Industrial Inorganic Chemistry
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Lecture – 39
Magnesium and it is Compounds

Hello everybody. Welcome back to this class where we are talking about the element Magnesium. So, how we get that particular element or the metal when we get in the metal ion form from the natural source and how we utilize that thing.

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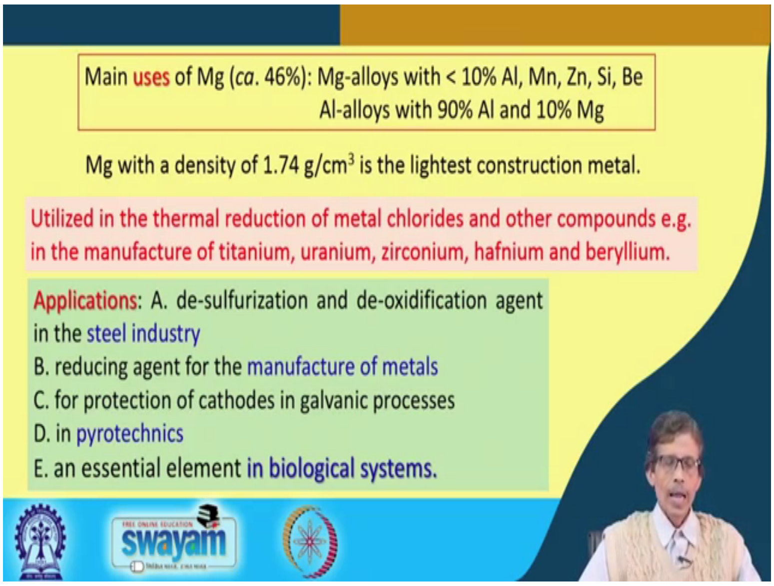

So, we have already discussed about the isolation of magnesium and their isolation in form of different compounds also, will see. So, if we consider that what are the main uses of magnesium because these are the very important informations we must always have. Otherwise, we cannot think of anything related to industrial chemistry or anything related to inorganic industrial chemistry.

So, basically we find that if we consider that about 46 percent of magnesium has been utilized for industrial purposes for making alloys. So, it is a very useful area of research or development in terms of metallurgical engineering also, the materials development also because one of the component for that particular purpose would be the magnesium metal, the magnesium element.

So, throughout the years, basically about say history of the say 100 or more years where the alloying thing has been utilized for different purposes. So, two categories of alloys have been identified very useful in terms of their magnesium content; one is known as the magnesium baring alloys and other is also basically a completely different one where you have the aluminum as the major component.

So, when people basically use, so, magnesium alloys are classified in terms of that 10 or even less than 10 percent of the element wise competition from the other elements like aluminium, manganese, zinc, silicone and beryllium. So, basically the whole material will be made up of about 90 percent of magnesium rest is the other element to increase the strain, the durability and any other factors what is associated for your improving the material characteristics or the metal characteristics or the alloy characteristics.

Similarly, when we go for aluminium alloys, so the basic thing is that 90 percent aluminium. As we know that from our school days, we know what is duralumin? So, duralumin has then again aluminium baring because aluminum is a very lighter metal. So, making of the aircraft or any other item even the corresponding body of the motors and all we require a very light fragment, particularly anything which we put up and which we have above the earth surface we can made it of alloy. It has about the thermal characteristics and all these things.

But why we use magnesium? That is why, the isolation and availability of magnesium is very important, why we should study magnesium is also because it is a very less dense material is density of this metal is just simply 1.74 grams per centimeter cube and thus it can be considered as the lightest construction metal or lightest construction element which can be used. So, if we want to make a material lighter and lighter than that, forget about the other component; that means the strain durability, the resistivity, the thermal conductivity and all these things. In terms of only the weight the lighter fragment, the lighter fragment in terms of that can be magnesium.

So, you see that 10 percent of the magnesium, so, drastically the huge material or huge thing if we want to get a aircraft or a jet propulsion thing anything where do we go for a 10 percent reduction in the weight in terms of your corresponding contribution into having magnesium instead of aluminium. It is also utilized in the thermal reduction basically.

