**Industrial Inorganic Chemistry**
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**Lecture – 02**
**Importance of Chemical Industry, Chemicals from Materials**

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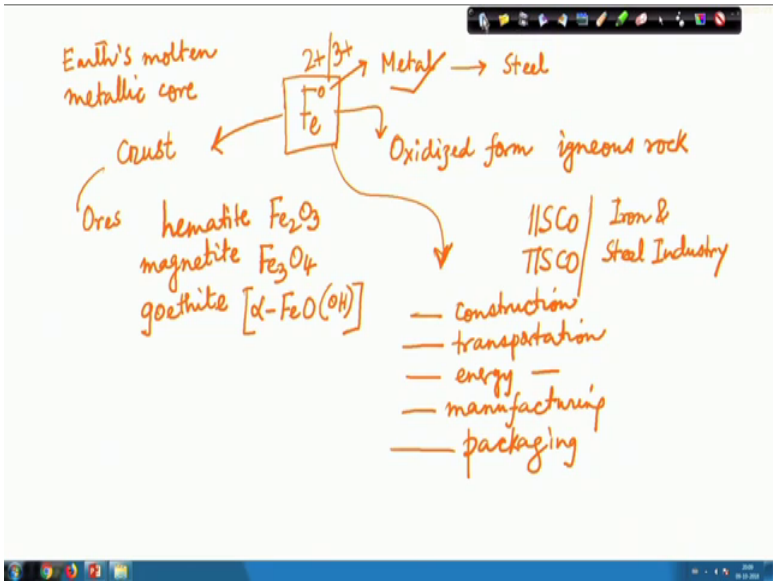


Welcome back to this class, where we are continuing our thing as the utilization of different elements for their useful purpose in industry. So, we have seen that we are used sodium ion, calcium ion. Similarly, one very important element is our iron. So, iron as metallic state that means, iron 0. So, this can be very useful material for construction to many other thing. And the metallurgies basically will be interested to handle this iron as the metal, because we all know that the most important part of this metal for making the steel.

So, what other thing is there, because iron has a very good source to us also. Because, we all know it is in the earth core. So, it is basically present over there in the earth's molten metallic core. So, it can have therefore on the soil or on the earth crust. So, how we get these in our earth crust? So, these are available as our different ores or minerals, so the most important three are hematite, which is F e 2 O 3, then magnetite which is a F e 3 O 4, or goethite which is one particular form or phase we call which is alpha phase of F e O OH, which is a very important material.

Because, in biological word also we require iron as we all know that iron is the major constituent of our blood. So, we can have the storehouse of this iron also. So, as on the earth crust similarly in our life also in the biological word also iron is getting stored. So, this is a very important material not only in terms of its metallic form, but it has very useful of two oxidation states. One is the two plus state, another is the three plus state that means the ferrous ion and the ferric ion.

So, when it is in the oxidized form that means this thing when they are in the mixed oxidized form. But, in most of the cases, it can go from it is 0, which is your metal. Then the ferrous state and the ferric state so these oxidized form, these oxidized form is available in different rock materials such as different igneous rock, we get the corresponding iron.

So, starting from our seawater to the different igneous rock, this can be very good starting material for inorganic industry or inorganic chemistry industry. So, for their usefulness basically that means, making this iron. So, we know that very old industries in our country, these are iron and steel industries. Like we all know that IISCO Indian Iron and Steel Company, then we have the TISCO. So, all these old companies, which are talking with or dealing with the iron as well as making steel, because these where the most useful material at that particular point where plastics or the other materials were not of that much use.

So, iron and steel industry, we can have so they are present in iron and steel industry. So, in this particular courses, we will see that how not only the iron present in this iron steel industry, because we will not considered all these thing, because of their not use of the all these materials. Nowadays, we are just slowly moving to get some new materials for making some new applications.

But, this iron and steel industry were useful for construction steel. They are being utilized for transportation also for making railway lines and all transportation; then for energy such as our system that means, electrochemistry the electrodes and the materials, then for manufacturing industry, then for packaging. So, this utilization of this iron can give us some idea that the how the different metallic ions or the free metals can be useful for our purpose in getting these as their bulk constituent for industry.

