Metals Assignment

Copper

Discovery: Copper was one of the first metals known to man due to its low reactivity with other elements. This means that it's found uncombined with other elements and often in large pieces. It was originally discovered around 9000BC in the Middle East according to historical evidence and became more plentiful as man established how to produce copper from copper ore. This established a short copper age (5000BC-3000BC) which later developed into the bronze age (3000BC-1000BC).

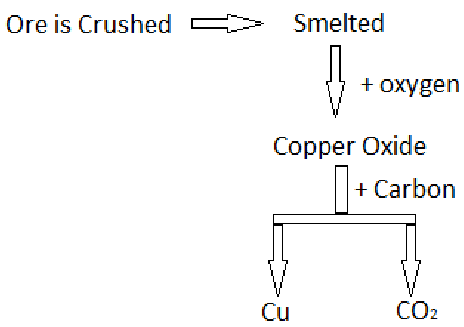
Alloys and their Comparison to Copper: When it was discovered that copper could be mixed with other elements to make an alloy there was a major step forward in the development of mankind. The most common and first discovered copper alloy was bronze which constituted of about 90% copper and 10% tin. Bronze and all other copper alloys are harder, stronger and tougher than copper and had many more uses for our kind than copper. Aluminium (5-11%) has also been added to copper to form an aluminium bronze, and zinc has been added to copper to form brass, manganese, nickel and silicon have also been found in alloys with copper but are less common in modern society. It is thought that these alloys may have been made because people used whatever scraps they could to strengthen the copper.

Uses and Reasoning: Before bronze was discovered man used copper for decorations and jewellery due to its pleasant attractiveness (colour and lustre) and because it simply was not strong enough to be used for weapons as it would easily bend out of shape. Many earrings, rings, broaches, bracelets, combs and decorative mirrors have being archeologically discovered made of copper but the most impressive to date has been a pendant dating back to 9000BC. This is the oldest piece of evidence we have so far and hence closely relates to the estimated date of discovery. Copper is still used today as an alternatively cheap metal for decorations, art and jewellery often sold in markets and "cheap" shops. Due to its ductility, copper is easily draw into wires and therefore makes for great electrical leads and connectors due to its ability to conduct electricity better than most other metals. It is also quiet malleable (hammered into sheets) and therefore could be used for plumbing pipes (as mentioned before, its low reactivity means that the copper will not react and corrode with the water and hence disintegrate becoming useless and needing often replacements).

Bronze was once used in boat and ship fittings (propellers and bearings) due to its resistants to salt water corrosion. Bronze is still used for this today but with the increasing popularity of stainless steel it is slowly dying out. Bronze, in ancient times, was also used to make tools and swords but it lost its popularity when iron was discovered because iron was stronger, harder and more durable than bronze. It was and still is also a very popular material to make musical instruments out of (e.g. bells, symbols and other percussion instruments). Many copper alloys including bronze was and still is used for sculpture in art. They are said to have an unusual property of expanding slightly just before setting and this is rather desirably for sculptures as it fills every tiny detail of the mould.

Brass, another copper alloy, was often used in the building trade. For example it was used for applications where no friction was required (such as locks, gears, bearings, doorknobs, ammunition and valves) because it didn't spark, for plumbing and electrical applications. It was also used as a decorative metal due to its pleasant colour, lustre and resistance to tarnish. It is very popular in applications where sparks must not be struck (e.g. as fittings and tools around explosive gasses).

Extraction of Copper in Ancient Times: Copper has many ores (chalcopyrite, chalcocite, covellite, bornite, tetrahedrite, malachite, azurite, cuprite, chrysocolla and tennantite) these are both oxides and sulphides but in Australia, sulphides are most common. Neanderthals found that to extract copper from its ores moderately high temperatures and an abundant supply of carbon were required. These conditions were achieved in traditional campfires or kilns that had previously been used for thousands of years before hand. The ore would be crushed and then roasted in the fire or kiln to decompose (This is known as smelting). The copper would react to form an oxide with the oxygen in the air and this would then react with the carbon (charcoal) to form pure copper and carbon dioxide. This is the redox reaction. i.e. the oxygen is oxidised and the copper is reduced. After the fire/kiln where put out solid pieces of copper would be found at the bottom.