So, like you all know that sodium metal itself is a very good reducing agent because sodium can be very easily oxidized to sodium ion and it can give the electron and that electron can be utilized for the reduction purpose. Similarly, magnesium also because if you have a very good or chief source of magnesium metal itself, we can use it for the magnesium metal reduction.

So, the thermal reduction; that means, it is always a very high temperature reduction because the reaction is only visible at a very high temperature where magnesium sometimes the molten magnesium is utilized for the reduction process. And other compounds that is particularly, the metal chlorides you take any metal chlorides some examples, if we consider if we have the titanium uranium to beryllium and all are in the chloride salts.

So, how we get the free element or the metal like titanium metal itself or the beryllium metal it itself. So, we will be using magnesium as the reducing agent. So, magnesium will not only reduce the metal center; that means, titanium chloride to titanium 0, the titanium elemental state or titanium metallic state, magnesium will at the same time after oxidation will be converted to magnesium chloride. So, if it is not even catalytic one because it is cannot be catalytic if there is no such other sacrificial reducing agent like hydrogen or any other thing.

So, stoichiometrically if we go for that particular reduction, what do you get you get at the same time, the product of other part; that means, the magnesium chloride. So, that is also very useful material. So, how that will also see, how you can get from the metallic magnesium or elemental magnesium to magnesium chloride. So, at the same time, you are reducing some pressures salts which is can be available from the earth's surface at the mineral or ore like say hafnium. So, hafnium if it is available as hafnium chloride. If we want to get as hafnium metal, you use magnesium.

Then, quickly we see that what are the basic application, basically apart from the application and alloy using alloy. It is a very useful material for de-sulfurization process or de-oxidification agent in the steel industry because steel industry is a very complicated industry where we use not only the de sulfurization is in process; that means, the sulfur is getting trapped within the material which we are getting from the iron or the iron ore.

Steel making process, the different types of steel we have now standardized is a very huge history.

So, historically, it is also important when we only know that incorporation of the carbon can improve the quality of the iron, even for the days of the medieval days or other previous days when we want to make source. How the material which can be very useful for making source out of that particular iron sample or the steel sample. So, we have the carbon, so, carbon content of the iron in the steel is giving you some particular type of method that we get for the typical type of that particular steel.

So, in that particular process, if sulfur content of that steel is there, so, sulfur is basically the presence of sulfur in that particular steel. We make the material brittle or sulfur is not also useful is also, its for the long term utilization is durability and all things will be hampered if the sulfur content is very high in that particular metal. So, we basically remove that particular sulfur, so, you take the help of magnesium. Similarly, if we go for some time, the de oxidification; that means, the removal of the oxygen that trapped oxygen and all this.

So, industrially this magnesium has magnesium metal is very useful. As we have seen just now that it can be used for the reduction process of metal chlorides, then it can also be very useful for all other type of metal manufacturing process. So, metal manufacturing industry will also be dependent on magnesium as a reducing agent. Then, you know that corrosion is taking place through that process, we know that in the air and the moisture and the water the electrochemical thing or the electrochemical sales are generated on the pipeline, on the water pipeline or the gas pipeline or the fuel pipeline, that the petrol pipeline that.

Then, we want to protect that one will be formed as the cathodic part and one will be formed as anode. So, electrolysis is goes on through that environmental environment that environment is there and that particular environment with huge amount of moisture and water will basically go for the electrolysis process with that of your sacrificial electrodes. What are those sacrificial electrodes? Sacrificial electrode is that some electro chemical part that is some electro chemical sale is being locally developed.

So, one part of the metallic part is developed as the cathode material and another part is serving as the anode material. So, it start oxidizing and reducing the material and the material which is your anode or which is your cathode is getting the corroded or getting decomposed or getting it is life lost.

So, for that particular protection, so, through that galvanic process we know that steel we give for the protection of the iron sample. Similarly, the magnesium is also giving for the protection of some of these materials. So, pipeline can be protected through a connectivity with the magnesium bar on magnesium rod because, whatever destruction can take place through that particular galvanic process is on the magnesium, not on the pipe itself. Then, for the different pyrotechnic process; that means, the thermally activated some processes if we want to get some pyrotechnic processes, we use magnesium.