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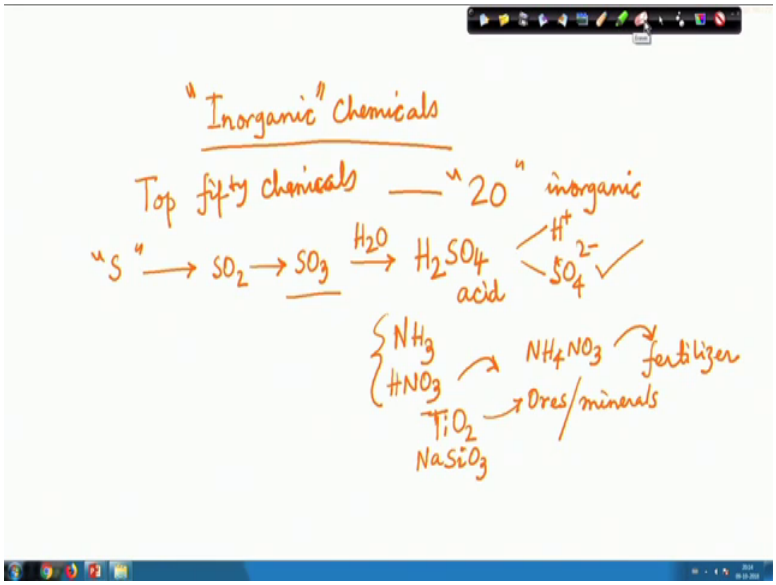


So, if we now go from there for the making of different inorganic chemicals, so what are those inorganic chemicals, which are very useful for industrial purpose that we will see. And we will categorise also their personal the percentage utilization or percentage production also.

So, among the top fifty chemicals, what industry can use? So, from those chemist chemicals the inorganic chemists chemicals basically if we have a list of top fifty chemicals, top fifty chemicals out of those the 20 will be typically inorganic. In terms of the amount, we produce not only by India by our country, but by some other advanced countries what they are producing.

So, 20 of out of this fifty chemicals, which are produced in huge amount are inorganic in nature. And they are basically starting from simple sulphuric acid, so the industry which are making sulphuric acid is very interesting. So, we consider them as the bulk chemicals, and how these bulk chemicals will be utilized for making some other compounds. Because, this can be very useful not only in terms of its acids that means, it is giving H plus as well as the sulph S O 4 2 minus.

And this we all know that this we can get from S O 3 or we can get from S O 2 or initially we get it from elemental sulphur. So, if we can huge amount of sulphur source in our hand that means, if we are able to produce sulphur, which can be oxidised to sulphur dioxide. And that sulphur dioxide can be oxidised to sulphur trioxide, and these on

reaction with water basically in presence of some catalyst giving you sulphuric acid. So, making or production of sulphuric acid will give us some idea that we can utilize these for making different salts.

So far we are considering that we can have some very important salts of calcium or important salts of sodium, where you can utilize at the corresponding sodium by sulphate or sodium sulphate, so these can be the very good source of sulphate ions. So, not only in terms of its inorganic acids form, so this is an inorganic acid. But, also is a very good supply giving very good supply of the corresponding ions as the sulphate or it can go for making the corresponding sulphonation reaction in organic chemistry.

So, the organic sulphates can also be produced from these, so that we will see that how this typical inorganic starting material can be use full for different industrial purposes. Then along with sulphuric acid, we can have the production of the corresponding ammonia. So, these include within this 20 numbers that means, 20 inorganic compounds. Then we can have the nitric acid, where it can have the corresponding property of acid as well as the corresponding nitrates. And this can also be utilised by combination of these two the corresponding formation of ammonium nitrate, which is useful for different purposes, which can be a good fertilizer.

Then we can have a metal ion based very important source of material as pigment, which is titanium dioxide rutile we know. Two forms are available for titanium dioxide, one is limonite and another is utile, but it has tremendous application in the industry. So, from the source of these as the corresponding ores or minerals, we can go for the production of titanium dioxide in industrial scale. And also we have seen that we are able to produce sodium silicate. So, this also comes under this particular number that means, the 20 numbers of a huge amount of inorganic chemical production that we will see.

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So, we will just now go for the checking all other thing that means, how we can utilize these as the corresponding one for making this as the corresponding one for our introduction part. So, we can have the typical industry, which is dealing with inorganic products.