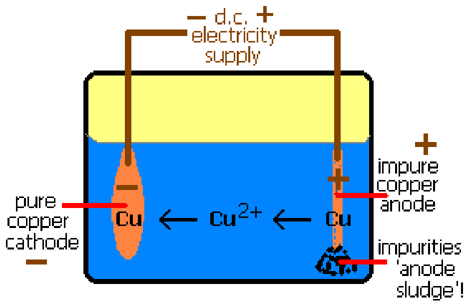


Extraction of Copper in Modern Times: In modern society the ores are extracted from the mine and crushed into a powder. They are then transported to froth floatation cells where the copper minerals are separated from gangue hence making the mixture more concentrated. This is done because much larger amounts of copper ore are to be produced these days (millions of tonnes) in a small amount of time. First the powdered mixture is added to water to form a slurry and a reagent is added to this mixture (e.g. pine oil is added to copper ores to make the gangue hydrophilic and the copper hydrophobic). The slurry is then introduced to a water bath and air is pumped through so that the gangue adheres to the bubbles. It is basically an extra step to rid the products of some un-chemically combined wastes hence speeding up the next process, smelting.

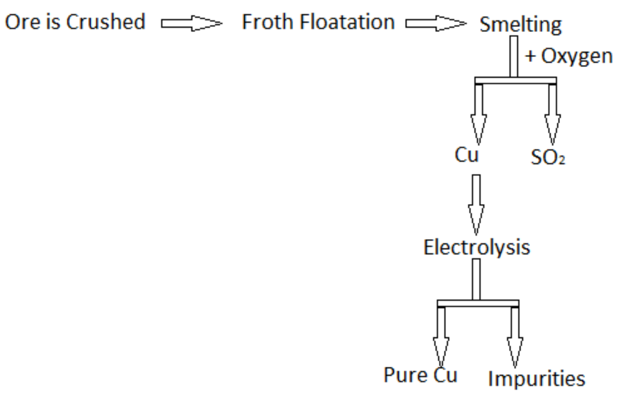
In smelting the copper compound concentrate is heated (melted) at 1000-1500 degrees Celsius and air (oxygen) is pumped through it. The waste metal will be turned to an oxide (e.g. if the ore is a sulphide, the waste will be sulfur dioxide). This is the red ox reaction because the waste metal, in most cases sulphur, is oxidised and the copper reduced. This is known as blister copper and is about 98% pure.

$2Cu^{+} + 2e^{-} \rightarrow 2Cu$ (reduction)
$S^{2-} + O_2 \rightarrow SO_2 + 2e^{-}$ (oxidation)
$2Cu^{+} + O_2 + S^{2-} \rightarrow 2Cu + SO_2$

The copper can be further refined by electrolysis. This involves making the blister copper into anodes (solid blocks) and having a cathode of pure copper which the new copper attaches to (in modern techniques, stainless steel may be used but the copper has to be plated off afterwards). These will be attached to an electric current and placed into a solution of copper ions (for copper in particular, copper sulphate solution would be used). When the electric current is turned on (passing through the battery, to the negative cathode, through the solution and to the positive anode), the positive copper ions on the positive anode that need to gain electrons, do so and are deposited on the cathode.



This process is a lot more involved than the ancient method of extraction but it mostly due to the fact that with the introduction of electricity humans are able to refine the copper even more to get it to the best quality.

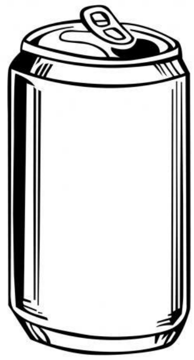


Environmental Impacts: Scientists had to come up with another way of smelting the copper ore because when it was done with carbon, unwanted carbon dioxide was produced. There is now controversy over the uses of carbon dioxide and producing excess in modern society. It is thought that it is destroying the atmosphere and along with loss of trees through logging we could be killing our planet. Some scientists would disagree with this and say that we have not produced that much excess carbon dioxide and that it is carbon monoxide that is doing the damage.

If logging occurs around a mine for storage of the created debris (there is especially large amount of debris created when mining copper) not only are there less plants to take in carbon dioxide as discussed above, but chances of erosion are significantly increased. When the trees are removed, their roots are taken with them and there is nothing left to stabilize the earth. This may lead to loss of biodiversity because the soil looses nutrients and becomes infertile and unable to sustain plants. The wastes may also be toxic which will also harm the environment making it infertile.