And lastly is the most important one, but we should know only because we are talking in terms of the industrial part because we will not be talking about the biological system. But, making some biological importance of the magnesium because all we know that magnesium as the corresponding divalent cation which is magnesium 2 plus is present in our chlorophyll. So, chlorophyll we know that magnesium is the metallic part in chlorophyll for all the plant material or the vegetation, you have the magnesium.

But we are not very much concerned about the presence of magnesium or the magnesium utilization through the soil and at the same time, magnesium utilization in our body also because the deficit in these magnesium can give some difficulties or some problems in our health as well as in the health of the plants. So, there will be a demand of those magnesium compounds like magnesium sulfate, magnesium chloride which can be useful for medical or the health benefit or can be useful in the biological systems also.

So, the demand for magnesium is always been raised. It is not only for magnesium any such other metal and the metal ions like iron, like calcium, we always have some good idea where the industrial demand will be in future for those metals and the metal ions. If we want to start some industry based on the magnesium processing and magnesium development and making of those compounds which will be useful for the biological systems.

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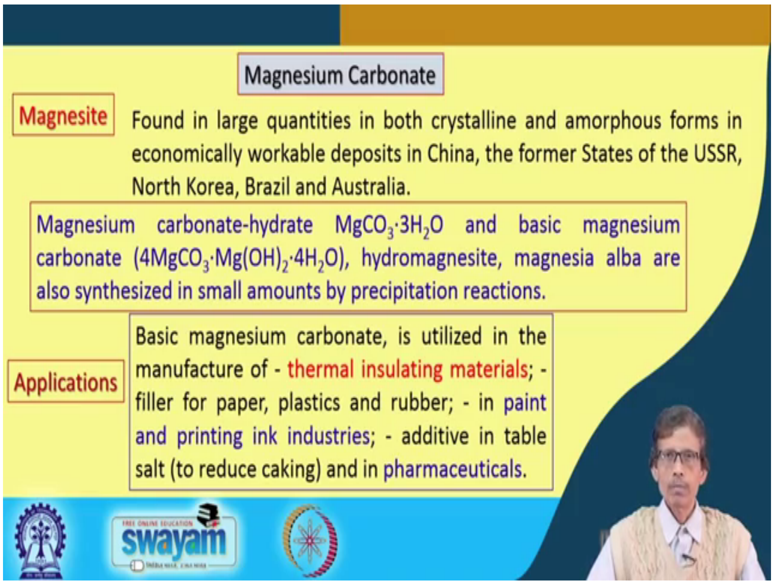

So, we see now that how we can go for a particular type one such compound is your magnesium carbonate which is nothing but MgCO 3. How we get that magnesium carbonate? So, this magnesium carbonate if we consider that we have the carbonate; that means, CO 3 parts there, it can function as a very useful antacids.

We take as the corresponding antacids which is the magnesium tablet us, but the part which is controlling for our pH in our stomach or pH in some other part is the carbonates by carbonate and carbonic acid equilibrium. So, origin of this magnesium carbonate is your magnesite. Where from we get this magnesite is basically found in large quantities in both crystalline and amorphous form.

So, two forms we can consider; one is the crystalline form and another is the amorphous or the powdery form which is non crystalline in nature. Where we have some area which is economically workable deposits because the any deposit we cannot handle because the percentage of the composition of that magnesium baring material should be very high. So, we have this magnesium, magnesite deposit in terms of the magnesium carbonate in China, in the USSR and the North Korea, Brazil and Australia.

So, all these countries have very huge deposits of this magnesite. So, we can use that magnesium as a very useful material for getting magnesium as well as the magnesium carbonate. So, the first of these thing is your magnesium carbonate hydrate which is three hydrate; that means, three water molecules are there which is also important for your crystallized in every time I say why this water of hydrate is so important. Another one is basic magnesium carbonate which is a mixture of magnesium carbonate and magnesium hide hydroxide in 4 is to 1 composition with 4 water of crystallization.

So, always try to remember something we leveled as magnesium carbonate or hydrate or they trihydrate and other is named as basic magnesium carbonate. So, it is always true; anything some carbonate salt is always true for any inorganic sample. It can be your zinc carbonate, it can be your copper carbonate, it can be your iron carbonate. If we talk in terms of the corresponding basic one; that means, basic copper carbonate or basic zinc carbonate or basic iron carbonate, what does it mean?