And I gave you all these examples, what are those corresponding in organic product, which can be utilized for different purposes. So, what are those purposes basically, it can increase the wealth or add value that means, we can have some value added products, by taking the raw materials such as this salt, what we have seen the typical sodium chloride salt.

So, at one hand we can have the sodium chloride, and on the other hand we can have the typical lime stones, and the oil. So, these will not cover definitely, because this is I will come under the petrochemical industry. And mostly this comes under the polymer industry or the organic chemistry industry, but this will not typically come under your inorganic chemical industry, so which are then either directly or indirectly can convert the different compounds to some value added product.

So, the entire range of chemicals. So, what we can have the entire range of chemicals, whether it can have a you can have a corresponding organic chemical or a polymeric chemical that can be converted by some chemical reaction to some other products, which we consider that are more sophisticated one compared to your bulk or raw materials.

So, what we will see therefore that these products basically can arguably improve our lives and lifestyles, and without these we could not leave the way we do without them. So, basically we can use all these materials, which can add some value addition to the products, which we use for our day to day purpose, and which can increase our lives and lifestyles.

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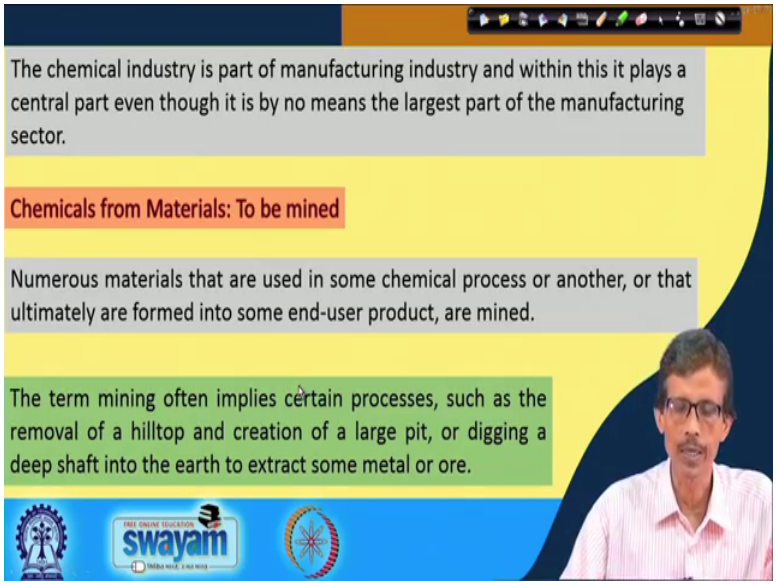


So, these basically we see for the chemical industry part. So, it is also coming under the corresponding part, where you can consider these as the manufacturing industry. So, if we are going for manufacturing chemicals, we can considered is as the typical manufacturing industry is not that you are making some mechanical products so mechanical engineering products for making these part, these chemicals are also can come under this manufacturing industry and within this it plays the central part and even though it is by no means the largest part of manufacturing sector, because the amount in terms of some million tons of this sulphuric acid, the ammonia, the ammonium nitrate and all this.

The amount of all this bulk and raw materials are huge in amount, so that is why they are a typical manufacturing centre, what we can consider. So, from the mining part that means, from the geological aspects or the geophysical aspects for mining of these ores and minerals, how we can convert the different chemicals to materials that we can see.

So, initially we can have the bulk materials, which are obtainable from our ores and minerals, and which will be converted to the different materials.

So, the materials giving us to form the different types of sophisticated other products is basically obtained for mining, and these are typically the natural products. So, large number of materials, which we considered as the numerous materials which can be used for chemical processes or another or that ultimately are formed into some end-user product are mined that means, which are useful like your hematite or magnetite or rutile or ilmenite. We will be go for we will go for mining those materials only, which can give rise to the some useful final products.

So, the numerous materials will be in our hand from the material what we are mining. What is mining then, so mining can be applicable to all other materials not only getting these for hematite or magnetite or limestone or gypsum. So, it is a typical term, which implies certain processes such as the removal of hilltop particular source we know if it is not underground one, and creation of a large pit through that pit will be able to dig out the material, which will be useful for our purpose or sometimes digging a deep shaft into the earth to extract some metal or ore.

So, typically we can get some metal from that particular pit or we can get some ore or mineral from which can we can utilize the formation of the different inorganic compounds. So, mining will be the integral part of industrial inorganic chemistry.

