Industrial Inorganic Chemistry
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Lecture – 03
Bulk and Commodity Chemicals

Hello good morning to everybody. And, welcome to this class of Industrial Inorganic Chemistry, where we were talking about some of the important inorganic chemicals, which can be useful for the industry as some starting material, for some other reactions, and also for the other industries like pharmaceutical industries or any other type of useful industries where inorganic chemicals are utilized for their production.

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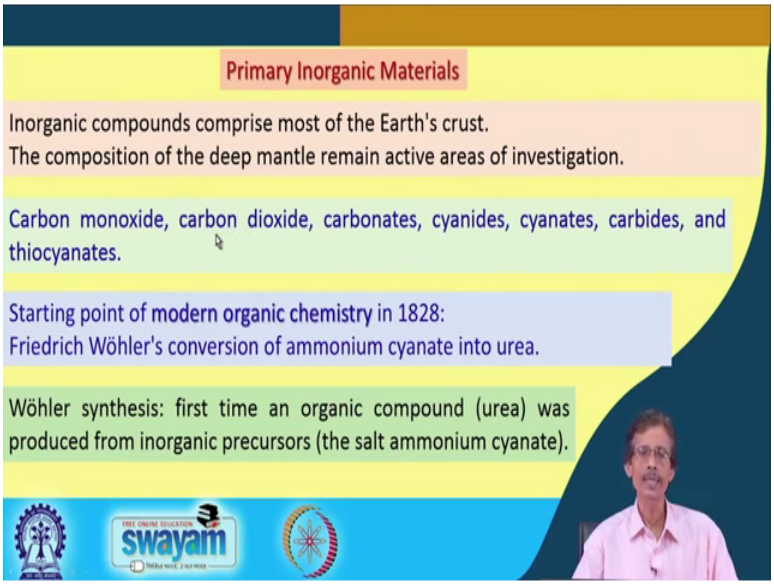

So, what we are talking about something which is our primary inorganic materials? So, what are those primary inorganic materials? So, when we talk in terms of purely inorganic compound, what we can say that as we all know from our early years of study including in the school days, that simple water molecule H 2 O molecule. How can we define as H 2 O molecule? It can be a very simple molecule, but it has large implication for the reactions for inorganic reactions, for the organic reactions, for the biochemical transformations.

So, H 2 O can also be considered as a primary inorganic material or compound, which can be useful for many types of the reactions, but we still do not know much about the useful chemistry of water. Because, water nowadays is very much contaminated and from the environmental aspects we also know that water is not useful in a pure form for all these reactions.

So, we can consider like these water and other inorganic acids like that of your mineral acids, hydrochloric acid, sulphuric acid and the nitric acid, as our primary inorganic materials. So, if we start our discussion in this particular class of primary inorganic materials, we have to consider simply the water molecule first then all other molecules which can come into play some important role in different reactions.

So, these will see that some of these inorganic compounds which can comprise most of the Earth's crust. Why we are saying all these things? Because, we all know that some of these useful materials like ores and the minerals we get it from the earth crust. Because, already the nature has accumulated all these materials for us and only thing we have to know where these materials are available and how we can get all these materials for our useful purpose, for our industry, for our applications, for our day to day use.

So, first thing what we should know the composition of the deep mantle remain active areas of investigation. So, we should know the composition of the mantle which is available, because we if we want to get these from the earth crust. Such as a typical mineral or a typical ore, such as that we all know that the iron containing materials, like hematite and magnetite which are available on the earth crust. And, these are the 2 useful ores where from we get iron. And, we all know that the iron this particular iron can be useful for making steel and any other types of alloys.

So, knowing this particular composition of the deep mantle can be a good area of research, where we know that whether we are getting a particular ore or mineral as the iron source or the manganese source as we all know that pyrolusite MNO 2 the manganese dioxide is also available as a natural source. So, these primary inorganic materials, we can consider them as the starting point of all inorganic industrial chemistry and these materials can be of naturally occurring.

So, all these ore and minerals are natural inorganic materials only thing that we have to utilize it properly and that should also be cost effective, because in a cheaper way we have to get these as the corresponding material. Even sometimes if we find that your hematite and magnetite those are not pure iron these are oxides.

So, one is fe 2 O 3 other is fe 3 O 4. So, these 2 oxide materials can sometimes also be useful if we are not getting these as the pure metal as the iron. Similarly, your manganese dioxide can be a useful material. So, these are also very good and useful oxide materials. So, we should be careful when we talk in terms of this deep mantle of the earth which is a huge source like that of your source from the ocean. So, earth crust can supply some of these useful inorganic materials for our purpose. The first thing that we have to identify the composition, then the percentage wise how much of these materials are present and then we try to get as their oxide materials or the pure metal ion.