So, if we add the name basic before the formula or the name of the compound as the magnesium carbonate should have the corresponding hydroxide part, metal itself has been converted to some amount as the hydroxide ion. So, the chronological history of the formation of these material, this material when it is formed on the earth crust or beneath the earth crust, what happened basically? That magnesium has magnesium 2 plus which is leaching out from some other source some rock source, that magnesium 2 plus in terms of its corresponding exposure to a carbonated water or the carbon dioxide environment or it is sometimes exposed only to bicarbonate and carbonate anions.

So, when it is directly reacting with those, the medium is little bit of basic depending upon the corresponding p k values, we know that 2 p k values, p k 1 and p k 2 for the carbonic acid which is H 2 CO 3. So, for that carbonic acid the corresponding pH basically control the equilibrium for the formation of this carbonate from the magnesium 2 plus. Along with that, what happens?

You have aqueous medium, the water medium you have and that water medium is also going for de protonation; that means, the water molecules the H 2 O molecules are going for the de protonation giving you hydroxide ions and oxide ions. So, when you have the typical co crystallization process, when magnesium carbonate is forming, along with that magnesium carbonate you can have the corresponding crystallized form of another thing which is also available which is plenty in the medium of that of your magnesium hydroxide.

So, basically together, these two they can crystallize it and your crystal structure will also tell us that not only these two but is at different ratio of one is 4, another is one and along with the 4 water of molecules because the water of molecule will, so hydrogen bonding interactions in a networking structure. So, all these things are very important because you get not only this pure magnesium carbonate one where hydroxide are missing but also the basic magnesium hydroxide. Then, we have the hydro magnesite, the magnesite with different level of hydration, hydration level than magnesia alba are also synthesized in small amount by precipitation reaction.

So, all these things whatever I told you that, you require the corresponding concentration of carbonate, bicarbonate, carbonic acid as well as water hydroxide ion and oxide ion. So, when they react together, all the species are in equilibrium, but they all have the different K S P values the solubility product and as well as the solubility. So, depending upon the different solubility where the material is crystallizing out, we know that the geothermal whence we call, all these holds on the rock whence basically, so there is geothermal whence or the rock whence the material is going there it has a particular type of temperature environment also.

And you get that when those small channels basically, these materials are getting a typical precipitation reaction what we find in a test tube. So, when you get a precipitate in a test tube, what happens basically we add one of the material to other a is reacting with b and you get a, b and that a, b is getting precipitated because that material what is forming which is less soluble with respect to the volume of the solvent which is available in that particular medium.

So, the starting material the starting components a and b have higher solubility, but the product a b will have lesser solubility. That is why, it is getting precipitated. In a similar way, naturally also we get all this material as the magnesium sample which is getting precipitate. So, the which we are following is the precipitation reactions. So, where we use magnesium carbonate is like that of your magnesium metal. So, we see quickly the applications of all these things.

So, if we take whatever we are talking about the basic one; the basic magnesium carbonate is basically very useful in thermal insulating material, because the thermal conductivity of this material is very less is not that, of your only magnesium carbonate but it is the basic magnesium carbonate which is a very complex crystal structure. Then, it can also be used as filler for papers because paper also require some amount of this inorganic salts to make that to corresponding mixture.

Then, for filler for plastics for rubber because it can improve the quality of that plastic quality of the rubber in terms of the material as the inorganic sample what is present there. In paint and printing ink industries also, making paint the paints and the ink also and also it is a very good additive in making table salt. We know that during monsoon, during rainy season, we know that the sodium chloride if it has a huge amount of magnesium chloride.

So, magnesium chloride is there and magnesium chloride is more hydroscopic than your sodium chloride. So, we know that is a very sticky material. What we get in our childhood times about 50 years back when we buy the table salt for our consumption, we get from the sack and that is basically a very sticky material one. But, as we know that is due to the presence of magnesium chloride because for the sea water is not very purified one. So, as we are increasing the purity of the material in terms of its sodium chloride content only, not that the other samples what is present from the sea level, we have to remove the magnesium chloride.