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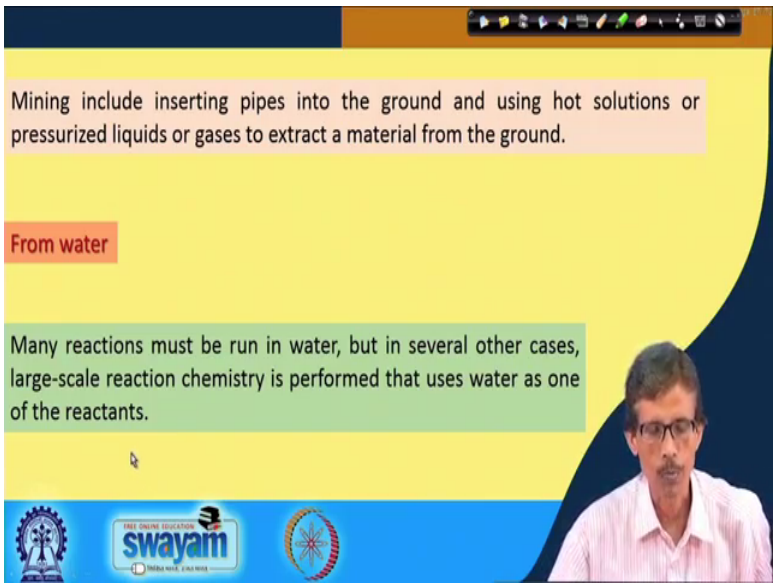

And how we can utilise those, stepwise we will see that what is in our hand. So, by doing so sometime we can utilise the insertion of pipes, so that include the inserting pipes into the ground, and utilization of hot solutions or pressurized liquids or sometime gases to extract a material from the ground level.

So, the typical material we can have suppose the elemental form of sulphur is present over there, how we can take out that sulphur from the ground level that is one important thing. But, sometimes like the oil industry the petrochemical industry or the petroleum, how petroleum can be removed, if we can have a source of petrol or the liquid like oil at the ground level. So, there will be different techniques for that particular purpose, which can be utilized to get those materials in our hand.

So, as we have given the example of seawater or the ocean water, where from we get different types of materials, which will be useful for our purpose. So, let us go back to that again that how the mining part or the mining of some important inorganic chemical is possible or the availability of that particular material will be there from the water, whether you can have a sea water or pond water or ocean water. And their particular utilisation, because we have seen in our previous class that a large amount of that particular water is always useful for industrial purpose particularly for washing, particularly for cooling, and for also for making solutions.

So, if we considered some typical reaction, whether if it the inorganic reactions or organic reactions or polymeric reactions or organometallic reactions, we will see that many reactions must be run in water. Because, most of these reactions, because there are certain sophisticated reactions, which we or we use for non aqueous medium, but most of the reactions we can do in water. But in several other cases large-scale reaction chemistry is basically being utilized by use of water as one of the reactants.

Just now we have seen that how sulphur can give you sulphur dioxide, and that sulphur dioxide can be converted to sulphur trioxide. And utilization of water then to that sulphur trioxide giving a sulphuric acid, the concentrated sulphuric acid very useful material for industry. So, this particular thing that means, use of water as one of the reactant basically. So, in all these cases we will see that the typical water is there, and that water can be utilised as one of the reactant. So, the quality of water, the purity of water, and its particular source is important for utilization of that water for industrial purpose.

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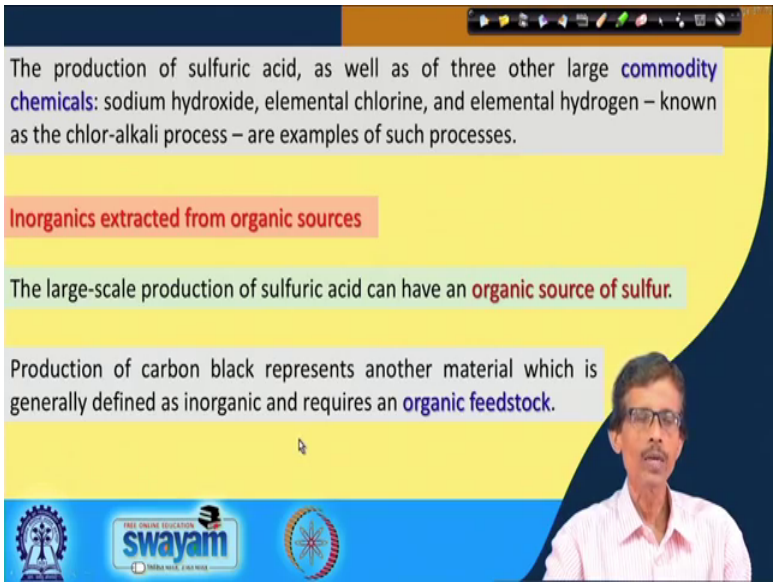