Similarly, along with these materials we can have the corresponding origin from the natural origin is the carbon monoxide, carbon dioxide, carbonates, cyanide, cyanates, carbides, and thiocyanates. These are all typical inorganic materials some of them are naturally available, some we try to fix it; that means, conversion as we all know that carbon dioxide can be converted to carbonates in strong alkaline medium.

Similarly, some of these ores and minerals are also available as the carbonates. If, these carbonates are forming that also give us some idea to know how the typical mineralization process is also occurring. In presence of some of these metal ions, like that of our zinc carbonate, if we take the example of zinc carbonate. And, the formation of zinc carbonate can take place in presence of the zinc ions only and we all know that the carbon dioxide is available in the atmosphere.

So, how nature can fix this particular carbon dioxide as carbonates. As carbonates for the zinc carbonate species that we also know. So, some of these metallic ions will be available and these metallic ions will give us some important information related to the fixing for the carbonates. So, other anions which we can derive it from there also that the cyanides, the cyanates, the carbides and thiocyanates. These can also form some of these ionic forms with that of your corresponding metal ion to giving you the corresponding cyanides, corresponding metal ion cyanates and the corresponding metal ion thiocyanates.

So, if we go from this inorganic aspect to the modern organic chemistry, which has started during 1828; when Friedrich Wohler can used to convert ammonium cyanate into urea. And, that time it was known to us that ammonium cyanate NH 4 CN O is a typical inorganic material. Because, we do not have anything of organic origin and that particular conversion gave us that time the first important information, that the typical inorganic compound which is ammonium cyanate can be converted to urea. And, we all know that urea is basically have some organic origin or biochemical origin or it is available from our biological stuff.

So, the formation of urea which is nothing, but NH 2 CO NH 2 from ammonium cyanate is the typical area of understanding, where modern organic chemistry has started developing from the typical inorganic material or inorganic compound which is our ammonium cyanate. So, these two are very much interrelated. Sometimes, we will find that the pure inorganic compound can also be useful for making some useful, organic molecules, or organic compounds or other organic materials.

So, the name which is bearing his fried Erich Wohler's name that Wohler synthesis the first time an organic compound if we consider urea is our. Organic counterpart was produced from inorganic precursors the salt of ammonium cyanate. So, the salt of ammonium cyanate conversion to urea gives us the first idea that we can get some of this useful transformation, that is also chemical transformations and related to some inorganic basic compound which is our ammonium cyanate. So, how we can make this particular ammonium cyanate that we also see that which is not typical cyanide CN minus, but it is CNO minus.

So, how we get cyanate and that also that corresponding ammonium salts. So, ammonium salts that making all these things, we can consider thinking from the very basic component. That means, if we go for elemental analysis of all these things that will give us some idea about the percentage of nitrogen, the percentage of carbon, percentage of hydrogen and percentage of oxygen. So, all these things basically are coming therefore, from pure nitrogen, from the carbon source, from the oxygen source, and from other elemental sources.

So, stepwise we will sees now that how the inorganic raw materials. If, we consider our carbon is your source for making your cyanate, nitrogen is our typical source for making ammonium ions or ammonia or urea which we all know that they are useful fertilizer compounds. So, these typical source; that means, nitrogen is available in the air and how we can fix that particular nitrogen for our useful purpose; that means, making ammonia, ammonium salts, like ammonium chloride, ammonium nitrate, or urea how we can convert this? Because, we have plenty of nitrogen available in the air, but the technology we should know which can convert that particular nitrogen to ammonia or urea is the difficult tasks and that is the typical tasks for studying this particular course, where we will be able to understand how the natural sources the primary inorganic material.

So, the gas molecules like oxygen, the gas molecule like nitrogen or gas molecules like carbon monoxide or carbon dioxide can be our useful primary inorganic materials, from which we can get large number of other converted products which can also be useful for this industry.