In most countries (usually not developing countries), mining companies are required to follow a strict environmental rehabilitation code in order to minimize the impact by humans on the planet.

Aluminium



Discovery: Aluminium is a reactive element and therefore isn't found in its pure form in nature hence wasn't as easily discovered as copper, gold and silver. In 1808 Sir Humphry Davy established the existence of aluminium but had no way of getting it to its pure form. In 1821 P. Berthier discovered bauxite, a red, clay-like aluminium ore containing 52% aluminium oxide. It wasn't until 1825 when Hans Christian Oersted reacted aluminium chloride with an alloy of potassium and mercury and heavily compressed it to boil off the mercury and produce potassium chloride that pure aluminium was discovered.

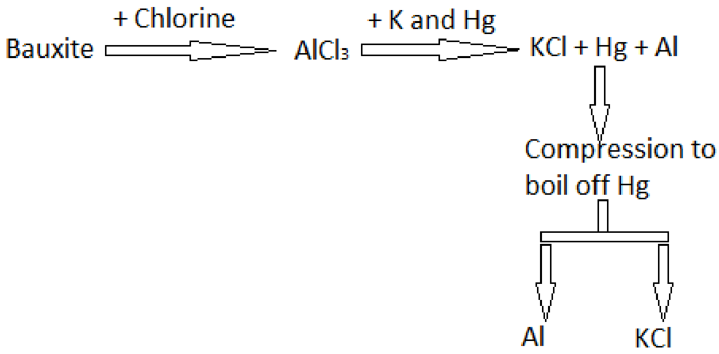
Aluminium in History: When first discovered, aluminium was very expansive as it was difficult to extract to its pure form. A lot of energy was needed to get it to get pure aluminium from its ore, bauxite, and at the time, electricity was very expansive. It was a very rare metal in its pure form and was considered more worthy than gold, platinum or silver. As people have discovered faster ways of making aluminium it has become cheaper and more common.

Uses: Aluminium is very corrosive on its own but has an important property of reacting with oxygen to form an oxide and therefore becoming resistant to further corrosion/oxidation. It is also very malleable, cheap, and light and as an oxide it is non-toxic and makes for a very good packaging product (aluminium foil and cans). Although it is not very helpful on its own, many aluminium compounds are. For example aluminium ammonium sulphate and aluminium sulphate are used in sewage treatments; aluminium sulphate is used in fire extinguishers; aluminium chlorohydrate is used as an antiperspirant; aluminium ions (found in aqueous solution) are used to treat fish parasites and many aluminium salts are used as an immune response booster in vaccines.

Uses as an Alloy and Comparison to Pure Metal: Aluminium is too weak and ductile to be used on its own for most applications so it is often made into alloys which are much, much stronger and more durable. Duralumin is an aluminium alloy with 4% copper and is much, much stronger than the original metal. Its first use was for airship frames and it is now used for precision tools (such as levels) and structural (including window and door) frames due to its light weight and strength. Aluminium-zinc alloys are the strongest of the aluminium alloy group and are now used for the entire aircraft body and wings, reducing the entire weight of the plane.

Aluminium with 2% magnesium is known as magnalium and is much stronger and corrosion resistant than pure aluminium. It also more workable and much easier to weld than pure aluminium. Magnalium is often found aircrafts as well but it is also found in many automobile parts. There is also another magnesium/aluminium alloy which is about 50% magnesium and is much more brittle and corrosive then aluminium. This may not seem of much use to start with but it actually very flammable when powdered and is used in pyrotechnics to produce sparks.

Old Extraction process: Nowadays the Bauxite (Al(OH)3) ore is mined and then purified by the Bayer process. This replaced the old refining method of reacting aluminium chloride with potassium (as mentioned above). The price of aluminium fell dramatically once this more economically viable method was introduced.