So, we go back to that example, what we have seen in terms of the formula that means, the production of sulphuric acid, how we produce these sulphuric acid is basically as well as of three other large commodity chemicals. So, we have seen that what we can consider as the raw material, we have seen as the bulk material or the bulk inorganic chemicals. Now, we can consider another terminology, we are utilizing it as the commodity chemicals.

So, this commodity chemicals like that of our apart from sulphuric acid, we can have sulphur, sodium hydroxide, elemental chloride, we can have or element sorry elemental chlorine, and elemental hydrogen is known as the chlor-alkali process are the examples of such processes, where we can utilize water.

So, the production of elemental chloride or production of elemental hydrogen, because the elemental hydrogen production that immediately tells us that we can get H 2 the elemental hydrogen as the hydrogen gas, which is a very useful material now a days for industrial purpose, we can get it from H 2 O that means, the water. Similarly, how we can get the elemental chloride, whether we get it from seawater or the ocean water, which is a huge source of chloride ions along with sodium ion as sodium chloride.

So, we can get in some other cases the inorganic materials or inorganic compounds or inorganics extracted from organic sources, how we can convert it, so that is a very important thing that whether we go from inorganic material to organic material or the

organic material can be consumed or utilized for making some useful in organic compound or material.

So, we have seen that if we consider sulphur as the typical organic source is a debatable definitely, it we can consider this as inorganic source also. So, large-scale production of sulphuric acid so, we need to have a good source of sulphur in our hand. So, we can have the different organic source of sulphur also that means, sulphur bearing organic compounds also can have the organic sulphur compounds also we can have from there we can also make the corresponding sulphates or the sulphuric acids.

Similarly, one other organic source is the production of carbon black from organic feedstock. So, any organic material the wood, the other jute material or any other thing, which can be burnt a way to get it as the corresponding carbon compound or the carbon black, because all these are organic feed stocks we all know the mostly they are making or they are forming from carbon hydrogen oxygen nitrogen and sulphur.

So, if they are available from simple carbon and hydrogen compound that means the hydrocarbons we all know like methane ethane and all other things, so the hydrocarbon can be burnt away. So, these hydrocarbons can be converted to your typical carbon black. Similarly, the alcohol type of thing where we can have carbon hydrogen and oxygen or any other compound, where you can have also nitrogen and also we can have sulphur.

So, the production of carbon black, because the carbon black has a huge market, and we can utilize from making the tyres, the road car tyres and all other things. This carbon black will be very much useful, if we can make them via some simple technique from the organic feedstock. So, this can be considered as typically inorganic, but it requires the organic feedstock. So, again like that of our sulphur, the carbon black only we considered as the inorganic material. So, the industry which is dealing with the carbon black can be considered as the inorganic industrial chemistry for making different quality of those blacks.

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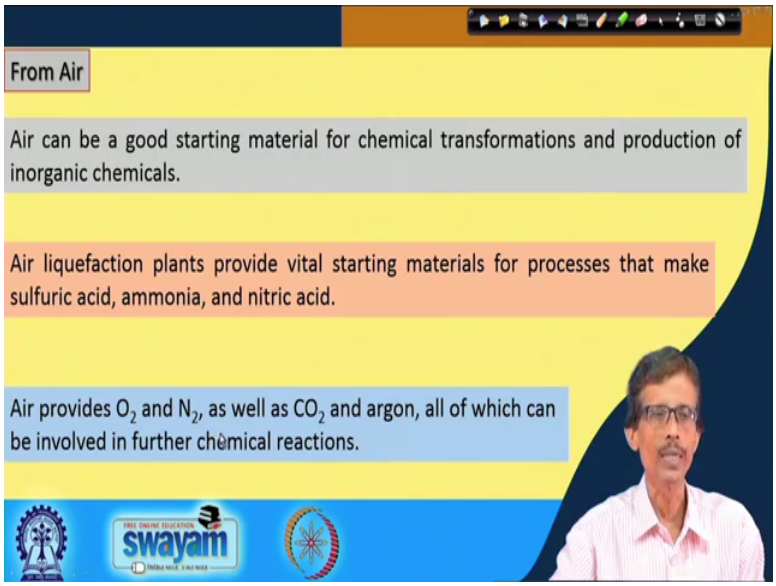