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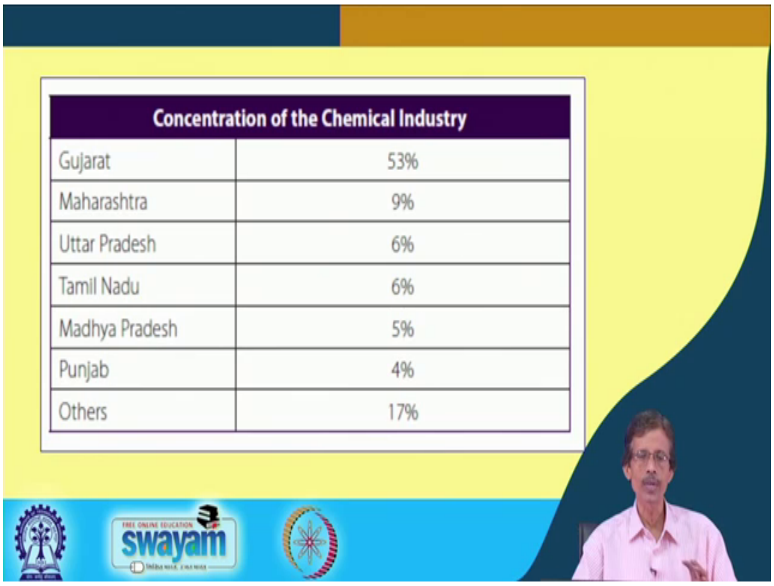

So, what we get now is that the different concentration of all these things; that means, the chemical industry, what we can have in our country in India? How they are concentrated in different zones and different areas. Particularly, if we consider that why the chemical industry is not many in this particular part distant region of our country, that we also try to understand because we must have the regular supply of the raw materials. And all these raw materials should be cheaply available because if your transportation cost is very much we cannot establish a chemical industry in that particular part. Interestingly, we can have very good sources of iron, we can have very good source of coal in this particular region.

So, we can have some industry related to the iron and steel making industry. And, we can have some other industry related to the metals and the metal ion processing, but the other typical in organic chemistry based chemical industries are mostly located here from Gujarat to the Punjab; that means the western part or the northern western part of this country. And, if we see that percentage wise only the other that mean the this part of the country, the eastern part of the country is only contributing 70 percent of these things. So, studying all these thing also can give you some idea that where we can establish a particular chemical industry.

And, if the materials such as that petrochemical industry if somebody is trying to establish a petrochemical industry, where the petrochemicals are cheaply available or the transportation copies cost is less. Then, we can establish that sort of industry, but in terms of your typical inorganic chemicals, starting from making some acids some other useful materials. In these areas or these states which can contribute much in our economy.

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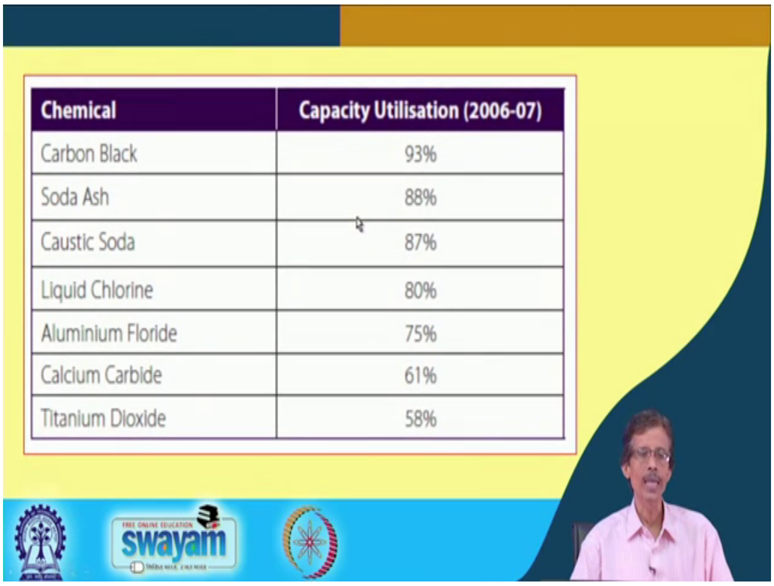

So, what we see also that, what are those materials in terms of the inorganic bulk compounds or inorganic materials, what we can produce? So, some data because we always try to compare it is a very little bit old data of 2006 and 7, where we can see that these things basically from there this, but particularly from amount; that means, the carbon black. What we can consider as the carbon black, whether it is a inorganic material or a organic material. So, when it is typically a carbon black or if we consider that we are talking in terms of the coal the coal industry.

So, this carbon black the capacity for this utilization is that how much we can contribute or how much we can use up all these materials? So, these are only few examples. So, these are all 7 examples where the typical inorganic compounds people can produce people can make all these things and people can sell in the market.