So, when you remove the magnesium chloride is basically improving the corresponding crystallinity of the pure sodium chloride. Definitely, the price will rise that is why nowadays what do you buy the price of the corresponding sodium chloride is little bit higher what we get in the packeted form is iodized also. These are all the value addition to the material, what we are making in a bulk in the industry. So, magnesium chloride is not helpful for that particular purpose but if we add a very small amount of this other one; that means, magnesium carbonate which is a dry one and which is not so hydroscopic.

But if it even if it is hydroscopic one, it can take out that extra amount of water which is being absorbed by sodium chloride because its so happens that, sometimes we find a salt in organic salt like your table salt or which is not very pure which can take that water. So, first the anhydrous one, it can also if it is anhydrous definitely, if it is anhydrous one, it can take up that water making it is a hydrated form. Then, hydrated form further can take water more since its nature is more hydro scoping more hydroscopic, ultimately it is being flooded. So, it is basically a solution then due to that absorption of water.

But if you add that magnesium carbonate, it is basically very pure one. It is crystalline one and it is also giving the typical characteristics for all this table salt which is being the free flow table salt nowadays we call. If you pour, it destroying freely particle after particle to your medium where you are going for cooking or any other purpose.

So, it is basically reduce the caking process, then caking process is due to that moisture absorption and the hydroscopic nature of the sample, as well as it can also so be used in making the pharmaceutical molecules also because large number of samples nowadays the medicines. If you are very careful enough and looking at the medicines what you are consuming is nowadays not these all organic molecules, big organic molecules what we are consuming as the medicine or the drug is not typically some time only the sodium salt because when you have the pure sample it is not.

So, soluble in our body in our gastric juice. But, if you make it to the sodium corresponding sodium solid, you increase the corresponding solubility and also sometimes we get the corresponding medicines and all these as the corresponding magnesium salts. So, you definitely have some magnesium source of getting these magnesium compounds.

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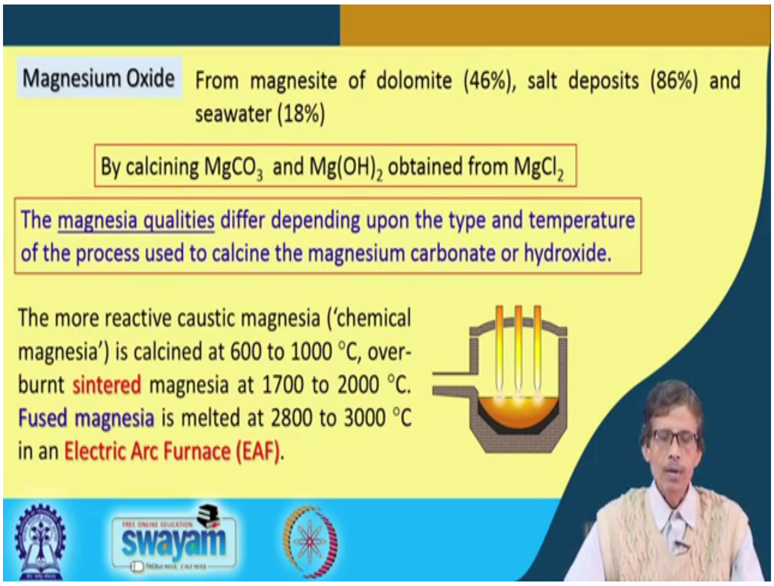

Then, how we get another very industrially important material is oxide because oxides are always very important one. If you go for making that oxide for making break or any other metallic oxide, for making cement or any other useful typical material characteristics from material characteristics; not the solution chemistry characteristics, but the material science or the materials engineering characteristics of that materials will be very high. So, what we get, we make magnesium oxide in MgO from magnesium of dolomite.

So, we know the dolomite which is magnesium carbonate calcium carbonate. From there, we can take out magnesium as magnesium oxide. From salt deposit, we get also and from the sea water definitely 18 percent we get. So, different percentages of these materials we get from the different sources and how we get very quickly is very simple one. If we are able to get the other samples that magnesium bicarbonate and magnesium hydroxide for magnesium chloride because the magnesium chloride is again is your sea water is the regular source of magnesium chloride and that magnesium chloride, you convert it to magnesium bicarbonate or hydroxide and then burn it.