So, one is the source of air like that of our water. So, what are the different things what we can get, because in our previous class what we have seen that we can categorize the thing that what are the materials, we can get from air like hydrogen we get can get some amount, the oxygen we can get, nitrogen we can get.

So, typical air can be a good or starting material for chemical transformations and production of inorganic chemicals. Suppose, we get typical di nitrogen. The nitrogen gas and nitrogen gas as typical example for different reactions. So, if we can convert that nitrogen like sulphur to nitrogen monoxide or nitrogen dioxide to ultimately to nitrates and nitric acids, so that nitric acid production like that of our sulphuric acid production is also a very useful inorganic chemical for industrial purpose, but that we basically get from air.

So, utilization of nitrogen from air is a useful practice or useful technique for getting some value added inorganic chemical like that of your nitric acid, we can also add of hydrogen to these nitrogen to get ammonia or urea or any other fertilizers, so that also give these that mean nitric acid is form so the liquefaction.

So, air liquefaction plants basically, so the liquid air we can have which can give us a vital starting material for processes that make sulphuric acid, because for the oxidation of sulphur, we require oxygen. And that oxygen can be utilized for making sulphuric acid,

then ammonia, then nitrogen from air is coming for making ammonia, and the same nitrogen can be utilized for making nitric acid.

So, all these cases are useful for getting nitrogen from air and converting that nitrogen to some useful material. So, those useful materials are sulphuric acid to nitric acid. So, along with this O 2 and N 2 what we are getting, so getting O 2 and N 2 from air is a useful thing and along with that we also get carbon dioxide, because certain amount of air we all know that certain amount of carbon dioxide is always present in air. And that carbon dioxide can be useful like silicon dioxide. We have seen that the silicon dioxide can be converted to silicates.

Similarly, if we are able to convert this carbon dioxide to carbonates, and those carbonates can be separated out as a very good starting material for different carbonate salts, like sodium carbonate or bicarbonate salts like sodium bicarbonate. Along with these that means, the source of O 2 source of N 2 and C O 2, we can have the inert gas like argon. So, this argon can also be separated out from liquid nitrogen, because we all know that industrially these liquid nitrogen or liquid oxygen plants are there. And those liquid nitrogen and liquid oxygen plants can also separate out this particular gas as the organ.

Also some amount of helium can also be separate out, because helium is also a very useful material for running different instruments and all other cases, so it has also very good industrial prospect for making helium in the industry scale for all these that we can have the further chemical reactions to follow to utilize these starting materials.

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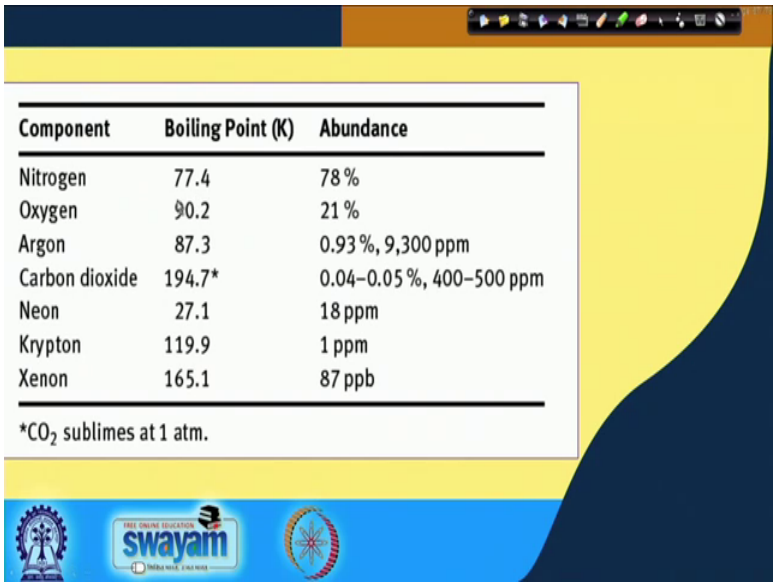


So, we can use these as for this so air. In air, what we can have? We can have the different components and so far we are considering three, why we are talking or why you are calling this three only, because the percentage wise these three are the maximum one.