So, one such is your carbon black then the soda ash; that means, the sodium hydroxide bearing all these compounds, then also the sodium chloride, sodium hydroxide, then the caustic products. Similarly, the caustic soda is also there then liquid chlorine, whether we will be able to make some amount of liquid chlorine as we all know like your sodium hypochlorite NaO CL is the typical bleaching agent.

Similarly, the liquid chlorine the chlorine we all know is a gas. So, it can also be available in the liquefied form. So, liquid chlorine can also be a useful material in organic material for different purposes; that means, sometimes if we consider that in a organic molecule, for some useful purpose we will be making and you can have a benzene ring and that benzene ring if we try to get that benzene ring for chlorination. So, that chlorination whether we can get it directly from the chlorine gas or using liquid chlorine that we can also see then aluminium fluoride.

So, these examples these are some typical examples that we are also see afterwards, when we study the chapter particularly devoted to aluminium as well as fluoride. Why aluminium fluoride which is ALF 3, can be useful for this inorganic industrial chemistry. Then calcium carbide when we all know that is a typical cac 2 molecule. So, starting from your carbon black where you can have only carbon and the different forms like your graphite and all other similarly this is this particular one you have cac 2.

So, the carbide anion the c 2 2 minus can also be useful, because we all know that can produce nicely the acetylene gas and all other things. Similarly, the Tio 2 the titanium dioxide, which is the basic component of our ore rutile. From rutile we get pure quality of titanium dioxide, because is a little bit sophisticated material, sometimes we call them as the speciality chemicals. These are not bulk chemicals because the carbon black soda ash and all these are bulk chemicals, we use in a huge amount and those huge amount can be utilized for a large industry, but sometimes these titanium dioxide like material can be produced in a very small scale, but the purity of these materials should be very high. Because, these are little bit sophisticated materials for electronic industry to any other sophisticated industry we use these as, because titanium dioxide is a very good paint material also is the paint industry they utilize this particular titanium dioxide.

So, the purity is also should be very high. So, as we move to from a bulk inorganic chemical to a specialty chemical, we always have to have some high level of quality control or high level of purity check, where you can increase the corresponding purity or the corresponding quality of the material to a high extent.

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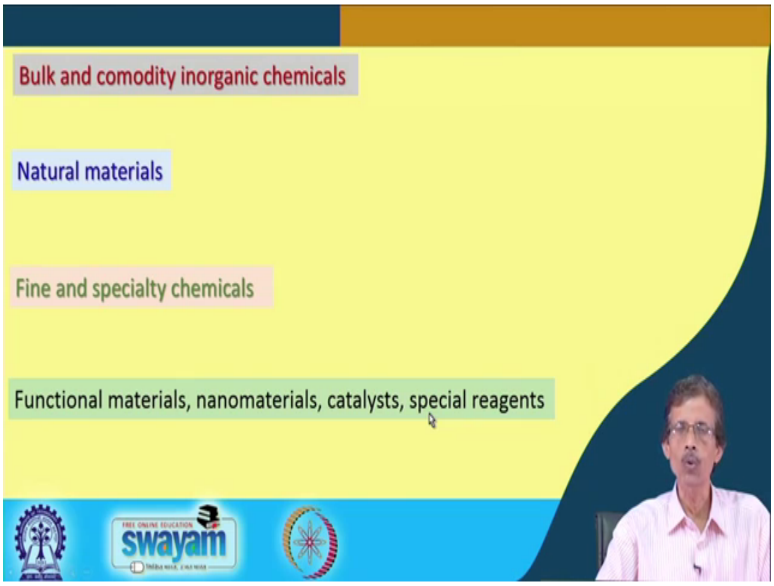

So, what we get therefore, that we can have in one hand the bulk and commodity inorganic materials. So, starting from with all these mineral acids the bases, the caustic soda, the caustic potash, the corresponding ammonia and all these we can produce in a large scale or in a large amount.

So, this bulk and commodity in organic chemicals are also useful for some other industries. And, those industries they buy in a huge amount, because they are also using these for making their molecules, but you always require this thing. As I was giving some very simple example, because your H 2 O molecule I can consider, it as a typical inorganic molecule because you do not have any carbon in it.

So, this H 2 O molecule depending upon it is quality of use. So, this can also be considered as the bulk and commodity inorganic chemical though it is readily available, but we do not know. The corresponding idea that, how good we will be using the corresponding water for a particular reaction. Suppose making of sulphuric acid H 2 S O 4. As, we all know that sulphur which can be bond to sulphur dioxide, which can further be oxidized to sulphur trioxide and when that sulphur trioxide is consuming H 2 O molecule we produce H 2 S O 4.