So, calcining of all these will give you your typical magnesium oxide. Now, that magnesium oxide like silica is your magnesia. So, the quality of that material so have is also dependent on itself; that means, the different types of magnesium oxides, you can have how because its depends on how you make it. That means, the calcining or the calcination of the material; that means, where at what particular temperature you are burning your magnesium carbonate.

So, different solid state forms as we all know that A l 2 O 3, the alumina, typical alumina but still we have some name attached to these that we have alpha alumina, beta alumina, gamma alumina because their solid state structures and the solid state behavior their hardness and all these things are different. So, the quality of that magnesia can be dependent upon the temperature of the process where do we go for calcination and the magnesium carbonate or hydroxide what we are utilizing for that particular process.

So, the more reactive caustic magnesia you can have so that caustic magnesia is the chemical magnesia and that chemical magnesia is basically heated or burned at a temperature of 600 to 1000 degrees centigrade. So, this is one category; that means, the low temperature burned process of making that magnesium is in this particular range. Then, we get another one which is beyond 1000.

Look at the temperature range very critically because you have to remember little bit; otherwise you cannot do not have that idea that why this particular material; that means, the caustic magnesia or chemical magnesia is different from sintered magnesia and sintered magnesia is different from the fused magnesia. So, the sintered one, we know that one type of crucible we use in our chemistry laboratories is the sintered glass bit crucibles.

So, sintering is a typical process, you heat it and then it is settling down that is called as a sintering one. So, sintering bed made of silica is the sintering bed. Similarly, the sintered magnesia was basically the material is obtained in the sintered form when you heat it at the 1700 to 2000 degrees centigrade. So, heating the material to 1700 to 2000 degrees centigrade giving you a sintered magnesia other one is a fused one.

Again, we had not have another type of crucible, we called the fused silica crucible; that means, the material which is used is the fused silica. Similarly, fused magnesia which is also a very hard one and which is the most robust one in terms of its stability is formed not a very simple process but a very high temperature calcination process is in the range of 28000 to 3000 degrees centigrade in E A F which is nothing but your Electric Arc Furnace. So, electric arc we use it.

So, you have the electrodes and those electrodes are utilized for this particular chamber and you use the corresponding magnesium carbonate and magnesium hydroxide or even only magnesium carbonate for heating this thing to get that particular material. So, three types of these magnesia you can have if you heat them together differently at different temperatures depending upon your requirement what you are making and the further processing out of this but you have the electric arc for the last category; that means, the fused magnesia preparation.

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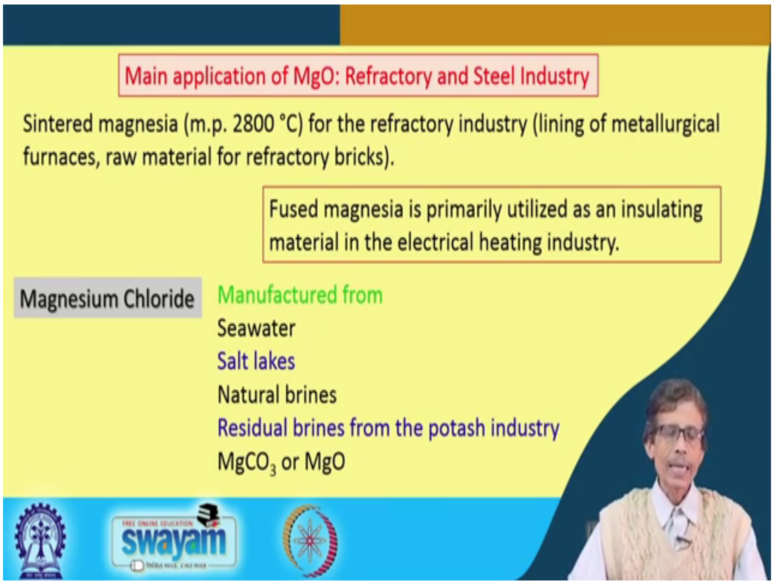

While we use since we are getting some huge and very heavy material out of this thing. So, these heavy material basically we can use is; that means, it can have very high temperature withstand that can it can very good refractory material and also in steel industry. That means, you can incorporate that magnesium in the steel material also. So, the last category; that means, the sintered magnesia is for the refractory industry for the lining the metallurgical furnaces, the raw material for the different refracted bricks basically.

