said diaphragm is a hydrophobic, open-celled, microporous polypropylene film.

5. The step of removing acid from the anode compartment, filtering the acid, and introducing the acid into a water solution of the zinc ore.

6. The step of introducing water into the leaching step which water is obtained from the cathode compartment and which includes a trace of the zinc anion in solution such that up to about 90% of the zinc is recovered at the cathode and the remainder of the zinc in solution is recycled through the leaching step.

Flow Sheet Of Zinc Extraction Process:



Applications

The main end-uses for zinc are as follows.

1. Galvanizing: 59% - cars and construction
2. Diecasting: 16% - motor housings, door furniture, toys
3. Brass & Bronze: 10% - taps and pipes
4. Rolled zinc: 6.5% - roofing and guttering in some parts of Europe, coffins in southern Europe, and batteries
5. Chemicals: 6.0% - tyres and zinc cream
6. Miscellaneous: 2.5% - includes dust in batteries

EXERCISE

Q1 what is the German name of zinc?

Q2.How much quantity of zinc is found in earth curst?

Q3.What is the most exploited zinc ore and where is large in found?

Q4.How is the pure metallic zinc discovered?

Q5.How much amount of soil, sea water contain zinc (in %)?

Q6.Which country produces largest amount of zinc, in tones?

PRACTICAL NO: 4

OBJECT: To study the Extraction lead

THEORY:

Lead is a main-group element with symbol Pb (Latin: plumbum) and atomic number 82. Lead is a soft, malleable poor metal, also considered to be one of the heavy metals. Lead has a bluish-white color when freshly cut, but tarnishes to a dull grayish color when exposed to air. It has a shiny chrome-silver luster when melted into a liquid.Lead is used in building construction, lead-acid batteries, bullets and shot, weights, and is part of solder, pewter, fusible alloys and radiation shields. Lead has the highest atomic number of all stable elements, although the next element, bismuth, has a half-life so long (longer than the estimated age of the universe) it can be considered stable.Lead is a poisonous metal that can damage nervous connections (especially in young children) and cause blood and brain disorders. Like mercury, another heavy metal, lead is a potent neurotoxin that accumulates in soft tissues and bone over time.

Lead is bright and silvery when freshly cut but the surface rapidly tarnishes in air to produce the commonly observed dull luster normally associated with lead. It is a dense, ductile, very soft, highly malleable, bluish-white metal that has poor electrical conductivity. This metal is highly resistant to corrosion, and because of this property, it is used to contain corrosive liquids (*e.g.*, sulfuric acid). Because lead is very malleable and resistant to corrosion it is extensively used in building construction, *e.g.*, external coverings of roofing joints. Lead can be toughened by addition of a small amount of antimony or other metals such as calcium. All lead, except ^{204}Pb, is the end product of a complex radioactive decay. Lead is also poisonous, as are its compounds.

Occurrence

Metallic lead does occur in nature, but it is rare. Lead is usually found in ore with zinc, silver and (most abundantly) copper, and is extracted together with these metals. The main lead mineral is galena (PbS), which contains 86.6% lead. Other common varieties are cerussite (PbCO3) and anglesite (PbSO4).

Lead Extraction Process:

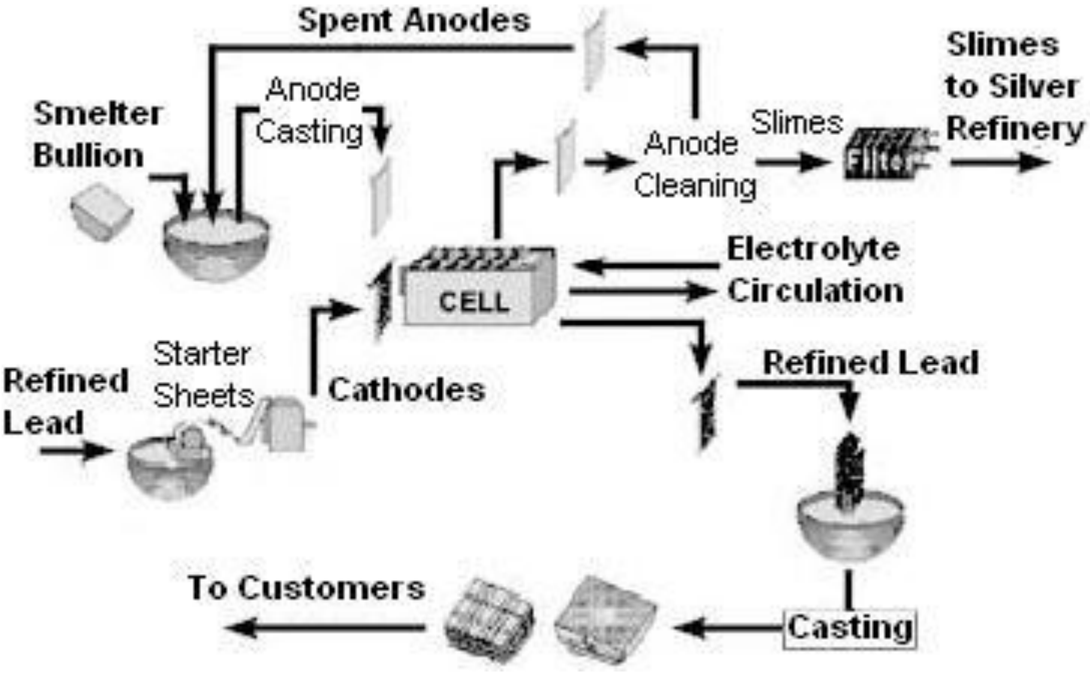
Most ores contain less than 10% lead, and ores containing as little as 3% lead can be economically exploited. Ores are crushed and concentrated by froth flotation typically to 70% or more. Sulfide ores are roasted, producing primarily lead oxide and a mixture of sulfates and silicates of lead and other metals contained in the ore. Lead oxide from the roasting process is reduced in a coke-fired blast furnaceThis converts most of the lead to its metallic form. Three additional layers separate in the process and float to the top of the metallic lead. These are slag (silicates containing 1.5% lead), matte (sulfides containing 15% lead), and speiss (arsenides of iron and copper). These wastes contain concentrations of copper, zinc, cadmium, and bismuth that can be recovered economically, as can their content of unreduced leadMetallic lead that results from the roasting and blast furnace processes still contains significant contaminants of arsenic, antimony, bismuth, zinc, copper, silver, and gold. The melt is treated in a reverberatory furnace with air, steam, and sulfur, which oxidizes the contaminants except silver, gold, and bismuth. The oxidized contaminants are removed by drossing, where they float to the top and are skimmed off.

Most lead ores contain significant concentrations of silver, resulting in the smelted metal also containing silver as a contaminant. Metallic silver as well as gold is removed and recovered economically by means of the Parkes process.

Desilvered lead is freed of bismuth according to the Betterton-Kroll process by treating it with metallic calcium and magnesium, which forms bismuth dross that can be skimmed off.

Very pure lead can be obtained by processing smelted lead electrolytically by means of the Betts process. The process uses anodes of impure lead and cathodes of pure lead in an electrolyte of silica fluoride.

Flow Sheet of Lead Extraction Process.



Applications of Lead

Lead alloys are largely used in industry. The addition of a small percentage of arsenic, or antimony, to the lead, increases its hardness and mechanical resistance, protecting it from abrasion. The calcium-lead and the tin-lead alloys are used in coating certain electrical cables.Generally, lead compounds are noxious for the animals. The effect of the absorption of the element in plants does not seem serious. However, this accumulate lead will be absorbed by the animals in case of ingestion. That is why lead compounds are not used in pesticides or insecticides.Lead and its sulfide are incapable of absorption, and are considered practically innocuous. However, the soluble salts, such as the chloride, the nitrate, the acetate, etc. are very poisonous. The main intoxication cause with lead is the exposure to vapors and dusts of its compounds. The intoxication symptoms are intestinal mal-function, strong abdominal pains, diarrhea, appetite loss, nausea, vomiting and cramps.

EXERCISE

Q1.What is the Latin word of lead?