So, we have nitrogen of 78 percent, oxygen of 21 percent, and then we can have a argon of 9,300 ppm compared to neon, which is 18 ppm only in air. So, it is possible to utilize the technique or the industrial process to get argon in the liquid form or the liquefied iron. And then we can have the liquid nitrogen also, ion also, the neon not only for the gas purpose, because the storing of all these materials will be useful, if we are able to store it in the liquefied form, then krypton and the xenon.

So, one we are going getting these from argon to carbon dioxide to xenon. And interestingly what we see that in air the concentration of argon is more than that of our carbon dioxide. So, whatever carbon dioxide, we can have we know that due to global warming and the environmental aspects, we always consider. And we concern is more our concern is more for the amount of carbon dioxide in air, but these are all in 400 to 500 ppm level.

So, this boiling point scale is also giving us some good idea about the corresponding liquefaction possibility or how quickly we can go for the liquid form, because this particular temperature is very useful, because some organic reactions some other

organometallic reactions and running the instruments this 77 k temperature is very useful.

So, cooling of some instruments like our NMR spectrometer or MRIS, then all these things we can have the magnet the permanent magnet. So, this permanent magnet is always dipped within this liquid nitrogen as well as the liquid helium. So, within liquid helium or the liquid nitrogen, we can have all these things. So, these are useful for making nitrogen in the liquid form or the liquefied form.

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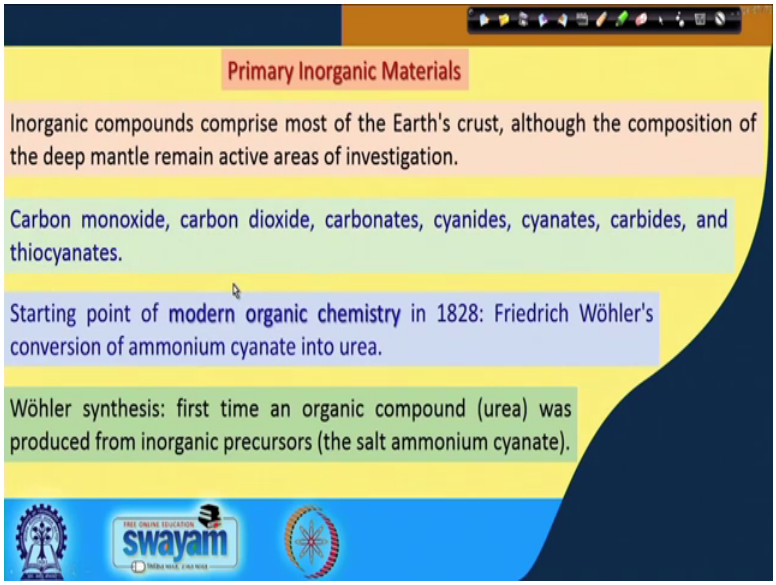


So, we can consider these as our next class, we will follow from here. So, we will follow the primary inorganic materials. The different inorganic materials how we can consider, because the different inorganic compounds we can have. So, not only these gases, but we can also have carbon monoxide, the different carbonates, the cyanides, cyanates, carbides, and thiocyanates.

So, in our next class, what we can consider that how we can utilize not only the sources. The two sources we are so far considered; one is the source of air, another is the source of water. And along with that if we are able to make some useful compounds like carbon monoxide, the different carbonates, the cyanides, the cyanates, the different carbides, and thiocyanates, we will see how we can incorporate those useful inorganic species that means, in carbonates we can have C O 3 2 minus, in cyanides we have C N minus, in

cyanates we have C N O minus, carbides C 2 2 minus, and thiocyanates that N C S minus.

So, only the inorganic part that means, nitrogen, carbon, sulphur, oxygen, and all these things. And their combinations, we will give us some anions and some anionic compounds or some useful anionic compounds, the sodium salt or the potassium salts can be utilized or we can make for some useful purposes, so that we will see in our next class.

Thank you very much.