So, making of this H 2 S O 4 from sulphur, is a typical process where we use water molecules for it is absorption by the sulphur trioxide molecule and also the typical oxidation process. So, if we consider that the sulphur which is available from nature, that sulphur we can utilize for oxidation in presence of the available O 2 from air. So, sulphur can be converted to sulphur dioxide and that sulphur dioxide can further be oxidized to sulphur trioxide in presence of some catalysts like vanadium pentoxide.

So, making this sulphur trioxide is a very useful one from the natural sources like sulphur as well as oxygen only with little bit use of your catalyst. So, that sulphur trioxide when combining with water molecule giving you sulphuric acid. So, we will be able to make huge amount of sulphuric acid as your again a bulk or commodity inorganic chemical, because sulphur to give you sulphuric acid and that sulphuric acid can be useful for many other industries.

So, this is one such example of your bulk and commodity inorganic chemicals where you can use this for our regular use, then natural materials. What are those natural materials as I earlier told you that your hematite, magnetite, to pyrolusite the manganese dioxide molecule can be your natural materials. Even your sulphur, what we just seeing that sulphur for giving you the corresponding sulphur oxidized form the sulphur dioxide and sulphur trioxide.

So, your natural material the sulphur can also be our natural material sometimes, what we find that if the purity or the purification process of these bulk materials, what is available from the nature can be improved, we can go for the quality improvement of these materials. And, those materials can be useful for giving us some other useful compound. As, I just now told you that a catalyst is used for the conversion of vana sulphur dioxide to sulphur trioxide and that conversion can be achieved by use of vanadium pentoxide the V 2 O 5.

But, we all know that vanadium can also be available from nature as some oxides. So, which can be V 2 O 3 the trivalent state of the vanadium oxide, which can further be oxidized to vanadium pentoxide and if we are getting a very good quality of vanadium pentoxide. So, high purity vanadium pentoxide can be available to us from the natural sources. So, we can consider that as a natural material and that vanadium pentoxide can be useful for a catalyst. Because, we all know that the quality or the purity of the material which can be used for catalyst is always should be very high, then we find that the different fine and the speciality chemicals. So, what are those speciality chemicals?

So, fine chemicals means, the fine chemical industry like that of your pharmaceutical industry, our perfumery industry, our food industry, everything should be dependent on this fine and specialty chemicals, as we are talking about water molecules. So, if we use the same water molecule. As a fine or specialty chemicals what does it mean then? That means, the quality of the water molecule should be very high, that is why you use distilled water for different types of pharmaceutical preparations, different types of making medicinal molecules and all these, what we use in a very low concentrations. Because, the different drug molecules, different medicines, what we take in our body in the milligram scale and sometime it go down to microgram to the nano gram level. So, when we use a particular compound in the milligram level.

So, the purity of the compound should be very high. So, that is why the injectable water, what we go for injection the water we use is the high purity, water which is our typical distilled water it has only H 2 O nothing else. So, the water what we get from the bulk sources, from the ocean bed, from the river, from the ponds, which can be considered as our bulk and commodity in organic materials; so, this is a very useful example that how we can consider, because the same H 2 O molecule will remain there.

So, this can also be considered as a natural material, then if we go for a high purity distilled water for our medicinal preparations; like our injections, making giving injections, this can also be fine and speciality chemicals. So, our simple water molecule can be a chemicals for us because we all know that the water can also be very good solvent for large number of chemical reactions. Then, we can have functional materials nano materials catalysts and the special reagents.

So, these are all coming from the aspects of inorganic chemistry. As, we just seen we have seen that these catalysts these catalysts. Say one example one very useful example from our school days example is our vanadium pentoxide. So, we will be talking about different types of catalysts, this can be homogeneous catalysts, this can be heterogeneous catalysts, for some special purposes. Then, we can have some functional materials. So, these functional materials what we fine is therefore, an interesting area of study is that, these functional materials what we get is for us is that it can show some useful functions. Like, that of our vanadium pentoxide we have seen the typical example just now that this is functioning as a catalyst.

But, if some material which is a huge material; like some of our poly oxo metalloids, some other bulk material useful material which can be useful for say storage of hydrogen molecule. Because, in our next class we will be seeing how we can get or how we can produce industrially hydrogen molecule, because hydrogen like water is a very useful material for our industry. So, if we can have a material, which can be naturally occurring or which can be available from our laboratory making process, that a functional material which is useful showing some useful function as the hydrogen storage material. Similarly, we can have some other molecule; that means can be used for gas storage like carbon monoxide storage or carbon dioxide storage molecule.