Q2.what is the color of lead?

Q3.What is the main lead mineral and how much amount it contain lead?

Q5.Which is the most popular method to rosting the lead ores?

Q6.What is the difference between Huntington heberleim rosting process and Dwight Lloyd sintering machine?

Q7.Why Dwight Lloyd process is especially suitable?

PRACTICAL NO: 5

OBJECT: To study the extraction process of magnesium

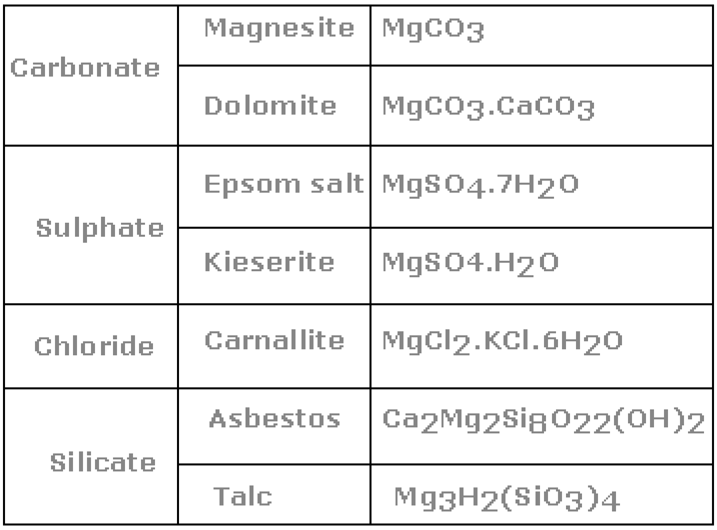
THEORY:

Magnesium (Mg) is a silvery white metal that is similar in appearance to aluminum but weighs one-third less. With a density of only 1.738 grams per cubic centimetre, it is the lightest structural metal known. It has a hexagonal close-packed (hcp) crystalline structure, so that, like most metals of this structure, it lacks ductility when worked at lower temperatures. In addition, in its pure form, it lacks sufficient strength for most structural applications agnesium is a silvery-white, soft and light metal (density = 1.75 g/mL).It melts at 651°C and boils at 1090°C. It sublimes in vacuum at 550°C.It is malleable and ductile.It is a good conductor of electricity and heat.

Occurrence

Magnesium being quite reactive does not occur in the Free State in nature but in the combined state

Magnesium is the eighth most abundant element found on the Earth. It occurs as,



Carbonate	Magnesite	$MgCO_3$
	Dolomite	$MgCO_3.CaCO_3$
Sulphate	Epsom salt	$MgSO_4.7H_2O$
	Kieserite	$MgSO_4.H_2O$
Chloride	Carnallite	$MgCl_2.KCl.6H_2O$
Silicate	Asbestos	$Ca_2Mg_2Si_8O_{22}(OH)_2$
	Talc	$Mg_3H_2(SiO_3)_4$

About 0.13% of $MgCl_2$ is present is sea water.

Extraction of magnesium

Magnesium metal is strong reducing agent and therefore, cannot be obtained by chemical reduction method. It is extracted by electrolysis of fused anhydrous salts.

A number of methods are available for the extraction of magnesium metal from its ores. The most widely used method is based on the electrolysis of magnesium chloride obtained from the seawater.

Dow's process

This process consists of the following steps:

Magnesium ions present in the sea water are precipitated as magnesium hydroxide by the addition of slaked lime, $Ca(OH)_2$ to the sea water.

$$\underset{\text{in sea water}}{Mg^{2+}} + Ca(OH)_2 \longrightarrow Mg(OH)_{2(s)} + Ca^{2+}_{(aq)}$$

Magnesium hydroxide is separated and converted to magnesium chloride by treatment with hydrochloric acid.

$$Mg(OH)_2 + 2HCl \longrightarrow MgCl_2 + 2H_2O$$

The magnesium chloride is crystallized as $MgCl_2.6H_2O$

- Fused magnesium chloride for electrolysis is obtained as follows:

Magnesium chloride hexa hydrate is partially dehydrated by passing a current of dry hydrogen chloride gas. The magnesium chloride thus obtained is added to a molten mixture of sodium chloride and calcium chloride (35 : 50 : 15). Magnesium chloride melts under this condition with the loss of water at about 1000 K (700 - 725°C).

$$MgCl_2.6H_2O \longrightarrow MgO + 2HCl + 5H_2O$$

The molten mixture of $MgCl_2$, NaCl and $CaCl_2$ is electrolyzed in an iron cell through which an inert gas (or coal gas) flows to avoid any reaction between the liberated metal and oxygen / nitrogen of the air. The cell wall acts as the cathode, while the carbon rod dipping into the melt acts as anode. Magnesium is obtained at the cathode and chlorine is evolved at the anode. This chlorine is used in making hydrochloric acid, which is required for obtaining magnesium chloride.

At cathode:

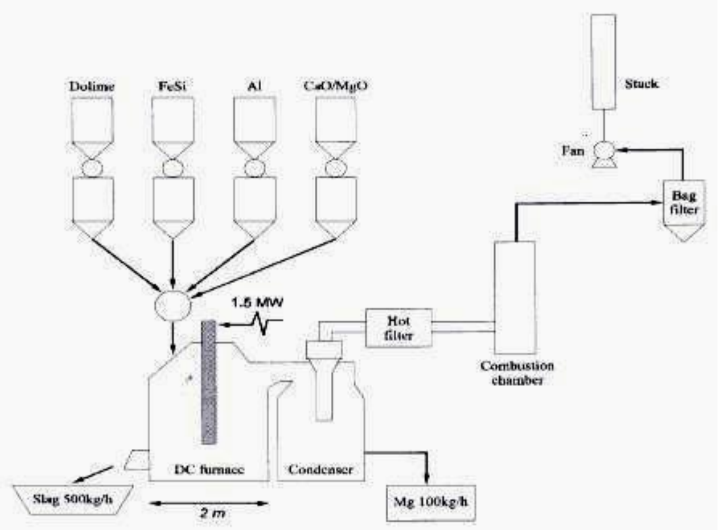
$$Mg^{2+} + 2e^- \longrightarrow Mg$$

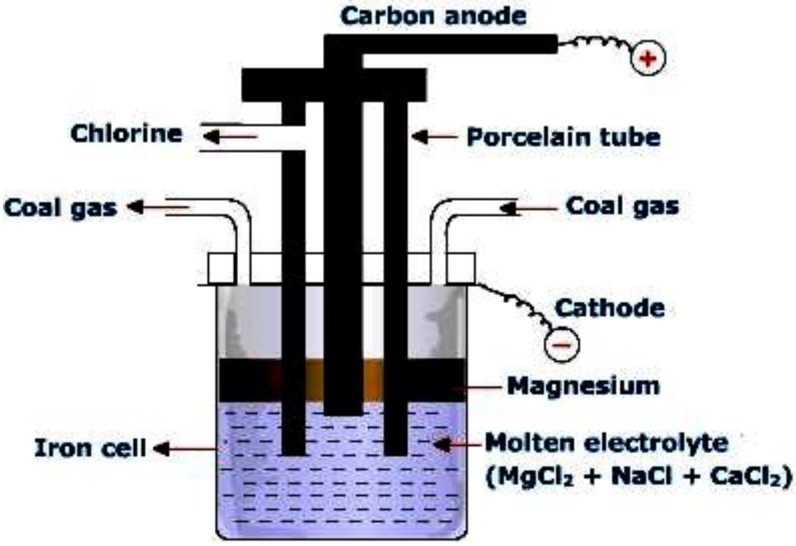
At anode:

$$2Cl^- \longrightarrow Cl_2 + 2e^-$$

The liberated metal being lighter than the electrolyte floats over the surface. Chlorine evolved at anode is obtained as a by-product. Metal of 99.9 per cent purity is obtained by this method.

Flow sheet of magnesium extraction process





Electrolysis process of magnesium

EXERCISE

Q1.What is the color of magnesium?

Q2.How much amount of magnesium present (in % approx.) in earth curst?