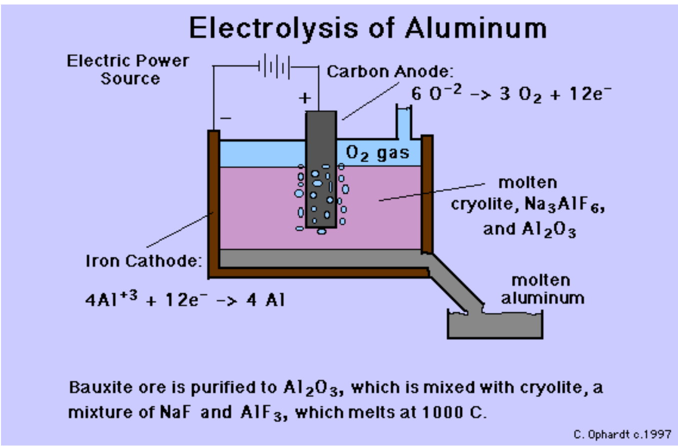


Modern Extraction Process: There are two main steps to this process. First the Bauxite is mixed with sodium hydroxide allowing the oxide of aluminium to dissolve. The other impurities will not dissolve and this makes for a simple process of removal by filtration. Carbon dioxide gas is then pumped through the remaining solution and forms a weak acid to neutralise the entire solution and causes the aluminium oxide to form a precipitate. The aluminium oxide (or alumina) can be obtained when the impurities are filtered off and the water is boiled off.

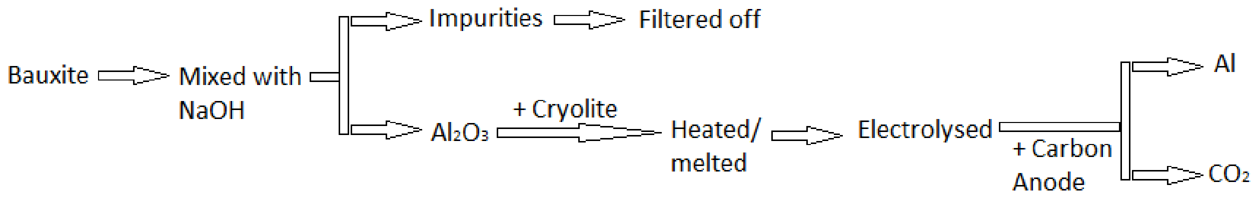
Once we have the purified aluminium oxide, the aluminium can be removed by the Hall-Heroult method. In this process the aluminium oxide is mixed with cryolite (sodium fluoride and aluminium fluoride) and is then heated to about 980 degrees Celsius. This melts all solids (even though aluminium oxide has a quiet high melting point, the cryolite lowers this).

The aluminium oxide is then electrolysed. An anode of carbon is put in the molten material which container's made of iron and forms the cathode. When the electric current is turned on, the oxygen ions are attracted to the carbon because they want to give electrons (oxidation reaction). The carbon looses electrons and is oxidised. These both react to give off a carbon dioxide gas. At the cathode pure aluminium is formed because the aluminium is left.

$Al^{3+} + 3e^- \rightarrow Al$ (reduction)
$2O^{2-} \rightarrow O_2 + 4e^-$ (oxidation)
$4Al^{3+} + 6O^{2-} \rightarrow 4Al + 3O_2$



Bauxite ore is purified to Al_2O_3, which is mixed with cryolite, a mixture of NaF and AlF_3, which melts at 1000 C.



Environmental Impacts: In this reaction, carbon dioxide is given off. This was discussed with copper and may be causing our atmosphere to decay. The bigger issue more closely related to aluminium is that it requires a large amount of energy to refine. At current humans are getting most of this energy from fossil fuels which are, for starters unrenewable, but secondly, when burnt producing more unwanted greenhouse gasses.

It has been found that when the alumina levels fall below the amount required for electrolysis to occur, the electricity cause the carbon anode and the fluorine from the cryolite to react and form PFC's. When released into the atmosphere the carbon atoms react with the ozone (03) and break it down to produce ordinary oxygen molecules and carbon dioxide molecules.

Aluminium as discussed earlier is a very reactive metal. It reacts with acidic water and soils (even pH6) and produces toxins making the area uninhabitable. For example fish may die or plants will be unable to grow. This destroys our biodiversity.

It is becoming more and more popular all over the world to recycle aluminium. Recycling only requires 5% of the energy required to refine new aluminium and there are no reasons why we shouldn't do it. More carbon dioxide and PFC's will not be produced and in the long run this will save our ozone layer and put less stress on the biodiversity of the world.

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