So, these functional materials when they are presents with some say poly oxo metalloids like all other different oxide materials. So, poly oxo metalloids that we will see some of these poly oxo materials how they can be utilized for storing some gas molecules. So, they can show some useful functions for this storing of these gas molecules. So, gas molecules are being stored. Similarly, some materials which are considered as nano materials; so, materials in the bulk and also these are fine material because the size of these materials are important.

Those are of nano sized particles, we considered these as the useful area of research also useful area for material synthesis the nano particles. Like our titanium dioxide the example what I gave you just now, that which is also a source material from rutile ore. So, titanium dioxide what we are making and that can be produced to a very small particles as a very small particles in the nano meter scale from one nano meter to 100 nano meter, but as we increase the surface area of these materials the function of these nano materials are also changing. So, that can be also useful for pain or different other types of useful applications and then we can have some special reagents. So, what are those special reagents, that we can know that if we can have a source of some compound?

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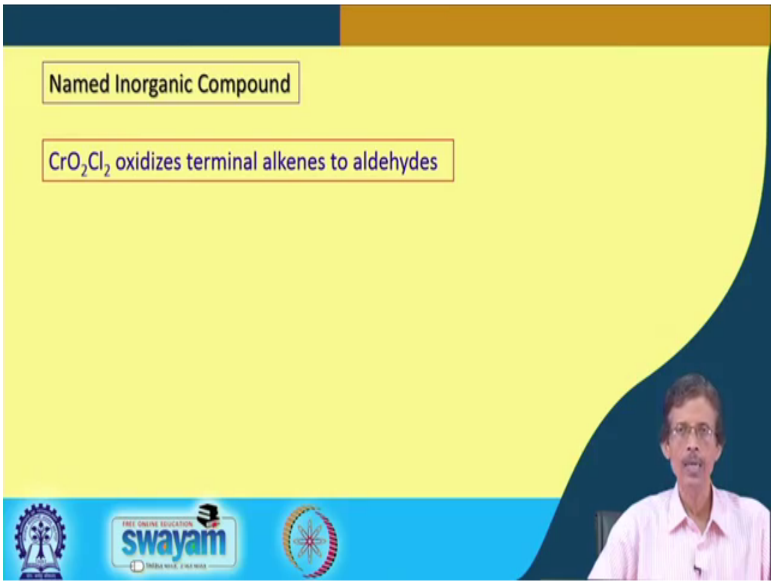

So, these special materials can be named from inorganic compounds, such as some compound if we can have in our hand a typical compound suppose we get it from a chromium metal. So, chromium metal ion can give you something because chromium we all know that when we mix carbon to the iron material we get sometimes the steel. So, alloying process in presence of carbon or any other material similarly when we put chromium we put nickel we get some amount of stainless steel.

So, that is the alloying process, but what is a typical inorganic compound? We are not talking or we are not discussing even right now as the inorganic metal ion complexes, but these are typical inorganic compound like that of our simple table salt the sodium chloride. So, if we can have a typical sodium chloride, but if it is not a very useful one or very useful catalyst or any other thing, we will not go for any particular naming of this compound, we can consider this as a typical compound, which is inorganic compound, which is sodium chloride compound and the usefulness of that sodium chloride can be considered, but if we have a chromium based compound like CrO 2 Cl 2.

So, the person or the scientist who can use this particular compound for some useful purpose, such as one such example of that compound for use of oxidizing agent of terminal alkenes to aldehydes this is a typical organic reaction. Where, the terminal alkyne can be converted to aldehydes and these aldehydes can show some other useful reactions. So, CrO_2Cl_2 preparation which is different from our typical chromium based compound.

So, we can have the chromium ore and from that chromium ore we can make that chromium compound like CrO_2Cl_2. The first thing what we should know is that how we can make this compound and a person who is using this particular compound for some useful reaction like that of your oxidation reaction of our alkynes or alkanes or any other thing, that particular name can be given to the inorganic compound and we can have some typical name reactions in organic chemistry what we all know.

So, our CrO_2Cl_2 can be a typical inorganic compound. So, typical inorganic compound based organic reactions and if this can be used as a catalyst this can be considered as a catalyst also. But, the first thing what we can know is that identification of this compound as it is character in terms of it is oxidation number. And, the number of other groups attached to these particular species we can see in our next class.

Thank you very much.