Q3.Why magnesium does not obtain through chemical reduction method?

Q4.In which forms magnesium is present in sea water and through which method it is extracted?

Q5.How much step are involve in Dow process?

PRACTICAL NO: 6

OBJECT: TO study the extraction process of chromium

THEORY:

Chromium is a chemical element which has the symbol **Cr** and atomic number 24, first element in Group 6. It is a steely-gray, lustrous, hard metal that takes a high polish and has a high melting point. It is also odorless, tasteless, and malleable. The name of the element is derived from the Greek word "chrōma" (χρωμα), meaning color, because many of its compounds are intensely colored. It was discovered by Louis Nicolas Vauquelin in the mineral crocoite (*lead chromate*) in 1797. Crocoite was used as a pigment, and after the discovery that the mineral chromite also contains chromium this latter mineral was used to produce pigments as well.

Chromium was regarded with great interest because of its high corrosion resistance and hardness. A major development was the discovery that steel could be made highly resistant to corrosion and discoloration by adding chromium to form stainless steel. This application, along with chrome plating (electroplating with chromium) are currently the highest-volume uses of the metal. Chromium and ferrochromium are produced from the single commercially viable ore, chromite, by silicothermic or aluminothermic reaction or by roasting and leaching processes. Although trivalent chromium (Cr(III)) is required in trace amounts for sugar and lipid metabolism, a few unusual cases have been reported where its complete removal from the diet has caused chromium deficiency.

Occurrence

Chromium does not occur in elemental form, but is found in Chrome Ochre, Cr2O3. The principal ores are Chromite, Fe(CrO2)2, and Crocoisite, PbCrO4, is also important as a source. Chromium is a trace component in semiprecious stones, emerald, jade, serpentine, etc.. Chromium is the 21st most abundant element in Earth's crust with an average concentration of 100 ppm Chromium compounds are found in the environment, due to erosion of chromium-containing rocks and can be distributed by volcanic eruptions. The concentrations range in soil is between 1 and 3000 mg/kg, in sea water 5 to 800 µg/liter, and in rivers and lakes 26 µg/liter to 5.2 mg/liter. The relation between Cr(III) and Cr(VI) strongly depends on pH and oxidative properties of the location, but in most cases, the Cr(III) is the dominating species, although in some areas the ground water can contain up to 39 µg of total chromium of which 30 µg is present as Cr(VI). Chromite oreChromium is mined as chromite ($FeCr_2O_4$) ore About two-fifths of the chromite ores and concentrates in the world are produced in South Africa, while Kazakhstan, India, Russia, and Turkey are also substantial producers. Untapped chromite deposits are plentiful, but geographically concentrated in Kazakhstan and southern Africa. Though native chromium deposits are rare, some native chromium metal has been discovered. The Udachnaya Pipe in Russia produces samples of the native metal. This mine is a kimberlite pipe rich in diamonds, and the reducing environment helped produce both elemental chromium and diamond.

Extraction process:

Chromium is made commercially by the Thermite Process, where Chromic Oxide is reduced by the stoichiometric amount of Silicon and Quick Lime in an electric arc furnace.

2 Cr2O3 + 3 Si + 3 CaO ==> 4 Cr + 3 CaSiO3

The two main products of chromium ore refining are ferrochromium and metallic chromium. For those products the ore smelter process differs considerably. For the production of ferrochromium, the chromite ore (FeCr2O4) is reduced in large scale in electric arc furnace or in smaller smelters with either aluminium or silicon in an aluminothermic reaction.For the production of pure chromium, the iron has to be separated from the chromium in a two step roasting and leaching process. The chromite ore is heated with a mixture of calcium carbonate and sodium carbonate in the presence of air. The chromium is oxidized to the hexavalent form, while the iron forms the stable Fe2O3. The subsequent leaching at higher elevated temperatures dissolves the chromates and leaves the insoluble iron oxide. The chromate is converted by sulfuric acid into the dichromate.

$$4\,FeCr_2O_4 + 8\,Na_2CO_3 + 7\,O_2 \rightarrow 8\,Na_2CrO_4 + 2\,Fe_2O_3 + 8\,CO_2$$
$$2\,Na_2CrO_4 + H_2SO_4 \rightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$$

The dichromate is converted to the chromium (III) oxide by reduction with carbon and then reduced in an aluminothermic reaction to chromium

$$Na_2Cr_2O_7 + 2\,C \rightarrow Cr_2O_3 + Na_2CO_3 + CO$$
$$Cr_2O_3 + 2\,Al \rightarrow Al_2O_3 + 2\,Cr$$

EXERCISE

Q1.From which type of ores, the chromium is extracted?