And the fuse magnesia is primarily utilized as an insulating material in the electrical heating industry. So, all these can withstand very high thermal conductivity or the temperature withstand. So, making all these materials because we are making this material the magnesium oxide, we are making at a very high temperature then that particular material. Since is not a very costly one is a very cheap one, you can use in making breaks, you can use it for the inner lining of the corresponding furnaces and so on.

Then, the most common one were from we are making these; that means, magnesium chloride you have. So, magnesium chloride is typically the process is the simple the isolation process. Then, you convert to the other compounds. So, we get these basically from typically the seawater from salt lakes, the natural brines and the residual brines from the potash industry already we discussed it that if you have some residual amount of this material in terms of is magnesium content we get it.

And also, the reverse one; that means, we are making magnesium carbonate and hydroxide from chloride salts there also can get magnesium chloride out of these two samples of magnesium carbonate and magnesium oxide.

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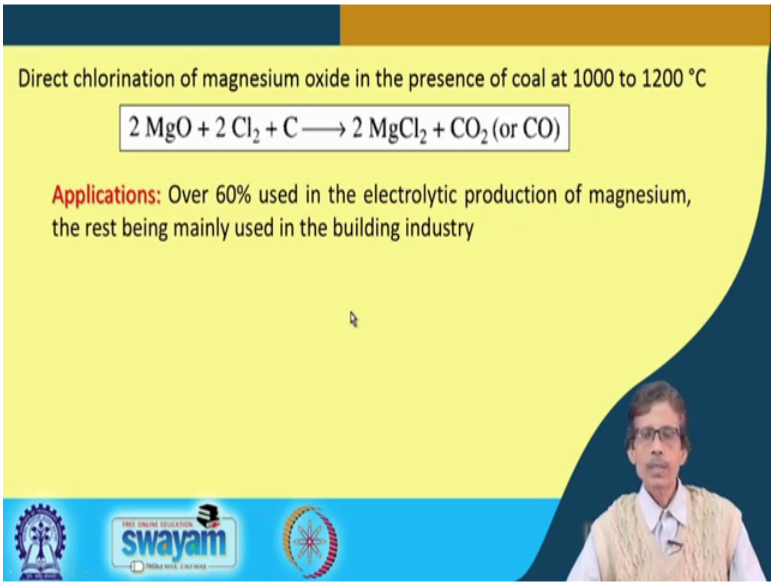

So, we get this by direct chlorination of magnesium oxide. So, you have MgO when you react with chlorine, it gives you a magnesium chloride with that of the removal of your chlorine. So, this particular one, so this chlorine as the gas mixtures, so that chlorine gas mixture will be directly reacting and presence of coke or carbon again at a very high temperature.

So, these are basically highly energy intensive process where we use these magnesium as burning process of these and we get it for the production of magnesium chloride. And that magnesium chloride is basically utilized for different purposes and through that particular process where we see that this magnesium oxide is the reacting with chlorine giving you magnesium chloride.

So, we are consuming the entire amount of chlorine as the chlorine gas to convert your magnesium to your magnesium chloride. At the same time, this carbon is being burned out of that particular oxygen which we are getting from magnesium. So, if we control the passage of air because we try to avoid the air because otherwise the air will be utilized at this high temperature for the oxidation of carbon to carbon monoxide or carbon dioxide. So, we can avoid that thing; that means, at low air presence we try to get the oxygen of it; that means, oxygen we have to remove.

Whatever oxygen is present in your magnesium, if it is removing at high temperature as oxygen gas also, should be consumed by your carbon that carbon will consume that particular oxygen to make your carbon monoxide and carbon dioxide. So, after making these magnesium chloride 60 percent of this is used for electrolytic production of magnesium because magnesium chloride is a very useful material for your electrolysis process and the waste being mainly used in the building industry.

So, we use this in the building industry. So, the remaining part we will just finish in our next class. So, whatever material we are talking about, most of these things, how we get it, how we make it, how we process it and then how we use that for the different sectors; that means the supply line. The supply channels we should also know where we can have the buyers who can buy the material, what we are making from the industry ok.

Thank you very much.