Q2.Who discovered the chromium?

Q3.Name of processes involved in the extraction of chromium?

Q4.What is the aluminothermic reaction? why it occur?

PRACTICAL NO: 7

OBJECT: To study the titanium extraction process

THEROY:

Titanium (Ti) is a soft, ductile, silvery gray metal with a melting point of 1,675° C (3,047° F). Owing to the formation on its surface of an oxide film that is relatively inert chemically, it has excellent corrosion resistance in most natural environments. In addition, it is light in weight, with a density (4.51 grams per cubic centimetre) midway between aluminum and iron. Its combination of low density and high strength gives it the most efficient strength-to-weight ratio of common metals for temperatures up to 600° C (1,100° F. Titanium was discovered in England by William Gregor in 1791 and named by Martin Heinrich Klaproth for the Titans of Greek mythology. Titanium can be alloyed with iron, aluminium, vanadium, molybdenum, among other elements, to produce strong lightweight alloys for aerospace (jet engines, missiles, and spacecraft), military, industrial process (chemicals and petro-chemicals, desalination plants, pulp, and paper), automotive, agri-food, medical prostheses, orthopedic implants, dental and endodontic instruments and files, dental implants, sporting goods, jewelry, mobile phones, and other applications.The element occurs within a number of mineral deposits, principally rutile and ilmenite, which are widely distributed in the Earth's crust and lithosphere, and it is found in almost all living things, rocks, water bodies, and soils. The two most useful properties of the metal form are corrosion resistance and the highest strength-to-weight ratio of any metal. In its unalloyed condition, titanium is as strong as some steels, but 45% lighter. There are two allotropic forms and five naturally occurring isotopes of this element; ^{46}Ti through ^{50}Ti, with ^{48}Ti being the most abundant (73.8%).Titanium's properties are chemically and physically similar to zirconium.

OCCURRENCE

Titanium is always bonded to other elements in nature. It is the ninth-most abundant element in the Earth's crust (0.63% by mass) and the seventh-most abundant metal. It is present in most igneous rocks and in sediments derived from them (as well as in living things and natural bodies of water). Of the 801 types of igneous rocks analyzed by the United States Geological Survey, 784 contained titanium. Its proportion in soils is approximately 0.5 to 1.5%.It is widely distributed and occurs primarily in the minerals anatase, brookite, ilmenite, perovskite, rutile, titanite (sphene), as well in many iron ores. Of these minerals, only rutile and ilmenite have any economic importance, yet even they are difficult to find in high concentrations. Significant titanium-bearing ilmenite deposits exist in western Australia, Canada, China, India, New Zealand, Norway, and Ukraine. Large quantities of rutile are also mined in North America and South Africa and help contribute to the annual production of 90,000 tonnes of the metal and 4.3 million tonnes of titanium dioxide. Total reserves of titanium are estimated to exceed 600 million tonnes. Titanium is contained in meteorites and has been detected in the sun and in M-type stars; the coolest type of star with a surface temperature of 3,200 °C (5,790 °F). Rocks brought back from the moon during the Apollo 17 mission are composed of 12.1% TiO_2. It is also found in coal ash, plants, and even the human body.

EXTRACTION PROCESS:

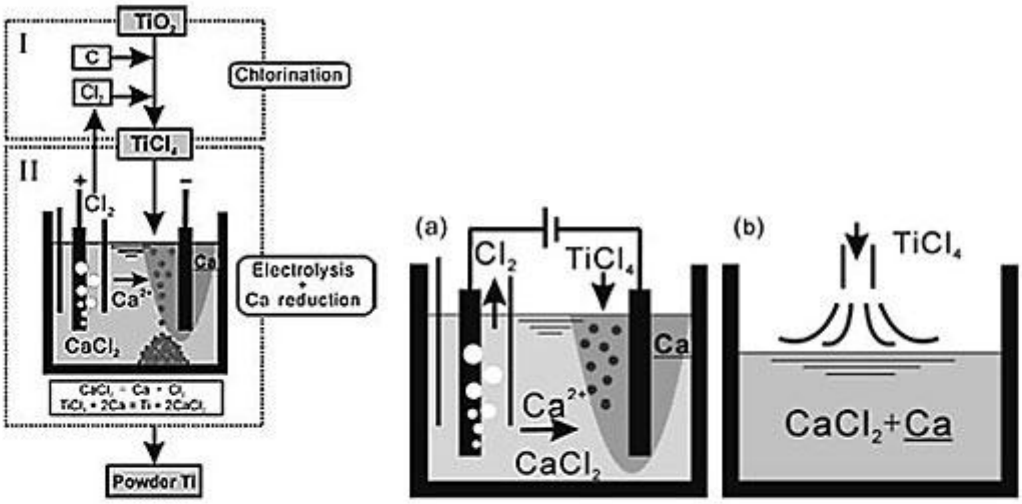
The metal is extracted from its principal mineral ores via the Kroll process or the Hunter process. Its most common compound, titanium dioxide, is a popular photocatalyst and is used in the manufacture of white pigments. Other compounds include titanium tetrachloride ($TiCl_4$), a component of smoke screens and catalysts; and titanium trichloride ($TiCl_3$), which is used as a catalyst in the production of polypropylene). The processing of titanium metal occurs in 4 major steps: reduction of titanium ore into "sponge", a porous form; melting of sponge, or sponge plus a master alloy to form an ingot; primary fabrication, where an ingot is converted into general mill products such as billet, bar, plate, sheet, strip, and tube; and secondary fabrication of finished shapes from mill products.

Because the metal reacts with oxygen at high temperatures it cannot be produced by reduction of its dioxide. Titanium metal is therefore produced commercially by the Kroll process, a complex and expensive batch process. (The relatively high market value of titanium is mainly due to its processing, which sacrifices another expensive metal, magnesium.) In the Kroll process, the oxide is first converted to chloride through carbochlorination, whereby chlorine gas is passed over red-hot rutile or ilmenite in the presence of carbon to make $TiCl_4$. This is condensed and purified by fractional distillation and then reduced with 800 °C molten magnesium in an argon atmosphere.A more recently developed method, the FFC Cambridge process, may eventually replace the Kroll process. This method uses titanium dioxide powder (which is a refined form of rutile) as feedstock to make the end product which is either a powder or sponge. If mixed oxide powders are used, the product is an alloy manufactured at a much lower cost than the conventional multi-step melting process. The FFC Cambridge process may render titanium a less rare and expensive material for the aerospace industry and the luxury goods market, and could be seen in many products currently manufactured using aluminium and specialist grades of steel.
Common titanium alloys are made by reduction. For example, cuprotitanium (rutile with copper added is reduced), ferrocarbon titanium (ilmenite reduced with coke in an electric furnace), and manganotitanium (rutile with manganese or manganese oxides) are reduced.

$$2\ FeTiO_3 + 7\ Cl_2 + 6\ C \rightarrow 2\ TiCl_4 + 2\ FeCl_3 + 6\ CO\ (900\ °C)$$

$$TiCl_4 + 2\ Mg \rightarrow 2\ MgCl_2 + Ti\ (1100\ °C)$$

Flow Sheet of Titanium.



EXERCISE

Q1.Why is titanium so expensive?

Q2.Why we can't use carbon reduction in titanium extraction process?

Q3.Who discovered the titanium metal?

Q4.Writedown the allotropic forms & naturally occurring isotopes of titanium.

Q5.Which is principle mineral through which titanium is extracted?

Q6.Why do we not produce titanium from reduction process?